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The Influence of IEEE on Key Patents

A study of IEEE's impact on 15 breakthrough innovations

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Executive Summary

This report measures the technological impact of patents through forward citations and their reliance on IEEE science. Prior studies performed by 1790 Analytics have demonstrated that IEEE is cited three times more in patents than any other publisher by the top patenting organizations. IEEE is also the top cited publisher among patents in many technology categories, including telecommunications, semiconductors, and other technologies. While very few patents have made a major technological impact or have significant financial value, this study found that IEEE can be linked to many high impact patents, as they list numerous citations to IEEE documents. This report includes examples of these important and valuable patents that build upon IEEE science.

In this report, 15 innovative companies are highlighted whose patents frequently reference IEEE publications and show evidence of having significant technological or financial value. Some of the patents highlighted have stimulated whole new areas of research. Other patents have had central roles in technology licenses and company acquisitions—deals valued at tens-, and in some cases, hundreds- of millions of dollars.

The study methodology includes first identifying patents that are cited frequently by later patents, since this implies that the patents are valuable and have shaped subsequent innovations. From among these high impact patents, we then identify those that cite at least four different IEEE articles as prior art. We then search for press releases and other announcements related to the patents to find evidence of high financial and/or technological value.

Examples of patents highlighted in the report include:

- A patent for "Preauthorized wearable biometric device, system and method for use thereof." This patent, assigned to **Nymi**, is for a biometric wristband that broadcasts the user's heartbeat. The promise of the technology is that unique features of user heartbeats can be used for everything from logging into computers to starting your car to purchasing items at a store or restaurant without ever needing a password or key or credit card. Nymi has raised $15 million in venture funding and has a pilot program with Mastercard to test the device as a contactless credit card. Their valuation was between $47M to $70M in 2017.

  The patent above references 6 IEEE articles as prior art. The two key papers appear to be (Biel et al., "ECG Anaysis: A new Approach in Human Identification," *IEEE Transactions on Instrumentation and Measurement*, Jun. 2001 and Hoekerna et al., "Geometrical Aspects of the Interindividual Variability of Multilead ECG Recordings," *IEEE Transactions on Biometrical Engineering*, May 2001.)

  This suggests that the enabling science showing that heartbeats could be used for biometrics was published in an IEEE journal 13 years before the Nymi patent was filed.

- **LuxVue** was a startup that had raised $43 million in venture funding before being acquired by **Apple** in 2014 (terms not disclosed). According to venture capitalist John Doer, LuxVue had "a technical breakthrough in displays" [LuxVue1]. Specifically, LuxVue's patents are related to micro-LED displays. According to Doer, one of the key advantages of micro-LED displays are they are nine times brighter yet use much less power than required today. Doer mentions that 90% of the power associated with a smartphone is used to power the display. The patents of LuxVue, which now have been reassigned to Apple, are very highly cited and extensively reference IEEE papers in the fields of Optics, MEMS (Micro-Electro-Mechanical Systems), and Semiconductors. These patents each cite at least 4 IEEE articles, and collectively contain 104 references to IEEE science.

Apple has not yet put Micro-LED's into a product, but it has put them into prototype Apple watches and considers Micro-LED's to be a "top-priority" according to a June 2020 article [LuxVue3]. That same article revealed that Apple is investing $330 million in a Taiwanese factory to develop and produce MicroLED displays for its next generation products.

- **Zoox** is an autonomous vehicle company. Unlike many of its competitors, Zoox's approach involves building self-driving cars from scratch, rather than providing sensory technology for traditional, human-controlled vehicles. The Zoox patents shown in the body of the report are all highly cited and all very dependent on IEEE science. Most of the patents have more than 10 references to IEEE and the 17 patents highlighted in the report collectively reference IEEE papers a combined 372 times. Zoox technology has drawn the interest of Amazon, which announced it will purchase Zoox for $1.3 billion in September 2020.

- **Butterfly Network** developed a technology it calls an "ultrasound-on-chip," which was designed to perform diagnostic imaging and measurement of blood vessels and examine the cardiac, abdominal, urological, fetal, gynecological, and musculoskeletal systems [Butterfly1].

  Instead of piezoelectric crystals, the Butterfly iQ device uses semiconductor chips allowing for a lower sales price and more versatility than traditional alternatives. The device retails for $2,000 compared to between $15,000 and $100,000 for traditional ultrasound systems. The global market for Ultrasound equipment is estimated to be about $6 billion.

  In 2018 Butterfly raised a $250 million Series D financing round that increased its total funding to more than $350 million and placed a valuation on the firm at $1.25 billion. Recently Butterfly has made the news as a tool for fighting the Covid-19 virus in areas with limited imaging capability. The portable ultrasound can be used to potentially diagnose the virus by looking for anomalies in the lower region of a patient's lung.

  Butterfly's 23 key patents are not only highly cited but also heavily reference IEEE science as prior art, specifically articles regarding ultrasonics. On average, each patent references IEEE about 20 times (468 total for 23 patents).

- **Kandou Technologies** is a Swiss startup co-founded in 2011 by former postdoc Harm Cronie and his Professor Amin Shokrollahi while at Ecole Polytechnique Federale de Lausanne (EPFL). Kandou was spun-off after raising $10 million in venture funding. Kandou designs high speed, energy and pin efficient serial links connecting integrated circuit components such as processor and memory, or processor and processor. Serial links account for a major part of the energy consumption of electronic devices and represent an energy and speed bottleneck. Any improvement in their design directly leads to faster and more energy efficient electronic devices. Kandou's technology uses a new mode of transmission on serial links to transmit more bits on existing connections, using less energy. The technology is based on a number of patents, which represent several years of research in discrete mathematics, circuit design, and high-speed algorithm design.

> In 2019 Kandou raised \$56 million, increasing its total to nearly \$100 million. Kandou licenses its technology to leading semiconductor companies including Marvell Technology Group and Coherent Logix. It has a valuation of \$224m - \$336m (Dealroom.co estimates Sep 2019.)
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> The Kandou patents included in this report are very highly cited and reference about 10 IEEE articles each on average. The paper (Wang et al., "Applying CDMA Technique to Network-on-Chip," IEEE Transactions on Very Large Scale Integration (VLSI) Systems, vol. 15, No. 10 (Oct. 1, 2007), pp. 1091-1100.) is referenced in 5 of the key patents.

A total of 15 stories like these are contained in the report. In each case, we have written summaries of potentially very valuable patents, which have already had a significant technological impact. In every case the patent or set of patents are highly cited and build extensively on IEEE science.

Contents

Introduction

This report is a new look at “blockbuster patents” – patents that contain interesting technology and are also shown to be valuable. We first investigated these kinds of patents in 2006 [Thomas1] and then again in 2009 [Breitzman1]. This is a completely new look at such patents with a slightly different methodology outlined below.

Placing a value on patents is, in general, a difficult endeavor. Economist Yi Deng [Deng] found that patents in electronics had a median value of only $14,000. That is, half of all patents in electronics are worth much less than the cost to file them.

Researchers such as Harhoff [Harhoff1] have shown that the values of patents are highly skewed, with more than 25% worth $50,000 or less, 75% worth less than $1 million and only about 0.3% worth $50 million. Although Deng’s research is based on European patents, and Harhoff’s on German patents, there is no reason to believe that a similarly skewed distribution does not exist for US patents.

In fact, there is reason to believe that Harhoff’s values are optimistic and that it’s likely that a much smaller percentage of US patents are worth $1 million or more. A figure that is frequently used in the US business press is that 97% of all patents never make any money [AllBusiness].

In this report we are interested in patents that are worth many millions of dollars. We highlight patents with significant financial and/or technological value. These patents contain key innovations that have spurred technological development in their industry or have led to significant financial benefits for their owners. The patents highlighted in this report also build extensively on IEEE publications. As such, IEEE science plays a major role in the scientific and technological foundation of these key innovations.

Methodology

In this report, our aim is to identify valuable patents that build upon IEEE research. To first identify valuable patents, we use citation analysis. Numerous validation studies – see [Breitzman2] for a review of such studies – have shown that patents cited by many later patents tend to contain important or valuable ideas that advance the state of the art. In simple terms, research suggests that highly cited patents tend to be more valuable than patents with few or no citations.

Citation distributions show the same skewed patterns as the patent valuations discussed above. For example, the mean number of citations received by a five-year-old patent is approximately five. However, this average consists of many patents with few or no citations, combined with a smaller number of patents with high numbers of citations. Specifically, for patents that are five years old, about 20% have received no citations, and 51% have two or fewer citations. Less than 10% have more than 10 citations and only 0.3% have more than 50 citations.

This skewed citation distribution has been shown to be related to the skewed value distribution. [Trajtenberg] and [Hall] both showed a correlation between patent value and citation frequency. Also [Harhoff2] showed that, among the 700+ patents in the Harhoff study referenced above, the patents with the most value tended to be the ones that were cited frequently by later patents.

Citations vary by age and technology category. Older patents have had a longer time to accumulate citations than recent patents and patents in fast moving active technologies like communications will receive more citations than older slower moving technologies such as ship-building. Therefore, the standard approach to examining citation impact is with a citation index [Colledge]. The way we construct our citation index is to calculate the mean number of citations for each year and technology category.

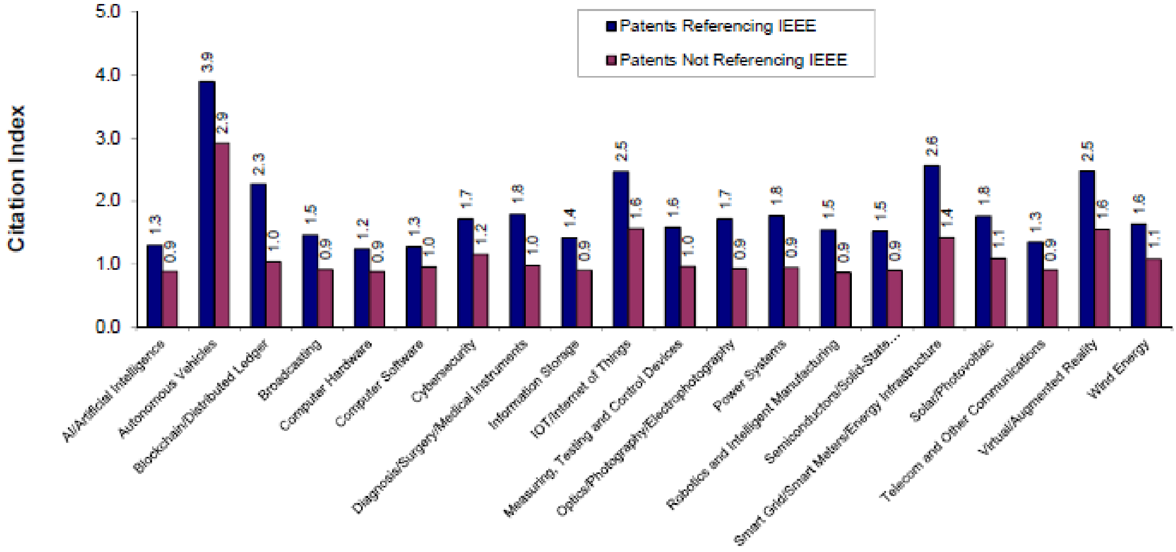
As an example consider patent 9,612,123 'Adaptive mapping to navigate autonomous vehicles responsive to physical environment changes.' This 2017 patent from Zoox, Inc. has already accumulated 33 citations through December 31, 2019. The patent office categorizes patents by a classification system called the CPC. This patent is in CPC class G01S. All of the patents issued in 2017 in class G01S have an average of 0.942 citations. Thus a typical patent from 2017 in this technology has 1 or fewer citations so far. The Zoox patent has 33 citations and therefore a citation index of 33/0.942 = 35.03. Typically a citation index of greater than 1.5 indicating 50% more citations than expected is a good indicator of high citation impact.

Our approach builds upon the relationships between citations and value suggested by this earlier research. Since we wish to find valuable patents that build upon IEEE science, we first identify patents that are cited frequently by later patents. We then identify which of these highly cited patents are themselves highly dependent on IEEE publications.

To find patents dependent upon IEEE, we examine the Non-Patent References (NPRs) provided by high-impact patents. NPRs contain prior art in the form of scientific papers, books, conference papers, and other published materials.

There is a good reason to put this second condition on the patents. Figure 1 taken from [Breitzman3] shows that patents that reference IEEE science tend to be cited higher than patents that do not.

Figure 1: 1999-2019 Citation Index of US Patents Referencing IEEE Papers and Conferences Versus US Patents not Referencing IEEE for 20 Technology Categories



Specifically, our approach is to identify patents that:

1. have a citation index of at least 1.5 (i.e. received at least 50% more citations than would be expected for a patent with the same patent classification and issue year) and
2. reference at least 4 different IEEE publications

Once that set of patents is identified as a superset of potentially high-value, high-impact patents, we research specific patents and companies looking for stories suggesting the patents or technology are valuable. In some cases the story may be about a single patent, but in many cases the technology is protected by a group of patents.

Below are 15 stories related to patented technology that is worth millions of dollars, and builds extensively on IEEE science. The remainder of the report is organized into the following sections: Autonomous Vehicles, Biometrics, Cameras, Computer Hardware, Computer Software, Defense Technologies, Medical Technologies, Robotics, Wireless Charging.

Results

Autonomous Vehicles

Zoox/Amazon

Zoox has patents in many technology areas (Autonomous vehicles, Artificial Intelligence, Robotics, Software, etc.) but is most accurately described as an autonomous vehicle firm.

This firm has been in the news recently because Amazon has a $1.3 billion offer to buy the firm and has most recently offered an additional $100 million in stock options aimed at retaining the key employees [zoox3]. The sale is expected to close in September 2020.

The key patents of Zoox can be found in Table 1 below. All of them are invented or co-invented by the Zoox founders Timothy Kentley Klay and Jesse Sol Levinson. Kentley Klay was CEO until August 2018, when he was suddenly fired by the board one month after Zoox closed a $500 million funding round at a $3.2 billion post-money valuation [zoox2]. Klay remained chairman of the board and co-founder Levinson went from CTO to President.

The Zoox patents shown in Table 1 are all highly cited and all very dependent on IEEE science. Most of the patents have more than 10 references to IEEE science and collectively the 17 patents in Table 1 reference IEEE a combined 372 times. See Appendix A for the specific IEEE articles referenced by the patents below. One of the key papers referenced in 20 of the patents below is ("Traffic Light Mapping, Localization, and State Detection for Autonomous Vehicles" by Levison et al., *IEEE International Conference on Robotics and Automation (ICRA)* in 2011.)

Other IEEE papers referenced by multiple patents in the set below can be found in Appendix B.

Table 1: Key Technology Patents of Zoox

Patent #	#IEEE References	Application Date	Grant Year	# Cites	Citation Index	Title	First 3 Inventors
9494940	22	20151104	2016	8	1.88	Quadrant configuration of robotic vehicles	Kentley; Timothy David

9507346	11	20151104	2016	43	10.10	Teleoperation system and method for trajectory modification of autonomous vehicles	Levinson; Jesse Sol, Kentley; Timothy David, Sibley; Gabriel Thurston
9517767	20	20151104	2016	12	6.37	Internal safety systems for robotic vehicles	Kentley; Timothy David, Gamara; Rachad Youssef, Behere; Sagar
9606539	14	20151104	2017	17	8.86	Autonomous vehicle fleet service and system	Kentley; Timothy David, Levinson; Jesse Sol, Gamara; Rachad Youssef
9612123	13	20151104	2017	33	35.03	Adaptive mapping to navigate autonomous vehicles responsive to physical environment changes	Levinson; Jesse Sol, Sibley; Gabriel Thurston
9630619	26	20151104	2017	14	14.59	Robotic vehicle active safety systems and methods	Kentley; Timothy David, Levinson; Jesse Sol, Lind; Amanda Blair
9632502	39	20151105	2017	23	11.99	Machine-learning systems and techniques to optimize teleoperation and/or planner decisions	Levinson; Jesse Sol, Sibley; Gabriel Thurston, Rege; Ashutosh Gajanan
9701239	26	20151104	2017	8	8.66	System of configuring active lighting to indicate directionality of an autonomous vehicle	Kentley; Timothy David, Gamara; Rachad Youssef
9720415	13	20151104	2017	15	7.82	Sensor-based object-detection optimization for autonomous vehicles	Levinson; Jesse Sol, Kentley; Timothy David, Douillard; Bertrand Robert
9734455	56	20151104	2017	14	10.42	Automated extraction of semantic information to enhance incremental mapping modifications for robotic vehicles	Levinson; Jesse Sol, Sibley; Gabriel Thurston, Rege; Ashutosh Gajanan
9754490	14	20151105	2017	21	12.55	Software application to request and control an autonomous vehicle service	Kentley; Timothy David, Gamara; Rachad Youssef, Linscott; Gary
9804599	17	20151104	2017	8	4.17	Active lighting control for communicating a state of an autonomous vehicle to entities in a surrounding environment	Kentley-Klay; Timothy David, Gamara; Rachad Youssef
9878664	28	20151104	2018	4	9.16	Method for robotic vehicle communication with an external environment via acoustic beam forming	Kentley-Klay; Timothy David, Levinson; Jesse Sol, Lind; Amanda Blair
9910441	11	20151104	2018	1	1.85	Adaptive autonomous vehicle planner logic	Levinson; Jesse Sol, Sibley; Gabriel Thurston, Kentley-Klay; Timothy David
9916703	11	20151104	2018	75	122.84	Calibration for autonomous vehicle operation	Levinson; Jesse Sol, Douillard; Bertrand Robert, Sibley; Gabriel Thurston
9958864	15	20151104	2018	3	5.56	Coordination of dispatching and maintaining fleet of autonomous vehicles	Kentley-Klay; Timothy David, Gamara; Rachad Youssef
10048683	36	20161228	2018	1	1.85	Machine learning systems and techniques to optimize teleoperation and/or planner decisions	Levinson; Jesse Sol, Sibley; Gabriel Thurston, Rege; Ashutosh Gajanan

Unlike many of its competitors, Zoox's approach involves building self-driving cars from scratch, rather than providing sensory technology for traditional, human-controlled vehicles. Its original business plan was to create a ride-hailing service to compete with Uber and Lyft, but if Amazon acquires it, analysts believe the new direction will be towards autonomous delivery vehicles.

Biometrics

Nymi/Bionym

Nymi (originally Bionym) is a Canadian company with technology right out of a science fiction movie. Everyone's heartbeat is unique based on the size and shape of the heart and the orientation of the heart valves. Nymi has used this idea to develop wearable devices that authenticate a person's identity via their heartbeat, giving access to secure places/sites by a watch-like band [Nymi1]. In May 2017, Nymi raised $15M in a second round of funding [Nymi2]. In terms of value, Nymi had a valuation of $47M to $70M in 2017 [Nymi6].

The original use-case was for authorized consumer payments. In a venture between TD Bank, Mastercard and Nymi, the prototype band is linked to the pilot participant's MasterCard account. The user is then able to purchase items at participating retail stores across Canada by holding the Nymi Band up to the tap-and-go terminal [Nymi3].

Other applications include replacing passwords for computers and smartphones. In January 2020, Nymi partnered with Werum IT Solutions to launch a biometric authentication solution to be used in a biopharmaceutical shop floor. It would enable individuals to securely and seamlessly authenticate to systems, devices and machines via a smart wristband [Nymi4].

The Nymi Band is a wearable device that can be worn under all types of protective clothing and is uniquely assigned to each user, based on their unique biometric identity. "We are convinced that having Nymi as part of our K.ME-IN biometric authentication solution is going to make our pharmaceutical and biotech customers even more productive," says Obay Alchorbaji, Product Manager, Werum IT Solutions. "With our new solution we address the very real challenge in the pharmaceutical and biopharmaceutical market of ensuring secure and fast authentication, while also meeting compliance and data integrity requirements. We help our customers cut authentication times by up to 75%, thus significantly increasing their production efficiency." [Nymi4]

The same article mentions that Nymi currently works with many of the top 100 pharmaceutical firms [Nymi4].

What makes the Nymi Band unique is that, once authenticated, it remains on, transmitting the wearer's identity until removed. It is considered the most secure biometric for authentication because the wearer needs to be alive and, unlike fingerprints or iris-scans, a person's unique heartbeat signal is difficult to reproduce [Nymi5].

Nymi has nine US patents, all of which are shown in Table 2. The key patent is #8,994,498 with the title "Preauthorized wearable biometric device, system and method for use thereof." Three other patents in the table have the same title and are continuations of the '498 patent. This patent has 125 citations in just 5 years, which is 43 times as many as expected for a patent of this age and technology.

Table 2: All US Patents Granted to Nymi

Patent #	#IEEE References	Application Date	Grant Date	# Cites	Citation Index	Title	First 3 Inventors

8994498	6	20140724	20150331	125	43.08	Preauthorized wearable biometric device, system and method for use thereof	Agrafioti; Foteini, Martin; Karl, Oung; Stephen
9032501	6	20140818	20150512	9	3.21	Cryptographic protocol for portable devices	Martin; Karl, Vahlis; Evgene
9189901	6	20150326	20151117	7	1.56	Preauthorized wearable biometric device, system and method for use thereof	Agrafioti; Foteini, Martin; Karl, Oung; Stephen
9197414	6	20150331	20151124	11	3.92	Cryptographic protocol for portable devices	Martin; Karl, Vahlis; Evgene
9349235	6	20151116	20160524	3	1.16	Preauthorized wearable biometric device, system and method for use thereof	Agrafioti; Foteini, Martin; Karl, Oung; Stephen
9407634	6	20151123	20160802	1	0.54	Cryptographic protocol for portable devices	Martin; Karl, Vahlis; Evgene
9472033	6	20160523	20161018	1	0.39	Preauthorized wearable biometric device, system and method for use thereof	Agrafioti; Foteini, Martin; Karl, Oung; Stephen
9646261	6	20120510	20170509	1	0.74	Enabling continuous or instantaneous identity recognition of a large group of people based on physiological biometric signals obtained from members of a small group of people	Agrafioti; Foteini, Bui; Francis Minhthang, Hatzinakos; Dimitrios
9832020	6	20160801	20171128	0	0.00	Cryptographic protocol for portable devices	Martin; Karl, Vahlis; Evgene

All nine of Nymi's patents reference the same six IEEE articles. Two of the articles seem to be key pieces of enabling prior art and predate the first Nymi patent application by 13 years:

- Biel et al., "ECG Anaysis: A new Approach in Human Identification," *IEEE Transactions on Instrumentation and Measurement*, vol. 50, No. 3, Jun. 2001, pp. 808-812.
- Hoekerna et al., "Geometrical Aspects of the Interindividual Variability of Multilead ECG Recordings," *IEEE Transactions on Biometrical Engineering*, vol. 48, No. 5, May 2001, pp. 551-559.

This suggests that the enabling science showing that heartbeats could be used for biometrics was published in an IEEE journal 13 years before the Nymi patent was filed. The other IEEE references are similar and can be found in Appendix A and Appendix B.

Cameras

Xperi/Pelican/Tessera

Pelican Imaging is a firm with imaging technology. The Pelican technology uses an array of lenses:

> The remarkable thing about Pelican's array camera is that it uses 16 distinct lenses and imaging channels in a 4x4 grid, as opposed to the traditional smartphone camera that has just one of everything. Each sub-camera captures only one color (red, green or blue), which improves image quality by removing the noise that results from cross-talk -- in much the same way as a pro video camera uses three separate sensor chips for each color. Moreover, since there are small distances between the sub-cameras, their output also contains 3D

> depth information. With clever software -- which is actually Pelican's specialty, more so than hardware -- all this info can be translated into a single JPEG file that's just 20 percent larger than a regular JPEG but contains some major advantages. Namely, a Pelican JPEG should have less noise at low light, and it should contain focus information for an entire scene, allowing the user to select the desired focus point Lytro-style, even after taking the image. (In fact, doing away with autofocus also has the happy byproduct of making the Pelican camera thinner and cheaper to manufacture, since it has no moving parts.) [Pelican1]

We identified 58 patents assigned to Pelican that mention a camera array or an array of lenses. The 58 patents combined have more than 2000 references to IEEE science. The 15 most highly cited patents from Pelican related to camera arrays are shown in Table 4.

Table 4: Key Technology Patents of Pelican

#IEEE References	Patent #	Application Date	Grant Year	# Cites	Citation Index	Title	First 3 Inventors
31	8619082	20130821	2013	249	29.42	Systems and methods for parallax detection and correction in images captured using array cameras that contain occlusions using subsets of images to perform depth estimation	Ciurea; Florian, Venkataraman; Kartik, Molina; Gabriel
29	8514491	20101122	2013	190	31.63	Capturing and processing of images using monolithic camera array with heterogeneous imagers	Duparre; Jacques
15	8804255	20120628	2014	143	45.54	Optical arrangements for use with an array camera	Duparre; Jacques
34	8885059	20140813	2014	137	48.19	Systems and methods for measuring depth using images captured by camera arrays	Venkataraman; Kartik, Jabbi; Amandeep S., Mullis; Robert H.
32	8866920	20101122	2014	136	47.84	Capturing and processing of images using monolithic camera array with heterogeneous imagers	Venkataraman; Kartik, Jabbi; Amandeep S., Mullis; Robert H.
9	8692893	20121102	2014	134	35.48	Systems and methods for transmitting and receiving array camera image data	McMahon; Andrew Kenneth John
34	8902321	20090520	2014	131	46.08	Capturing and processing of images using monolithic camera array with heterogeneous imagers	Venkataraman; Kartik, Jabbi; Amandeep S., Mullis; Robert H.
64	8861089	20130722	2014	128	40.76	Capturing and processing of images using monolithic camera array with heterogeneous imagers	Duparre; Jacques
32	8896719	20140730	2014	125	43.97	Systems and methods for parallax measurement using camera arrays incorporating 3 x 3 camera configurations	Venkataraman; Kartik, Jabbi; Amandeep S., Mullis; Robert H.
30	8866912	20130310	2014	107	37.64	System and methods for calibration of an array camera using a single captured image	Mullis; Robert
30	8928793	20110512	2015	96	42.75	Imager array interfaces	McMahon; Andrew Kenneth John
33	9041829	20140902	2015	91	40.52	Capturing and processing of high dynamic range images using camera arrays	Venkataraman; Kartik, Jabbi; Amandeep S., Mullis; Robert H.

32	9041823	20140730	2015	86	38.30	Systems and methods for performing post capture refocus using images captured by camera arrays	Venkataraman; Kartik, Jabbi; Amandeep S., Mullis; Robert H.
60	9264610	20140902	2016	77	60.43	Capturing and processing of images including occlusions captured by heterogeneous camera arrays	Duparre; Jacques
72	9123118	20141028	2015	73	32.88	System and methods for measuring depth using an array camera employing a bayer filter	Ciurea; Florian, Venkataraman; Kartik, Molina; Gabriel

The patents in this special subset are cited 30 to 60 times as often as their peers and reference 36 IEEE articles per patent on average. Table 5 below shows some of the IEEE references from the first patent in Table 4 (# 8,619,082). We see from the references that this patent builds on science from several IEEE technical areas such as Computer Vision, Pattern Analysis, Image Processing, Signal Processing, Solid-State Circuits etc.

Table 5: IEEE References from Patent #8,619,082

Farsiu et al., "Fast and Robust Multiframe Super Resolution", *IEEE Transactions on Image Processing*, Oct. 2004, vol. 13, No. 10, pp. 1327-1344.
Farsiu et al., "Multiframe Demosaicing and Super-Resolution of Color Images", *IEEE Transactions on Image Processing*, Jan. 2006, vol. 15, No. 1, pp. 141-159.
Feris et al., "Multi-Flash Stereopsis: Depth Edge Preserving Stereo with Small Baseline Illumination", *IEEE Trans on PAMI*, 2006, 31 pgs.
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Vaish et al., "Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform", *IEEE Workshop on A3DISS*, CVPR, 2005, 8 pgs.
Vaish et al., "Using Plane + Parallax for Calibrating Dense Camera Arrays", *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2004, 8 pgs.
Wilburn et al., "High-Speed Videography Using a Dense Camera Array", Proceeding, *CVPR'04 Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, pp. 294-301.

Zomet et al., "Robust Super-Resolution", IEEE, 2001, pp. 1-6.
aker et al., "Limits on Super-Resolution and How to Break Them", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Sep. 2002, vol. 24, No. 9, pp. 1167-1183.
Bose et al., "Superresolution and Noise Filtering Using Moving Least Squares*", IEEE Transactions on Image Processing*, 15(8), Aug. 2006, pp. 2239-2248.
Chan et al., "Investigation of Computational Compound-Eye Imaging System with Super-Resolution Reconstruction", IEEE, *ISASSP* 2006, pp. 1177-1180.
Drouin et al., "Geo-Consistency for Wide Multi-Camera Stereo", Proceedings of the 2005 *IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, 2005, 8 pgs.

One of the key papers is ("Investigation of Computational Compound-Eye Imaging System with Super-Resolution Reconstruction", from Chan et al., 2006 *IEEE International Conference on Acoustics Speech and Signal Processing Proceedings*.) We see in Appendix B (page B-12) that this paper is referenced by all 15 of the patents from Table 4 above. This suggests that the super-resolution idea appeared in the IEEE papers 6 to 7 years before it became patented technology.

In 2016, the patent assets of Pelican Imaging were acquired by Tessera (now Xperi Corp). Pelican's advanced imaging technologies were to be used by Tessera's FotoNation subsidiary, to accelerate development of new, high performance, low power computational imaging solutions for use in next generation applications and devices [Pelican2]. Terms of the deal were not announced, but three years earlier Pelican raised $20 million from Nokia and Qualcomm to help develop the technology [Pelican3].

Communications

BAE Systems/UK Army (See Defense Related)

The BAE Systems Tactical Hotspot is a compact mobile digital communications system that could go in the communications category. However, since it is being used by the UK army, and is aimed at other defense departments, the story can be found in the defense-related technology section below.

Cap Wireless/Triquint/Qorvo (See Semiconductors)

Cap Wireless - which invented the Spatium™ broadband amplifiers product line - could be placed in the communications category. However, since it was purchased by Triquint Semiconductors, the story can be found in the semiconductor section below.

Computer Hardware and Peripherals

Project SOLI-Google

Project Soli is a new gesture-recognition technology based on radar, unlike established approaches based on visual or infrared light such as stereo cameras, structured light, or time-of-flight sensors. This novel approach uses small high-speed sensors and data-analysis techniques to detect fine motions with sub-millimeter accuracy [Soli2]. Thus, for instance, Project Soli technology enables a user to issue commands to a computer by rubbing a thumb and forefinger together in pre-defined patterns. Applications might include sensors embedded in clothing, switches that don't require physical contact, and accessibility technology [Soli2].

The project is headed by Ivan Poupyrev a former scientist for Disney Imagineering who was named one of Fast Company's "100 Most Creative People in Business 2013" [Soli3]. Poupyrev is now the head of

Google's Advanced Technology and Projects group (ATAP) and the head of project Soli and Jacard amongst others. He is also lead inventor on several of Google's gesture recognition patents shown in Table 7.

Table 7: Patents related to Google's Project SOLI

Patent #	#IEEE References	Application Date	Grant Date	# Cites	Citation Index	Title	First 3 Inventors
10139916	9	20160429	20181127	16	40.64	Wide-field radar-based gesture recognition	Poupyrev; Ivan
9971415	8	20170110	20180515	20	50.80	Radar-based gesture-recognition through a wearable device	Poupyrev; Ivan, Aiello; Gaetano Roberto
9921660	10	20141001	20180320	26	66.03	Radar-based gesture recognition	Poupyrev; Ivan
10088908	9	20150923	20181002	19	48.26	Gesture detection and interactions	Poupyrev; Ivan, Schwesig; Carsten, Schulze; Jack
9575560	5	20140623	20170221	27	27.92	Radar-based gesture-recognition through a wearable device	Poupyrev; Ivan, Aiello; Gaetano Roberto
9646481	5	20141222	20170509	9	6.11	Alarm setting and interfacing with gesture contact interfacing controls	Messenger; Jayson, Yuen; Shelten
9811164	7	20141014	20171107	25	25.85	Radar-based gesture sensing and data transmission	Poupyrev; Ivan
9778749	12	20140924	20171003	28	28.96	Occluded gesture recognition	Poupyrev; Ivan
8812259	4	20131009	20140819	13	4.37	Alarm setting and interfacing with gesture contact interfacing controls	Messenger; Jayson, Yuen; Shelten

The patents are all very highly cited and reference IEEE science extensively. The nine patents in Table 7 reference IEEE 69 times (an average of 7.6 IEEE references per patent). Poupyrev is also an author on a whitepaper describing the technology [Soli1] which references 23 different IEEE published articles.

One of the papers referenced in all 7 of the patents above is (Wang,"Micro-Doppler Signatures for Intelligent Human Gait Recognition Using a UWB Impulse Radar", *2011 IEEE International Symposium on Antennas and Propagation (APSURSI)*, Jul. 3, 2011, pp. 2103-2106.) Another is (Espina,"Wireless Body Sensor Network for Continuous Cuff-less Blood Pressure Monitoring", *IEEE/EMBS International Summer School on Medical Devices and Biosensors*, Sep. 2006.) The is also this paper that is referenced in 6 of the 7 patents above (Pu,"Whole-Home Gesture Recognition Using Wireless Signals", MobiCom '13 *IEEE/ACM Proceedings of the 19th annual international conference on Mobile computing & networking*, Aug. 27, 2013.)

The list of all IEEE articles referenced in the patents above can be found in Appendix A.

In Jan. 2019 the *Patently Apple* website mentioned that Google won a major patent for an In-Air Gesturing System in November 2019 [Soli4]. Although the website did not specifically mention patent #10,139,916, this patent appears to be the one in question. They go on to say:

> What makes this granted patent interesting is that The Federal Communications Commission (FCC) said in an order late on Monday that it would grant Google a waiver to operate the Soli sensors at higher power levels than currently allowed. … Google says the virtual tools can approximate the precision of natural human hand motion and the sensor can be embedded in wearables, phones, computers

> and vehicles. The FCC also noted that the sensors can also be operated aboard aircraft. … The system could apply to home automation and control systems, entertainment systems, audio systems, other home appliances, security systems, netbooks, and e-readers. Note that computing device can be wearable, non-wearable but mobile, or relatively immobile (e.g., desktops and appliances) [Soli4]

The gesture features made their commercial debut in the Google Pixel 4 smartphone but they have plans that go beyond phones. According to *Wired*, the Pixel 4 has only a few gesture controls: snoozing alarms, skipping songs, silencing phone calls.

> But by the time Pixel owners get used to pinching their fingers together and rotating their thumb on invisible dials, a seismic shift will already be underway. Gesture technology will further turn our devices into extensions of ourselves; we move our fingers, and the feedback shows up on a screen. That type of interaction won't end with phones. One day, we might control every screen with a flick of the wrist. Google's gesture technology is merely a glimpse of a touchless future. Just like the iPhone taught millions of people to interact with their world by tapping and swiping, the Pixel may train us on a new kind of interaction, changing how we expect to interact with all of our devices going forward. [Soli5]

The future for gesture technology seems certain: Grand View Research estimates that the global gesture recognition market will be worth nearly $31 billion by 2025, up from $6.2 billion in 2017 [Soli6].

LuxVue/Apple

An interesting set of patents are those filed by LuxVue, which were then assigned to Apple after its acquisition of LuxVue in 2014. Terms of the deal were not disclosed but LuxVue had raised $43 million in venture capital funding from Kleiner Perkins, iD Ventures America, and other companies prior to the sale.

According to venture capitalist John Doer, LuxVue had "a technical breakthrough in displays." LuxVue's patents are related to micro-LED displays. According to Doer, one of the other killer advantages of micro-LED displays are they are 9X brighter yet use much less power than required today. Doer mentions that 90% of the power associated with a smartphone is used to power the display [LuxVue1].

Table 8 shows 21 patents that were reassigned from LuxVue Technology to Apple as part of the acquisition. This set of patents are at the heart of the acquisition and are interesting for several reasons. They are all very highly cited, each with a Citation Index above seven, and some above 100. Note that a Citation Index has an expected value of 1.0, so patent #8,791,474 with 126 citations is actually cited 23 times as often as peer patents of the same age and technology class. Each of the patents in Table 8 reference at least 4 IEEE articles, and collectively these 21 patents contain 104 references to IEEE science.

Many of the patents in Table 8 are invented or co-invented by Andreas Bibl, Kapil Sakanriya or Kelly McGrody. Bibl was the CEO of LuxVue prior to the acquisition and continues to have patents granted with Apple. Sakanriya was the VP of technology with LuxVue prior to the acquisition and now holds the title Director, Engineering and Product development with Apple. McGrody was Director of LED Device Technology at LuxVue and then a Senior Engineering Manager at Apple through 2018 and is now self-employed.

Hence, with the LuxVue acquisition by Apple, we see evidence of a valuable display technology developed by researchers building extensively on IEEE science.

Table 8: Patents reassigned from LuxVue to Apple

Patent #	#IEEE References	Application Date	Grant Year	# Cites	Citation Index	Title	First 3 Inventors
8426227	6	20120213	2013	89	21.67	Method of forming a micro light emitting diode array	Bibl; Andreas, Higginson; John A., Law; Hung-Fai Stephen
8552436	5	20121207	2013	43	10.75	Light emitting diode structure	Bibl; Andreas, Higginson; John A., Law; Hung-Fai Stephen
8791474	5	20130315	2014	126	23.43	Light emitting diode display with redundancy scheme	Bibl; Andreas, Sakariya; Kapil V., Griggs; Charles R.
8928021	5	20130618	2015	19	9.35	LED light pipe	Bibl; Andreas, McGroddy; Kelly
8987765	5	20130617	2015	117	57.61	Reflective bank structure and method for integrating a light emitting device	Bibl; Andreas, Griggs; Charles R.
9087764	6	20130726	2015	17	8.37	Adhesive wafer bonding with controlled thickness variation	Chan; Clayton Ka Tsun, Bibl; Andreas
9111464	7	20130618	2015	19	12.86	LED display with wavelength conversion layer	Bibl; Andreas, McGroddy; Kelly
9153171	4	20121217	2015	88	63.90	Smart pixel lighting and display microcontroller	Sakariya; Kapil V., Bibl; Andreas, McGroddy; Kelly
9178123	5	20121210	2015	69	33.97	Light emitting device reflective bank structure	Sakariya; Kapil V., Bibl; Andreas, Hu; Hsin-Hua
9240397	5	20150123	2016	29	18.88	Method for integrating a light emitting device	Bibl; Andreas, Griggs; Charles R.
9252375	5	20130315	2016	27	17.58	Method of fabricating a light emitting diode display with integrated defect detection test	Bibl; Andreas, Sakariya; Kapil V., Griggs; Charles R.
9318475	5	20140515	2016	30	19.53	Flexible display and method of formation with sacrificial release layer	Bibl; Andreas, Golda; Dariusz
9343448	4	20150921	2016	11	7.16	Active matrix emissive micro LED display	Sakariya; Kapil V., Bibl; Andreas, Hu; Hsin-Hua
9367094	5	20131217	2016	20	11.77	Display module and system applications	Bibl; Andreas, Sakariya; Kapil V., Pavate; Vikram
9484504	8	20130514	2016	33	21.48	Micro LED with wavelength conversion layer	Bibl; Andreas, McGroddy; Kelly
9570427	5	20151221	2017	18	22.70	Method for integrating a light emitting device	Bibl; Andreas, Griggs; Charles R.
9583466	6	20131227	2017	22	27.74	Etch removal of current distribution layer for LED current confinement	McGroddy; Kelly, Hu; Hsin-Hua, Bibl; Andreas
9583533	5	20140313	2017	29	36.57	LED device with embedded nanowire LEDs	Hu; Hsin-Hua, Bibl; Andreas
9626908	4	20150819	2017	56	102.90	Smart pixel lighting and display microcontroller	Sakariya; Kapil V., Bibl; Andreas, McGroddy; Kelly
9865832	4	20150713	2018	24	74.83	Light emitting diode display with redundancy scheme	Bibl; Andreas, Sakariya; Kapil V., Griggs; Charles R.

The IEEE papers referenced in these patents are related to Optics, MEMS (Micro-Electro-Mechanical Systems), and Semiconductors. A full list of the papers can be found in Appendix A and the IEEE papers referenced 3 or more times can be found in Appendix B starting at page B-7.

Apple has not yet put Micro-LED's into a product, but it has put them into prototype Apple watches and it considers Micro-LED's to be a "top-priority" according to a recent article [LuxVue3]. That same article revealed that Apple is investing $330 million in a Taiwanese factory to develop and produce MicroLED displays for its next generation products.

Synaptics Inc/Pacinian

The case study of Pacinian should be taught in every business school. The two founders raised $6 million in angel funding between 2007 and 2012 and sold their firm to Synaptics in 2012 for $30 million before ever launching a product [Pacinian1].

Co-founders Jim Schlosser and Cody Peterson observed that computers were becoming smaller and sleeker but that keyboards were still heavy, clunky, and easily damaged. They developed a ThinTouch™ keyboard that uses tiny magnets and a small ramp to generate the desired typing feel. Pressing the keys makes the magnets separate and allows a tiny depression of the key. Users feel they are pressing down keys, but the keys barely move – less than 1 millimeter. The smaller key depression meant keyboards could be skinnier – barely more than the width of two credit cards [Pacinian1].

Between 2007 and 2009 the two men filed 19 patents related to their keyboard. All have been subsequently reassigned to Synaptics. The 14 patents with five or more citations are shown in Table 10. The key patent "Touchpad with capacitive force sensing" has 79 citations in just four years (peer patents of the same age and technology class have less than one citation on average). All of the patents in Table 10 are highly cited relative to their peers and each references 3.7 IEEE articles on average.

In addition to keyboards, Synaptics now uses the capacitive touch technology in smart-phones, biometric devices and touchpads in the IOT (Internet-of-things) and automotive industry [Pacinian2].

Table 10: Key patents reassigned from Pacinian to Synaptics

Patent #	#IEEE References	Application Date	Grant Year	# Cites	Citation Index	Title	First 3 Inventors
7741979	3	20071127	2010	25	4.33	Haptic keyboard systems and methods	Schlosser; James William, Peterson; Cody George, Huska; Andrew
8199033	4	20090127	2012	15	2.51	Haptic keyboard systems and methods	Peterson; Cody George, Huska; Andrew Parris, Schlosser; James William
8203531	4	20090312	2012	14	2.47	Vector-specific haptic feedback	Peterson; Cody George, Huska; Andrew Parris, Schlosser; James William
8248277	4	20090127	2012	39	6.53	Haptic keyboard systems and methods	Peterson; Cody George, Huska; Andrew Parris, Schlosser; James William
8248278	6	20100601	2012	43	7.20	Haptic keyboard assemblies, systems and methods	Schlosser; James William, Peterson; Cody George, Huska; Andrew
8294600	4	20090213	2012	36	6.02	Keyboard adaptive haptic response	Peterson; Cody George, Huska; Andrew Parris, Schlosser; James William
8309870	4	20111212	2012	28	4.08	Leveled touchsurface with planar translational responsiveness to vertical travel	Peterson; Cody G., Krumpelman; Douglas M., Levin; Michael D.
8310444	4	20090127	2012	19	1.62	Projected field haptic actuation	Peterson; Cody George, Huska; Andrew P., Schlosser; James William

8542134	0	20120831	2013	24	5.98	Keyboard adaptive haptic response	Peterson; Cody George, Huska; Andrew Parris, Schlosser; James William
8599047	3	20120427	2013	25	6.23	Haptic keyboard assemblies and methods	Schlosser; James William, Peterson; Cody George, Huska; Andrew
8735755	0	20120306	2014	30	10.86	Capacitive keyswitch technologies	Peterson; Cody George, Krumpelman; Douglas M., Huska; Andrew P.
8760413	7	20091015	2014	26	4.20	Tactile surface	Peterson; Cody George, Krumpelman; Douglas M., Huska; Andrew P.
8912458	5	20120806	2014	7	1.78	Touchsurface with level and planar translational travel responsiveness	Peterson; Cody G., Krumpelman; Douglas M., Levin; Michael D.
9349552	4	20120906	2016	79	81.69	Touchpad with capacitive force sensing	Huska; Andrew P., Krumpelman; Douglas M., Peterson; Cody G.

The key IEEE papers are from the field of robotics.

- "Touch and Haptics", *2004 IEEE/RSJ International Conference on Intelligent Robots and Systems*
- Bar-Cohen, Yoseph "Electric Flex", *IEEE Spectrum Online*, (Jun. 2004),6 pages.
- Biggs, James "Some Useful Information for Tactile Display Design", *IEEE Transactions on Man-Machine Systems*, vol. 11, No. 1,(1970), pp. 19-24.

The first is actually an incomplete reference. Touch and Haptics was a workshop within the *IEEE/RSJ Conference on Robots and Systems*, but the incomplete reference is repeated in 7 of the patents above. It could potentially be for the paper (Kheddar, A., "Problems in designing inclusive haptic devices." In: *Touch and Haptics Workshop, IEEE/RSJ International Conference on Intelligent Robots and Systems,* Sendai, Japan 2004.) or it could be for other papers in the workshop. The second paper above has the cryptic title "Electric Flex" but it is related to electrically activated plastic muscles in a robotic arm. It's not clear how this is related to haptic keyboards but this paper is referenced by 7 of the patents above as well. The third paper (referenced in 5 of the patents above) is related to a tactile display. Other referenced IEEE papers can be found in Appendix A and Appendix B.

Computer Software

Palantir

Palantir is a Data Mining and Cybersecurity firm co-founded in 2003 by billionaire Peter Thiel (PayPal co-founder). Although it is not primarily a cybersecurity firm it gained its foothold with the CIA and other agencies in cybersecurity. In 2017, it was famously fired by its largest private cybersecurity client Home Depot for being too expensive [Palantir1].

Palantir has two software products 'Gotham' and 'Foundry' whose main purpose is data fusion or integration (taking structured data like databases and spreadsheets as well as unstructured data like email and integrating and transforming it into a single data asset).

The company has not yet made a profit but that is likely to change in 2020. In March 2020 it won an $80 million Navy contract, beating out the more well-known defense contractor Raytheon as well as 30 other firms. "The Navy will use Palantir's software to fuse together existing data sets that are walled off from one another, forming a broader operating system the Pentagon is calling Naval Operational Business

Logistics Enterprise, or NOBLE. The terms of the deal were finalized last week," Palantir spokeswoman Lisa Gordon said [Palantir2].

One month earlier, Palantir and BAE systems won a joint bid to update the army's intelligence software suite which could be worth $823 million over eight years. This bid was also won against Raytheon [Palantir3]. This contract is interesting because Raytheon won the initial contract several years ago and Palantir sued the US Army saying that the government was paying Raytheon to reinvent software that was already available off-the-shelf from Palantir. A judge agreed and the bidding for updating the original system was opened to Palantir [Palantir4].

The key Palantir patents related to Artificial Intelligence, Computer Software, and Cybersecurity can be found in Table 11. The patents are highly cited for their age and reference IEEE heavily. The 20 patents in Table 11 have 106 references to IEEE articles (about 5.3 IEEE references per patent on average).

Table 11: Key patents of Palantir

Patent #	#IEEE References	Application Date	Grant Date	# Cites	Citation Index	Title	First 3 Inventors
9009827	3	20140516	20150414	169	60.21	Security sharing system	Albertson; Jacob, Hildebrandt; Melody, Singh; Harkirat
9648036	8	20160713	20170509	58	52.32	Systems for network risk assessment including processing of user access rights associated with a network of devices	Seiver; Miles, Cohen; Stephen
9021260	6	20140829	20150428	138	47.56	Malware data item analysis	Falk; Matthew, Yousaf; Timothy, Staehle; Joseph
9116975	3	20141001	20150825	113	38.95	Systems and user interfaces for dynamic and interactive simultaneous querying of multiple data stores	Shankar; Ankit, Ash; Andrew, Stowe; Geoff
9043696	5	20140227	20150526	106	36.53	Systems and methods for visual definition of data associations	Meiklejohn; David, Fedderly; Matthew, Henke; Joseph
8855999	3	20140205	20141007	77	19.59	Method and system for generating a parser and parsing complex data	Elliot; Mark
9367872	6	20141222	20160614	38	16.53	Systems and user interfaces for dynamic and interactive investigation of bad actor behavior based on automatic clustering of related data in various data structures	Visbal; Alexander, Thompson; James, Sum; Marvin
9953445	5	20140703	20180424	5	15.85	Interactive data object map	Cervelli; Dan, GoGwilt; Cai, Prochnow; Bobby
9891808	5	20160316	20180213	5	12.70	Interactive user interfaces for location-based data analysis	Wilson; Matthew Julius, Alexander; Tom, Cervelli; Daniel
8930897	4	20131002	20150106	33	11.37	Data integration tool	Nassar; Anthony Albert
9857958	3	20150424	20180102	4	10.16	Systems and user interfaces for dynamic and interactive access of, investigation of, and analysis of data objects stored in one or more databases	Ma; Jason, Davidson; Aaron
9646396	3	20150114	20170509	8	10.11	Generating object time series and data objects	Sharma; Tilak, Chuang; Steve, Chiu; Rico

9998485	6	20140915	20180612	4	8.07	Network intrusion data item clustering and analysis	Cohen; David, Ma; Jason, Fu; Bing Jie
9898509	3	20161027	20180220	3	7.62	Malicious activity detection system capable of efficiently processing data accessed from databases and generating alerts for display in interactive user interfaces	Saperstein; Craig, Schwartz; Eric, Cho; Hongjai
9558352	9	20150428	20170131	7	7.24	Malicious software detection in a computing system	Dennison; Drew, Stowe; Geoff, Anderson; Adam
9965937	3	20140829	20180508	4	6.36	External malware data item clustering and analysis	Cohen; David, Ma; Jason, Fu; Bing Jie
9589299	6	20160511	20170307	6	5.28	Systems and user interfaces for dynamic and interactive investigation of bad actor behavior based on automatic clustering of related data in various data structures	Visbal; Alexander, Thompson; James, Sum; Marvin
9880987	9	20150519	20180130	2	5.08	System and method for parameterizing documents for automatic workflow generation	Burr; Brandon, Pundle; Akshay, Simler; Kevin
9898335	9	20160502	20180220	2	5.08	System and method for batch evaluation programs	Marinelli, III; Eugene E., Namara; Yogy
9100430	7	20141229	20150804	10	3.56	Systems for network risk assessment including processing of user access rights associated with a network of devices	Seiver; Miles, Rosenblum; Charles

The key IEEE papers referenced by the patents above can be found in Appendix A and B. Most are related to data integration or malware detection. One paper (Li et al., "Interactive Multimodal Visual Search on Mobile Device," *IEEE Transactions on Multimedia*, vol. 15, No. 3, Apr. 1, 2013, pp. 594-607.) is a data integration paper that is referenced in 11 of the patents above as we see in page B-11.

Defense Related

BAE Systems/US Department of Defense

Less than 4% of US patents are co-assigned (that is co-owned by two or more entities). Generally, companies are secretive about their technology and only occasionally will inventors from multiple organizations cooperate on an invention. When we see co-assigned patents, they are generally between companies in a joint venture, or a company and a university professor or lab. Given this background, we were intrigued when we found three patents (numbers 8,437,700, 8,442,445, and 8,515,473) that are co-assigned to BAE Systems and the US Army. The first two share the same title “Protocol reference model, security and inter-operability in a cognitive communications system” and were granted days apart (See Table 12).

After some research we found that BAE Systems has contracts for cognitive communication systems with the Department of Defense (DOD), US Navy, US Army, and DARPA (Defense Advanced Research Projects Agency).

A cognitive communication system is a kind of smart radio that automatically detects the best wireless channels in its vicinity to avoid user interference and congestion. Such a radio automatically detects available channels in wireless spectrum, then changes its transmission or reception parameters accordingly to allow more concurrent wireless communications in a given spectrum band at one location [BAE3].

According to MarketWatch.com, the Global Cognitive Radio market in 2019 was $3.7 billion and is expected to reach $7 billion by 2026. The market leaders are BAE Systems followed by Raytheon and Thales.

We were able to locate additional relevant patents by the same inventors related to cognitive communications (See Table 12). With BAE being a market leader in the space they probably have several more patents, but these seem to be the closest in terms of title language. The three patents mentioned above are very highly cited with citation indexes between 7.3 and 9.9. The eight patents in Table 12 reference 58 IEEE articles and standards with the two of the top patents citing 18 IEEE articles.

Many of the references are to Draft Standard IEEE 802.22 as well as articles about the standard. A sample of the IEEE references from the patents below follows:

- Lim et al., IEEE 802.22-07/0257r10 MAC-SM-SSF Interface, Jul. 7, 2007, pp. 1-22.
- Cavalcanti et al., IEEE 802.22-07/xxxxr0 Updated Figures for draft 0.3, May 2007, pp. 1-4.
- Kim et al., IEEE 802.22-07/0523r0 WRAN Protocol Reference Model (PRM), Nov. 7, 2007, pp. 1-9.
- Ko et al., IEEE 802.22-07/0523r1 WRAN Protocol Reference Model (PRM), Nov. 7, 2007, pp. 1-8.
- Stevenson et al., IEEE 802.22-05/0007r47 Functional Requirements for the 802.22 WRAN Standard, Jan. 2006, pp. 1-49.
- IEEE P802.22/D04.3 Draft Standard for Wireless Regional Area Networks Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Policies and procedures for operation in the TV Bands, Nov. 2007, pp. 1-350.
- IEEE P802.22/WD05.0 Draft Standard for Wireless Regional Area Networks Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Policies and procedures for operation in the TV Bands, May 11, 2006, pp. 1-372.
- Cordeiro et al., “IEEE 802.22: An Introduction to the First Wireless Standard based on Cognitive Radios”, Journal of Communications, vol. 1, No. 1, Apr. 2006, 10 pages.
- Mody et al., “IEEE P802.22 Wireless RANs Protocol Reference Model Enhancements in 802.22”, May 15, 2005, 4 pages.
- Mody et al., “IEEE 802.22 Wireless RANs Meeting Minutes of the Security Ad-Hoc Group in 802.22”, Jun. 9, 2008, 3 pages., Vo. 47, No. 3, Mar. 2012.

Table 12: BAE patents related to cognitive communication

Patent #	#IEEE References	Application Date	Grant Year	# Cites	Citation Index	Title	First 3 Inventors
8515473	4	20080306	20130820	34	9.90	Cognitive radio methodology, physical layer policies and machine learning	Mody; Apurva N., Blatt; Stephen R., Mills; Diane G.
8437700	18	20080811	20130507	34	7.77	Protocol reference model, security and inter-operability in a cognitive communications system	Mody; Apurva N., Sherman; Matthew J., McNeil; Kevin

8442445	18	20080811	20130514	32	7.31	Protocol reference model, security and inter-operability in a cognitive communications system	Mody; Apurva N., Sherman; Matthew J., Reddy; Ranga
8154666	5	20081223	20120410	7	1.55	Spectrum sensing function for cognitive radio applications	Mody; Apurva N
8898468	3	20101203	20141125	7	2.28	Method for ensuring security and privacy in a wireless cognitive network	Reddy; Ranga, Kiernan; Thomas, Mody; Apurva N.
9445263	5	20141030	20160913	1	0.73	Method for ensuring security and privacy in a wireless cognitive network	Reddy; Ranga, Kiernan; Thomas, Mody; Apurva N.
9420454	5	20141030	20160816	0	0.00	Method for ensuring security and privacy in a wireless cognitive network	Reddy; Ranga, Kiernan; Thomas, Mody; Apurva N.

BAE Systems/UK Army

In 2017 BAE Systems, Airbus, and General Dynamics (GD) partnered to develop the Strike Tactical Hotspot concept demonstrator, a new network technology for the British Army. Tactical Hotspot is a compact mobile digital communications set that can be deployed securely in an armored vehicle to enable front-line troops to communicate securely with their command headquarters. When fitted to an adapted, Panther-armored combat vehicle with self-erecting radio masts, the hotspot can provide secure connectivity over several miles. Under a contract worth $1.62 million, BAE will supply two experimental Strike Tactical Hotspots to the British Army [BAE1].

Compared to the other stories in this report, $1.62 million may not sound like very much money, but that is only to build the two hotspots for demonstration purposes. BAE is hoping to sell many more, not only to the UK army, but also many other NATO countries. While this technology will serve immediate needs, BAE is looking ahead to 2030 and beyond to understand how soldiers will operate and communicate. “In the future we’ll see a huge increase in numbers of unmanned vehicles, and that will place a training and communication burden upon the military,” says Amy Ennion, a systems engineer within BAE Systems [BAE2].

There are likely multiple patents related to the technology but the most similar BAE patent is also among its most highly cited. Patent number 9,119,179 “Skypoint for mobile hotspots” has 124 citations in less than five years (see Table 13). Peer patents of the same age and technology have fewer than three citations on average so this patent has a citation index of 49.72. That is, this patent is cited almost 50 times more than expected. The patent leans heavily on IEEE science. Ten of its 13 Non-Patent references are to papers in IEEE journals and conferences.

Although this is technology to be deployed in 2030, it actually relies on science from the early 2000’s. The paper that seems to be most similar is “Anticipatory Routing for Highly Mobile Endpoints,” by Fabrice Tchakountio and Ram Ramanathan from the *IEEE Workshop on Mobile Computing Systems and Applications (WMCSA 2004)*.

Table 13: BAE Patent number 9,119,179

Patent #	#IEEE References	Application Date	Grant Date	# Cites	Citation Index	Title	Inventors

9119179	10	20130606	20150825	124	49.72	Skypoint for mobile hotspots	Firoiu; Victor, LaPrise; Scott B.

Since there is only one patent related to this story, the IEEE papers will not appear in Appendix B. However, we see from Appendix A page A-6 that the IEEE references come from military conferences such as *MILCOM the IEEE Military Communications Conference* and periodicals such as *IEEE Journal on Selected Areas in Communications, IEEE Transactions on Communications, IEEE Communications Magazine.*

Medical Related

Butterfly Network

Butterfly Network was founded by Dr. Jonathan Rothberg, a serial entrepreneur in the medical technology industry who is known for his contributions to gene sequencing. He started Butterfly Network in 2011 after his daughter developed a rare disease called tuberos sclerosis that required constant imaging and he was struck at how inaccessible and expensive traditional ultrasounds were. Butterfly's technology, which it calls an "ultrasound-on-chip" is designed to perform diagnostic imaging and measurement of blood vessels and examine the cardiac, abdominal, urological, fetal, gynecological, and musculoskeletal systems [Butterfly1].

Instead of piezoelectric crystals, Butterfly iQ's device uses semiconductor chips allowing for a lower sales price and more versatility than traditional alternatives. It consists of an ultrasound scanner using its semiconductor chip and connects to a smartphone to view the image. The device retails for $2,000, with an additional monthly subscription fee for the associated software that ranges from $35 to $100. Traditional ultrasound machines cost between $15,000 and $100,000. The global market for Ultrasound equipment is estimated to be about $6 billion [Butterfly1].

"Just as putting a camera on a semiconductor chip made photography accessible to anyone with a smartphone and putting a computer on a chip enabled the revolution in personal computing before that, Butterfly's ultrasound-on-a-chip technology enables a low-cost window into the human body, making high-quality diagnostic imaging accessible to anyone," Rothberg said in a statement [Butterfly1].

In developing countries, ultrasound can be used as a diagnostically superior and safer method than X-ray to diagnose critical global health issues like pediatric pneumonia. Butterfly has teamed with the Gates Foundation to distribute their portable device to developing countries or other areas without access to existing ultrasound technology. [Butterfly1]

In 2018 Butterfly raised a $250 million Series D financing round that increased its total funding to more than $350 million and placed a valuation on the firm at $1.25 billion [Butterfly1].

Recently Butterfly has made the news as a tool for fighting the Covid-19 virus in areas with limited imaging capability. The portable ultrasound can be used to potentially diagnose the virus by looking for anomalies in the lower region of a patient's lung [Butterfly2].

Butterfly currently has 68 US patents but many of them were filed and granted subsequent to their big funding rounds. The 23 patents shown in Table 14 are most likely related to the key innovation. These patents were issued before the end of 2018 and have at least five citations and a citation index above 1.0.

Virtually all of them list Dr. Rothberg as the first inventor. The patents in Table 14 are not only highly cited but they heavily reference IEEE science as prior art. On average each patent references IEEE about 20 times (468 total for 23 patents).

Table 14: Key patents of Butterfly Networks

Patent #	#IEEE References	Application Date	Grant Date	# Cites	Citation Index	Title	First 3 Inventors
9067779	20	20150302	20150630	37	15.51	Microfabricated ultrasonic transducers and related apparatus and methods	Rothberg; Jonathan M., Alie; Susan A., Fife; Keith G.
8852103	30	20121017	20141007	30	2.18	Transmissive imaging and related apparatus and methods	Rothberg; Jonathan M., Sanchez; Nevada J., Charvat; Gregory L.
9061318	12	20141205	20150623	27	8.74	Complementary metal oxide semiconductor (CMOS) ultrasonic transducers and methods for forming the same	Rothberg; Jonathan M., Fife; Keith G., Ralston; Tyler S.
9242275	17	20140313	20160126	25	11.32	Complementary metal oxide semiconductor (CMOS) ultrasonic transducers and methods for forming the same	Rothberg; Jonathan M., Fife; Keith G., Ralston; Tyler S.
9394162	27	20150519	20160719	21	23.24	Microfabricated ultrasonic transducers and related apparatus and methods	Rothberg; Jonathan M., Alie; Susan A., Fife; Keith G.
9229097	18	20150417	20160105	21	9.66	Architecture of single substrate ultrasonic imaging devices, related apparatuses, and methods	Rothberg; Jonathan M., Ralston; Tyler S., Sanchez; Nevada J.
9290375	17	20150513	20160322	20	15.02	Complementary metal oxide semiconductor (CMOS) ultrasonic transducers and methods for forming the same	Rothberg; Jonathan M., Fife; Keith G., Ralston; Tyler S.
9505030	17	20150417	20161129	16	7.24	Ultrasonic transducers in complementary metal oxide semiconductor (CMOS) wafers and related apparatus and methods	Rothberg; Jonathan M., Fife; Keith G., Sanchez; Nevada J.
9533873	17	20140204	20170103	15	25.87	CMOS ultrasonic transducers and related apparatus and methods	Rothberg; Jonathan M., Fife; Keith G., Ralston; Tyler S.
9499392	17	20140204	20161122	15	11.26	CMOS ultrasonic transducers and related apparatus and methods	Rothberg; Jonathan M., Fife; Keith G., Ralston; Tyler S.
9499395	17	20160212	20161122	15	11.26	Complementary metal oxide semiconductor (CMOS) ultrasonic transducers and methods for forming the same	Rothberg; Jonathan M., Fife; Keith G., Ralston; Tyler S.
9351706	28	20141205	20160531	10	1.17	Interconnectable ultrasound transducer probes and related methods and apparatus	Rothberg; Jonathan M., Fife; Keith G., Sanchez; Nevada J.
9327142	27	20141205	20160503	10	3.38	Monolithic ultrasonic imaging devices, systems and methods	Rothberg; Jonathan M., Fife; Keith G., Ralston; Tyler S.

9910017	27	20160609	20180306	9	50.11	Microfabricated ultrasonic transducers and related apparatus and methods	Rothberg; Jonathan M., Alie; Susan A., Fife; Keith G.
9910018	26	20160609	20180306	9	50.11	Microfabricated ultrasonic transducers and related apparatus and methods	Rothberg; Jonathan M., Alie; Susan A., Fife; Keith G.
9899371	17	20160908	20180220	9	28.06	Ultrasonic transducers in complementary metal oxide semiconductor (CMOS) wafers and related apparatus and methods	Rothberg; Jonathan M., Fife; Keith G., Sanchez; Nevada J.
9705518	9	20151202	20170711	9	8.39	Asynchronous successive approximation analog-to-digital converter and related methods and apparatus	Chen; Kailiang, Ralston; Tyler S.
9492144	8	20151202	20161115	9	1.05	Multi-level pulser and related apparatus and methods	Chen; Kailiang, Ralston; Tyler S.
9944514	27	20170619	20180417	8	27.20	Complementary metal oxide semiconductor (CMOS) ultrasonic transducers and methods for forming the same	Rothberg; Jonathan M., Fife; Keith G., Ralston; Tyler S.
9895718	17	20161111	20180220	8	12.26	CMOS ultrasonic transducers and related apparatus and methods	Rothberg; Jonathan M., Fife; Keith G., Ralston; Tyler S.
9738514	27	20161012	20170822	8	17.56	Complementary metal oxide semiconductor (CMOS) ultrasonic transducers and methods for forming the same	Rothberg; Jonathan M., Fife; Keith G., Ralston; Tyler S.
9718098	17	20160519	20170801	8	5.61	CMOS ultrasonic transducers and related apparatus and methods	Rothberg; Jonathan M., Fife; Keith G., Ralston; Tyler S.
9268015	29	20140227	20160223	5	2.30	Image-guided high intensity focused ultrasound and related apparatus and methods	Rothberg; Jonathan M., Sanchez; Nevada J., Charvat; Gregory L.

Several of the IEEE patents are referenced in multiple patents. For example the paper (Nikoozadeh et al., “Forward-Looking Intracardiac Ultrasound Imaging Using a 1-D CMUT Array Integrated With Custom Front-End Electronics,” *IEEE Trans Ultrason Ferroelectr Freq Contr*. Dec. 2008;55(12):2651-60.) is cited in 21 of the 23 patents above.

There are several other IEEE papers referenced in multiple patents above that can be found in Appendix B. Most of the papers are from the *IEEE Ultrasonics Symposium* or the *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control.*

Conformis

Conformis claims to sell the only “truly patient-specific total knee replacement” (individually sized and shaped, or customized, to fit each patient's unique anatomy). “Conformis knee replacements are designed to match every aspect of your natural knee. The goal of any knee replacement is to be pain-free, restore natural motion, and for patients to return to their everyday activities” according to their website [Conformis1].

Although Conformis has hundreds of patents, the 45 patents in Table 15 are the patents related to the Conformis patient-specific knee products (iUni, iDUO, and iTotal Knee Replacement Systems) [Conformis2].

As shown in Table 15, the 45 patents typically mention “patient-selectable” or “patient-adapted” to describe the customized fitting knee replacements. These patents are very highly cited, and as a collection are cited about six times as often as expected (average citation index of 6.15). The 45 patents also contain 219 references to IEEE journals and conferences (average of 4.86 IEEE references) which is rather high given that medical devices are not really thought of as a core area for IEEE.

A list of the IEEE papers referenced in the 45 patents can be found in Appendix A and Appendix B. Many of the papers are referenced in multiple patents. Multiple papers are published in IEEE Transactions on Medical Imaging as well as the IEEE Nuclear Science Symposium and Medical Imaging Conference and International Conference of the IEEE Engineering in Medicine and Biology Society.

In 2013 Conformis received $167 million in funding to develop the custom knee replacements [Conformis3]. In October 2019 they signed a $30 million licensing deal with Stryker. $14 million is to license Conformis’ patient-specific instrumentation for use with Stryker’s Triathlon total knee replacement system and $16 million to develop a new patient-specific knee replacement system to be sold under the Stryker name [Conformis4].

“Conformis is excited to partner with Stryker – a leader in orthopedic surgical innovation – to further expand CT-based solutions to the market. Such solutions are the future of healthcare, enabling surgeons to provide personalized care based on a patient’s unique anatomy,” said Conformis CEO Mark Augusti [Conformis4].

Table 15: Patents related to Conformis patient-specific knee products

Patent #	#IEEE References	Application Date	Grant Date	# Cites	Citation Index	Title	First 3 Inventors
7468075	10	20021127	20081223	429	7.02	Methods and compositions for articular repair	Lang; Philipp, Steines; Daniel, Timsari; Bijan
7618451	2	20031125	20091117	428	8.02	Patient selectable joint arthroplasty devices and surgical tools facilitating increased accuracy, speed and simplicity in performing total and partial joint arthroplasty	Berez; Aaron, Fitz; Wolfgang, Lang; Philipp
7981158	2	20080609	20110719	343	11.34	Patient selectable joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Bojarski; Raymond A.
8083745	2	20080314	20111227	264	7.25	Surgical tools for arthroplasty	Lang; Philipp, Fitz; Wolfgang, Bojarski; Ray
8066708	2	20070206	20111129	262	6.81	Patient selectable joint arthroplasty devices and surgical tools	Lang; Philipp, Fitz; Wolfgang, Bojarski; Raymond A.
8105330	2	20080609	20120131	249	8.01	Patient selectable joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Bojarski; Raymond A.
8122582	2	20090128	20120228	188	22.90	Surgical tools facilitating increased accuracy, speed and simplicity in performing joint arthroplasty	Burdulis, Jr.; Albert G., Fitz; Wolfgang, Vargas-Voracek; Rene
7634119	0	20031204	20091215	176	13.07	Fusion of multiple imaging planes for isotropic imaging in MRI and quantitative image analysis using isotropic or near-isotropic imaging	Tsougarakis; Konstantinos, Steines; Daniel, Timsari; Bijan

8337501	4	20100510	20121225	176	11.04	Patient selectable joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Bojarski; Raymond A.
8234097	5	20100224	20120731	157	24.52	Automated systems for manufacturing patient-specific orthopedic implants and instrumentation	Steines; Daniel, Zhuravlev; Alexey
8377129	2	20091027	20130219	130	6.24	Joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Steines; Daniel
8337507	10	20081222	20121225	127	5.51	Methods and compositions for articular repair	Lang; Philipp, Steines; Daniel, Tsougarakis; Konstantinos
8480754	10	20100225	20130709	123	6.57	Patient-adapted and improved articular implants, designs and related guide tools	Bojarski; Ray, Chao; Nam, Fitz; Wolfgang
8439926	2	20090305	20130514	121	4.02	Patient selectable joint arthroplasty devices and surgical tools	Bojarski; Raymond, Fitz; Wolfgang, Lang; Philipp
8366771	4	20100510	20130205	117	5.61	Surgical tools facilitating increased accuracy, speed and simplicity in performing joint arthroplasty	Burdulis, Jr.; Albert G., Fitz; Wolfgang, Vargas-Voracek; Rene
8551099	4	20100510	20131008	110	6.90	Surgical tools for arthroplasty	Lang; Philipp, Fitz; Wolfgang, Bojarski; Raymond A.
8556983	10	20110309	20131015	108	5.77	Patient-adapted and improved orthopedic implants, designs and related tools	Bojarski; Raymond A., Chao; Nam, Slamin; John
8545569	10	20040105	20131001	103	5.50	Patient selectable knee arthroplasty devices	Fitz; Wolfgang, Lang; Philipp, Steines; Daniel
8551103	2	20120924	20131008	95	3.15	Joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Steines; Daniel
8634617	6	20111206	20140121	92	21.51	Methods for determining meniscal size and shape and for devising treatment	Tsougarakis; Konstantinos, Steines; Daniel, Vissa; Bhaskar Rao
8657827	2	20111122	20140225	92	5.19	Surgical tools for arthroplasty	Fitz; Wolfgang, Lang; Philipp, Bojarski; Raymond
8623026	2	20110810	20140107	92	6.28	Patient selectable joint arthroplasty devices and surgical tools incorporating anatomical relief	Wong; Terrance, Bojarski; Raymond A., Steines; Daniel
8551102	2	20120924	20131008	92	3.05	Joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Steines; Daniel
8529630	2	20120924	20130910	92	4.91	Patient selectable joint arthroplasty devices and surgical tools	Bojarski; Raymond A., Fitz; Wolfgang, Chao; Nam T.
8556907	2	20120924	20131015	91	3.93	Joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Steines; Daniel
8556906	4	20120924	20131015	90	3.88	Joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Steines; Daniel
8638998	2	20120109	20140128	90	21.05	Fusion of multiple imaging planes for isotropic imaging in MRI and quantitative image analysis using isotropic or near-isotropic imaging	Steines; Daniel, Timsari; Bijan, Tsougarakis; Konstantinos
8562618	2	20120924	20131022	90	2.99	Joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Steines; Daniel
8561278	2	20120924	20131022	90	21.31	Joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Steines; Daniel

8568480	2	20120924	20131029	88	4.22	Joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Steines; Daniel
8568479	2	20120924	20131029	88	4.22	Joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Steines; Daniel
8709089	12	20100503	20140429	70	5.77	Minimally invasive joint implant with 3-dimensional geometry matching the articular surfaces	Lang; Philipp, Steines; Daniel, Bouadi; Hacene
8771365	10	20100623	20140708	54	5.18	Patient-adapted and improved orthopedic implants, designs, and related tools	Bojarski; Raymond A., Lang; Philipp, Chao; Nam
8882847	5	20041124	20141111	52	6.15	Patient selectable knee joint arthroplasty devices	Burdulis, Jr.; Albert G., Fitz; Wolfgang, Lang; Philipp
8768028	12	20100511	20140701	49	11.59	Methods and compositions for articular repair	Lang; Philipp, Steines; Daniel
8585708	4	20100511	20131119	45	1.49	Patient selectable joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Bojarski; Raymond A.
8906107	10	20111111	20141209	26	2.49	Patient-adapted and improved orthopedic implants, designs and related tools	Bojarski; Raymond A., Chao; Nam, Slamin; John
9055953	14	20100511	20150616	26	2.06	Methods and compositions for articular repair	Lang; Philipp, Steines; Daniel
9107680	6	20121218	20150818	23	1.83	Patient selectable joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Bojarski; Raymond A.
8951260	2	20080613	20150210	19	1.51	Surgical cutting guide	Lang; Philipp, Fitz; Wolfgang, Steines; Daniel
8945230	5	20100512	20150203	17	3.23	Patient selectable knee joint arthroplasty devices	Lang; Philipp, Steines; Daniel, Fitz; Wolfgang
8974539	10	20111111	20150310	17	3.23	Patient-adapted and improved articular implants, designs and related guide tools	Bojarski; Raymond A., Chao; Nam, Slamin; John
9326780	3	20140106	20160503	16	1.87	Patient selectable joint arthroplasty devices and surgical tools incorporating anatomical relief	Wong; Terrance, Bojarski; Raymond A., Steines; Daniel
9358018	3	20120227	20160607	6	0.70	Joint arthroplasty devices and surgical tools	Fitz; Wolfgang, Lang; Philipp, Steines; Daniel
9387079	8	20131010	20160712	5	1.84	Patient-adapted and improved articular implants, designs and related guide tools	Bojarski; Raymond A., Slamin; John, Lang; Philipp

InTouch Health/Teladoc Health

InTouch Health makes medical tele-robotic systems. In January 2020, Teladoc Health announced it would acquire InTouch for $600 million. The acquisition is expected to close by the end of June 2020 [InTouch1].

InTouch, with $80 million in sales in 2019, is the much smaller firm. However, it supports more than 3,600 care locations around the world - including many of the top 20 U.S. health systems - as they deploy telehealth programs across their enterprises [InTouch1].

Teladoc was Ranked #1 among direct-to-consumer telehealth providers in the J.D. Power 2019 U.S. Telehealth Satisfaction Study. Services from Teladoc Health include telehealth, expert medical services, AI and analytics, and licensable platform services. The organization delivers care in 130 countries and in more than 30 languages, partnering with employers, hospitals and health systems, and insurers to transform care delivery [InTouch1].

The tele-medicine industry has gotten a large boost from the Covid-19 pandemic as this excerpt from the Motley Fool points out:

> Specifically, hospitals have been busy dealing with COVID-19 patients, and to reserve resources for those suffering from the potentially deadly disease -- and to avoid unnecessary exposure to the virus on the part of the public -- many turned to telehealth services for some routine medical needs. Teladoc famously reported that its number of visits skyrocketed in March, and demand will likely remain high for a little while. These developments have boosted the profile of telehealth providers, leading many to conclude that people will seek to continue to have access to these services even after the pandemic subsides. Donna O'Shea, chief medical officer of population health management for UnitedHealthcare (one of the largest health insurance companies in the U.S.), certainly believes that. In a recent virtual conference called Telehealth's Tipping Point, O'Shea asserted that UnitedHealthcare's members will want to "continue to have access to their providers through telehealth." This bodes well for the future of telehealth, and in particular for Teladoc, which remains the biggest player in this industry [InTouch2]

As we see in Figure 2, Teladoc (which is publicly listed on the NYSE) has seen its stock price more than double since January 1, 2020 while the market is down slightly for the year. This suggests that investors are not only bullish on telehealth, but are also in favor of the acquisition of InTouch.

Figure 2: Year-to-date Stock Returns of Teladoc versus S&P 500 through June 9, 2020.

Source: Google Finance

InTouch has 96 US patents through 2019. The key patents related to tele-robotics, tele-presence, and video conferencing are shown in Table 16. Many of the patents are invented by Yulun Wang who founded the firm and retired as CEO in 2016 but remains chairman. These patents are very highly cited. Overall the set of 33 key patents is cited about five times as often as expected with the top two patents cited over 400 times each. These 33 patents reference IEEE science heavily. Each of the patents has about 26 references to IEEE articles on average with one (#8,209,051 Medical tele-robotic system) having 75 references to IEEE.

Table 16: Key patents of InTouch

Patent #	#IEEE References	Application Date	Grant Date	# Cites	Citation Index	Title	First 3 Inventors
8996165	35	20081021	20150331	419	144.41	Telepresence robot with a camera boom	Wang; Yulun, Jordan; Charles S., Hanrahan; Kevin
8170241	13	20080417	20120501	475	34.35	Mobile tele-presence system with a microphone system	Roe; David Bjorn, Sanchez; Daniel Steven, Pinter; Marco
8849679	96	20081125	20140930	47	16.53	Remote controlled robot system that provides medical images	Wang; Yulun, Jordan; Charles S., Pinter; Marco
8902278	34	20120725	20141202	52	11.41	Systems and methods for visualizing and managing telepresence devices in healthcare networks	Pinter; Marco, Brallier; Greg, Ross; Scott
8401275	56	20090327	20130319	61	11.26	Mobile robot with a head-based movement mapping scheme	Wang; Yulun, Jordan; Charles S., Laby; Keith P.
8670017	56	20100304	20140311	48	10.54	Remote presence system including a cart that supports a robot face and an overhead camera	Stuart; David, Sanchez; Daniel Steven, Lai; Fuji
8849680	66	20090129	20140930	46	8.87	Documentation through a remote presence robot	Wright; Timothy C., Lai; Fuji, Pinter; Marco
8897920	22	20090417	20141125	45	8.67	Tele-presence robot system with software modularity, projector and laser pointer	Wang; Yulun, Pinter; Marco, Hanrahan; Kevin
8861750	16	20120328	20141014	42	8.10	Mobile tele-presence system with a microphone system	Roe; David Bjorn, Sanchez; Daniel Steven, Pinter; Marco
8179418	26	20080414	20120515	62	6.77	Robotic based health care system	Wright; Timothy C., Lai; Fuji, Pinter; Marco
8463435	48	20090106	20130611	56	6.58	Server connectivity control for tele-presence robot	Herzog; John Cody, Whitney; Blair, Wang; Yulun
8340819	56	20090916	20121225	56	5.98	Mobile videoconferencing robot system with network adaptive driving	Mangaser; Amante, Southard; Jonathan, Pinter; Marco
7769492	28	20060222	20100803	77	4.88	Graphical interface for a remote presence system	Wang; Yulun, Jordan; Charles S., Pinter; Marco
8116910	28	20070823	20120214	56	4.80	Telepresence robot with a printer	Walters; Derek, Pinter; Marco, Southard; Jonathan
7593030	22	20041015	20090922	69	4.75	Tele-robotic videoconferencing in a corporate environment	Wang; Yulun, Jordan; Charles S., Southard; Jonathan
8209051	75	20060927	20120626	59	4.72	Medical tele-robotic system	Wang; Yulun, Laby; Keith Phillip, Jordan; Charles S.
7171286	2	20030912	20070130	97	4.68	Healthcare tele-robotic system with a robot that also functions as a remote station	Wang; Yulun, Jordan; Charles S., Laby; Keith Phillip
7262573	6	20040217	20070828	85	4.15	Medical tele-robotic system with a head worn device	Wang; Yulun, Jordan; Charles S., Laby; Keith Phillip

7161322	2	20031118	20070109	84	4.11	Robot with a manipulator arm	Wang; Yulun, Laby; Keith Phillip, Mukherjee; Ranjan
7761185	16	20061003	20100720	63	3.86	Remote presence display through remotely controlled robot	Wang; Yulun, Jordan; Charles S., Pinter; Marco
9098611	37	20130314	20150804	10	3.45	Enhanced video interaction for a user interface of a telepresence network	Pinter; Marco, Jordan; Charles S., Sanchez; Daniel
8836751	33	20111108	20140916	45	3.27	Tele-presence system with a user interface that displays different communication links	Ballantyne; James, Temby; Kelton, Rosenthal; James
7142947	3	20040806	20061128	75	3.24	Medical tele-robotic method	Wang; Yulun, Laby; Keith Phillip, Jordan; Charles S.
7813836	28	20031209	20101012	55	3.18	Protocol for a remotely controlled videoconferencing robot	Wang; Yulun, Jordan; Charles S., Pinter; Marco
7158859	3	20030514	20070102	101	2.92	5 degrees of freedom mobile robot	Wang; Yulun, Laby; Keith Phillip, Jordan; Charles S.
7222000	7	20050118	20070522	56	2.70	Mobile videoconferencing platform with automatic shut-off features	Wang; Yulun, Jordan; Charles S., Pinter; Marco
7164969	6	20040102	20070116	92	2.66	Apparatus and method for patient rounding with a remote controlled robot	Wang; Yulun, Kavoussi; Louis
7289883	15	20070105	20071030	85	2.46	Apparatus and method for patient rounding with a remote controlled robot	Wang; Yulun, Kavoussi; Louis
7158860	3	20030912	20070102	81	2.34	Healthcare tele-robotic system which allows parallel remote station observation	Wang; Yulun, Jordan; Charles S., Pinter; Marco
6320947	0	19990914	20011120	94	2.20	Telephony platform and method for providing enhanced communication services	Joyce; Simon James, Gupta; Prafulla C., Vaidya; Manohar S.
7164970	6	20040806	20070116	72	2.08	Medical tele-robotic system	Wang; Yulun, Laby; Keith Phillip, Jordan; Charles S.
7158861	7	20030918	20070102	69	1.99	Tele-robotic system used to provide remote consultation services	Wang; Yulun, Jordan; Charles S.
7142945	6	20040806	20061128	83	1.99	Medical tele-robotic system	Wang; Yulun, Laby; Keith Phillip, Jordan; Charles S.

These articles are both referenced in all 16 of the patents above:

- Paulos, et al., "Designing Personal Tele-Embodiment", Presented at the IEEE International Conference on Robotics and Animation, Leuven, Belgium, May 20, 1998.
- Pin et al., "A New Family of Omnidirectional and Holonomic Wheeled Platforms for Mobile Robots", IEEE, vol. 10, No. 4, Aug. 1994.

Other IEEE papers that are referenced in multiple patents above can be found on page B-4 of Appendix B.

Robotics

InTouch Health/Teladoc Health (See Medical Related)

InTouch's technology could be placed in the robotics category, but the story can be found in the Medical Related category above.

Olis/BluHaptic/University of Washington

This firm was started by Dr. Howard Chizeck, professor of electrical and computer engineering and adjunct professor of bioengineering at the University of Washington [Olis1].

Olis is a very interesting startup. Here is an excerpt from a recent interview with Dr. Chizeck:

> While at the University of Washington, I was working on trying to provide a sense of touch for surgeons performing robotic surgery. With National Science Foundation (NSF) support, we developed technology using the Microsoft Kinect to generate point clouds and render haptic forces. An opportunity was presented by the Strategic Environmental Research and Development Program (SERDP) – a consortium program of the Department of Defense, Environmental Protection Agency, and Department of Energy – to remove unexploded munitions from lake bottoms. We figured that since we were already remotely manipulating a teleoperated robot for surgery, how could that be so different from underwater munitions? So I started a company, BluHaptics (later changed to Olis Robotics) and we wrote a seed grant proposal that got funded. We were then committed to try and make that work. Then, in the development of that technology for underwater munitions, it became apparent that there were a lot of other underwater applications that could use telerobotics.

Table 17: Olis Haptic and Telerobotic patents

Patent #	#IEEE References	Application Date	Grant Date	# Cites	Citation Index	Title	First 3 Inventors
9148443	18	20130703	20150929	18	6.41	Enhanced security and safety in telerobotic systems	Chizeck; Howard Jay, Bonaci; Tamara, Lendvay; Thomas
9471142	57	20120615	20161018	2	1.18	Methods and systems for haptic rendering and creating virtual fixtures from point clouds	Chizeck; Howard Jay, Rydén; Fredrik, Kosari; Sina Nia
9477307	61	20140124	20161025	3	1.77	Methods and systems for six degree-of-freedom haptic interaction with streaming point data	Chizeck; Howard Jay, Ryden; Fredrik
9686306	9	20131030	20170620	1	0.90	Using supplemental encrypted signals to mitigate man-in-the-middle attacks on teleoperated systems	Chizeck; Howard Jay, Bonaci; Tamara
9736167	18	20150917	20170815	0	0.00	Enhanced security and safety in telerobotic systems	Chizeck; Howard Jay, Bonaci; Tamara, Lendvay; Thomas
9753542	58	20161011	20170905	7	7.24	Methods and systems for six-degree-of-freedom haptic interaction with streaming point data	Chizeck; Howard Jay, Ryden; Fredrik, Stewart; Andrew

10226869	57	20150302	20190312	0	0.00	Haptic virtual fixture tools	Chizeck; Howard Jay, Stewart; Andrew, Ryden; Fredrik
10394327	40	20150911	20190827	0	0.00	Integration of auxiliary sensors with point cloud-based haptic rendering and virtual fixtures	Chizeck; Howard Jay, Huang; Kevin, Ryden; Fredrik

After spinning out of the University of Washington in 2013, Olis has had a number of accomplishments.

- In 2014 it won a grant from the National Science Foundation (NSF) and Small Business Administration (SBA) totaling $897,000 through 2016 [Olis3].
- In 2017 it raised $1.36 million in angel investment [Olis2].
- In 2017 it won a grant from NASA and SBA totaling $873,000 through 2018 [Olis3].
- In 2019 Olis won a $50,000 grant to study options for satellite-servicing robots. This may turn into a $1.5 million grant in the future [Olis4]
- In 2019 Olis announced a partnership with Forum Energy Technologies (terms not disclosed) to develop Olis Remotely Operated Vehicles (ROVs) controllers for the offshore energy market [Olis4].
- In 2019 Olis entered into an agreement with iCsys, part of the Envirex Group, for sales, distribution and support of Olis Robotics machine-learning ROV controllers (terms not disclosed) [Olis4].
- In 2019 Olis partnered with one of the biggest names in space, Maxar Technologies, to work on a new robotic mission that is part of NASA's planned mission back to the moon in 2024 [Olis4].

The firm has only eight patents related to haptics and telerobotics (Table 17). The oldest patent is less than five years old and has 18 citations, which is six times as many as expected for a patent of that age and technology class. All the patents are co-authored by Dr. Chizeck and all rely on IEEE science for prior art. The eight patents have a total of 318 references to IEEE conference and journal articles (an average of 39 each).

The key papers (see Appendix A and Appendix B) are mostly robotics related and appear in journals and conferences such as *IEEE/ASME Transactions on Mechatronics*, *IEEE/RSJ Int'l Conf. on Intelligent Robots and Systems*, *IEEE International Conference on Robotics and Automation*, and *IEEE Virtual Reality Annual International Symposium.*

Semiconductors

Butterfly Network (See Medical Related)

Butterfly's technology, which it calls an "ultrasound-on-chip" could be categorized with the semiconductor cases, but we placed it in the Medical Related category above.

Kandou

Kandou Technologies is a Swiss startup co-founded in 2011 by former postdoc Harm Cronie and his Professor Amin Shokrollahi while at Ecole Polytechnique Federale de Lausanne (EPFL). Kandou was spun-off after raising $10 million in venture funding.

Kandou designs high speed, energy and pin efficient serial links connecting integrated circuit components such as processor and memory, or processor and processor. Serial links account for a major part of the energy consumption of electronic devices and represent an energy and speed bottleneck. Any improvement in their design directly leads to faster and more energy efficient electronic devices. Kandou's technology uses a new mode of transmission on serial links to transmit more bits on existing connections, using less energy. The technology is based on a number of patents which represent several man-years of research in discrete mathematics, circuit design, and high-speed algorithm design [Kandou1].

In 2019 Kandou raised another $56 million raising its total to nearly $100 million [Kandou2]. Kandou licenses its technology to leading semiconductor companies including Marvell Technology Group and Coherent Logix. It has a valuation of $224m - $336m (Dealroom.co estimates Sep 2019.)

Table 18 shows the early key patents filed in 2013 and earlier while both co-founders were still with the firm (Cronie Harm has since left). The table contains patents assigned to EPFL as well as those assigned to Kandou. These are the patents for the original technology from which Kandou raised its early funding. It now has more than 100 patents but many of those are to build a firewall around the original technology. The patents in Table 18 are very highly cited and most have many references to IEEE prior art (121 total, an average of ten each).

Table 18: Key patents of Kandou

Patent #	#IEEE References	Application Date	Grant Date	# Cites	Citation Index	Title	First 3 Inventors
8539318	3	20101230	20130917	84	26.23	Power and pin efficient chip-to-chip communications with common-mode rejection and SSO resilience	Cronie; Harm, Shokrollahi; Amin
8593305	6	20120705	20131126	97	22.05	Efficient processing and detection of balanced codes	Tajalli; Armin, Cronie; Harm, Shokrollahi; Amin
8649445	5	20110217	20140211	96	26.46	Methods and systems for noise resilient, pin-efficient and low power communications with sparse signaling codes	Cronie; Harm, Shokrollahi; Amin, Tajalli; Armin
8718184	6	20120503	20140506	98	28.04	Finite state encoders and decoders for vector signaling codes	Cronie; Harm, Shokrollahi; Amin
8989317	6	20121107	20150324	96	31.07	Crossbar switch decoder for vector signaling codes	Holden; Brian, Shokrollahi; Amin
9015566	10	20130916	20150421	64	22.80	Power and pin efficient chip-to-chip communications with common-mode rejection and SSO resilience	Cronie; Harm, Shokrollahi; Amin
9083576	7	20130315	20150714	47	16.74	Methods and systems for error detection and correction using vector signal prediction	Hormati; Ali
9288082	15	20130515	20160315	56	30.32	Circuits for efficient detection of vector signaling codes for chip-to-chip communication using sums of differences	Ulrich; Roger, Hunt; Peter
9288089	15	20100520	20160315	59	31.95	Orthogonal differential vector signaling	Cronie; Harm, Shokrollahi; Amin
9300503	15	20130315	20160329	42	22.74	Methods and systems for skew tolerance in and advanced detectors for vector signaling codes for chip-to-chip communication	Holden; Brian, Shokrollahi; Amin, Singh; Anant
9401828	16	20110705	20160726	53	28.70	Methods and systems for low-power and pin-efficient communications with superposition signaling codes	Cronie; Harm, Shokrollahi; Amin
9667379	17	20110606	20170530	41	36.99	Error control coding for orthogonal differential vector signaling	Cronie; Harm, Shokrollahi; Amin

The paper (Wang et al., "Applying CDMA Technique to Network-on-Chip," IEEE Transactions on Very Large Scale Integration (VLSI) Systems, vol. 15, No. 10 (Oct. 1, 2007), pp. 1091-1100.) is referenced in 5 of the patents above. Other frequently referenced papers appear in semiconductor or communications journals and conferences such as *IEEE Transactions Audio and Electroacoustics, IEEE Transactions of Information Theory, IEEE International Conference on Communications, IEEE Journal of Solid-State Circuits* and others.

Cap Wireless/Triquint/Qorvo

In 2013, Triquint Semiconductor purchased Cap Wireless for $14.8 million. Cap owned the Spatium™ broadband amplifiers product line and the five patents in Table 19 related to the amplifiers [Cap1].

Table 19: Cap Wireless patents related to Spatium amplifiers

Patent #	#IEEE References	Application Date	Grant Date	# Cites	Citation Index	Title	First 3 Inventors
9276304	29	20121126	20160301	183	37.20	Power combiner using tri-plane antennas	Behan; Scott, Courtney; Patrick
9287605	29	20121218	20160315	183	37.20	Passive coaxial power splitter/combiner	Daughenbaugh, Jr.; Paul, Behan; Scott, Courtney; Patrick
9293801	29	20121126	20160322	180	36.59	Power combiner	Courtney; Patrick, Behan; Scott
7215220	30	20040823	20070508	223	17.98	Broadband power combining device using antipodal finline structure	Jia; Pengcheng
7911271	0	20081210	20110322	12	1.96	Hybrid broadband power amplifier with capacitor matching network	Jia; Pengcheng

According to Triquint's press release announcing the acquisition: "Spatium technology dramatically improves broadband RF power efficiency through the use of patented coaxial spatial combining techniques. Spatium provides other performance advantages including solid-state reliability, smaller form factors, higher power densities and reduced weight compared to either TWTA-based systems or conventional planar power combining products. Spatium can provide faster time-to-market and can seamlessly incorporate GaN MMIC performance breakthroughs while reducing product lifecycle costs" [Cap2].

The press release goes on to say that the global market for these devices is $600 million [Cap2]. In 2015 Triquint Semiconductor merged with RFMD and the combined entity renamed itself Qorvo [Cap3].

Qorvo in 2020 has revenues in excess of $3 billion and continues to sell the Spatium amplifiers. According to its website: "Qorvo's patented Spatium RF power combining technology provides a highly reliable, efficient alternative to traveling wave tube amplifiers (TWTAs). It delivers a higher standard of efficiency, reliability and bandwidth as well as clear size, weight, power and cost (SWaP-C) advantage in Commercial and defense communications, Radar systems, Electronic warfare (EW), Test and measurement, and Other defense systems" [Cap4].

All of the five patents acquired with Cap Wireless are highly cited, but 4 of the 5 are extremely highly cited (most patents get fewer than 15 citations over their lifetime, but these have 180 to 223 citations). Three of the very highly cited patents also reference 29 IEEE articles and the fourth references 30 IEEE articles. The common inventor on three of the patents Scott Behan, recently retired as the Senior Product Marketing Manager at Qorvo [Cap4].

Most of the IEEE papers referenced in the patents above are related to Microwaves. The paper (York, Robert A. et al., "Quasi-Optical Power Combining Using Mutually Synchronized Oscillator Arrays," *IEEE Transactions on Microwave Theory and Techniques*, vol. 39, No. 6, Jun. 1991, pp. 1000-1009.) is typical. This paper is referenced in 3 of the 5 patents above. Other papers (see Appendix A and Appendix B) are from *IEEE Microwave and Wireless Components Letters*, *Microwave Symposium Digest*, and *IEEE Microwave and Guided Wave Letters*, and other Microwave related journals and conferences.

Conclusions

This report has examined the influence of IEEE science upon key patented technologies across a range of cutting-edge technologies. It highlights fifteen stories of companies that have designed products around patents with significant technological and/or financial impact, and that build extensively on IEEE science.

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

BAE-Cognitive

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08515473	9.90	34	2013	Mody; Apurva N. Blatt; Stephen R. Mills; Diane G. McElwain; Thomas P. Thammakhoune; Ned B.	Cognitive radio methodology, physical layer policies and machine learning

NPR #	IEEE References Cited in Non-Patent Literature
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

BAE-Cognitive

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08437700	7.77	34	2013	Mody; Apurva N. Sherman; Matthew J. McNeil; Kevin Khuu; Phong Dudgeon; Dan E.	Protocol reference model, security and inter-operability in a cognitive communications system

NPR #	IEEE References Cited in Non-Patent Literature
1	IEEE P802.22™/D0.1 Draft Standard for Wireless Regional Area Networks Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Policies and procedures for operation in the TV Bands, May 2006, pp. 1-299.
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3	Mishra et al., Cooperative Sensing among Cognitive Radios, Jun. 2006, IEEE ICC 2006 proceedings vol. 4, pp. 1658-1663.
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21	Liu Jinnan Huawei Hisi, “IEEE P802.22 Wireless RANs Dynamic Sensing Schemes,”, Sep. 5, 2007, 11 pages.
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23	Mody et al., “IEEE 802.22 Wireless RANs Meeting Minutes of the Security Ad-Hoc Group in 802.22”, Jun. 9, 2008, 3 pages.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

BAE-Cognitive

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08442445	7.31	32	2013	Mody; Apurva N. Sherman; Matthew J. Reddy; Ranga Kiernan; Thomas	Protocol reference model, security and inter-operability in a cognitive communications system

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BAE-Cognitive

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08898468	2.28	7	2014	Reddy; Ranga Kiernan; Thomas Mody; Apurva N.	Method for ensuring security and privacy in a wireless cognitive network

NPR #	IEEE References Cited in Non-Patent Literature
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BAE-Cognitive

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08154666	1.55	7	2012	Mody; Apurva N	Spectrum sensing function for cognitive radio applications

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09445263	0.73	1	2016	Reddy; Ranga Kiernan; Thomas Mody; Apurva N.	Method for ensuring security and privacy in a wireless cognitive network

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09420454	0.00	0	2016	Reddy; Ranga Kiernan; Thomas Mody; Apurva N.	Method for ensuring security and privacy in a wireless cognitive network

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BAE-MobileHotspot

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09119179	49.72	124	2015	Firoiu; Victor LaPrise; Scott B.	Skypoint for mobile hotspots

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
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NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09910018	50.11	9	2018	Rothberg; Jonathan M. Alie; Susan A. Fife; Keith G. Sanchez; Nevada J. Ralston; Tyler S.	Microfabricated ultrasonic transducers and related apparatus and methods

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
09899371	28.06	9	2018	Rothberg; Jonathan M. Fife; Keith G. Sanchez; Nevada J. Alie; Susan A.	Ultrasonic transducers in complementary metal oxide semiconductor (CMOS) wafers and related apparatus and methods

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09944514	27.20	8	2018	Rothberg; Jonathan M. Fife; Keith G. Ralston; Tyler S. Charvat; Gregory L. Sanchez; Nevada J.	Complementary metal oxide semiconductor (CMOS) ultrasonic transducers and methods for forming the same

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58 Yu et al., Dual-bottom-electrode CMUT based on standard CMOS process. NEMS. 2001 IEEE International Conference. Feb. 20, 2011;21-4.

59 Zahorian et al., Single chip CMUT arrays with integrated CMOS electronics: fabrication process development and experimental results. Proc Ultrason Symp. 2008;386-9. 2008 IEEE Ultrasonics Symposium

61 Zhuang et al., Wafer-bonded 2-D CMUT arrays incorporating through-wafer trench-isolated interconnects with a supporting frame. IEEE Trans Ultrason Ferroelectr Freq Control. Jan. 2009;56(1):182-92. doi: 10.1109/TUFFC.2009.1018.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Butterfly

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09533873	25.87	15	2017	Rothberg; Jonathan M. Fife; Keith G. Ralston; Tyler S. Charvat; Gregory L. Sanchez; Nevada J.	CMOS ultrasonic transducers and related apparatus and methods

NPR #	IEEE References Cited in Non-Patent Literature
4	Helin et al., Poly-SiGe-based CMUT array with high acoustical pressure. MEMS. 2012 IEEE 25th International Conference on Micro Electro Mechanical Systems. Jan. 29, 2012;305-8.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09394162	23.24	21	2016	Rothberg; Jonathan M. Alie; Susan A. Fife; Keith G. Sanchez; Nevada J. Ralston; Tyler S.	Microfabricated ultrasonic transducers and related apparatus and methods

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09738514	17.56	8	2017	Rothberg; Jonathan M. Fife; Keith G. Ralston; Tyler S. Charvat; Gregory L. Sanchez; Nevada J.	Complementary metal oxide semiconductor (CMOS) ultrasonic transducers and methods for forming the same

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Butterfly

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09067779	15.51	37	2015	Rothberg; Jonathan M. Alie; Susan A. Fife; Keith G. Sanchez; Nevada J. Ralston; Tyler S.	Microfabricated ultrasonic transducers and related apparatus and methods

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09290375	15.02	20	2016	Rothberg; Jonathan M. Fife; Keith G. Ralston; Tyler S. Charvat; Gregory L. Sanchez; Nevada J.	Complementary metal oxide semiconductor (CMOS) ultrasonic transducers and methods for forming the same

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09895718	12.26	8	2018	Rothberg; Jonathan M. Fife; Keith G. Ralston; Tyler S. Charvat; Gregory L. Sanchez; Nevada J.	CMOS ultrasonic transducers and related apparatus and methods

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09242275	11.32	25	2016	Rothberg; Jonathan M. Fife; Keith G. Ralston; Tyler S. Charvat; Gregory L. Sanchez; Nevada J.	Complementary metal oxide semiconductor (CMOS) ultrasonic transducers and methods for forming the same

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
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09061318	8.74	27	2015	Rothberg; Jonathan M. Fife; Keith G. Ralston; Tyler S. Charvat; Gregory L. Sanchez; Nevada J.	Complementary metal oxide semiconductor (CMOS) ultrasonic transducers and methods for forming the same

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09505030	7.24	16	2016	Rothberg; Jonathan M. Fife; Keith G. Sanchez; Nevada J. Alie; Susan A.	Ultrasonic transducers in complementary metal oxide semiconductor (CMOS) wafers and related apparatus and methods

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09718098	5.61	8	2017	Rothberg; Jonathan M. Fife; Keith G. Ralston; Tyler S. Charvat; Gregory L. Sanchez; Nevada J.	CMOS ultrasonic transducers and related apparatus and methods

NPR #	IEEE References Cited in Non-Patent Literature
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09327142	3.38	10	2016	Rothberg; Jonathan M. Fife; Keith G. Ralston; Tyler S. Charvat; Gregory L. Sanchez; Nevada J.	Monolithic ultrasonic imaging devices, systems and methods

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Appendix A: Blockbuster Patents with IEEE References

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08852103	2.18	30	2014	Rothberg; Jonathan M. Sanchez; Nevada J. Charvat; Gregory L. Ralston; Tyler S.	Transmissive imaging and related apparatus and methods

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09351706	1.17	10	2016	Rothberg; Jonathan M. Fife; Keith G. Sanchez; Nevada J. Ralston; Tyler S. Charvat; Gregory L.	Interconnectable ultrasound transducer probes and related methods and apparatus

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09492144	1.05	9	2016	Chen; Kailiang Ralston; Tyler S.	Multi-level pulser and related apparatus and methods

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08234097	24.52	157	2012	Steines; Daniel Zhuravlev; Alexey	Automated systems for manufacturing patient-specific orthopedic implants and instrumentation

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08122582	22.90	188	2012	Burdulis, Jr.; Albert G. Fitz; Wolfgang Vargas-Voracek; Rene Lang; Philipp Steines; Daniel	Surgical tools facilitating increased accuracy, speed and simplicity in performing joint arthroplasty

NPR #	IEEE References Cited in Non-Patent Literature
7	Carr et al., "Surface Interpolation with Radial Basis Functions for Medical Imaging," IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08634617	21.51	92	2014	Tsougarakis; Konstantinos Steines; Daniel Vissa; Bhaskar Rao Lang; Philipp Linder; Barry J.	Methods for determining meniscal size and shape and for devising treatment

NPR #	IEEE References Cited in Non-Patent Literature
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182	Noll et al., "Homodyne detection in magnetic resonance imaging," IEEE Trans Med Imag 10(2): 154-163 (1991).
414	Radermacher et al., "Computer Assisted Matching of Planning and Execution in Orthopedic Surgery", IEEE, EMBS, San Diego, 1993, pp. 946-947.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08561278	21.31	90	2013	Fitz; Wolfgang Lang; Philipp Steines; Daniel	Joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
7	Carr et al., "Surface Interpolation with Radial Basis Functions for Medical Imaging," IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
113	Radermacher et al., "Computer Assisted Matching of Planning and Execution in Orthopedic Surgery", IEEE, EMBS, San Diego, 1993, pp. 946-947.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08638998	21.05	90	2014	Steines; Daniel Timsari; Bijan Tsougarakis; Konstantinos Lang; Philipp	Fusion of multiple imaging planes for isotropic imaging in MRI and quantitative image analysis using isotropic or near-isotropic imaging

NPR #	IEEE References Cited in Non-Patent Literature
35	Radermacher et al., "Computer Assisted Matching of Planning and Execution in Orthopedic Surgery", IEEE, EMBS, San Diego, 1993, pp. 946-947.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07634119	13.07	176	2009	Tsougarakis; Konstantinos Steines; Daniel Timsari; Bijan	Fusion of multiple imaging planes for isotropic imaging in MRI and quantitative image analysis using isotropic or near-isotropic imaging

NPR #	IEEE References Cited in Non-Patent Literature
0	None

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08768028	11.59	49	2014	Lang; Philipp Steines; Daniel	Methods and compositions for articular repair

NPR #	IEEE References Cited in Non-Patent Literature
33	Bregler et al., “Recovering non-rigid 3D shape from image streams,” Proc. IEEE Conference on Computer Vision and Pattern Recognition (Jun. 2000).
44	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
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176	Noll et al., “Homodyne detection in magnetic resonance imaging,” IEEE Trans Med Imag 10(2): 154-163 (1991).
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07981158	11.34	343	2011	Fitz; Wolfgang Lang; Philipp Bojarski; Raymond A. Steines; Daniel	Patient selectable joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
25	Carr et al., "Surface Interpolation with Radial Basis Functions for Medical Imaging," IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08337501	11.04	176	2012	Fitz; Wolfgang Lang; Philipp Bojarski; Raymond A. Steines; Daniel	Patient selectable joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
7	Carr et al., "Surface Interpolation with Radial Basis Functions for Medical Imaging," IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07618451	8.02	428	2009	Berez; Aaron Fitz; Wolfgang Lang; Philipp Steines; Daniel Tsougarakis; Konstantinos	Patient selectable joint arthroplasty devices and surgical tools facilitating increased accuracy, speed and simplicity in performing total and partial joint arthroplasty

NPR #	IEEE References Cited in Non-Patent Literature
3	Carr J.C. et al., "Surface Interpolation with Radial Basis Functions for Medical Imaging", IEEE Transactions on Medical Imaging, IEEE, Inc., New York, vol. 16, No. 1, Feb. 1, 1997, pp. 96-107.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08105330	8.01	249	2012	Fitz; Wolfgang Lang; Philipp Bojarski; Raymond A. Steines; Daniel	Patient selectable joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
12	Carr et al., "Surface Interpolation with Radial Basis Functions for Medical Imaging," IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08083745	7.25	264	2011	Lang; Philipp Fitz; Wolfgang Bojarski; Ray Steines; Daniel Burdulis; Albert G.	Surgical tools for arthroplasty

NPR #	IEEE References Cited in Non-Patent Literature
24	Carr et al. "Surface Interpolation with Radial Basis Functions for Medical Imaging," IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07468075	7.02	429	2008	Lang; Philipp Steines; Daniel Timsari; Bijan Tsougarakis; Konstantinos	Methods and compositions for articular repair

NPR #	IEEE References Cited in Non-Patent Literature
14	Carr J.C. et al., "Surface Interpolation with Radial Basis Functions for Medical Imaging", IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, No. 1, Feb. 1, 1997, pp. 96-107.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08551099	6.90	110	2013	Lang; Philipp Fitz; Wolfgang Bojarski; Raymond A. Steines; Daniel Burdulis, Jr.; Albert G.	Surgical tools for arthroplasty

NPR #	IEEE References Cited in Non-Patent Literature
7	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08066708	6.81	262	2011	Lang; Philipp Fitz; Wolfgang Bojarski; Raymond A. Steines; Daniel Burdulis, Jr.; Albert G.	Patient selectable joint arthroplasty devices and surgical tools

NPR #	*IEEE References Cited in Non-Patent Literature*
20	Carr J.C. et al., "Surface Interpolation with Radial Basis Functions for Medical Imaging", IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, No. 1, Feb. 1, 1997, pp. 96-107.

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08480754	6.57	123	2013	Bojarski; Ray Chao; Nam Fitz; Wolfgang Lang; Philipp Slamin; John	Patient-adapted and improved articular implants, designs and related guide tools

NPR #	*IEEE References Cited in Non-Patent Literature*
33	Bregler et al., “Recovering non-rigid 3D shape from image streams,” Proc. IEEE Conference on Computer Vision and Pattern Recognition (Jun. 2000).
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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08623026	6.28	92	2014	Wong; Terrance Bojarski; Raymond A. Steines; Daniel Lang; Philipp	Patient selectable joint arthroplasty devices and surgical tools incorporating anatomical relief

NPR #	*IEEE References Cited in Non-Patent Literature*
7	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08377129	6.24	130	2013	Fitz; Wolfgang Lang; Philipp Steines; Daniel Tsougarakis; Konstantinos Vargas-Voracek; Rene	Joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
10	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
141	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08882847	6.15	52	2014	Burdulis, Jr.; Albert G. Fitz; Wolfgang Lang; Philipp Steines; Daniel Tsougarakis; Konstantinos	Patient selectable knee joint arthroplasty devices

NPR #	IEEE References Cited in Non-Patent Literature
4	Carr J.C. et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging”, IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, No. 1, Feb. 1, 1997, pp. 96-107.
75	Bregler et al., “Recovering non-rigid 3D shape from image streams,” Proc. IEEE Conference on Computer Vision and Pattern Recognition (Jun. 2000).
124	Gouraud, “Continuous shading of curved surfaces,” IEEE Trans on Computers C-20(6) (1971).
169	Li et al., A Boundary Optimization Algorithm for Delineating Brain Objects from CT Scans: Nuclear Science Symposium and Medical Imaging Conference 1993 IEEE Conference Record, San Francisco, CA (1993).
196	Noll et al., “Homodyne detection in magnetic resonance imaging,” IEEE Trans Med Imag 10(2): 154-163 (1991).

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08556983	5.77	108	2013	Bojarski; Raymond A. Chao; Nam Slamin; John Lang; Philipp Fitz; Wolfgang	Patient-adapted and improved orthopedic implants, designs and related tools

NPR #	IEEE References Cited in Non-Patent Literature
35	Bregler et al. “Recovering non-rigid 3D shape from image streams,” Proc. IEEE Conference on Computer Vision and Pattern Recognition (Jun. 2000).
47	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
93	Gouraud, “Continuous shading of curved surfaces,” IEEE Trans on Computers C-20(6) (1971).
148	Li et al., A Boundary Optimization Algorithm for Delineating Brain Objects from CT Scans: Nuclear Science Symposium and Medical Imaging Conference 1993 IEEE Conference Record, San Francisco, CA (1993).
182	Noll et al., “Homodyne detection in magnetic resonance imaging,” IEEE Trans Med Imag 10(2): 154-163 (1991).

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08709089	5.77	70	2014	Lang; Philipp Steines; Daniel Bouadi; Hacene Miller; David	Minimally invasive joint implant with 3-dimensional geometry matching the articular surfaces

NPR #	IEEE References Cited in Non-Patent Literature
33	Bregler et al., “Recovering non-rigid 3D shape from image streams,” Proc. IEEE Conference on Computer Vision and Pattern Recognition (Jun. 2000).
44	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
89	Gouraud, “Continuous shading of curved surfaces,” IEEE Trans on Computers C-20(6) (1971).
142	Li et al., A Boundary Optimization Algorithm for Delineating Brain Objects from CT Scans: Nuclear Science Symposium and Medical Imaging Conference 1993 IEEE Conference Record, San Francisco, CA (1993).
176	Noll et al., “Homodyne detection in magnetic resonance imaging,” IEEE Trans Med Imag 10(2): 154-163 (1991).
390	Tsai, et al., “Accurate Surface Voxelization for Manipulating Volumetric Surfaces and Solids with Application in Simulating Musculoskeletal Surgery”, IEEE, May 2001, pp. 234-243.
415	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08366771	5.61	117	2013	Burdulis, Jr.; Albert G. Fitz; Wolfgang Vargas-Voracek; Rene Lang; Philipp Steines; Daniel	Surgical tools facilitating increased accuracy, speed and simplicity in performing joint arthroplasty

NPR #	IEEE References Cited in Non-Patent Literature
7	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
113	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08337507	5.51	127	2012	Lang; Philipp Steines; Daniel Tsourgarakis; Konstantinos	Methods and compositions for articular repair

NPR #	IEEE References Cited in Non-Patent Literature
31	Bregler et al., "Recovering non-rigid 3D shape from image streams," Proc. IEEE Conference on Computer Vision and Pattern Recognition (Jun. 2000).
42	Carr et al., "Surface Interpolation with Radial Basis Functions for Medical Imaging," IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
87	Gouraud, "Continuous shading of curved surfaces," IEEE Trans on Computers C-20(6) (1971).
139	Li et al., A Boundary Optimization Algorithm for Delineating Brain Objects from CT Scans: Nuclear Science Symposium and Medical Imaging Conference 1993 IEEE Conference Record, San Francisco, CA (1993).
169	Noll et al., "Homodyne detection in magnetic resonance imaging," IEEE Trans Med Imag 10(2): 154-163 (1991).

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08545569	5.50	103	2013	Fitz; Wolfgang Lang; Philipp Steines; Daniel Tsougarakis; Konstantinos Vargas-Voracek; Rene	Patient selectable knee arthroplasty devices

NPR #	IEEE References Cited in Non-Patent Literature
14	Carr, J.C. et al., Surface Interpolation with Radial Basis Functions for Medical Imaging:, IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, No. 1, Feb. 1, 1997, pp. 96-107.
69	Bregler et al., “Recovering non-rigid 3D shape from image streams,” Proc. IEEE Conference on Computer Vision and Pattern Recognition (Jun. 2000).
118	Gouraud, “Continuous shading of curved surfaces,” IEEE Trans on Computers C-20(6) (1971).
163	Li et al., A Boundary Optimization Algorithm for Delineating Brain Objects from CT Scans: Nuclear Science Symposium and Medical Imaging Conference 1993 IEEE Conference Record, San Francisco, CA (1993).
190	Noll et al., “Homodyne detection in magnetic resonance imaging,” IEEE Trans Med Imag 10(2): 154-163 (1991).

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08657827	5.19	92	2014	Fitz; Wolfgang Lang; Philipp Bojarski; Raymond A. Steines; Daniel Burdulis, Jr.; Albert G.	Surgical tools for arthroplasty

NPR #	IEEE References Cited in Non-Patent Literature
17	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.
78	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08771365	5.18	54	2014	Bojarski; Raymond A. Lang; Philipp Chao; Nam Fitz; Wolfgang Slamin; John	Patient-adapted and improved orthopedic implants, designs, and related tools

NPR #	IEEE References Cited in Non-Patent Literature
38	Bregler et al., “Recovering non-rigid 3D shape from image streams,” Proc. IEEE Conference on Computer Vision and Pattern Recognition (Jun. 2000).
50	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
97	Gouraud, “Continuous shading of curved surfaces,” IEEE Trans on Computers C-20(6) (1971).
152	Li et al., A Boundary Optimization Algorithm for Delineating Brain Objects from CT Scans: Nuclear Science Symposium and Medical Imaging Conference 1993 IEEE Conference Record, San Francisco, CA (1993).
186	Noll et al., “Homodyne detection in magnetic resonance imaging,” IEEE Trans Med Imag 10(2): 154-163 (1991).

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08529630	4.91	92	2013	Bojarski; Raymond A. Fitz; Wolfgang Chao; Nam T.	Patient selectable joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
7	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
113	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08568479	4.22	88	2013	Fitz; Wolfgang Lang; Philipp Steines; Daniel	Joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
17	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.
78	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).

Conformis

Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08568480	4.22	88	2013	Fitz; Wolfgang Lang; Philipp Steines; Daniel	Joint arthroplasty devices and surgical tools

NPR #	*IEEE References Cited in Non-Patent Literature*
7	Carr et al., "Surface Interpolation with Radial Basis Functions for Medical Imaging," IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
113	Radermacher et al., "Computer Assisted Matching of Planning and Execution in Orthopedic Surgery", IEEE, EMBS, San Diego, 1993, pp. 946-947.

Conformis

Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08439926	4.02	121	2013	Bojarski; Raymond Fitz; Wolfgang Lang; Philipp	Patient selectable joint arthroplasty devices and surgical tools

NPR #	*IEEE References Cited in Non-Patent Literature*
7	Carr et al., "Surface Interpolation with Radial Basis Functions for Medical Imaging," IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
149	Radermacher et al., "Computer Assisted Matching of Planning and Execution in Orthopedic Surgery", IEEE, EMBS, San Diego, 1993, pp. 946-947.

Conformis

Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08556907	3.93	91	2013	Fitz; Wolfgang Lang; Philipp Steines; Daniel	Joint arthroplasty devices and surgical tools

NPR #	*IEEE References Cited in Non-Patent Literature*
17	Radermacher et al., "Computer Assisted Matching of Planning and Execution in Orthopedic Surgery", IEEE, EMBS, San Diego, 1993, pp. 946-947.
78	Carr et al., "Surface Interpolation with Radial Basis Functions for Medical Imaging," IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08556906	3.88	90	2013	Fitz; Wolfgang Lang; Philipp Steines; Daniel	Joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
7	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pgs. 96-107 (Feb. 1997).
116	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08945230	3.23	17	2015	Lang; Philipp Steines; Daniel Fitz; Wolfgang Tsougarakis; Konstantinos Vargas-Voracek; Rene	Patient selectable knee joint arthroplasty devices

NPR #	IEEE References Cited in Non-Patent Literature
33	Bregler et al., “Recovering non-rigid 3D shape from image streams,” Proc. IEEE Conference on Computer Vision and Pattern Recognition (Jun. 2000).
44	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
89	Gouraud, “Continuous shading of curved surfaces,” IEEE Trans on Computers C-20(6) (1971).
142	Li et al., A Boundary Optimization Algorithm for Delineating Brain Objects from CT Scans: Nuclear Science Symposium and Medical Imaging Conference 1993 IEEE Conference Record, San Francisco, CA (1993).
176	Noll et al., “Homodyne detection in magnetic resonance imaging,” IEEE Trans Med Imag 10(2): 154-163 (1991).

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08974539	3.23	17	2015	Bojarski; Raymond A. Chao; Nam Slamin; John Lang; Philipp Fitz; Wolfgang	Patient-adapted and improved articular implants, designs and related guide tools

NPR #	IEEE References Cited in Non-Patent Literature
35	Bregler et al., “Recovering non-rigid 3D shape from image streams,” Proc. IEEE Conference on Computer Vision and Pattern Recognition (Jun. 2000).
47	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
93	Gouraud, “Continuous shading of curved surfaces,” IEEE Trans on Computers C-20(6) (1971).
148	Li et al., A Boundary Optimization Algorithm for Delineating Brain Objects from CT Scans: Nuclear Science Symposium and Medical Imaging Conference 1993 IEEE Conference Record, San Francisco, CA (1993).
182	Noll et al., “Homodyne detection in magnetic resonance imaging,” IEEE Trans Med Imag 10(2): 154-163 (1991).

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08551103	3.15	95	2013	Fitz; Wolfgang Lang; Philipp Steines; Daniel	Joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
17	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.
78	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08551102	3.05	92	2013	Fitz; Wolfgang Lang; Philipp Steines; Daniel	Joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
17	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.
78	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08562618	2.99	90	2013	Fitz; Wolfgang Lang; Philipp Steines; Daniel	Joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
17	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.
78	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08906107	2.49	26	2014	Bojarski; Raymond A. Chao; Nam Slamin; John Lang; Philipp Fitz; Wolfgang	Patient-adapted and improved orthopedic implants, designs and related tools

NPR #	IEEE References Cited in Non-Patent Literature
35	Bregler et al. “Recovering non-rigid 3D shape from image streams,” Proc. IEEE Conference on Computer Vision and Pattern Recognition (Jun. 2000).
47	Carr et al. “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
93	Gouraud, “Continuous shading of curved surfaces,” IEEE Trans on Computers C-20(6) (1971).
148	Li et al. A Boundary Optimization Algorithm for Delineating Brain Objects from CT Scans: Nuclear Science Symposium and Medical Imaging Conference 1993 IEEE Conference Record, San Francisco, CA (1993).
182	Noll et al., “Homodyne detection in magnetic resonance imaging,” IEEE Trans Med Imag 10(2): 154-163 (1991).

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09055953	2.06	26	2015	Lang; Philipp Steines; Daniel	Methods and compositions for articular repair

NPR #	IEEE References Cited in Non-Patent Literature
33	Bregler et al., “Recovering non-rigid 3D shape from image streams,” Proc. IEEE Conference on Computer Vision and Pattern Recognition (Jun. 2000).
44	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
89	Gouraud, “Continuous shading of curved surfaces,” IEEE Trans on Computers C-20(6) (1971).
142	Li et al., A Boundary Optimization Algorithm for Delineating Brain Objects from CT Scans: Nuclear Science Symposium and Medical Imaging Conference 1993 IEEE Conference Record, San Francisco, CA (1993).
176	Noll et al., “Homodyne detection in magnetic resonance imaging,” IEEE Trans Med Imag 10(2): 154-163 (1991).
427	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.
491	Rhodes et al., “An Application of Computer Graphics and Networks to Anatomic Model and Prosthesis Manufacturing”, IEEE CG&A, pp. 12-25, Feb. 1987.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09326780	1.87	16	2016	Wong; Terrance Bojarski; Raymond A. Steines; Daniel Lang; Philipp	Patient selectable joint arthroplasty devices and surgical tools incorporating anatomical relief

NPR #	IEEE References Cited in Non-Patent Literature
5	Rhodes et al., “An Application of Computer Graphics and Networks to Anatomic Model and Prosthesis Manufacturing”, IEEE CG&A, pp. 12-25, Feb. 1987.
30	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
90	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09387079	1.84	5	2016	Bojarski; Raymond A. Slamin; John Lang; Philipp Fitz; Wolfgang Steines; Daniel	Patient-adapted and improved articular implants, designs and related guide tools

NPR #	IEEE References Cited in Non-Patent Literature
35	Bregler et al., “Recovering non-rigid 3D shape from image streams,” Proc. IEEE Conference on Computer Vision and Pattern Recognition (Jun. 2000).
47	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
95	Gouraud, “Continuous shading of curved surfaces,” IEEE Trans on Computers C-20(6) (1971).
151	Li et al., A Boundary Optimization Algorithm for Delineating Brain Objects from CT Scans: Nuclear Science Symposium and Medical Imaging Conference 1993 IEEE Conference Record, San Francisco, CA (1993).
186	Noll et al., “Homodyne detection in magnetic resonance imaging,” IEEE Trans Med Imag 10(2): 154-163 (1991).

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09107680	1.83	23	2015	Fitz; Wolfgang Lang; Philipp Bojarski; Raymond A. Steines; Daniel	Patient selectable joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
11	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
67	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.
297	Rhodes et al., “An Application of Computer Graphics and Networks to Anatomic Model and Prosthesis Manufacturing”, IEEE CG&A, pp. 12-25, Feb. 1987.

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08951260	1.51	19	2015	Lang; Philipp Fitz; Wolfgang Steines; Daniel Bojarski; Raymond A.	Surgical cutting guide

NPR #	IEEE References Cited in Non-Patent Literature
34	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.
100	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08585708	1.49	45	2013	Fitz; Wolfgang Lang; Philipp Bojarski; Raymond A. Steines; Daniel	Patient selectable joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
7	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
113	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.

Conformis

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09358018	0.70	6	2016	Fitz; Wolfgang Lang; Philipp Steines; Daniel Tsougarakis; Konstantinos Vargas-Voracek; Rene	Joint arthroplasty devices and surgical tools

NPR #	IEEE References Cited in Non-Patent Literature
27	Carr et al., “Surface Interpolation with Radial Basis Functions for Medical Imaging,” IEEE Transactions on Medical Imaging, IEEE, Inc. New York, vol. 16, pp. 96-107 (Feb. 1997).
83	Radermacher et al., “Computer Assisted Matching of Planning and Execution in Orthopedic Surgery”, IEEE, EMBS, San Diego, 1993, pp. 946-947.
194	Rhodes et al., “An Application of Computer Graphics and Networks to Anatomic Model and Prosthesis Manufacturing”, IEEE CG&A, pp. 12-25, Feb. 1987.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09921660	66.03	26	2018	Poupyrev; Ivan	Radar-based gesture recognition

NPR #	IEEE References Cited in Non-Patent Literature
4	Balakrishnan,"Detecting Pulse from Head Motions in Video", In Proceedings: CVPR '13 Proceedings of the 2013 IEEE Conference on Computer Vision and Pattern Recognition Available at: <http://people.csail.mit.edu/mrub/vidmag/papers/Balakrishnan_Detecting_Pulse_from_2013_CVPR_paper.pdf>, Jun. 23, 2013, 8 pages.
8	Wang,"Exploiting Spatial Redundancy of Image Sensor for Motion Robust rPPG", In Proceedings: IEEE Transactions on Biomedical Engineering, vol. 62, Issue 2, Jan. 19, 2015, 11 pages.
20	Pu, "Whole-Home Gesture Recognition Using Wireless Signals", MobiCom '13 Proceedings of the 19th annual international conference on Mobile computing & networking, Aug. 27, 2013, 12 pages. Joint IEEE and ACM
34	Arbabian,"A 94GHz mm-Wave to Baseband Pulsed-Radar for Imaging and Gesture Recognition", 2012 IEEE, 2012 Symposium on VLSI Circuits Digest of Technical Papers, 2012, 2 pages.
35	Cheng,"Smart Textiles: From Niche to Mainstream", IEEE Pervasive Computing, Jul. 2013, pp. 81-84.
36	Farringdon,"Wearable Sensor Badge & Sensor Jacket for Context Awareness", Third International Symposium on Wearable Computers, Oct. 1999, 7 pages. Joint IEEE and ACM
39	Patel,"Applications of Electrically Conductive Yarns in Technical Textiles", International Conference on Power System Technology (POWECON), Oct. 30, 2012, 6 pages. 2012 IEEE International Conference on Power System Technology (POWERCON)
41	Wijesiriwardana,"Capacitive Fibre-Meshed Transducer for Touch & Proximity Sensing Applications", IEEE Sensors Journal, IEEE Service Center, Oct. 1, 2005, 5 pages.
97	Espina,"Wireless Body Sensor Network for Continuous Cuff-less Blood Pressure Monitoring", International Summer School on Medical Devices and Biosensors, 2006, Sep. 2006, 5 pages. 2006 3rd IEEE/EMBS International Summer School on Medical Devices and Biosensors
100	Wang,"Micro-Doppler Signatures for Intelligent Human Gait Recognition Using a UWB Impulse Radar", 2011 IEEE International Symposium on Antennas and Propagation (APSURSI), Jul. 3, 2011, pp. 2103-2106.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09971415	50.79	20	2018	Poupyrev; Ivan Aiello; Gaetano Roberto	Radar-based gesture-recognition through a wearable device

NPR #	IEEE References Cited in Non-Patent Literature
45	Arbabian,"A 94GHz mm-Wave to Baseband Pulsed-Radar for Imaging and Gesture Recognition", 2012 IEEE, 2012 Symposium on VLSI Circuits Digest of Technical Papers, 2012, 2 pages, Jun. 15, 2012.
46	Balakrishnan,"Detecting Pulse from Head Motions in Video", In Proceedings: CVPR '13 Proceedings of the 2013 IEEE Conference on Computer Vision and Pattern Recognition Available at: <http://people.csail.mit.edu/mrub/vidmag/papers/Balakrishnan_Detecting_Pulse_from_2013_CVPR_paper.pdf>, Jun. 23, 2013, 8 pages.
47	Cheng,"Smart Textiles: From Niche to Mainstream", IEEE Pervasive Computing, Jul. 2013, pp. 81-84.
49	Espina,"Wireless Body Sensor Network for Continuous Cuff-less Blood Pressure Monitoring", International Summer School on Medical Devices and Biosensors, 2006, Sep. 2006, 5 pages. 2006 3rd IEEE/EMBS International Summer School on Medical Devices and Biosensors
50	Farringdon,"Wearable Sensor Badge & Sensor Jacket for Context Awareness", Third International Symposium on Wearable Computers, Oct. 1999, 7 pages. Joint IEEE and ACM
55	Patel,"Applications of Electrically Conductive Yarns in Technical Textiles", International Conference on Power System Technology (POWECON), Oct. 30, 2012, 6 pages. 2012 IEEE International Conference on Power System Technology (POWERCON)
59	Pu,"Whole-Home Gesture Recognition Using Wireless Signals", MobiCom '13 Proceedings of the 19th annual international conference on Mobile computing & networking, Aug. 27, 2013, 12 pages. Joint IEEE and ACM
61	Wang,"Exploiting Spatial Redundancy of Image Sensor for Motion Robust rPPG", In Proceedings: IEEE Transactions on Biomedical Engineering, vol. 62, Issue 2, Jan. 19, 2015, 11 pages.
62	Wang,"Micro-Doppler Signatures for Intelligent Human Gait Recognition Using a UWB Impulse Radar", 2011 IEEE International Symposium on Antennas and Propagation (APSURSI), Jul. 3, 2011, pp. 2103-2106.
63	Wijesiriwardana,"Capacitive Fibre-Meshed Transducer for Touch & Proximity Sensing Applications", IEEE Sensors Journal, IEEE Service Center, Oct. 1, 2005, 5 pages.
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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
10088908	48.25	19	2018	Poupyrev; Ivan Schwesig; Carsten Schulze; Jack Arnall; Timo Bishop; Durrell Grant Bevington	Gesture detection and interactions

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
10139916	40.64	16	2018	Poupyrev; Ivan	Wide-field radar-based gesture recognition

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09778749	28.96	28	2017	Poupyrev; Ivan	Occluded gesture recognition

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09575560	27.92	27	2017	Poupyrev; Ivan Aiello; Gaetano Roberto	Radar-based gesture-recognition through a wearable device

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09811164	25.85	25	2017	Poupyrev; Ivan	Radar-based gesture sensing and data transmission

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09646481	6.11	9	2017	Messenger; Jayson Yuen; Shelten	Alarm setting and interfacing with gesture contact interfacing controls

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08812259	4.37	13	2014	Messenger; Jayson Yuen; Shelten	Alarm setting and interfacing with gesture contact interfacing controls

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Citation Counts and Citation Indexes through 12/31/2019

InTouch

Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08996165	144.41	419	2015	Wang; Yulun Jordan; Charles S. Hanrahan; Kevin Sanchez; Daniel Steven Pinter; Marco	Telepresence robot with a camera boom

NPR #	*IEEE References Cited in Non-Patent Literature*
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08170241	34.35	475	2012	Roe; David Bjorn Sanchez; Daniel Steven Pinter; Marco Walters; Derek Jordan; Charles S.	Mobile tele-presence system with a microphone system

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47 Tendick et al., "Human-Machine Interfaces for Minimally Invasive Surgery", 1997, IEEE, pp. 2771-2776.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08849679	16.53	47	2014	Wang; Yulun Jordan; Charles S. Pinter; Marco	Remote controlled robot system that provides medical images

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08902278	11.41	52	2014	Pinter; Marco Brallier; Greg Ross; Scott	Systems and methods for visualizing and managing telepresence devices in healthcare networks

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08401275	11.26	61	2013	Wang; Yulun Jordan; Charles S. Laby; Keith P. Southard; Jonathan Pinter; Marco	Mobile robot with a head-based movement mapping scheme

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08670017	10.54	48	2014	Stuart; David Sanchez; Daniel Steven Lai; Fuji Hanrahan; Kevin Jordan; Charles S.	Remote presence system including a cart that supports a robot face and an overhead camera

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08849680	8.87	46	2014	Wright; Timothy C. Lai; Fuji Pinter; Marco Wang; Yulun	Documentation through a remote presence robot

NPR #	*IEEE References Cited in Non-Patent Literature*
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08897920	8.67	45	2014	Wang; Yulun Pinter; Marco Hanrahan; Kevin Sanchez; Daniel Steven Jordan; Charles S.	Tele-presence robot system with software modularity, projector and laser pointer

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

InTouch

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08861750	8.10	42	2014	Roe; David Bjorn Sanchez; Daniel Steven Pinter; Marco Walters; Derek Jordan; Charles S.	Mobile tele-presence system with a microphone system

NPR # IEEE References Cited in Non-Patent Literature

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08179418	6.77	62	2012	Wright; Timothy C. Lai; Fuji Pinter; Marco Wang; Yulun	Robotic based health care system

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2	F. Ando et al., "A Multimedia Self-service Terminal with Conferencing Functions", 1995, IEEE, pp. 357-362.
5	Bauer, John et al., "Remote telesurgical mentoring: feasibility and efficacy", 2000, IEEE, pp. 1-9.
16	Goldberg et al., "Collaborative Teleoperation via the Internet", IEEE International Conference on Robotics and Automation, Apr. 2000, San Francisco, California.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08463435	6.58	56	2013	Herzog; John Cody Whitney; Blair Wang; Yulun Jordan; Charles S. Pinter; Marco	Server connectivity control for tele-presence robot

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08340819	5.98	56	2012	Mangaser; Amante Southard; Jonathan Pinter; Marco Herzog; John Cody Jordan; Charles Steve	Mobile videoconferencing robot system with network adaptive driving

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07769492	4.88	77	2010	Wang; Yulun Jordan; Charles S. Pinter; Marco Brallier; Greg Mears; Jon	Graphical interface for a remote presence system

NPR #	IEEE References Cited in Non-Patent Literature
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08116910	4.80	56	2012	Walters; Derek Pinter; Marco Southard; Jonathan Jordan; Charles S.	Telepresence robot with a printer

NPR #	IEEE References Cited in Non-Patent Literature
1	F. Ando et al., "A Multimedia Self-service Terminal with Conferencing Functions", 1995, IEEE, pp. 357-362.
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

InTouch

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07593030	4.75	69	2009	Wang; Yulun Jordan; Charles S. Southard; Jonathan Pinter; Marco	Tele-robotic videoconferencing in a corporate environment

NPR #	IEEE References Cited in Non-Patent Literature
13	Kanehiro, Fumio et al., Virtual Humanoid Robot Platform to Develop Controllers of Real Humanoid Robots without Porting, 2001,IEEE, pp. 3217-3276.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08209051	4.72	59	2012	Wang; Yulun Laby; Keith Phillip Jordan; Charles S. Butner; Steven Edward Southard; Jonathan	Medical tele-robotic system

NPR #	IEEE References Cited in Non-Patent Literature
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100	Siegwart, "Interacting Mobile Robots on the Web", Proceedings of the 1999 IEEE International Conference on Robotics and Automation, May 1999.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07171286	4.68	97	2007	Wang; Yulun Jordan; Charles S. Laby; Keith Phillip Southard; Jonathan Pinter; Marco	Healthcare tele-robotic system with a robot that also functions as a remote station

NPR #	IEEE References Cited in Non-Patent Literature
1	.quadrature..quadrature.Mack, Minimally invasive and robotic surgery, 2001, IEEE, pp. 568-572.
4	Tendick et al., Human-machine interfaces for minimally invasive surgery, 1997, IEEE, pp. 1-6.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07262573	4.15	85	2007	Wang; Yulun Jordan; Charles S. Laby; Keith Phillip Southard; Jonathan	Medical tele-robotic system with a head worn device

NPR #	IEEE References Cited in Non-Patent Literature
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16	Lim, Hun-ok et al., Control to Realize Human-like Walking of a Biped Humanoid Robot, IEE 2000, pp. 3271-3276. Smc 2000 conference proceedings. 2000 ieee international conference on systems, man and cybernetics. 'cybernetics evolving to systems, humans, organizations, and their complex interactions' (cat. no.0
18	Mack, "Minimally invasive and robotic surgery", 2001, IEEE, pp. 568-572.
22	Ojha, Anad, "An application of Virtual Reality in Rehabilitation", Jan. 1994, IEEE, pp. 4-6.
26	Paulos, et al., "Designing Personal Tele-Embodiment", Presented at the IEEE International Conference on Robotics and Animation, Leuven, Belgium, May 20, 1998.
27	Pin et al., "A New Family of Omnidirectional and Holonomic Wheeled Platforms for Mobile Robots", IEEE, vol. 10, No. 4, Aug. 1994.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07161322	4.11	84	2007	Wang; Yulun Laby; Keith Phillip Mukherjee; Ranjan	Robot with a manipulator arm

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07761185	3.86	63	2010	Wang; Yulun Jordan; Charles S. Pinter; Marco Chan; Michael C.	Remote presence display through remotely controlled robot

NPR #	IEEE References Cited in Non-Patent Literature
15	Ishihara, Ken et al., "Intelligent Microrobot DDS (Drug Delivery System) Measured and Controlled by Ultrasonics", 1991, IEEE/RSJ, pp. 1145-1150, vol. 2.
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

InTouch

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09098611	3.45	10	2015	Pinter; Marco Jordan; Charles S. Sanchez; Daniel Hanrahan; Kevin Lambrecht; Chris	Enhanced video interaction for a user interface of a telepresence network

NPR #	IEEE References Cited in Non-Patent Literature
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25	Gaidioz et al., “Synchronizing Network Probes to Avoid Measurement Intrusiveness with the Network Weather Service”, High-Performance Distributed Computing, Proceedings of the Ninth International Symposium, 2000, pp. 147-154. IEEE int Symp on High Performance Distributed comp
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48	Ando, et al., “A Multimedia Self-service Terminal with Conferencing Functions”, IEEE, Jul. 5-7, 1995, pp. 357-362.
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118	Kanehiro, et al., “Virtual Humanoid Robot Platform to Develop Controllers of Real Humanoid Robots without Porting”, IEEE, 2001, pp. 3217-3276.
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201 Brenner, Pablo, “A Technical Tutorial on the IEEE 802.11 Protocol”, BreezeCOM Wireless Communications, Jul. 18, 1996, pp. 1-24.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

InTouch

Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08836751	3.27	45	2014	Ballantyne; James Temby; Kelton Rosenthal; James Roe; David B.	Tele-presence system with a user interface that displays different communication links

NPR #	*IEEE References Cited in Non-Patent Literature*
2	Brooks, “A Robust Layered Control System for a Mobile Robot,” IEEE Journal of Robotics and Automation, 2 (1), Mar. 1986, 10 pgs.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07142947	3.24	75	2006	Wang; Yulun Laby; Keith Phillip Jordan; Charles S. Butner; Steven Edward Southard; Jonathan	Medical tele-robotic method

NPR # IEEE References Cited in Non-Patent Literature

4 Ojha et al., An application of virtual reality in rehabilitation, 1994, IEEE, p. 4-6.
17 Kanehiro, Fumio et al., Virtual Humanoid Robot Platform to Develop Controllers of Real Humanoid Robots without Porting, 2001,IEEE, pp. 3217-3276.
18 Lim, Hun-ok et al., Control to Realize Human-like Walking of a Biped Humanoid Robot, IEE 2000, pp. 3271-3276. Smc 2000 conference proceedings. 2000 ieee international conference on systems, man and cybernetics. 'cybernetics evolving to systems, humans, organizations, and their complex interactions' (cat. no.0
20 Mack, "Minimally invasive and robotic surgery", 2001, IEEE, pp. 568-572.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07813836	3.18	55	2010	Wang; Yulun Jordan; Charles S. Pinter; Marco Southard; Jonathan	Protocol for a remotely controlled videoconferencing robot

NPR #	IEEE References Cited in Non-Patent Literature
3	F. Ando et al., "A Multimedia Self-service Terminal with Conferencing Functions", 1995, IEEE, pp. 357-362.
5	Bauer, John et al., "Remote telesurgical mentoring: feasibility and efficicacy", 2000, IEEE, pp. 1-9.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07158859	2.92	101	2007	Wang; Yulun Laby; Keith Phillip Jordan; Charles S. Butner; Steven Edward Cuevas; James	5 degrees of freedom mobile robot

NPR #	IEEE References Cited in Non-Patent Literature
1	Mack, Minimally invasive and robotic surgery, 2001, IEEE, pp. 568-572.
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07222000	2.70	56	2007	Wang; Yulun Jordan; Charles S. Pinter; Marco Southard; Jonathan	Mobile videoconferencing platform with automatic shut-off features

NPR #	IEEE References Cited in Non-Patent Literature
3	Shimoga et al., Touch and force reflection for telpresence surgery, 1994, IEEE, p. 1049-1050.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07164969	2.66	92	2007	Wang; Yulun Kavoussi; Louis	Apparatus and method for patient rounding with a remote controlled robot

NPR #	IEEE References Cited in Non-Patent Literature
10	Kanehiro, Fumio et al., Virtual Humanoid Robot Platform to Develop Controllers of Real Humanoid Robots without Porting, 2001,IEEE, pp. 3217-3276.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07289883	2.46	85	2007	Wang; Yulun Kavoussi; Louis	Apparatus and method for patient rounding with a remote controlled robot

NPR #	IEEE References Cited in Non-Patent Literature
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32	Pin et al., "A New Family of Omnidirectional and Holonomic Wheeled Platforms for Mobile Robots", IEEE, vol. 10, No. 4, Aug. 1994.
35	Sandt, Frederic et al., "Perceptions for a Transport Robot in Public Environments", 1997, IROS '97. IEEE/RSJ
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07158860	2.34	81	2007	Wang; Yulun Jordan; Charles S. Pinter; Marco Southard; Jonathan	Healthcare tele-robotic system which allows parallel remote station observation

NPR #	IEEE References Cited in Non-Patent Literature
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4	Tendick et al., Human-machine interfaces for minimally invasive surgery, 1997, IEEE, pp. 1-6.
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

InTouch

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
06320947	2.20	94	2001	Joyce; Simon James Gupta; Prafulla C. Vaidya; Manohar S. Alla; Rajesh Reddy; Ashok K.	Telephony platform and method for providing enhanced communication services

NPR #	IEEE References Cited in Non-Patent Literature
0	None

InTouch

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07164970	2.08	72	2007	Wang; Yulun Laby; Keith Phillip Jordan; Charles S. Butner; Steven Edward Southard; Jonathan	Medical tele-robotic system

NPR #	IEEE References Cited in Non-Patent Literature
4	Ojha et al., An application of virtual reality in rehabilitation, 1994, IEEE, p. 4-6.
16	Kanehiro, Fumio et al., Virtual Humanoid Robot Platform to Develop Controllers of Real Humanoid Robots without Porting, 2001,IEEE, pp. 3217-3276.
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31	Tendick et al., "Human-Machine Interfaces for Minimally Invasive Surgery", 1997, IEEE, pp. 1-6.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07158861	1.99	69	2007	Wang; Yulun Jordan; Charles S.	Tele-robotic system used to provide remote consultation services

NPR #	IEEE References Cited in Non-Patent Literature
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4	Davies, Robotics in Minimilly invasive surgery, IEEE, p. 5/1-5/2.
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InTouch

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07142945	1.99	83	2006	Wang; Yulun Laby; Keith Phillip Jordan; Charles S. Butner; Steven Edward Southard; Jonathan	Medical tele-robotic system

NPR #	IEEE References Cited in Non-Patent Literature
4	Ojha et al., An application of virtual reality in rehabilitation, 1994, IEEE, p., 4-6.
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09667379	36.99	41	2017	Cronie; Harm Shokrollahi; Amin	Error control coding for orthogonal differential vector signaling

NPR #	IEEE References Cited in Non-Patent Literature
1	Abbasafar "Generalized Differential Vector Signaling", IEEE International Conference on Communications, ICC'09 (Jun. 14, 2009), pp. 1-5.
8	She et al., "A Framework of Cross-Layer Superposition Coded Multicast for Robust IPTV Services over WiMAX," IEEE Communications Society subject matter experts for publication in the WCNC 2008 proceedings, Mar. 31, 2008-Apr. 3, 2008, pp. 3139-3144.
14	Slepian, D., "Premutation Modulation", IEEE, vol. 52, No. 3, Mar. 1965, pp. 228-236.
15	Stan, M., et al., "Bus-Invert Coding for Low-Power I/O, IEEE Transactions on Very Large Scale Integration (VLSI) Systems", vol. 3, No. 1, Mar. 1995, pp. 49-58.
16	Tallini, L., et al., "Transmission Time Analysis for the Parallel Asynchronous Communication Scheme", IEEE Tranactions on Computers, vol. 52, No. 5, May 2003, pp. 558-571.
21	Ericson, T., et al., "Spherical Codes Generated by Binary Partitions of Symmetric Pointsets", IEEE Transactions on Information Theory, vol. 41, No. 1, Jan. 1995, pp. 107-129.
22	Farzan, K., et al., "Coding Schemes for Chip-to-Chip Interconnect Applications", IEEE Transactions on Very Large Scale Integration (VLSI) Systems, vol. 14, No. 4, Apr. 2006, pp. 393-406.
23	Abbasfar, A., "Generalized Differential Vector Signaling", IEEE International Conference on Communications, ICC '09, (Jun. 14, 2009), pp. 1-5.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09288089	31.95	59	2016	Cronie; Harm Shokrollahi; Amin	Orthogonal differential vector signaling

NPR #	IEEE References Cited in Non-Patent Literature
1	Aliazam Abbasfar, Generalized Differential Vector Signalling, 2009, 2009 IEEE international conference on Coomunications, 2009, p. 1-5.
2	David Slepian, Permutation Modulation, IEEE, vol. 53, No. 3, Mar. 1965, pp. 228-236.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08989317	31.07	96	2015	Holden; Brian Shokrollahi; Amin	Crossbar switch decoder for vector signaling codes

NPR #	IEEE References Cited in Non-Patent Literature
1	Abbasfar. A., “Generalized Differential Vector Signaling,” IEEE International Conference on Communications, ICC '09 (Jun. 14, 2009), pp. 1-5.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09288082	30.32	56	2016	Ulrich; Roger Hunt; Peter	Circuits for efficient detection of vector signaling codes for chip-to-chip communication using sums of differences

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09401828	28.70	53	2016	Cronie; Harm Shokrollahi; Amin	Methods and systems for low-power and pin-efficient communications with superposition signaling codes

NPR #	IEEE References Cited in Non-Patent Literature
2	David Sleplan ("Permutation modulation",Proceedings of the IEEE (vol. 53) , Mar. 1965, pp. 228-236.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08718184	28.04	98	2014	Cronie; Harm Shokrollahi; Amin	Finite state encoders and decoders for vector signaling codes

NPR #	IEEE References Cited in Non-Patent Literature
1	Abbasfar, A. “Generalized Differential Vector Signaling,” IEEE International Conference on Communications, ICC '09, (Jun. 14, 2009), pp. 1-5.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08649445	26.46	96	2014	Cronie; Harm Shokrollahi; Amin Tajalli; Armin	Methods and systems for noise resilient, pin-efficient and low power communications with sparse signaling codes

NPR #	IEEE References Cited in Non-Patent Literature
2	Abbasfar, A., “Generalized Differential Vector Signaling,” IEEE International Conference on Communications, ICC '09, Jun. 14, 2009, pp. 1-5.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08539318	26.23	84	2013	Cronie; Harm Shokrollahi; Amin	Power and pin efficient chip-to-chip communications with common-mode rejection and SSO resilience

NPR #	IEEE References Cited in Non-Patent Literature
1	Slepian, D., “Permutation Modulation”; 1965, Proceedings of the IEEE, vol. 53, No. 3, pp. 228-236.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09015566	22.80	64	2015	Cronie; Harm Shokrollahi; Amin	Power and pin efficient chip-to-chip communications with common-mode rejection and SSO resilience

NPR #	IEEE References Cited in Non-Patent Literature
1	David Slepian, Permutation Modulation, Proceedings of the IEEE, vol. 53, No. 3, 1965, pp. 228-236.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09300503	22.74	42	2016	Holden; Brian Shokrollahi; Amin Singh; Anant	Methods and systems for skew tolerance in and advanced detectors for vector signaling codes for chip-to-chip communication

NPR #	IEEE References Cited in Non-Patent Literature
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13	Stan, M., et al., “Bus-Invert Coding Low-Power I/O, IEEE Transactions on Very Large Scale Integration (VLSI) Systems”, vol. 3, No. 1 Mar. 1995, pp. 49-58.
14	Tallani, L., et al., “Transmission Time Analysis for the Parallel Asynchronous Communication Scheme”, IEEE Tranactions on Computers, vol. 52, No. 5, May 2003, pp. 558-571.
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23	Wang et al., “Applying CDMA Technique to Network-on-Chip”, IEEE Transactions on Very Large Scale Integration (VLSI) Systems, vol. 15, No. 10 (Oct. 1, 2007), pp. 1091-1100.
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31	Tierney, J., et al., “A digital frequency synthesizer,” Audio and Electroacoustics, IEEE Transactions, Mar. 1971, pp. 48-57, vol. 19, Issue 1, 1 page Abstract from http://ieeexplore.
37	Jiang, A., et al., “Rank Modulation for Flash Memories”, IEEE Transactions of Information Theory, Jun. 2006, vol. 55, No. 6, pp. 2659-2673.
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Kandou

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08593305	22.05	97	2013	Tajalli; Armin Cronie; Harm Shokrollahi; Amin	Efficient processing and detection of balanced codes

NPR #	IEEE References Cited in Non-Patent Literature
1	Abbasfar. A., “Generalized Differential Vector Signaling,” IEEE International Conference on Communications, ICC '09 (Jun. 14, 2009), pp. 1-5.
2	Dasilva et al., “Multicarrier Orthogonal CDMA Signals for Quasi-Synchronous Communication Systems,” IEEE Journal on Selected Areas in communications, vol. 12, No. 5 (Jun. 1, 1994), pp. 842-852.
4	Slepian, D., “Permutation Modulation,” Proceedings of the IEEE, vol. 53, No. 3 (1965), pp. 228-236.
5	Stan, et al. “Bus-Invert Coding for Low-Power I/O,” IEEE Transactions on VLSI Systems, vol. 3, No. 1 (1995), pp. 49-50.
6	Tallini et al., “Transmission Time Analysis for the Parallel Asynchronous Communication Scheme,” IEEE Transactions on Computers, vol. 52, No. 5 (2003), pp. 558-571.
7	Wang et al., “Applying CDMA Technique to Network-on-Chip,” IEEE Transactions on Very Large Scale Integration (VLSI) Systems, vol. 15, No. 10 (Oct. 1, 2007), pp. 1091-1100.

Kandou

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09083576	16.74	47	2015	Hormati; Ali	Methods and systems for error detection and correction using vector signal prediction

NPR #	IEEE References Cited in Non-Patent Literature
1	“Delayed Decision-Feedback Sequence Estimation” IEEE Transactions on Communications, vol. 37 No. 5, May 1989.
3	Abbasfar, A. “Generalized Differential Vector Signaling,” IEEE International Conference on Communications, ICC '09, (Jun. 14, 2009), pp. 1-5.
4	Dasilva, et al., “Multicarrier Orthogonal CDMA Signals for Quasi-Synchronous Communication Systems,” IEEE Journal on Selected Areas in Communications, vol. 12, No. 5 (Jun. 1, 1994), pp. 842-852.
5	Slepian, D., “Permutation Modulation”; 1965, Proceedings of the IEEE, vol. 53, No. 3, pp. 228-236.
6	Stan, M. et al.; “Bus-Invert Coding for Low-power I/O”; 1995, IEEE Transactions on VLSI systems, vol. 3, No. 1, pp. 49-50.
7	Tallini, L., et al.; “Transmission Time Analysis for the Parallel Asynchronous Communication Scheme”; 2003, IEEE Transactions on Computers, vol. 52, No. 5, pp. 558-571.
8	Wang et al., “Applying CDMA Technique to Network-on-Chip,” IEEE Transactions on Very Large Scale Integration (VLSI) Systems, vol. 15, No. 10 (Oct. 1, 2007), pp. 1091-1100.

Luxview-Apple

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09626908	102.90	56	2017	Sakariya; Kapil V. Bibl; Andreas McGroddy; Kelly	Smart pixel lighting and display microcontroller

NPR #	IEEE References Cited in Non-Patent Literature
2	Asano, Kazutoshi, et al., "Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling" IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
3	Bower, C.A., et al., "Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits", IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
5	Guerre, Roland, et al, "Selective Transfer Technology for Microdevice Distribution" IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
13	Mercado, Lei, L., et al., "A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem" 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.

Luxview-Apple

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09865832	74.83	24	2018	Bibl; Andreas Sakariya; Kapil V. Griggs; Charles R. Perkins; James Michael	Light emitting diode display with redundancy scheme

NPR #	IEEE References Cited in Non-Patent Literature
3	Asano, Kazutoshi, et al., "Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling" IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
4	Bower, C.A., et al., "Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits", IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
8	Guerre, Roland, et al, "Selective Transfer Technology for Microdevice Distribution" IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
19	Mercado, Lei, L., et al., "A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem" 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.

Luxview-Apple

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09153171	63.90	88	2015	Sakariya; Kapil V. Bibl; Andreas McGroddy; Kelly	Smart pixel lighting and display microcontroller

NPR #	IEEE References Cited in Non-Patent Literature
5	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
6	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
8	Guerre, Roland, et al, “Selective Transfer Technology for Microdevice Distribution” IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
16	Mercado, Lei, L., et al., “A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem” 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.

Luxview-Apple

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08987765	57.61	117	2015	Bibl; Andreas Griggs; Charles R.	Reflective bank structure and method for integrating a light emitting device

NPR #	IEEE References Cited in Non-Patent Literature
1	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
2	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
4	Guerre, Roland, et al, “Selective Transfer Technology for Microdevice Distribution” IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
12	Mercado, Lei, L., et al., “A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem” 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.
17	Griffin, C., et al, “Micro-pixellated flip-chip InGaN and AlInGaN light-emitting diodes,” Optical Society of America, 2007, 2 pgs. 2007 Conference on Lasers and Electro-Optics (CLEO)
18	Patel, Prachi, “Quantum Dots Are Behind New Displays,” IEEE Spectrum, accessed at http://spectrum.ieee.org/consumer-electronics/audiovideo/quantum-dots-are-behind-new-displays, Jun. 13, 2012, updated Jul. 17, 2012, 3 pgs.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09583533	36.57	29	2017	Hu; Hsin-Hua Bibl; Andreas	LED device with embedded nanowire LEDs

NPR #	IEEE References Cited in Non-Patent Literature
2	Asano, Kazutoshi, et al., "Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling" IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
3	Bower, C.A., et al., "Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits", IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
5	Guerre, Roland, et al, "Selective Transfer Technology for Microdevice Distribution" IEEE IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
13	Mercado, Lei, L., et al., "A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem" 2003 IEEE IEEE Electronic Components and Technology Conference, pp. 377-384.
19	Krames et al., "Why Nanowire LEDs?" IEEE J. Display Tech., Jun. 2007, pp. 5-6.

Luxview-Apple

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09178123	33.97	69	2015	Sakariya; Kapil V. Bibl; Andreas Hu; Hsin-Hua	Light emitting device reflective bank structure

NPR #	IEEE References Cited in Non-Patent Literature
1	Bower, et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits,” IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09583466	27.74	22	2017	McGroddy; Kelly Hu; Hsin-Hua Bibl; Andreas Chan; Clayton Ka Tsun	Etch removal of current distribution layer for LED current confinement

NPR #	IEEE References Cited in Non-Patent Literature
2	Asano, Kazutoshi, et al., "Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling" IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
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Luxview-Apple

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08791474	23.43	126	2014	Bibl; Andreas Sakariya; Kapil V. Griggs; Charles R. Perkins; James Michael	Light emitting diode display with redundancy scheme

NPR #	IEEE References Cited in Non-Patent Literature
1	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
2	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
4	Guerre, Roland, et al, “Selective Transfer Technology for Microdevice Distribution” IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
12	Mercado, Lei, L., et al., “A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem” 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.
20	Bower, et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits,” IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09570427	22.70	18	2017	Bibl; Andreas Griggs; Charles R.	Method for integrating a light emitting device

NPR #	IEEE References Cited in Non-Patent Literature
2	Asano, Kazutoshi, et al., "Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling" IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
3	Bower, C.A., et al., "Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits", IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
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13	Mercado, Lei, L., et al., "A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem" 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.
18	Griffin, C., et al, “Micro-pixellated flip-chip InGaN and AlInGaN light-emitting diodes,” Optical Society of America, 2007, 2 pgs. 2007 Conference on Lasers and Electro-Optics (CLEO)
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08426227	21.67	89	2013	Bibl; Andreas Higginson; John A. Law; Hung-Fai Stephen Hu; Hsin-Hua	Method of forming a micro light emitting diode array

NPR #	IEEE References Cited in Non-Patent Literature
6	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
14	Overstolz, et al., “A Clean Wafer-Scale Chip-Release Process without Dicing Based on Vapor Phase Etching,” Presented at the 17th IEEE International Conference on Micro Electro Mechanical Systems, Jan. 25-29, 2004, Maaastricht, The Netherlands. Published in the Technical Digest, ISBN 0-7803-8265-X, pp. 717-720, 4 pgs.
16	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
18	Guerre, Roland, et al, “Selective Transfer Technology for Microdevice Distribution” IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09484504	21.48	33	2016	Bibl; Andreas McGroddy; Kelly	Micro LED with wavelength conversion layer

NPR #	IEEE References Cited in Non-Patent Literature
1	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
2	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
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12	Mercado, Lei, L., et al., “A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem” 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.
17	Park, et al., “Fabrication of Capacitive Micromachined Ultrasonic Transducers via Local Oxidation and Direct Wafer Bonding,” IEEE, Journal of Microelectromechanical Systems, vol. 20, No. 1, Feb. 2011, pp. 95-103.
18	Patel, Prachi, “Quantum Dots Are Behind New Displays,” IEEE Spectrum, accessed at http://spectrum.ieee.org/consumer-electronics/audiovideo/quantum-dots-are-behind-new-displays, Jun. 13, 2012, updated Jul. 17, 2012, 3 pgs.
22	Griffin, C., et al, “Micro-pixellated flip-chip InGaN and AlInGaN light-emitting diodes,” Optical Society of America, 2007, 2 pgs. 2007 Conference on Lasers and Electro-Optics (CLEO)
23	Furman, et al., “A High Concentration Photovoltaic Module Utilizing Micro-Transfer Printing and Surface Mount Technology” Photovoltaic Specialists Conference (PVSC), 2010 35th IEEE, 2010, pp. 000475-000480.
28	Long, K., et al., “Active-Matrix Amorphous-Silicon TFT Arrays at 180°C on Clear Plastic and Glass Substrates for Organic Light-Emitting Displays,” IEEE Transactions on Electron Devices, vol. 53, No. 8, Aug. 2006, pp. 1789-1796.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09318475	19.53	30	2016	Bibl; Andreas Golda; Dariusz	Flexible display and method of formation with sacrificial release layer

NPR #	IEEE References Cited in Non-Patent Literature
1	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
2	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
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12	Mercado, Lei, L., et al., “A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem” 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.
19	Takahashi, et al., “High Density LED Display Panel on Silicon Microreflector and Integrated Circuit,” Proceedings of the (Japan) International Electronic Manufacturing Technology Symposium, New York, IEEE, Dec. 4, 1995, pp. 272-275.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Luxview-Apple

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09240397	18.88	29	2016	Bibl; Andreas Griggs; Charles R.	Method for integrating a light emitting device

NPR #	IEEE References Cited in Non-Patent Literature
1	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
2	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
4	Guerre, Roland, et al, “Selective Transfer Technology for Microdevice Distribution” IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
12	Mercado, Lei, L., et al., “A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem” 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.
17	Griffin, C., et al, “Micro-pixellated flip-chip InGaN and AlInGaN light-emitting diodes,” Optical Society of America, 2007, 2 pgs. 2007 Conference on Lasers and Electro-Optics (CLEO)
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Luxview-Apple

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09252375	17.58	27	2016	Bibl; Andreas Sakariya; Kapil V. Griggs; Charles R. Perkins; James Michael	Method of fabricating a light emitting diode display with integrated defect detection test

NPR #	IEEE References Cited in Non-Patent Literature
1	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
2	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
4	Guerre, Roland, et al, “Selective Transfer Technology for Microdevice Distribution” IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
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20	Bower, et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits,” IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.

Luxview-Apple

Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
09111464	12.86	19	2015	Bibl; Andreas McGroddy; Kelly	LED display with wavelength conversion layer

NPR #	*IEEE References Cited in Non-Patent Literature*
2	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
3	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
5	Guerre, Roland, et al, “Selective Transfer Technology for Microdevice Distribution” IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
13	Mercado, Lei, L., et al., “A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem” 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.
18	Griffin, C., et al, “Micro-pixellated flip-chip InGaN and AlInGaN light-emitting diodes,” Optical Society of America, 2007, 2 pgs. 2007 Conference on Lasers and Electro-Optics (CLEO)
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29	Furman, et al., “A High Concentration Photovoltaic Module Utilizing Micro-Transfer Printing and Surface Mount Technology” Photovoltaic Specialists Conference (PVSC), 2010 35th IEEE, 2010, pp. 000475-000480.
32	Long, K., et al., “Active-Matrix Amorphous-Silicon TFT Arrays at 180 ° C. on Clear Plastic and Glass Substrates for Organic Light-Emitting Displays,” IEEE Transactions on Electron Devices, vol. 53, No. 8, Aug. 2006, pp. 1789-1796.

Luxview-Apple

Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
09367094	11.77	20	2016	Bibl; Andreas Sakariya; Kapil V. Pavate; Vikram	Display module and system applications

NPR #	*IEEE References Cited in Non-Patent Literature*
2	Takahashi, et al., “High density LED display panel on silicon microreflector and integrated circuit,” Electronic Manufacturing Technology Symposium, 1995, Proceedings of 1995 Japan International, 18th IEEE/CPMT International, pp. 271-275.
4	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
5	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
7	Guerre, Roland, et al, “Selective Transfer Technology for Microdevice Distribution” IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
15	Mercado, Lei, L., et al., “A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem” 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08552436	10.75	43	2013	Bibl; Andreas Higginson; John A. Law; Hung-Fai Stephen Hu; Hsin-Hua	Light emitting diode structure

NPR #	IEEE References Cited in Non-Patent Literature
12	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
13	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
15	Guerre, Roland, et al, “Selective Transfer Technology for Microdevice Distribution” IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
23	Mercado, Lei, L., et al., “A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem” 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.
25	Overstolz, et al., “A Clean Wafer-Scale Chip-Release Process without Dicing Based on Vapor Phase Etching,” Presented at the 17th IEEE International Conference on Micro Electro Mechanical Systems, Jan. 25-29, 2004, Maaastricht, The Netherlands. Published in the Technical Digest, ISBN 0-7803-8265-X, pp. 717-720, 4 pgs.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08928021	9.35	19	2015	Bibl; Andreas McGroddy; Kelly	LED light pipe

NPR #	IEEE References Cited in Non-Patent Literature
1	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
2	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
4	Guerre, Roland, et al, “Selective Transfer Technology for Microdevice Distribution” IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
12	Mercado, Lei, L., et al., “A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem” 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.
17	Griffin, C., et al, “Micro-pixellated flip-chip InGaN and AlInGaN light-emitting diodes,” Optical Society of America, 2007, 2 pgs. 2007 Conference on Lasers and Electro-Optics (CLEO)
18	Patel, Prachi, “Quantum Dots Are Behind New Displays,” IEEE Spectrum, accessed at http://spectrum.ieee.org/consumer-electronics/audiovideo/quantum-dots-are-behind-new-displays, Jun. 13, 2012, updated Jul. 17, 2012, 3 pgs.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09087764	8.37	17	2015	Chan; Clayton Ka Tsun Bibl; Andreas	Adhesive wafer bonding with controlled thickness variation

NPR #	IEEE References Cited in Non-Patent Literature
1	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
2	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
4	Guerre, Roland, et al, “Selective Transfer Technology for Microdevice Distribution” IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
12	Mercado, Lei, L., et al., “A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem” 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.
17	Overstolz, et al., “A Clean Wafer-Scale Chip-Release Process without Dicing Based on Vapor Phase Etching,” Presented at the 17th IEEE International Conference on Micro Electro Mechanical Systems, Jan. 25-29, 2004, Maaastricht, The Netherlands. Published in the Technical Digest, ISBN 0-7803-8265-X, pp. 717-720, 4 pgs.
20	Wohrmann, et al., “Low Temperature Cure of BCB and the Influence on the Mechanical Stress,” 2011 Electronic Components and Technology Conference, pp. 392-400. 2011 IEEE 61st Electronic Components and Technology Conference (ECTC)

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09343448	7.16	11	2016	Sakariya; Kapil V. Bibl; Andreas Hu; Hsin-Hua	Active matrix emissive micro LED display

NPR #	IEEE References Cited in Non-Patent Literature
1	Asano, Kazutoshi, et al., “Fundamental Study of an Electrostatic Chuck for Silicon Wafer Handling” IEEE Transactions on Industry Applications, vol. 38, No. 3, May/Jun. 2002, pp. 840-845.
2	Bower, C.A., et al., “Active-Matrix OLED Display Backplanes Using Transfer-Printed Microscale Integrated Circuits”, IEEE, 2010 Electronic Components and Technology Conference, pp. 1339-1343.
4	Guerre, Roland, et al, “Selective Transfer Technology for Microdevice Distribution” IEEE Journal of Microelectromechanical Systems, vol. 17, No. 1, Feb. 2008, pp. 157-165.
12	Mercado, Lei, L., et al., “A Mechanical Approach to Overcome RF MEMS Switch Stiction Problem” 2003 IEEE Electronic Components and Technology Conference, pp. 377-384.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09866810	48.55	13	2018	Knight; Timothy Pitts; Colvin Akeley; Kurt Romanenko; Yuriy Craddock; Carl (Warren)	Optimization of optical systems for improved light field capture and manipulation

NPR #	IEEE References Cited in Non-Patent Literature
1	Chen, S., et al. "A CMOS Image Sensor with On-Chip Image Compression Based on Predictive Boundary Adaptation and Memoryless QTD Algorithm", Very Large Scale Integration (VLSI) Systems, IEEE Transactions, vol. 19, Issue 4, Apr. 2011.
13	Levoy, M., "Light Fields and Computational Imaging" IEEE Computer Society, Aug. 2006, pp. 46-55.
16	Maeda, Y., et al., "A CMOS Image Sensor with Pseudorandom Pixel Placement for Clear Imaging", IEEE int symp on Intelligent sig proc and comm sys (ISPACS), Dec. 2009.
18	Nakamura, J., “Image Sensors and Signal Processing for Digital Still Cameras” (Optical Science and Engineering), 2005. IEEE Sensors, 2005.
24	Teranishi, N., "Evolution of Optical Structure in Image Sensors", Electron Devices Meeting (IEDM) 2012 IEEE International.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09001226	38.30	86	2015	Ng; Yi-Ren Liang; Chia-Kai Akeley; Kurt Barton Wilburn; Bennett	Capturing and relighting images using multiple devices

NPR #	IEEE References Cited in Non-Patent Literature
1	Nakamura, J., “Image Sensors and Signal Processing for Digital Still Cameras” (Optical Science and Engineering), 2005. IEEE Sensors, 2005.
15	Dorsey, J., et al., “Interactive design of complex time dependent lighting”, IEEE Computer Graphics and Applications 15, 2 (Mar. 1995), 26-36.
26	Belhumeur, Peter et al., “The Bas-Relief Ambiguity”, International Journal of Computer Vision, 1997, pp. 1060-1066. Proceedings of IEEE Computer Society Conference on Computer Vision and Pattern Recognition
28	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
37	Jackson et al., “Selection of a Convolution Function for Fourier Inversion Using Gridding” IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
40	Levoy, “Light Fields and Computational Imaging” IEEE Computer Society, Aug. 2006, pp. 46-55.
50	Vaish, V., et al., “Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform,” Workshop on Advanced 3D Imaging for Safety and Security (in conjunction with CVPR 2005), 2005. 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - Workshops
51	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
59	Magnor, M., et al., “Model-Aided Coding of Multi-Viewpoint Image Data,” Proc. IEEE International Conference on Image Processing, ICIP-2000, Vancouver, Canada, Sep. 2000. https://graphics.tu-bs.de/static/people/magnor/publications/icip00.pdf.

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
09607424	24.01	19	2017	Ng; Yi-Ren Cheng; Eric Liang; Chia-Kai Fatahalian; Kayvon Evans; David John	Depth-assigned content for depth-enhanced pictures

NPR #	*IEEE References Cited in Non-Patent Literature*
1	Adelson et al., "Single Lens Stereo with a Plenoptic Camera" IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
10	Jackson et al., "Selection of a Convolution Function for Fourier Inversion Using Gridding" IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
13	Levoy, "Light Fields and Computational Imaging" IEEE Computer Society, Aug. 2006, pp. 46-55.
23	Vaish, V., et al., “Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform,” Workshop on Advanced 3D Imaging for Safety and Security (in conjunction with CVPR 2005), 2005. 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - Workshops
24	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
32	Girod, B., "Mobile Visual Search", IEEE Signal Processing Magazine, Jul. 2011.
35	Nakamura, J., “Image Sensors and Signal Processing for Digital Still Cameras” (Optical Science and Engineering), 2005. IEEE Sensors, 2005.

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08289440	22.52	145	2012	Knight; Timothy J. Ng; Yi-Ren Pitts; Colvin	Light field data acquisition devices, and methods of using and manufacturing same

NPR #	*IEEE References Cited in Non-Patent Literature*
4	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
7	Jackson et al., "Selection of a Convolution Function for Fourier Inversion Using Gridding" IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
10	Adelson et al., "Single Lens Stereo with a Plenoptic Camera" IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
20	Levoy, "Light Fields and Computational Imaging" IEEE Computer Society, Aug. 2006, pp. 46-55.
24	Vaish, V., et al., “Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform,” Workshop on Advanced 3D Imaging for Safety and Security (in conjunction with CVPR 2005), 2005. 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - Workshops

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08749620	17.59	50	2014	Knight; Timothy J. Pitts; Colvin Ng; Yi-Ren Fishman; Alex	3D light field cameras, images and files, and methods of using, operating, processing and viewing same

NPR #	IEEE References Cited in Non-Patent Literature
1	Adelson et al , “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
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24	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
31	Nakamura, J., “Image Sensors and Signal Processing for Digital Still Cameras” (Optical Science and Engineering), 2005. IEEE Sensors, 2005.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09386288	12.56	16	2016	Akeley; Kurt Barton Cabral; Brian Pitts; Colvin Liang; Chia-Kai Wilburn; Bennett	Compensating for sensor saturation and microlens modulation during light-field image processing

NPR #	IEEE References Cited in Non-Patent Literature
13	Nakamura, J., “Image Sensors and Signal Processing for Digital Still Cameras” (Optical Science and Engineering), 2005. IEEE Sensors, 2005.
26	Dorsey, J., et al., “Interactive design of complex time dependent lighting”, IEEE Computer Graphics and Applications 15, 2 (Mar. 1995), 26-36.
37	Belhumeur, Peter et al., “The Bas-Relief Ambiguity”, International Journal of Computer Vision, 1997, pp. 1060-1066. Proceedings of IEEE Computer Society Conference on Computer Vision and Pattern Recognition
39	Wetzstein, Gordon, et al., “Sensor Saturation in Fourier Multiplexed Imaging”, IEEE Conference on Computer Vision and Pattern Recognition (2010).
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43	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
52	Jackson et al., “Selection of a Convolution Function for Fourier Inversion Using Gridding” IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09300932	11.77	15	2016	Knight; Timothy Pitts; Colvin Akeley; Kurt Romanenko; Yuriy Craddock; Carl (Warren)	Optimization of optical systems for improved light field capture and manipulation

NPR #	IEEE References Cited in Non-Patent Literature
1	Chen, S., et al. “A CMOS Image Sensor with On-Chip Image Compression Based on Predictive Boundary Adaptation and Memoryless QTD Algorithm”, Very Large Scale Integration (VLSI) Systems, IEEE Transactions, vol. 19, Issue 4, Apr. 2011.
13	Levoy, M., “Light Fields and Computational Imaging” IEEE Computer Society, Aug. 2006, pp. 46-55.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09467607	11.77	15	2016	Ng; Yi-Ren Pitts; Colvin Knight; Timothy	Light field data acquisition

NPR #	IEEE References Cited in Non-Patent Literature
1	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
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24	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
32	Nakamura, J., “Image Sensors and Signal Processing for Digital Still Cameras” (Optical Science and Engineering), 2005. IEEE Sensors, 2005.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08948545	10.24	23	2015	Akeley; Kurt Barton Cabral; Brian Pitts; Colvin Liang; Chia-Kai Wilburn; Bennett	Compensating for sensor saturation and microlens modulation during light-field image processing

NPR #	IEEE References Cited in Non-Patent Literature
1	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08811769	10.14	35	2014	Pitts; Colvin Knight; Timothy James Liang; Chia-Kai Ng; Yi-Ren	Extended depth of field and variable center of perspective in light-field processing

NPR #	IEEE References Cited in Non-Patent Literature
3	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
12	Jackson et al., “Selection of a Convolution Function for Fourier Inversion Using Gridding” IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
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26	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
30	J. Sun, H.-Y. Shum and N.-N. Zheng, “Stereo Matching using Belief Propagation,” IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 25, No. 7, pp. 787-800, 2003.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09305956	9.11	14	2016	Pitts; Colvin Ng; Yi-Ren Oliver; Steven	Optical assembly including plenoptic microlens array

NPR #	IEEE References Cited in Non-Patent Literature
1	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
10	Jackson et al., “Selection of a Convolution Function for Fourier Inversion Using Gridding” IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
13	Levoy, “Light Fields and Computational Imaging” IEEE Computer Society, Aug. 2006, pp. 46-55.
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24	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
32	Hirigoyen, F., et al., “1.1 um Backside Imager vs. Frontside Image: an optics-dedicated FDTD approach”, IEEE 2009 International Image Sensor Workshop.
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42	Teranishi, N., “Evolution of Optical Structure in Image Sensors”, Electron Devices Meeting (IEDM) 2012 IEEE International.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08724014	8.47	31	2014	Ng; Yi-Ren Pitts; Colvin Knight; Timothy	Light field data acquisition

NPR #	IEEE References Cited in Non-Patent Literature
1	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
10	Jackson et al., “Selection of a Convolution Function for Fourier Inversion Using Gridding” IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
13	Levoy, “Light Fields and Computational Imaging” IEEE Computer Society, Aug. 2006, pp. 46-55.
23	Vaish, V., et al., “Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform,” Workshop on Advanced 3D Imaging for Safety and Security (in conjunction with CVPR 2005), 2005. 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - Workshops
24	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
32	Nakamura, J., “Image Sensors and Signal Processing for Digital Still Cameras” (Optical Science and Engineering), 2005. IEEE Sensors, 2005.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Lytro-Google

Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
09419049	8.46	13	2016	Pitts; Colvin Ng; Yi-Ren Oliver; Steven	Optical assembly including plenoptic microlens array

NPR #	*IEEE References Cited in Non-Patent Literature*
1	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
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32	Hirigoyen, F., et al., “1.1 um Backside Imager vs. Frontside Image: an optics-dedicated FDTD approach”, IEEE 2009 International Image Sensor Workshop.
35	Nakamura, J., “Image Sensors and Signal Processing for Digital Still Cameras” (Optical Science and Engineering), 2005. IEEE Sensors, 2005.
42	Teranishi, N., “Evolution of Optical Structure in Image Sensors”, Electron Devices Meeting (IEDM) 2012 IEEE International.

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08831377	8.40	29	2014	Pitts; Colvin Knight; Timothy James Liang; Chia-Kai Ng; Yi-Ren	Compensating for variation in microlens position during light-field image processing

NPR #	*IEEE References Cited in Non-Patent Literature*
13	Nakamura, J., “Image Sensors and Signal Processing for Digital Still Cameras” (Optical Science and Engineering), 2005. IEEE Sensors, 2005.
25	Dorsey, J., et al., “Interactive design of complex time dependent lighting”, IEEE Computer Graphics and Applications 15, 2 (Mar. 1995), 26-36.
36	Belhumeur, Peter et al., “The Bas-Relief Ambiguity”, International Journal of Computer Vision, 1997, pp. 1060-1066. Proceedings of IEEE Computer Society Conference on Computer Vision and Pattern Recognition
38	Wetzstein, Gordon, et al., “Sensor Saturation in Fourier Multiplexed Imaging”, IEEE Conference on Computer Vision and Pattern Recognition (2010).
39	Nayar, Shree, et al., “Shape from Focus”, IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 16, No. 8, pp. 824-831, Aug. 1994.
44	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
53	Jackson et al., “Selection of a Convolution Function for Fourier Inversion Using Gridding” IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
56	Levoy, “Light Fields and Computational Imaging” IEEE Computer Society, Aug. 2006, pp, 46-55.
66	Vaish, V., et al., “Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform,” Workshop on Advanced 3D Imaging for Safety and Security (in conjunction with CVPR 2005), 2005. 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - Workshops
67	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Lytro-Google

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08995785	8.02	18	2015	Knight; Timothy James Pitts; Colvin Ng; Yi-Ren Fishman; Alex Romanenko; Yuriy	Light-field processing and analysis, camera control, and user interfaces and interaction on light-field capture devices

NPR #	IEEE References Cited in Non-Patent Literature
18	Nakamura, J., “Image Sensors and Signal Processing for Digital Still Cameras” (Optical Science and Engineering), 2005. IEEE Sensors, 2005.
32	Dorsey, J., et al., “Interactive design of complex time dependent lighting”, IEEE Computer Graphics and Applications 15, 2 (Mar. 1995), 26-36.
43	Belhumeur, Peter et al., “The Bas-Relief Ambiguity”, International Journal of Computer Vision, 1997, pp. 1060-1066. Proceedings of IEEE Computer Society Conference on Computer Vision and Pattern Recognition
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48	Nayar, Shree, et al., “Shape from Focus”, IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 16, No. 8, pp. 824-831, Aug. 1994.
51	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
60	Jackson et al., “Selection of a Convolution Function for Fourier Inversion Using Gridding” IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
63	Levoy, “Light Fields and Computational Imaging” IEEE Computer Society, Aug. 2006, pp. 46-55.
73	Vaish, V., et al., “Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform,” Workshop on Advanced 3D Imaging for Safety and Security (in conjunction with CVPR 2005), 2005. 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - Workshops
74	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
86	Girod, B., “Mobile Visual Search”, IEEE Signal Processing Magazine, Jul. 2011.
87	Hirigoyen, F., et al., “1.1 um Backside Imager vs. Frontside Image: an optics-dedicated FDTD approach”, IEEE 2009 International Image Sensor Workshop.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Lytro-Google

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08908058	7.39	21	2014	Akeley; Kurt Barton Ng; Yi-Ren Waters; Kenneth Wayne Fatahalian; Kayvon Knight; Timothy James	Storage and transmission of pictures including multiple frames

NPR #	IEEE References Cited in Non-Patent Literature
1	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
10	Jackson et al., “Selection of a Convolution Function for Fourier Inversion Using Gridding” IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
13	Levoy, “Light Fields and Computational Imaging” IEEE Computer Society, Aug. 2006, pp. 46-55.
23	Vaish, V., et al., “Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform,” Workshop on Advanced 3D Imaging for Safety and Security (in conjunction with CVPR 2005), 2005. 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - Workshops
24	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
34	Nakamura, J., “Image Sensors and Signal Processing for Digital Still Cameras” (Optical Science and Engineering), 2005. IEEE Sensors, 2005.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09184199	7.39	15	2015	Pitts; Colvin Ng; Yi-Ren Oliver; Steven	Optical assembly including plenoptic microlens array

NPR #	IEEE References Cited in Non-Patent Literature
1	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
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32	Hirigoyen, F., et al., “1.1 um Backside Imager vs. Frontside Image: an optics-dedicated FDTD approach”, IEEE 2009 International Image Sensor Workshop.
35	Nakamura, J., “Image Sensors and Signal Processing for Digital Still Cameras” (Optical Science and Engineering), 2005. IEEE Sensors, 2005.
42	Teranishi, N., “Evolution of Optical Structure in Image Sensors”, Electron Devices Meeting (IEDM) 2012 IEEE International.

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Citation Counts and Citation Indexes through 12/31/2019

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08971625	7.21	16	2015	Pitts; Colvin Knight; Timothy James Liang; Chia-Kai Ng; Yi-Ren	Generating dolly zoom effect using light field image data

NPR #	*IEEE References Cited in Non-Patent Literature*
1	Adelson et al., "Single Lens Stereo with a Plenoptic Camera" IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08976288	7.12	16	2015	Ng; Yi-Ren Pitts; Colvin Knight; Timothy	Light field data acquisition

NPR #	*IEEE References Cited in Non-Patent Literature*
1	Adelson et al., "Single Lens Stereo with a Plenoptic Camera" IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
10	Jackson et al., "Selection of a Convolution Function for Fourier Inversion Using Gridding" IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
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23	Vaish, V., et al., "Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform," Workshop on Advanced 3D Imaging for Safety and Security (in conjunction with CVPR 2005), 2005. 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - Workshops
24	Vaish et al., "Using plane + parallax for calibrating dense camera arrays", In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
32	Nakamura, J., "Image Sensors and Signal Processing for Digital Still Cameras" (Optical Science and Engineering), 2005. IEEE Sensors, 2005.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Lytro-Google

Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
09172853	5.79	13	2015	Pitts; Colvin Knight; Timothy James Liang; Chia-Kai Ng; Yi-Ren	Microlens array architecture for avoiding ghosting in projected images

NPR #	*IEEE References Cited in Non-Patent Literature*
11	Dorsey, J., et al., "Interactive design of complex time dependent lighting", IEEE Computer Graphics and Applications 15, 2 (Mar. 1995), 26-36.
22	Belhumeur, Peter et al., "The Bas-Relief Ambiguity", International Journal of Computer Vision, 1997, pp. 1060-1066. Proceedings of IEEE Computer Society Conference on Computer Vision and Pattern Recognition
24	Wetzstein, Gordon, et al., "Sensor Saturation in Fourier Multiplexed Imaging", IEEE Conference on Computer Vision and Pattern Recognition (2010).
25	Nayar, Shree, et al., "Shape from Focus", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 16, No. 8, pp. 824-831, Aug. 1994.
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44	Levoy, "Light Fields and Computational Imaging" IEEE Computer Society, Aug. 2006, pp, 46-55.
54	Vaish, V., et al., "Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform," Workshop on Advanced 3D Imaging for Safety and Security (in conjunction with CVPR 2005), 2005. 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - Workshops
55	Vaish et al., "Using plane + parallax for calibrating dense camera arrays", In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
80	Nakamura, J., "Image Sensors and Signal Processing for Digital Still Cameras" (Optical Science and Engineering), 2005. IEEE Sensors, 2005.

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08559705	5.10	37	2013	Ng; Yi-Ren	Interactive refocusing of electronic images

NPR #	*IEEE References Cited in Non-Patent Literature*
8	Vaish, V., et al., "Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform," Workshop on Advanced 3D Imaging for Safety and Security (in conjunction with CVPR 2005), 2005. 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - Workshops
10	Vaish et al., "Using plane + parallax for calibrating dense camera arrays", In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
13	Jackson et al., "Selection of a Convolution Function for Fourier Inversion Using Gridding" IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
16	Adelson et al., "Single Lens Stereo with a Plenoptic Camera" IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08768102	4.83	19	2014	Ng; Yi-Ren Akeley; Kurt Barton Knight; Timothy James Pitts; Colvin	Downsampling light field images

NPR #	IEEE References Cited in Non-Patent Literature
1	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
10	Jackson et al., “Selection of a Convolution Function for Fourier Inversion Using Gridding” IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
13	Levoy, “Light Fields and Computational Imaging” IEEE Computer Society, Aug. 2006, pp. 46-55.
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24	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
33	Nakamura, J., “Image Sensors and Signal Processing for Digital Still Cameras” (Optical Science and Engineering), 2005. IEEE Sensors, 2005.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08446516	4.61	24	2013	Pitts; Colvin Ng; Yi-Ren	Generating and outputting video data from refocusable light field video data

NPR #	IEEE References Cited in Non-Patent Literature
1	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
9	Jackson et al., “Selection of a Convolution Function for Fourier Inversion Using Gridding” IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
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22	Vaish, V., et al., “Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform,” Workshop on Advanced 3D Imaging for Safety and Security (in conjunction with CVPR 2005), 2005. 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - Workshops
23	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
36	Georgiev, Todor, et al., “Plenoptic Camera 2.0”, CVPR 2008. IEEE CVPR

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08570426	4.61	24	2013	Pitts; Colvin Ng; Yi-Ren	System of and method for video refocusing

NPR #	IEEE References Cited in Non-Patent Literature
5	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.
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11	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
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25	Vaish, V., et al., “Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform,” Workshop on Advanced 3D Imaging for Safety and Security (in conjunction with CVPR 2005), 2005. 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - Workshops

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08997021	4.53	14	2015	Liang; Chia-Kai Knott; Michael Marculescu; Mugur Wilson; Jason Ng; Yi-Ren	Parallax and/or three-dimensional effects for thumbnail image displays

NPR #	IEEE References Cited in Non-Patent Literature
1	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
10	Jackson et al., “Selection of a Convolution Function for Fourier Inversion Using Gridding” IEEE Transactions on Medical Imaging, Sep. 1991, vol. 10, No. 3, pp. 473-478.
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Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08614764	3.45	18	2013	Pitts; Colvin Ng; Yi-Ren	Acquiring, editing, generating and outputting video data

NPR #	IEEE References Cited in Non-Patent Literature
1	Adelson et al., “Single Lens Stereo with a Plenoptic Camera” IEEE Translation on Pattern Analysis and Machine Intelligence, Feb. 1992. vol. 14, No. 2, pp. 99-106.
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24	Vaish et al., “Using plane + parallax for calibrating dense camera arrays”, In Proceedings CVPR 2004, pp. 2-9. Proceedings of the 2004 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2004. CVPR 2004.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Nomadix

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08364806	23.78	192	2013	Short; Joel E. Pagan; Florence C. I. Goldstein; Josh J.	Systems and methods for providing content and services on a network system

NPR #	IEEE References Cited in Non-Patent Literature
3	Aceves, Wireless Internet Gateways (Wings), Proc. IEEE MILCOM '97, Monterey, California', Nov. 1997.
7	Agrawal, SWAN: A Mobile Multimedia Wireless Network, IEEE Personal Communications, Apr. 1996.
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Citation Counts and Citation Indexes through 12/31/2019

Nomadix

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08266266	6.42	53	2012	Short; Joel E Pagan; Florence C. I. Goldstein; Josh J	Systems and methods for providing dynamic network authorization, authentication and accounting

NPR #	IEEE References Cited in Non-Patent Literature
29	Susan Hinrichs; <i> Policy-Based Management Bridging the Gap </i> ; Dec. 6, 1999; pp. 209-218; Computer Security Applications Conference, 1999 (ACSAC 1999), Proceedings, 15 th Annual Phoenix, Arizona, USA Dec. 6-10, 1999, Los Alamitos, California; IEEE Comput. Soc.; XP010368586.
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188	Inouye, Dynamic Network Reconfiguration Support for Mobile Computers, Proceedings of the 3rd annual ACM/IEEE international conference on Mobile computing and networking, Sep. 26, 1997.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08156246	5.59	50	2012	Short; Joel E. Pagan; Florence C. I. Goldstein; Josh J.	Systems and methods for providing content and services on a network system

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Nomadix

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08266269	5.57	46	2012	Short; Joel E. Pagan; Florence C. I. Goldstein; Josh J.	Systems and methods for providing content and services on a network system

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
06636894	4.09	333	2003	Short; Joel E. Delley; Frederic Logan; Mark F. Pagan; Florence C. I.	Systems and methods for redirecting users having transparent computer access to a network using a gateway device having redirection capability

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Nomadix

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
06868399	2.03	106	2005	Short; Joel E. Perelyubskiy; Denis I.	Systems and methods for integrating a network gateway device with management systems

NPR #	IEEE References Cited in Non-Patent Literature
0	None

Nymi

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08994498	43.08	125	2015	Agrafioti; Foteini Martin; Karl Oung; Stephen	Preauthorized wearable biometric device, system and method for use thereof

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09197414	3.92	11	2015	Martin; Karl Vahlis; Evgene	Cryptographic protocol for portable devices

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09032501	3.21	9	2015	Martin; Karl Vahlis; Evgene	Cryptographic protocol for portable devices

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09189901	1.56	7	2015	Agrafioti; Foteini Martin; Karl Oung; Stephen	Preauthorized wearable biometric device, system and method for use thereof

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09349235	1.16	3	2016	Agrafioti; Foteini Martin; Karl Oung; Stephen	Preauthorized wearable biometric device, system and method for use thereof

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09646261	0.74	1	2017	Agrafioti; Foteini Bui; Francis Minhthang Hatzinakos; Dimitrios	Enabling continuous or instantaneous identity recognition of a large group of people based on physiological biometric signals obtained from members of a small group of people

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09407634	0.54	1	2016	Martin; Karl Vahlis; Evgene	Cryptographic protocol for portable devices

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09472033	0.39	1	2016	Agrafioti; Foteini Martin; Karl Oung; Stephen	Preauthorized wearable biometric device, system and method for use thereof

NPR #	IEEE References Cited in Non-Patent Literature
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09832020	0.00	0	2017	Martin; Karl Vahlis; Evgene	Cryptographic protocol for portable devices

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09753542	7.24	7	2017	Chizeck; Howard Jay Ryden; Fredrik Stewart; Andrew	Methods and systems for six-degree-of-freedom haptic interaction with streaming point data

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09148443	6.41	18	2015	Chizeck; Howard Jay Bonaci; Tamara Lendvay; Thomas	Enhanced security and safety in telerobotic systems

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09477307	1.77	3	2016	Chizeck; Howard Jay Ryden; Fredrik	Methods and systems for six degree-of-freedom haptic interaction with streaming point data

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09471142	1.18	2	2016	Chizeck; Howard Jay Rydén; Fredrik Kosari; Sina Nia Hannaford; Blake Gustafsson; Nicklas	Methods and systems for haptic rendering and creating virtual fixtures from point clouds

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
09736167	0.00	0	2017	Chizeck; Howard Jay Bonaci; Tamara Lendvay; Thomas	Enhanced security and safety in telerobotic systems

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09349552	81.69	79	2016	Huska; Andrew P. Krumpelman; Douglas M. Peterson; Cody G.	Touchpad with capacitive force sensing

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08735755	10.86	30	2014	Peterson; Cody George Krumpelman; Douglas M. Huska; Andrew P.	Capacitive keyswitch technologies

NPR #	IEEE References Cited in Non-Patent Literature
0	None

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08248278	7.20	43	2012	Schlosser; James William Peterson; Cody George Huska; Andrew	Haptic keyboard assemblies, systems and methods

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12	Zou, Jun et al., "Design of a Wide Tuning Range Micromachined Tunable Capacitor for Wireless Communications", <i> First IEEE Electro/Information Technology, Conference </i> , Jun. 8-11, Chicago, IL, 2000, (Jun. 8-Jun. 11, 2000), 6 pages.
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41	Seeger, Joseph I., et al., "Dynamics and Control of Parallel-Plate Actuators Beyond the Electrostatic Instability", <i> IEEE Transducers "99, The 10th International Conference on Solid State Sensors and Actuators </i> , (Jun. 1999),4 pages.
50	Wagner, Christopher et al., "Integrating Tactile and Force Feedback with Finite Element Models", <i> Proceedings of the 2005 IEEE international Conference on Robotics and Automation </i> , Apr. 18-22, 2005, Division of Engineering and Applied Sciences, Harvard University,6pages.

Pacinian-Synaptics

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08248277	6.53	39	2012	Peterson; Cody George Huska; Andrew Parris Schlosser; James William	Haptic keyboard systems and methods

NPR #	IEEE References Cited in Non-Patent Literature
31	"Touch and Haptics", <i> 2004 IEEE/ RSJ International Conference on Intelligent Robots and Systems </i> , (Sep. 28, 2004),32 pages.
33	Biggs, James "Some Useful Information for Tacttile Display Design", <i> IEEE Transactions on Man-Machine Systems </i> , vol. 11, No. 1,(1970),pp. 19-24.
39	Bar-Cohen, Yoseph "Electric Flex", <i> IEEE Spectrum Online </i> , (Jun. 2004),6 pages.
43	Seeger, Joseph et al., "Dynamics and Control of Parallel-Plate Actuators Beyond the Electrostatic Instability", <i> IEEE Transducers "99 The 10th International Conference on Solid State Sensors and Actuators </i> , (Jun. 1999),pp. 474-477.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08599047	6.23	25	2013	Schlosser; James William Peterson; Cody George Huska; Andrew	Haptic keyboard assemblies and methods

NPR #	IEEE References Cited in Non-Patent Literature
29	“Touch and Haptics”, 2004 IEEE/ RSJ International Conference on Intelligent Robots and Systems, (Sep. 28, 2004),32 pages.
33	Bar-Cohen, Yoseph “Electric Flex”, IEEE Spectrum Online, (Jun. 2004),6 pages.
43	Biggs, James “Some Useful Information for Tactile Display Design”, IEEE Transactions on Man-Machine Systems, vol. 11, No. 1,(1970),pp. 19-24.
64	Seeger, Joseph et al., “Dynamics and Control of Parallel-Plate Actuators Beyond the Electrostatic Instability”, IEEE Transducers ″99 The 10th International Conference on Solid State Sensors and Actuators, (Jun. 1999),pp. 474-477.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08294600	6.02	36	2012	Peterson; Cody George Huska; Andrew Parris Schlosser; James William	Keyboard adaptive haptic response

NPR #	IEEE References Cited in Non-Patent Literature
46	"Touch and Haptics", <i> 2004 IEEE/ RSJ International Conference on Intelligent Robots and Systems </i> , (Sep. 28, 2004),32 pages.
48	Biggs, James "Some Useful Information for Tacttile Display Design", <i> IEEE Transactions on Man-Machine Systems </i> ,vol. 11, No. 1,(1970),pp. 19-24.
54	Bar-Cohen, Yoseph "Electric Flex", <i> IEEE Spectrum Online </i> , (Jun. 2004),6 pages.
59	Seeger, Joseph et al., "Dynamics and Control of Parallel-Plate Actuators Beyond the Electrostatic Instability", <i> IEEE Transducers "99 The 10th Interrnational Conference on Solid State Sensors and Actuators </i> , (Jun. 1999),pp. 474-477.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08542134	5.98	24	2013	Peterson; Cody George Huska; Andrew Parris Schlosser; James William	Keyboard adaptive haptic response

NPR #	IEEE References Cited in Non-Patent Literature
0	None

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
07741979	4.33	25	2010	Schlosser; James William Peterson; Cody George Huska; Andrew	Haptic keyboard systems and methods

NPR #	*IEEE References Cited in Non-Patent Literature*
29	"Touch and Haptics", <i> 2004 IEEE/ RSJ International Conference on Intelligent Robots and Systems </i> , (Sep. 28, 2004),32 pages.
31	Biggs, James "Some Useful Information for Tacttile Display Design", <i> IEEE Transactions on Man-Machine Systems </i> , vol. 11, No. 1,(1970),pp. 19-24.
37	Bar-Cohen, Yoseph "Electric Flex", <i> IEEE Spectrum Online </i> , (Jun. 2004),6 pages.
41	Seeger, Joseph et al., "Dynamics and Control of Parallel-Plate Actuators Beyond the Electrostatic Instability", <i> IEEE Transducers "99 The 10th Interrnational Conference on Solid State Sensors and Actuators </i> , (Jun. 1999),pp. 474-477.

Pacinian-Synaptics

Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08760413	4.20	26	2014	Peterson; Cody George Krumpelman; Douglas M. Huska; Andrew P.	Tactile surface

NPR #	*IEEE References Cited in Non-Patent Literature*
12	Zou, Jun et al., “Design of a Wide Tuning Range Micromachined Tunable Capacitor for Wireless Communications”, First IEEE Electro/Information Technology, Conference, Jun. 8-11, Chicago, IL, 2000, (Jun. 8-Jun. 11, 2000),6 pages.
28	“Touch and Haptics”, 2004 IEEE/ RSJ International Conference on Intelligent Robots and Systems, (Sep. 28, 2004),32 pages.
30	Biggs, James “Some Useful Information for Tactile Display Design”, IEEE Transactions on Man-Machine Systems, vol. 11, No. 1, (1970),pp. 19-24.
36	Bar-Cohen, Yoseph “Electric Flex”, IEEE Spectrum Online, (Jun. 2004),6 pages.
40	Seeger, Joseph I., et al., “Dynamics and Control of Parallel-Plate Actuators Beyond the Electrostatic Instability”, IEEE Transducers "99, The 10th International Conference on Solid State Sensors and Actuators, (Jun. 1999),4 pages.
49	Wagner, Christopher et al., “Integrating Tactile and Force Feedback with Finite Element Models”, Proceedings of the 2005 IEEE international Conference on Robotics and Automation, Apr. 18-22, 2005, Division of Engineering and Applied Sciences, Harvard University,6 pages.
69	Seeger, Joseph et al., “Dynamics and Control of Parallel-Plate Actuators Beyond the Electrostatic Instability”, IEEE Transducers "99 The 10th International Conference on Solid State Sensors and Actuators, (Jun. 1999),pp. 474-477.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08309870	4.08	28	2012	Peterson; Cody George Krumpelman; Douglas M. Levin; Michael D.	Leveled touchsurface with planar translational responsiveness to vertical travel

NPR #	IEEE References Cited in Non-Patent Literature
10	"Touch and Haptics", 2004 IEEE/ RSJ International Conference on Intelligent Robots and Systems, (Sep. 28, 2004),32 pages.
14	Bar-Cohen, Yoseph "Electric Flex", IEEE Spectrum Online, (Jun. 2004),6 pages.
25	Biggs, James "Some Useful Information for Tactile Display Design", IEEE Transactions on Man-Machine Systems, vol. 11, No. 1,(1970),pp. 19-24.
63	Zou, Jun et al., "Design of a Wide Turning Range Micromachined Turnable Capacitor for Wireless Communications", First IEEE Electro/Information Technology Conference, Jun. 8-11, Chicago, IL, 2000, 6 pages.

Pacinian-Synaptics

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08199033	2.51	15	2012	Peterson; Cody George Huska; Andrew Parris Schlosser; James William	Haptic keyboard systems and methods

NPR #	IEEE References Cited in Non-Patent Literature
31	"Touch And Haptics", <i> 2004 IEEE/ RSJ International Conference on Intelligent Robots and Systems </i> , (Sep. 28, 2004),32 pages.
33	Biggs, James "Some Useful Information for Tacttile Display Design", <i> IEEE Transactions on Man-Machine Systems </i> , vol. 11, No. 1,(1970),pp. 19-24.
39	Bar-Cohen, Yoseph "Electric Flex", <i> IEEE Spectrum Online </i> , (Jun. 2004),6 pages.
44	Seeger, Joseph et al., "Dynamics and Control of Parallel-Plate Actuators Beyond the Electrostatic Instability", <i> IEEE Transducers "99 the 10th Interrnational Conference on Solid State Sensors and Actuators </i> , (Jun. 1999),pp. 474-477.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08203531	2.47	14	2012	Peterson; Cody George Huska; Andrew Parris Schlosser; James William Krumpelman; Douglas M.	Vector-specific haptic feedback

NPR #	IEEE References Cited in Non-Patent Literature
16	"Touch and Haptics", <i> 2004 IEEE/ RSJ International Conference on Intelligent Robots and Systems </i> , (Sep. 28, 2004),32 pages.
18	Biggs, James "Some Useful Information for Tacttile Display Design", <i> IEEE Transactions on Man-Machine Systems </i> , vol. 11, No. 1,(1970),pp. 19-24.
23	Bar-Cohen, Yoseph "Electric Flex", <i> IEEE Spectrum Online </i> , (Jun. 2004),6 pages.
28	Seeger, Joseph et al., "Dynamics and Control of Parallel-Plate Actuators Beyond the Electrostatic Instability", <i> IEEE Transducers 99 the 10th Interrnational Conference on Solid State Sensors and Actuators </i> , (Jun. 1999),pp. 474-477.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08912458	1.78	7	2014	Peterson; Cody G. Krumpelman; Douglas M. Levin; Michael D.	Touchsurface with level and planar translational travel responsiveness

NPR #	IEEE References Cited in Non-Patent Literature
19	Zou, Jun et al., “Design of a Wide Turning Range Micromachined Turnable Capacitor for Wireless Communications”, First IEEE Electro/Information Technology Conference, Jun. 8-11, Chicago, IL, 2000, 6 pages.
29	“Touch and Haptics”, 2004 IEEE/ RSJ International Conference on Intelligent Robots and Systems, (Sep. 28, 2004),32 pages.
33	Bar-Cohen, Yoseph “Electric Flex”, IEEE Spectrum Online, (Jun. 2004),6 pages.
43	Biggs, James “Some Useful Information for Tactile Display Design”, IEEE Transactions on Man-Machine Systems, vol. 11, No. 1,(1970),pp. 19-24.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08310444	1.62	19	2012	Peterson; Cody George Huska; Andrew P. Schlosser; James William	Projected field haptic actuation

NPR #	IEEE References Cited in Non-Patent Literature
35	"Touch and Haptics", <i> 2004 IEEE/ RSJ International Conference on Intelligent Robots and Systems </i> , (Sep. 28, 2004),32 pages.
37	Biggs, James "Some Useful Information for Tacttile Display Design", <i> IEEE Transactions on Man-Machine Systems </i> , vol. 11, No. 1,(1970),pp. 19-24.
43	Bar-Cohen, Yoseph "Electric Flex", <i> IEEE Spectrum Online </i> , (Jun. 2004),6 pages.
48	Seeger, Joseph et al., "Dynamics and Control of Parallel-Plate Actuators Beyond the Electrostatic Instability", <i> IEEE Transducers "99 The 10th Interrnational Conference on Solid State Sensors and Actuators </i> , (Jun. 1999),pp. 474-477.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09009827	60.21	169	2015	Albertson; Jacob Hildebrandt; Melody Singh; Harkirat Sankar; Shyam Ducott; Rick	Security sharing system

NPR #	IEEE References Cited in Non-Patent Literature
38	Wiggerts, T.A., “Using Clustering Algorithms in Legacy Systems Remodularization,”Reverse Engineering, Proceedings of the Fourth Working Conference, Netherlands, Oct. 6-8, 1997, IEEE Computer Soc., pp. 33-43.
54	Holliday, JoAnne, “Replicated Database Recovery using Multicast Communication,” IEEE 2002, pp. 11.
62	Parker, Jr. et al., “Detection of Mutual Inconsistency in Distributed Systems,” IEEE Transactions in Software Engineering, May 1983, vol. SE-9, No. 3, pp. 241-247.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09648036	52.32	58	2017	Seiver; Miles Cohen; Stephen	Systems for network risk assessment including processing of user access rights associated with a network of devices

NPR #	IEEE References Cited in Non-Patent Literature
4	Bhuyan et al., "Network Anomaly Detection: Methods, Systems and Tools" First Quarter 2014, IEEE, 34 pages.
8	Dantu et al., "Risk Management Using Behavior Based Attack Graphs," Proceedings of the International Conference on Information Technology, Coding and Computing (ITCC '04), 2004, pp. 5. IEEE int conf on inf tech Coding and comp Proc ITCC
15	Harmantzis et al., "Security Risk Analysis and Evaluation," 2004 IEEE International Conference on Communications, vol. 4, Jun. 20-24, 2004, pp. 1897-1901.
19	Idika et al., "Extending Attack Graph-Based Security Metrics and Aggregating Their Application," IEEE Transactions on Dependable and Secure Computing, vol. 9, No. 1, Jan./Feb. 2012, pp. 75-85.
20	Ingols et al., "Practical Attack Graph Generation for Network Defense," MIT, Proceedings of the 22nd Annual Computer Security Applications Conference (ACSAC '06), 2006, pp. 10. ASCA/IEEE
23	Jha et al., "Two Formal Analyses of Attack Graphs," CSFW '02 Proceedings of the 15th IEEE Workshop on Computer Security Foundations, 2002, pp. 15.
43	Nicol et al., "Model-Based Evaluation: From Dependability to Security," Dependable and Secure Computing, IEEE Transactions, vol. 1, No. 1, 2004, pp. 48-65.
54	Sommestad et al., "Cyber Security Risks Assessment with Bayesian Defense Graphs and Architectural Models," IEEE Hawaii Int Conf on Sys Sci (HICSS), Jan. 5-8, 2009, pp. 1-10.
72	Zhang et al., "An Effective Method to Generate Attack Graph," IEEE int conf on mach Learning and Cybernetics, Guangzhou, Aug. 18-21, 2005, pp. 3926-3931.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09021260	47.56	138	2015	Falk; Matthew Yousaf; Timothy Staehle; Joseph Lemanowicz; Lucas Noury; Sebastien	Malware data item analysis

NPR #	IEEE References Cited in Non-Patent Literature
20	Holliday, JoAnne, “Replicated Database Recovery using Multicast Communication,” IEEE 2002, pp. 11.
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49	Wiggerts, T.A., “Using Clustering Algorithms in Legacy Systems Remodularization,” Reverse Engineering, Proceedings of the Fourth Working Conference, Netherlands, Oct. 6-8, 1997, IEEE Computer Soc., pp. 33-43.
73	Palmas, et al., “An Edge-Bundling Layout for Interactive Parallel Coordinates,” Proceedings of the 2014 IEEE Pacific Visualization Symposium, Mar. 2014, pp. 57-64.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09116975	38.95	113	2015	Shankar; Ankit Ash; Andrew Stowe; Geoff Petracca; Thomas Duffield; Benjamin	Systems and user interfaces for dynamic and interactive simultaneous querying of multiple data stores

NPR #	IEEE References Cited in Non-Patent Literature
43	Mentzas et al. “An Architecture for Intelligent Assistance in the Forecasting Process,” IEEE Hawaii Int Conf on Sys Sci (HICSS), Jan. 3-6, 1995, vol. 3, pp. 167-176.
84	Palmas et al., “An Edge-Bunding Layout for Interactive Parallel Coordinates” 2014 IEEE Pacific Visualization Symposium, pp. 57-64.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09043696	36.53	106	2015	Meiklejohn; David Fedderly; Matthew Henke; Joseph Xing; Yichen	Systems and methods for visual definition of data associations

NPR #	IEEE References Cited in Non-Patent Literature
15	Litwin et al., “Multidatabase Interoperability,” IEEE Computer, Dec. 1986, vol. 19, No. 12, pp. 10-18. <http://www.lamsade.dauphine.fr/˜litwin/mdb-interoperability.pdf>.
16	Qiang et al., “A Mutual-Information-Based Approach to Entity Reconciliation in Heterogeneous Databases,” Proceedings of 2008 International Conference on Computer Science & Software Engineering, IEEE Computer Society, New York, NY, Dec. 12-14, 2008, pp. 666-669.
55	Mentzas et al. “An Architecture for Intelligent Assistance in the Forecasting Process,” IEEE Hawaii Int Conf on Sys Sci (HICSS), Jan. 3-6, 1995, vol. 3, pp. 167-176.
58	Palmas et al., “An Edge-Bunding Layout for Interactive Parallel Coordinates” 2014 IEEE Pacific Visualization Symposium, pp. 57-64.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08855999	19.59	77	2014	Elliot; Mark	Method and system for generating a parser and parsing complex data

NPR #	IEEE References Cited in Non-Patent Literature
13	Litwin et al., “Multidatabase Interoperability,” IEEE Computer, Dec. 1986, vol. 19, No. 12, pp. 10-18. <http://www.lamsade.dauphine.fr/˜litwin/mdb-interoperability.pdf>.
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53	Haralick el al., “Image Analysis Using Mathematical Morphology,” Pattern Analysis and Machine Intelligence, IEEE Transactions, Jul. 1987, vol. PAMI-9, No. 4, pp. 532-550.
71	Mentzas et al. “An Architecture for Intelligent Assistance in the Forecasting Process,” IEEE Hawaii Int Conf on Sys Sci (HICSS), Jan. 3-6, 1995, vol. 3, pp. 167-176.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
09367872	16.53	38	2016	Visbal; Alexander Thompson; James Sum; Marvin Ma; Jason Fu; Bing Jie	Systems and user interfaces for dynamic and interactive investigation of bad actor behavior based on automatic clustering of related data in various data structures

NPR #	*IEEE References Cited in Non-Patent Literature*
40	Palmas, et al., “An Edge-Bundling Layout for Interactive Parallel Coordinates,” Proceedings of the 2014 IEEE Pacific Visualization Symposium, Mar. 2014, pp. 57-64.
47	Wiggerts, T.A., “Using Clustering Algorithms in Legacy Systems Remodularization,” Reverse Engineering, Proceedings of the Fourth Working Conference, Netherlands, Oct. 6-8, 1997, IEEE Computer Soc., pp. 33-43.
77	Li et al., “Interactive Multimodal Visual Search on Mobile Device,” IEEE Transactions on Multimedia, vol. 15, No. 3, Apr. 1, 2013, pp. 594-607.
80	Nolan et al., “MCARTA: A Malicious Code Automated Run-Time Analysis Framework,” Homeland Security, 2012 IEEE Conference on Technologies for, Nov. 13, 2012, pp. 13-17.
87	Shi et al., “A Scalable Implementation of Malware Detection Based on Network Connection Behaviors,” 2013 International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery, IEEE, Oct. 10, 2013, pp. 59-66.

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
09953445	15.85	5	2018	Cervelli; Dan GoGwilt; Cai Prochnow; Bobby	Interactive data object map

NPR #	*IEEE References Cited in Non-Patent Literature*
17	Li et al., "Interactive Multimodal Visual Search on Mobile Device," IEEE Transactions on Multimedia, vol. 15, No. 3, Apr. 1, 2013, pp. 594-607.
22	Palmas et al., "An Edge-Bunding Layout for Interactive Parallel Coordinates" 2014 IEEE Pacific Visualization Symposium, pp. 57-64.
130	Haralick et al., "Image Analysis Using Mathematical Morphology," Pattern Analysis and Machine Intelligence, IEEE Transactions, Jul. 1987, vol. PAMI-9, No. 4, pp. 532-550.
202	Nolan et al., "MCARTA: A Malicious Code Automated Run-Time Analysis Framework," Homeland Security, 2012 IEEE Conference on Technologies for, Nov. 13, 2012, pp. 13-17.
213	Shi et al., "A Scalable Implementation of Malware Detection Based on Network Connection Behaviors," 2013 International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery, IEEE, Oct. 10, 2013, pp. 59-66.
225	Wang et al., "Research on a Clustering Data De-Duplication Mechanism Based on Bloom Filter," IEEE 2010, 5 pages.
384	Harville et al., "Mediabeads: An Architecture for Path-Enhanced Media Applications," 2004 IEEE International Conference on Multimedia and Expo, Jun. 27-30, 2004, Taipei, Taiwan, vol. 1, pp. 455-458.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
09891808	12.70	5	2018	Wilson; Matthew Julius Alexander; Tom Cervelli; Daniel Fountain; Trevor Spencer-Harper; Quentin	Interactive user interfaces for location-based data analysis

NPR #	*IEEE References Cited in Non-Patent Literature*
23	Wang et al., "Research on a Clustering Data De-Duplication Mechanism Based on Bloom Filter," IEEE 2010, 5 pages.
106	Haralick et al., "Image Analysis Using Mathematical Morphology," Pattern Analysis and Machine Intelligence, IEEE Transactions, Jul. 1987, vol. PAMI-9, No. 4, pp. 532-550.
122	Li et al., "Interactive Multimodal Visual Search on Mobile Device," IEEE Transactions on Multimedia, vol. 15, No. 3, Apr. 1, 2013, pp. 594-607.
141	Nolan et al., "McArta: A Malicious Code Automated Run-Time Analysis Framework," Homeland Security, 2012 IEEE Conference on Technologies for, Nov. 13, 2012, pp. 13-17.
145	Palmas et al., "An Edge-Bunding Layout for Interactive Parallel Coordinates" 2014 IEEE Pacific Visualization Symposium, pp. 57-64.
159	Shi et al., "A Scalable Implementation of Malware Detection Based on Network Connection Behaviors," 2013 International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery, IEEE, Oct. 10, 2013, pp. 59-66.
371	Harville et al., "Mediabeads: An Architecture for Path-Enhanced Media Applications," 2004 IEEE International Conference on Multimedia and Expo, Jun. 27-30, 2004, Taipei, Taiwan, vol. 1, pp. 455-458.

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08930897	11.37	33	2015	Nassar; Anthony Albert	Data integration tool

NPR #	*IEEE References Cited in Non-Patent Literature*
48	Haralick et al., “Image Analysis Using Mathematical Morphology,” Pattern Analysis and Machine Intelligence, IEEE Transactions, Jul. 1987, vol. PAMI-9, No. 4, pp. 532-550.
57	Litwin et al., “Multidatabase Interoperability,” IEEE Computer, Dec. 1986, vol. 19, No. 12, pp. 10-18. <http://www.lamsade.dauphine.fr/˜litwin/mdb-interoperability.pdf>.
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81	Qiang et al., “A Mutual-Information-Based Approach to Entity Reconciliation in Heterogeneous Databases,” Proceedings of 2008 Internation Conference on Computer Science & Software Engineering, IEEE Computer Society, New York, NY, Dec. 12-14, 2008, pp. 666-669.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09857958	10.16	4	2018	Ma; Jason Davidson; Aaron	Systems and user interfaces for dynamic and interactive access of, investigation of, and analysis of data objects stored in one or more databases

NPR #	IEEE References Cited in Non-Patent Literature
74	Li et al., "Interactive Multimodal Visual Search on Mobile Device," IEEE Transactions on Multimedia, vol. 15, No. 3, Apr. 1, 2013, pp. 594-607.
88	Palmas et al., "An Edge-Bunding Layout for Interactive Parallel Coordinates" 2014 IEEE Pacific Visualization Symposium, pp. 57-64.
161	Nolan et al., "MCARTA: A Malicious Code Automated Run-Time Analysis Framework," Homeland Security, 2012 IEEE Conference on Technologies for, Nov. 13, 2012, pp. 13-17.
164	Shi et al., "A Scalable Implementation of Malware Detection Based on Network Connection Behaviors," 2013 International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery, IEEE, Oct. 10, 2013, pp. 59-66.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09646396	10.11	8	2017	Sharma; Tilak Chuang; Steve Chiu; Rico Shi; Andrew Canfield; Lindsay	Generating object time series and data objects

NPR #	IEEE References Cited in Non-Patent Literature
19	Li et al., "Interactive Multimodal Visual Search on Mobile Device," IEEE Transactions on Multimedia, vol. 15, No. 3, Apr. 1, 2013, pp. 594-607.
21	Nolan et al., "MCARTA: A Malicious Code Automated Run-Time Analysis Framework," Homeland Security, 2012 IEEE Conference on Technologies for, Nov. 13, 2012, pp. 13-17.
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220	Palmas, et al., "An Edge-Bundling Layout for Interactive Parallel Coordinates," Proceedings of the 2014 IEEE Pacific Visualization Symposium, Mar. 2014, pp. 57-64.

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Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09998485	8.07	4	2018	Cohen; David Ma; Jason Fu; Bing Jie Nepomnyashchiy; Ilya Berler; Steven	Network intrusion data item clustering and analysis

NPR #	IEEE References Cited in Non-Patent Literature
43	Wiggerts, T.A., "Using Clustering Algorithms in Legacy Systems Remodularization," Reverse Engineering, Proceedings of the Fourth Working Conference, Netherlands, Oct. 6-8, 1997, IEEE Computer Soc., pp. 33-43.
73	Li et al., "Interactive Multimodal Visual Search on Mobile Device," IEEE Transactions on Multimedia, vol. 15, No. 3, Apr. 1, 2013, pp. 594-607.
79	Nolan et al., "MCARTA: A Malicious Code Automated Run-Time Analysis Framework," Homeland Security (HST) 2012 IEEE Conference on Technologies for, Nov. 13, 2012, pp. 13-17.
82	Palmas et al., "An Edge-Bunding Layout for Interactive Parallel Coordinates" 2014 IEEE Pacific Visualization Symposium, pp. 57-64.
89	Shi et al., "A Scalable Implementation of Malware Detection Based on Network Connection Behaviors," 2013 International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery, IEEE, Oct. 10, 2013, pp. 59-66.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09898509	7.62	3	2018	Saperstein; Craig Schwartz; Eric Cho; Hongjai	Malicious activity detection system capable of efficiently processing data accessed from databases and generating alerts for display in interactive user interfaces

NPR #	IEEE References Cited in Non-Patent Literature
35	Wang et al., "Research on a Clustering Data De-Duplication Mechanism Based on Bloom Filter," IEEE 2010, 5 pages.
149	Li et al., "Interactive Multimodal Visual Search on Mobile Device," IEEE Transactions on Multimedia, vol. 15, No. 3, Apr. 1, 2013, pp. 594-607.
161	Nolan et al., "MCARTA: A Malicious Code Automated Run-Time Analysis Framework," Homeland Security (HST) 2012 IEEE Conference on Technologies for, Nov. 13, 2012, pp. 13-17.
163	Palmas et al., "An Edge-Bunding Layout for Interactive Parallel Coordinates" 2014 IEEE Pacific Visualization Symposium, pp. 57-64.
167	Shi et al., "A Scalable Implementation of Malware Detection Based on Network Connection Behaviors," 2013 International Conference on Cyber-Enabled Distributed Computing Knowledge Discovery, IEEE, Oct. 10, 2013, pp. 59-66.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09558352	7.24	7	2017	Dennison; Drew Stowe; Geoff Anderson; Adam	Malicious software detection in a computing system

NPR #	IEEE References Cited in Non-Patent Literature
42	Palmas et al., "An Edge-Bunding Layout for Interactive Parallel Coordinates" 2014 IEEE Pacific Visualization Symposium, pp. 57-64.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09965937	6.36	4	2018	Cohen; David Ma; Jason Fu; Bing Jie Nepomnyashchiy; Ilya Berler; Steven	External malware data item clustering and analysis

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Appendix A: Blockbuster Patents with IEEE References

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09589299	5.28	6	2017	Visbal; Alexander Thompson; James Sum; Marvin Ma; Jason Fu; Bing Jie	Systems and user interfaces for dynamic and interactive investigation of bad actor behavior based on automatic clustering of related data in various data structures

NPR #	IEEE References Cited in Non-Patent Literature
189	Li et al., "Interactive Multimodal Visual Search on Mobile Device," IEEE Transactions on Multimedia, vol. 15, No. 3, Apr. 1, 2013, pp. 594-607.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09880987	5.08	2	2018	Burr; Brandon Pundle; Akshay Simler; Kevin Miyake; Nick	System and method for parameterizing documents for automatic workflow generation

NPR #	IEEE References Cited in Non-Patent Literature
249	Mendes et al., "TcruziKB: Enabling Complex Queries for Genomic Data Exploration," IEEE International Conference on Semantic Computing, Aug. 2008, pp. 432-439.
308	Chen et al., "A Novel Emergency Vehicle Dispatching System," 2013 IEEE 77th Vehicular Technology Conference, IEEE, Jun. 2, 2013, 5 pages.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09898335	5.08	2	2018	Marinelli, III; Eugene E. Namara; Yogy	System and method for batch evaluation programs

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09100430	3.56	10	2015	Seiver; Miles Rosenblum; Charles	Systems for network risk assessment including processing of user access rights associated with a network of devices

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08885059	48.19	137	2014	Venkataraman; Kartik Jabbi; Amandeep S. Mullis; Robert H.	Systems and methods for measuring depth using images captured by camera arrays

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08866920	47.84	136	2014	Venkataraman; Kartik Jabbi; Amandeep S. Mullis; Robert H. Duparre; Jacques Hu; Shane Ching-Feng	Capturing and processing of images using monolithic camera array with heterogeneous imagers

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116 Rander et al., “Virtualized Reality: Constructing Time-Varying Virtual Worlds From Real World Events”, Proc. of IEEE Visualization '97, Phoenix, Arizona, Oct. 19-24, 1997, pp. 277-283, 552.

117 Rhemann et al, “Fast Cost-Volume Filtering for Visual Correspondence and Beyond”, IEEE Trans. Pattern Anal. Mach. Intell, 2013, vol. 35, No. 2, pp. 504-511.

118 Robertson et al., “Dynamic Range Improvement Through Multiple Exposures”, In Proc. of the Int. Conf. on Image Processing, 1999, 5 pgs. Proceedings of IEEE International Conference on Image Processing (ICIP)

121 Sauer et al., “Parallel Computation of Sequential Pixel Updates in Statistical Tomographic Reconstruction”, IEEE ICIP 1995, pp. 93-96.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Pelican-Tessera

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08902321	46.08	131	2014	Venkataraman; Kartik Jabbi; Amandeep S. Mullis; Robert H.	Capturing and processing of images using monolithic camera array with heterogeneous imagers

NPR #	IEEE References Cited in Non-Patent Literature
2	Bishop, et al., “Light Field Superresolution”, Retrieved from http://home.eps.hw.ac.uk/˜sz73/ICCP09/LightFieldSuperresolution.pdf, 9 pgs. 2009 IEEE International Conference on Computational Photography (ICCP)
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18	Protter et al., “Generalizing the Nonlocal-Means to Super-Resolution Reconstruction”, IEEE Transactions on Image Processing, Jan. 2009, vol. 18, No. 1, pp. 36-51.
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26	Vaish et al., “Synthetic Aperture Focusing Using a Shear-Warp Factorization of the Viewing Transform”, IEEE Workshop on A3DISS, CVPR, 2005, 8 pgs.
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50	Drouin et al., “Geo-Consistency for Wide Multi-Camera Stereo”, Proceedings of the 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2005, 8 pgs.
54	Farsiu et al., “Fast and Robust Multiframe Super Resolution”, IEEE Transactions on Image Processing, Oct. 2004, vol. 13, No. 10, pp. 1327-1344.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08804255	45.54	143	2014	Duparre; Jacques	Optical arrangements for use with an array camera

NPR #	IEEE References Cited in Non-Patent Literature
5	Bose et al., “Superresolution and Noise Filtering Using Moving Least Squares”, IEEE Transactions on Image Processing, date unknown, 21 pgs.
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08896719	43.97	125	2014	Venkataraman; Kartik Jabbi; Amandeep S. Mullis; Robert H.	Systems and methods for parallax measurement using camera arrays incorporating 3 x 3 camera configurations

NPR #	IEEE References Cited in Non-Patent Literature
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Pelican-Tessera

Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08928793	42.75	96	2015	McMahon; Andrew Kenneth John	Imager array interfaces

NPR #	*IEEE References Cited in Non-Patent Literature*
7	Chan et al., "Investigation of Computational Compound-Eye Imaging System with Super-Resolution Reconstruction", IEEE, ISASSP 2006, pp. 1177-1180.
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08861089	40.76	128	2014	Duparre; Jacques	Capturing and processing of images using monolithic camera array with heterogeneous imagers

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Pelican-Tessera

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09041829	40.52	91	2015	Venkataraman; Kartik Jabbi; Amandeep S. Mullis; Robert H.	Capturing and processing of high dynamic range images using camera arrays

NPR #	IEEE References Cited in Non-Patent Literature
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Citation Counts and Citation Indexes through 12/31/2019

Pelican-Tessera

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09041823	38.30	86	2015	Venkataraman; Kartik Jabbi; Amandeep S. Mullis; Robert H.	Systems and methods for performing post capture refocus using images captured by camera arrays

NPR #	IEEE References Cited in Non-Patent Literature
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Pelican-Tessera

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08866912	37.64	107	2014	Mullis; Robert	System and methods for calibration of an array camera using a single captured image

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08692893	35.48	134	2014	McMahon; Andrew Kenneth John	Systems and methods for transmitting and receiving array camera image data

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09123118	32.88	73	2015	Ciurea; Florian Venkataraman; Kartik Molina; Gabriel Lelescu; Dan	System and methods for measuring depth using an array camera employing a bayer filter

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
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Pelican-Tessera

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08619082	29.42	249	2013	Ciurea; Florian Venkataraman; Kartik Molina; Gabriel Lelescu; Dan	Systems and methods for parallax detection and correction in images captured using array cameras that contain occlusions using subsets of images to perform depth estimation

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09276304	37.20	183	2016	Behan; Scott Courtney; Patrick	Power combiner using tri-plane antennas

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09287605	37.20	183	2016	Daughenbaugh, Jr.; Paul Behan; Scott Courtney; Patrick	Passive coaxial power splitter/combiner

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09293801	36.59	180	2016	Courtney; Patrick Behan; Scott	Power combiner

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07215220	17.98	223	2007	Jia; Pengcheng	Broadband power combining device using antipodal finline structure

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
07911271	1.96	12	2011	Jia; Pengcheng	Hybrid broadband power amplifier with capacitor matching network

NPR #	IEEE References Cited in Non-Patent Literature
0	None

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Sonos

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09195258	21.71	63	2015	Millington; Nicholas A. J.	System and method for synchronizing operations among a plurality of independently clocked digital data processing devices

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08588949	19.52	175	2013	Lambourne; Robert A. Millington; Nicholas A. J.	Method and apparatus for adjusting volume levels in a multi-zone system

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09219959	7.01	24	2015	Kallai; Christopher Ericson; Michael Darrell Andrew Lambourne; Robert A. Reimann; Robert Triplett; Mark	Multi-channel pairing in a media system

NPR #	IEEE References Cited in Non-Patent Literature
0	None

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Sonos

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
10209953	0.00	0	2019	Millington; Nicholas A. J.	Playback device

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
10439896	0.00	0	2019	Millington; Nicholas A. J. Hainsworth; Paul V.	Playback device connection

NPR #	IEEE References Cited in Non-Patent Literature
150	Lienhart et al., "On the Importance of Exact Synchronization for Distributed Audio Signal Processing," Session L: Poster Session II-ICASSP'03 Papers, 2002, 1 page. 2003 IEEE International Conference on Acoustics, Speech, and Signal Processing, 2003. Proceedings. (ICASSP '03).
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490	Issues with Mixed IEEE 802.b/802.11g Networks, AVAGO0058, Agere Systems, Feb. 2004, 5 pages.

Ubeam-Sonic Energy

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09001622	82.15	203	2015	Perry; Meredith	Receiver communications for wireless power transfer

NPR #	IEEE References Cited in Non-Patent Literature
1	Germano, “Flexure Mode Piezoelectric Transducers,” Morgan Electro Ceramics, Technical Publication TP-218. J. Acoust. Soc. Am. Volume 50, Issue 1A, pp. 1-6 (1971). IEEE Transactions on Audio and Electroacoustics
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09094112	8.50	21	2015	Perry; Meredith	Sender controller for wireless power transfer

NPR #	IEEE References Cited in Non-Patent Literature
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Citation Counts and Citation Indexes through 12/31/2019

Ubeam-Sonic Energy

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09094110	8.09	20	2015	Perry; Meredith	Sender transducer for wireless power transfer

NPR #	IEEE References Cited in Non-Patent Literature
5	Sherrit et al.,“Cornparison of the Mason and KLM Equivalent Circuits for Piezoelectric Resonators in the Thickness Mode”, IEEE Ultrasonics Symposium, vol. 2, pp. 921-926, 1999.
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Ubeam-Sonic Energy

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09214151	5.99	20	2015	Perry; Meredith	Receiver controller for wireless power transfer

NPR #	IEEE References Cited in Non-Patent Literature
3	Germano, “Flexure Mode Piezoelectric Transducers,” Morgan Electro Ceramics, Technical Publication TP-218. J. Acoust. Soc. Am. Volume 50, Issue 1A, pp. 1-6 (1971). IEEE Transactions on Audio and Electroacoustics
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Witricity

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09318898	82.89	209	2016	John; Michael Sasha	Wireless power harvesting and transmission with heterogeneous signals

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12	Abe et al. “A Noncontact Charger Using a Resonant Converter with Parallel Capacitor of the Secondary Coil”. IEEE, 36(2):444-451, Mar./Apr. 2000.
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Witricity

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08729737	66.12	221	2014	Schatz; David A. Hall; Katherine L. Kesler; Morris P. Kurs; Andre B. Kulikowski; Konrad J.	Wireless energy transfer using repeater resonators

NPR #	IEEE References Cited in Non-Patent Literature
7	Tesla, Nikola, “High Frequency Oscillators for Electro-Therapeutic and Other Purposes”, Proceedings of the IEEE, vol. 87, No. 7, Jul. 1999, pp. 1282-1292.
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Witricity

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08937408	46.88	204	2015	Ganem; Steven J. Kesler; Morris P. Hall; Katherine L. Schatz; David A.	Wireless energy transfer for medical applications

NPR #	IEEE References Cited in Non-Patent Literature
18	Schneider, David, “Electrons Unplugged, Wireless power at a distance is still far away,” IEEE Spectrum, May 2010, pp. 35-39.
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82	Jacob, M V. ““Lithium Tantalate—A High Permittivity Dielectric Material for Microwave Communication Systems””, Proceedings of IEEE TENCON Poster papers 2003 , 1362-1366.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09369182	21.38	47	2016	Kurs; Andre B. Karalis; Aristeidis Kesler; Morris P. Campanella; Andrew J. Hall; Katherine L.	Wireless energy transfer using variable size resonators and system monitoring

NPR #	IEEE References Cited in Non-Patent Literature
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Witricity

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08963488	16.54	72	2015	Campanella; Andrew J. Hall; Katherine L. Karalis; Aristeidis Kesler; Morris P. Kulikowski; Konrad	Position insensitive wireless charging

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08901778	12.74	30	2014	Kesler; Morris P. Hall; Katherine L. Kulikowski; Konrad Karalis; Aristeidis Kurs; Andre B.	Wireless energy transfer with variable size resonators for implanted medical devices

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
08912687	12.44	41	2014	Kesler; Morris P. Kurs; Andre B. Karalis; Aristeidis Soljacic; Marin Hall; Katherine L.	Secure wireless energy transfer for vehicle applications

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08629578	12.28	159	2014	Kurs; Andre B. Karalis; Aristeidis Kesler; Morris P. Campanella; Andrew J. Hall; Katherine L.	Wireless energy transfer systems

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08035255	10.76	287	2011	Kurs; Andre B. Karalis; Aristeidis Hall; Katherine L. Kesler; Morris P. Soljacic; Marin	Wireless energy transfer using planar capacitively loaded conducting loop resonators

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08667452	10.20	34	2014	Verghese; Simon Efe; Volkan Kesler; Morris P. Kurs; Andre B. Karalis; Aristeidis	Wireless energy transfer modeling tool

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08692412	9.87	33	2014	Fiorello; Ron Kulikowski; Konrad J.	Temperature compensation in a wireless transfer system

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

Witricity

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08643326	9.09	154	2014	Campanella; Andrew J. Lou; Herbert T. Kesler; Morris P. Hall; Katherine L. Fiorello; Ron	Tunable wireless energy transfer systems

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08106539	8.57	211	2012	Schatz; David A. Lou; Herbert T. Kesler; Morris P. Hall; Katherine L. Kulikowski; Konrad J.	Wireless energy transfer for refrigerator application

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08928276	8.50	37	2015	Kesler; Morris P. Kurs; Andre B. Karalis; Aristeidis Soljacic; Marin Hall; Katherine L.	Integrated repeaters for cell phone applications

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08946938	6.89	30	2015	Kesler; Morris P. Kulikowski; Konrad Lou; Herbert Toby Hall; Katherine L. Fiorello; Ron	Safety systems for wireless energy transfer in vehicle applications

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Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09515494	6.74	17	2016	Kurs; Andre B. Karalis; Aristeidis Campanella; Andrew J. Kesler; Morris P.	Wireless power system including impedance matching network

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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
08324759	6.42	158	2012	Karalis; Aristeidis Kurs; Andre B. Campanella; Andrew J. Kulikowski; Konrad J. Hall; Katherine L.	Wireless energy transfer using magnetic materials to shape field and reduce loss

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Zoox-Amazon

Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09612123	35.03	33	2017	Levinson; Jesse Sol Sibley; Gabriel Thurston	Adaptive mapping to navigate autonomous vehicles responsive to physical environment changes

NPR #	IEEE References Cited in Non-Patent Literature
1	Bodensteiner et al, "Monocular Camera Trajectory Optimization using LiDAR data," Computer Vision Workshops (ICCV Workshops), 2011 IEEE International Conference on, Barcelona, 2011, pp. 2018-2025.
11	Group Induction; Teichman, Alex, Thrun, Sebastian, Proc. of the IEEE/RSJ Intl Conf on Intelligent Robotics and Systems (IROS) (2013).
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18	Practical Object Recognition in Autonomous Driving and Beyond; Teichman, Alex, Thrun, Sebastian; IEEE Workshop on Advanced Robotics and its Social Impacts (ARSO) (2011).
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09630619	14.59	14	2017	Kentley; Timothy David Levinson; Jesse Sol Lind; Amanda Blair	Robotic vehicle active safety systems and methods

NPR #	IEEE References Cited in Non-Patent Literature
2	Group Induction; Teichman, Alex, Thrun, Sebastian, Proc. of the IEEE/RSJ Intl Conf on Intelligent Robotics and Systems (IROS) (2013).
4	Precision Tracking With Sparse 3D and Dense Color 2D Data; Held, David, Levinson, Jesse, Thrun, Sebastian; International Conference on Robotics and Automation (ICRA) (2013). 2013 IEEE International Conference on Robotics and Automation
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33	Bodensteiner et al., "Monocular Camera Trajectory Optimization using LiDAR Data", IEEE International Conference on Computer Vision Workshops, 2011, 8 pages.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
09754490	12.55	21	2017	Kentley; Timothy David Gamara; Rachad Youssef Linscott; Gary	Software application to request and control an autonomous vehicle service

NPR #	*IEEE References Cited in Non-Patent Literature*
1	Bodensteiner et al., "Monocular Camera Trajectory Optimization using LiDAR Data", IEEE International Conference on Computer Vision Workshops, 2011, 8 pages.
6	Group Induction; Teichman, Alex, Thrun, Sebastian, Proc. of the IEEE/RSJ Intl Conf on Intelligent Robotics and Systems (IROS) (2013).
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66	Gnatzig, et al., "Human-Machine Interaction as Key Technology for Driverless Driving-A Trajectory-Based Shared Autonomy Control Approach", RO-MAN, IEEE, 2012, pp. 913-918.

Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	*Citation Index*	*Cite Count*	*Pub Year*	*Inventors*	*Patent Title*
09632502	11.99	23	2017	Levinson; Jesse Sol Sibley; Gabriel Thurston Rege; Ashutosh Gajanan	Machine-learning systems and techniques to optimize teleoperation and/or planner decisions

NPR #	*IEEE References Cited in Non-Patent Literature*
1	Bodensteiner et al., "Monocular Camera Trajectory Optimization using LiDAR Data", IEEE International Conference on Computer Vision Workshops, 2011, 8 pages.
6	Group Induction; Teichman, Alex, Thrun, Sebastian, Proc. of the IEEE/RSJ Intl Conf on Intelligent Robotics and Systems (IROS) (2013).
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09734455	10.42	14	2017	Levinson; Jesse Sol Sibley; Gabriel Thurston Rege; Ashutosh Gajanan	Automated extraction of semantic information to enhance incremental mapping modifications for robotic vehicles

NPR #	IEEE References Cited in Non-Patent Literature
2	Group Induction; Teichman, Alex, Thrun, Sebastian, Proc. of the IEEE/RSJ Intl Conf on Intelligent Robotics and Systems (IROS) (2013).
4	Precision Tracking With Sparse 3D and Dense Color 2D Data; Held, David, Levinson, Jesse, Thrun, Sebastian; International Conference on Robotics and Automation (ICRA) (2013). 2013 IEEE International Conference on Robotics and Automation
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09507346	10.10	43	2016	Levinson; Jesse Sol Kentley; Timothy David Sibley; Gabriel Thurston Gamara; Rachad Youssef Rege; Ashutosh Gajanan	Teleoperation system and method for trajectory modification of autonomous vehicles

NPR #	IEEE References Cited in Non-Patent Literature
2	Group Induction; Teichman, Alex, Thrun, Sebastian, Proc. of the IEEE/RSJ Intl Conf on Intelligent Robotics and Systems (IROS) (2013).
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09878664	9.16	4	2018	Kentley-Klay; Timothy David Levinson; Jesse Sol Lind; Amanda Blair	Method for robotic vehicle communication with an external environment via acoustic beam forming

NPR #	IEEE References Cited in Non-Patent Literature
30	Bodensteiner et al., "Monocular Camera Trajectory Optimization using LiDAR Data", IEEE International Conference on computer Vision Workshops, 2011, 8 pages.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09606539	8.86	17	2017	Kentley; Timothy David Levinson; Jesse Sol Gamara; Rachad Youssef Sibley; Gabriel Thurston	Autonomous vehicle fleet service and system

NPR #	IEEE References Cited in Non-Patent Literature
3	Group Induction; Teichman, Alex, Thrun, Sebastian, Proc. of the IEEE/RSJ Intl Conf on Intelligent Robotics and Systems (IROS) (2013).
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Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09701239	8.66	8	2017	Kentley; Timothy David Gamara; Rachad Youssef	System of configuring active lighting to indicate directionality of an autonomous vehicle

NPR #	IEEE References Cited in Non-Patent Literature
1	Bodensteiner et al., "Monocular Camera Trajectory Optimization using LiDAR Data", IEEE International Conference on Computer Vision Workshops, 2011, 8 pages.
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09720415	7.82	15	2017	Levinson; Jesse Sol Kentley; Timothy David Douillard; Bertrand Robert	Sensor-based object-detection optimization for autonomous vehicles

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46	Practical Object Recognition in Autonomous Driving and Beyond; Teichman, Alex, Thrun, Sebastian; IEEE Workshop on Advanced Robotics and its Social Impacts (ARSO) (2011).
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09517767	6.37	12	2016	Kentley; Timothy David Gamara; Rachad Youssef Behere; Sagar	Internal safety systems for robotic vehicles

NPR #	IEEE References Cited in Non-Patent Literature
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09958864	5.56	3	2018	Kentley-Klay; Timothy David Gamara; Rachad Youssef	Coordination of dispatching and maintaining fleet of autonomous vehicles

NPR #	IEEE References Cited in Non-Patent Literature
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09804599	4.17	8	2017	Kentley-Klay; Timothy David Gamara; Rachad Youssef	Active lighting control for communicating a state of an autonomous vehicle to entities in a surrounding environment

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83 Online Slam With Any-Time Self-Calibration and Automatic Change Detection; Nima Keivan and Gabe Sibley; IEEE International Conference on Robotics and Automation (ICRA); (2014), 8 pages.

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09494940	1.88	8	2016	Kentley; Timothy David	Quadrant configuration of robotic vehicles

NPR #	IEEE References Cited in Non-Patent Literature
2	Group Induction; Teichman, Alex, Thrun, Sebastian, Proc. of the IEEE/RSJ Intl Conf on Intelligent Robotics and Systems (IROS) (2013).
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Appendix A: Blockbuster Patents with IEEE References

Citation Counts and Citation Indexes through 12/31/2019

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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
09910441	1.85	1	2018	Levinson; Jesse Sol Sibley; Gabriel Thurston Kentley-Klay; Timothy David	Adaptive autonomous vehicle planner logic

NPR #	IEEE References Cited in Non-Patent Literature
3	Group Induction; Teichman, Alex, Thrun, Sebastian, Proc. of the IEEE/RSJ Intl Conf on Intelligent Robotics and Systems (IROS) (2013).
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Patent	Citation Index	Cite Count	Pub Year	Inventors	Patent Title
10048683	1.85	1	2018	Levinson; Jesse Sol Sibley; Gabriel Thurston Rege; Ashutosh Gajanan	Machine learning systems and techniques to optimize teleoperation and/or planner decisions

NPR #	IEEE References Cited in Non-Patent Literature
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Appendix B: IEEE Papers Appearing 3+ Times in Appendix A

BAE-Cognitive

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21	Nikoozadeh et al., Forward-Looking Intracardiac Ultrasound Imaging Using a 1-D CMUT Array Integrated With Custom Front-End Electronics. IEEE Trans Ultrason Ferroelectr Freq Contr. Dec. 2008;55(12):2651-60.
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Appendix B: IEEE Papers Appearing 3+ Times in Appendix A

17	Zhuang et al., Wafer-bonded 2-D CMUT arrays incorporating through-wafer trench-isolated interconnects with a supporting frame. IEEE Trans Ultrason Ferroelectr Freq Control. Jan. 2009;56(1):182-92. doi: 10.1109/TUFFC.2009.1018.
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8	Lemmerhirt et al., A 32×32 capacitive micromachined ultrasonic transducer array manufactured in standard CMOS. IEEE Trans Ultrason Ferroelectr Freq Control. Jul. 2012;59(7):1521-36. doi: 10.1109/TUFFC.2012.2352.
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3	Bavaro et al., Element Shape Design of 2-D CMUT Arrays for Reducing Grating Lobes. IEEE Trans Ultrason Ferroelectr Freq Contr. Feb. 2008;55(2):308-18.

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