Technology **Insight Report**

FIBER OPTIC SENSORS

Patent iNSIGHT Pro
Transform Patents to Intelligence

A fiber optic sensor is a sensor that uses optical fiber either as the sensing element ("intrinsic sensors"), or as a means of relaying signals from a remote sensor to the electronics that process the signals ("extrinsic sensors"). Fibers have many uses in remote sensing. Depending on the application, fiber may be used because of its small size, or the fact that no electrical power is needed at the remote location, or because many sensors can be multiplexed along the length of a fiber by using different wavelengths of light for each sensor, or by sensing the time delay as light passes along the fiber through each sensor. Time delay can be determined using a device such as an optical time-domain reflectometer.

This report takes a look into the patenting activity around fiber optic sensors uncovering the inventors, patents, the companies and the intellectual property history behind these devices.

Note: The original version of this report dated Aug 3, 2011 was reviewed and corrected on Aug 9, 2011 based on feedback received from our readers. Specifically, the patent search strategy has been improved upon in this new version.

Brief History of Fiber Optic Sensor

Fiber optics, though used extensively in the modern world, is a fairly simple and old technology. Guiding of light by refraction, the principle that makes fiber optics possible, was first demonstrated by Daniel Colladon and Jacques Babinet in Paris in the early 1840s. John Tyndall included a demonstration of it in his public lectures in London a dozen years later.

It was in the year 1956 that Kapany first officially introduced the term “fiber optics”. He defined fiber optics as the art of the active and passive guidance of light, in the ultraviolet, visible, and infrared regions of the spectrum, along transparent fibers through predetermined paths. Since then, fiber optics has been used in various photo-electronics devices, data processing, and photocopying systems. Today, optical fibers are primary components of global and local telecommunication systems. The primary method of transmitting information via optical fiber is digitally, that is, by sequences of optical pulses whose positions, widths, or occurrences can be modulated. The invention of the laser in 1962 immediately stimulated a revolution that designers created fiber optic sensors combining optical fibers and optoelectronic devices with the application of this coherent light source.

Fiber optic sensors are attractive because they offer excellent sensitivity and dynamic range, compatibility with optical data transmission and processing, long lifetimes and potential, low cost and high reliability. They are immune to electromagnetic interference. Fiber optic sensors can also work in other hostile environments, where there may be high temperatures, high-voltage, corrosive materials, all-solid-state configurations, vibration and explosion hazards, and where traditional sensors and transducers do not work well. The lightweight and small sizes of these devices are critical in such areas as aerospace and provide substantial advantages to many products. The comparable low cost is another advantage of fiber optic sensors. With each new successful product the cost of existing and newly introduced components continues to drop, opening the door for new waves of fiber sensor products. These developments include the replacement of conventional spinning mass-inertial sensors with fiber optic gyros, widespread use of fiber optic sensors in process control and manufacturing, electrical isolation of patients in medicine, and fiber optic health monitoring systems in the aerospace and construction industries.

Overview

With the help of Patent iNSIGHT Pro, we will analyze the all the patent data around Fiber Optic Sensors to find answers to the following:

- What does the IP publication trend for Fiber Optic Sensors look like and how has activity around filings evolved?
- Who are the top assignees or key players in Fiber Optic Sensors and what are their technology wise trends?
- How is the Assignee portfolio spread across different sensor types and application areas?

To get deeper insights the patent set has been classified as follows:

By Types

- Extrinsic/Hybrid Fiber Optic Sensors
  a) Bragg Grating Sensors
  b) Extrinsic Fabry Perot Fiber Sensors

- Intrinsic Fiber Optic Sensors
  a) Distributed Sensors
  b) Interferometric Sensors
  c) Intrinsic Fabry Perot Fiber Sensors
  d) Microbend Sensors

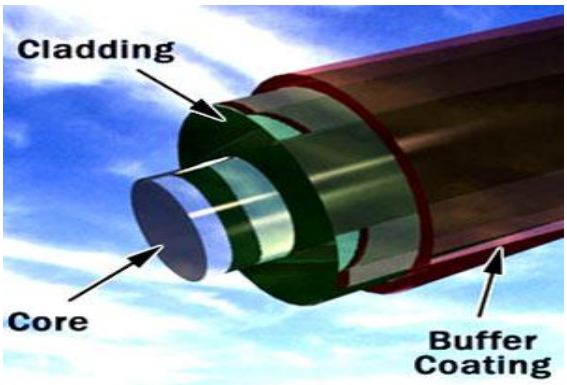


Image Source:
http://communication.howstuffworks.com/fiber-optic-communications/fiber-optic.htm

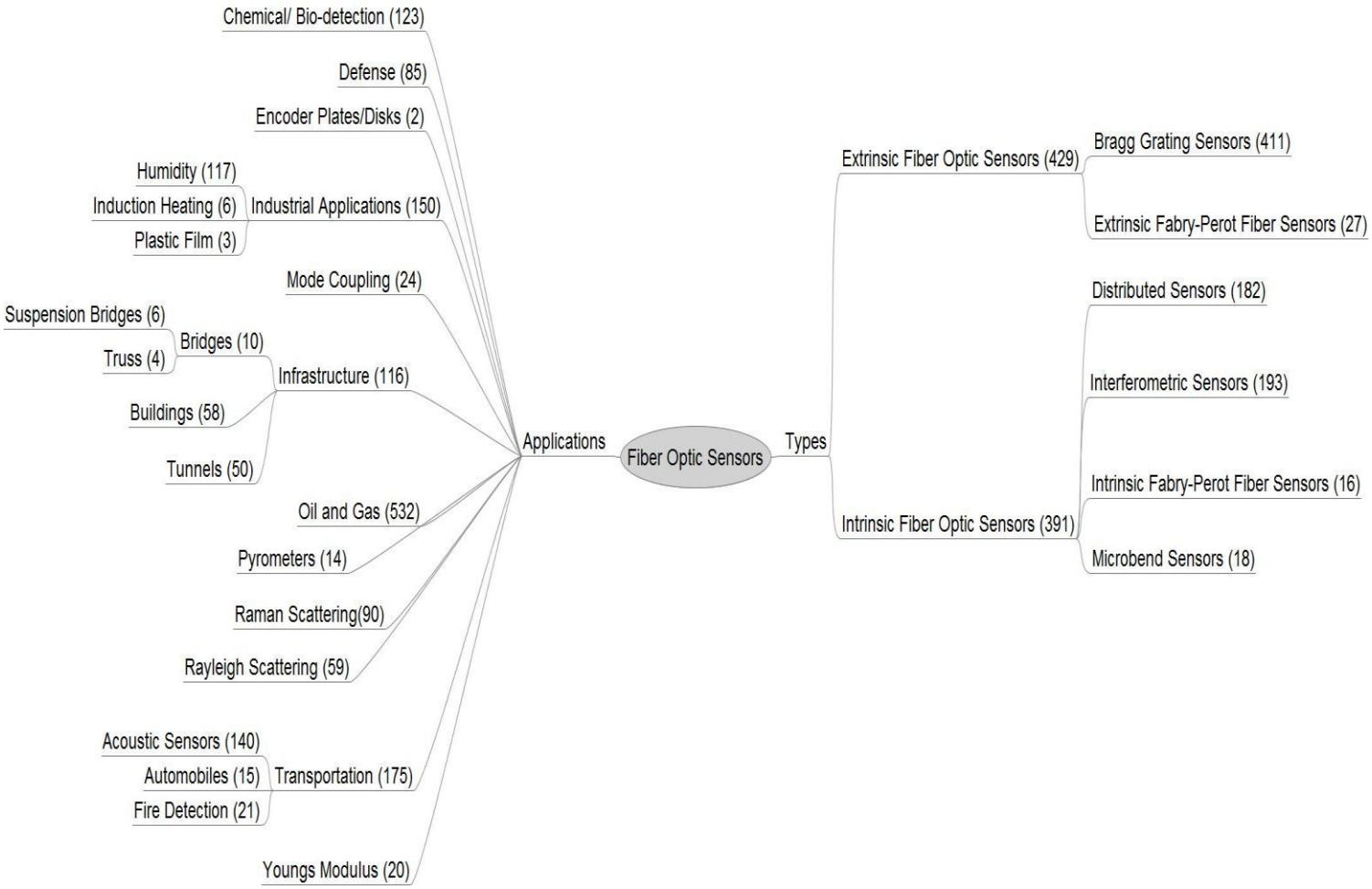
By Applications

- Chemical/ Bio Detection
- Defense
- Encoder Plates/ Disks
- Industrial Applications
  a) Humidity
  b) Induction Heating
  c) Plastic Film
- Mode Coupling
- Infrastructure
  a) Bridges
i) Suspension Bridges
ii) Truss
  b) Buildings
  c) Tunnels
- Oil and Gas
- Pyrometers
- Raman Scattering
- Rayleigh Scattering
- Transportation
a) Acoustic Sensors

b) Automobiles
c) Fire Detection

- Youngs Modulus

The illustration below shows the different categories prepared and the number of records in each. The categorization involved defining a search strategy for each topic and then conducting the search using the Advanced Searching capability in Patent iNSIGHT Pro. Details of search strings used for each category are given in Appendix B.



The Search Strategy

Using the commercial patent database PatBase as our data source we used the following search query to create our patent set.

TAC – Title Abstract Claims

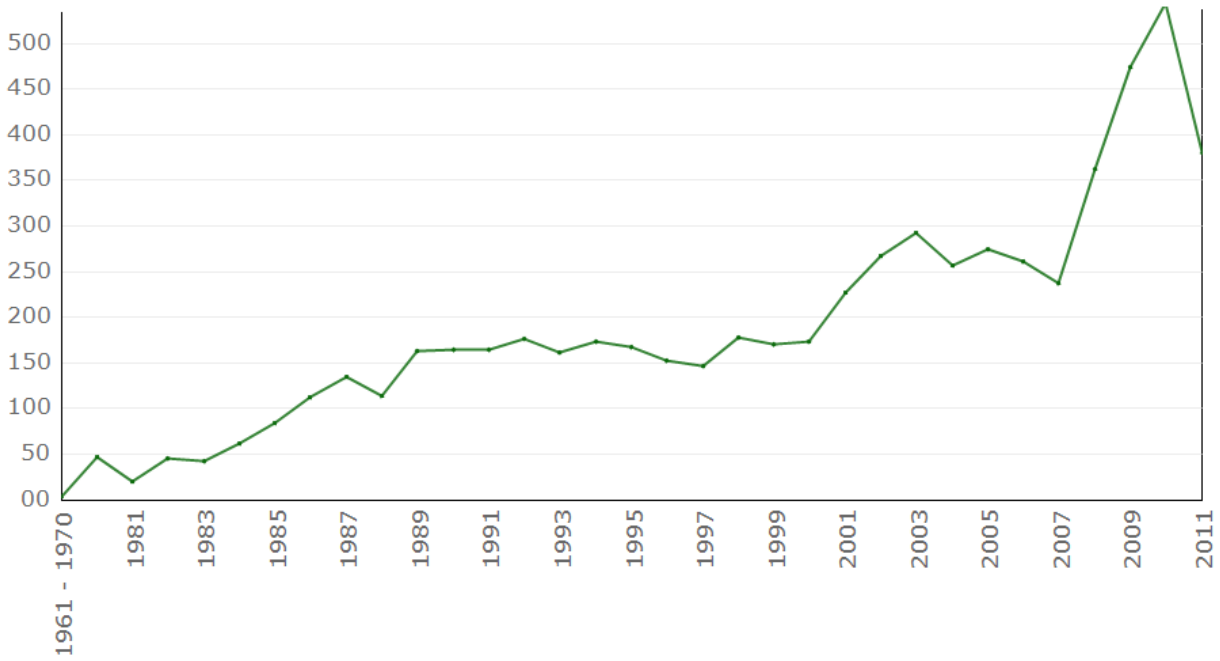
(TAC= ((fiber or fibre) w/3 optic*) w/3 (detector* or sensor* or demodulator* or "sensing element")))

The query was directed to search through the title, abstract and claims and a patent set of 6235 records with one publication per family was generated.

The publications included in the report are updated as of **10th August, 2011.**

Publication Trend

What has been the IP publication trend for Fiber Optic Sensors?



The patent publication trend in the form of a bar graph shows activity from as early as the 1960's and 1970's, although the number of filings remained relatively low all the way up till the year 2000. From 2001, which saw a jump to 300 patents published, there was increase in number of publications from 2007 which saw more than 450 patents.

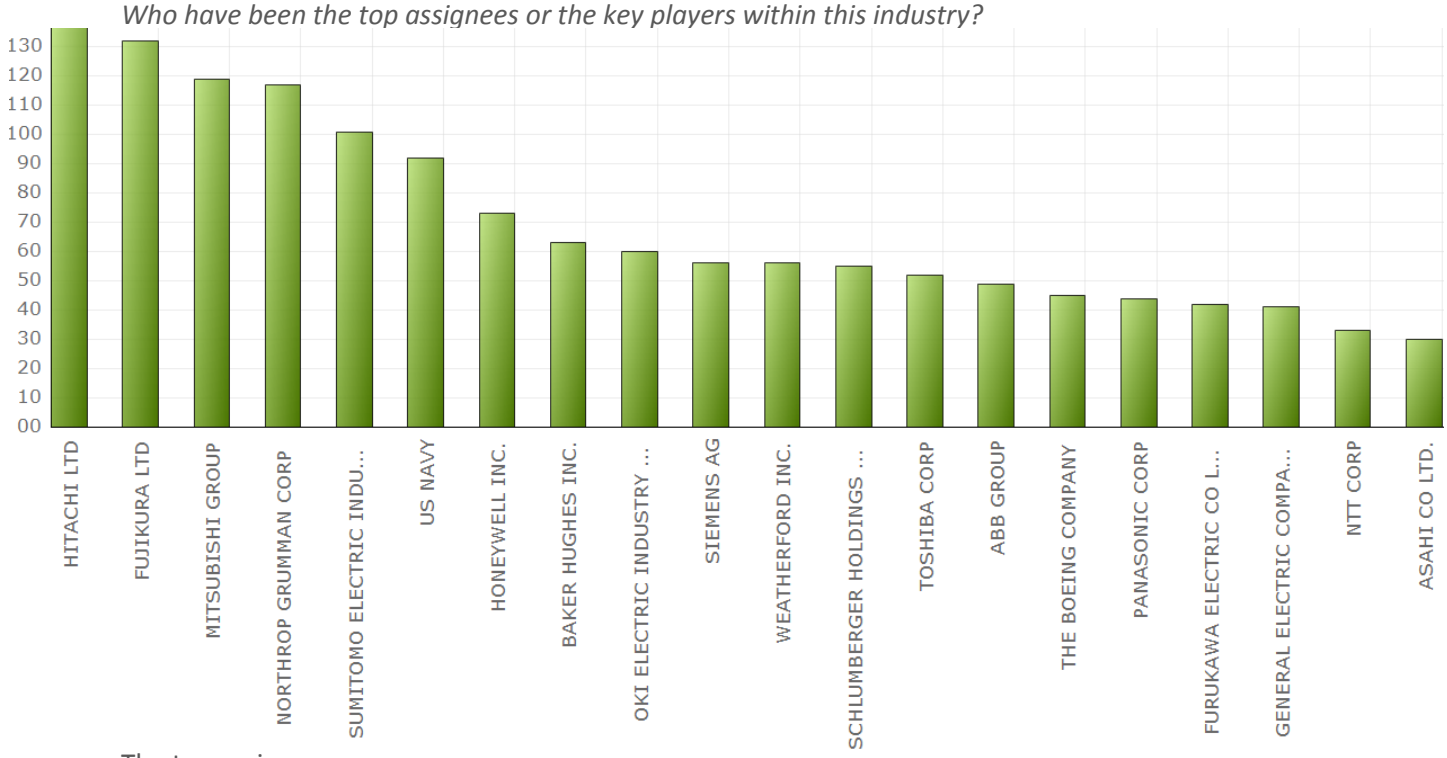
It's clear the current activity around these technologies is likely to continue seeing more innovation in the near future.

How we did it?

Once the patents were populated in Patent iNSIGHT Pro, the publication trend chart was generated on a single click using the dashboard tool.

Top Assignees

Who have been the top assignees or the key players within this industry?



The top assignees are:

1. HITACHI LTD.
2. FUJIKURA LTD.
3. MITSUBISHI GROUP
4. NORTHROP GRUMMAN CORP
5. SUMIOTMO ELECTRIC INDUSTRY
6. US NAVY
7. HONEYWELL INC.
8. BAKER HUGHES INC.
9. OKI ELECTRIC INDUSTRY
10. SIEMENS AG
11. WEATHERFORD INC.
12. SCHLUMBERGER HOLDINGS
13. TOSHIBA CORP
14. ABB GROUP
15. THE BOEING COMPANY
16. PANASONIC CORP
17. FURUKAWA ELECTRIC CO LTD
18. GENERAL ELECTRIC COMPANY
19. NTT CORP
20. ASAHI CO LTD.

How we did it?

Once the patents were populated in Patent iNSIGHT Pro, the assignee clean- up tools were used to normalize the names. Different cleanup tools were leveraged:

- To locate assignees for unassigned records
- To clean up records having multiple assignees
- To locate the correct assignee names for US records using the US assignments database
- To merge assignees that resulted from a merger or acquisition or name change.

Please refer Appendix A for more details on Assignee merging.

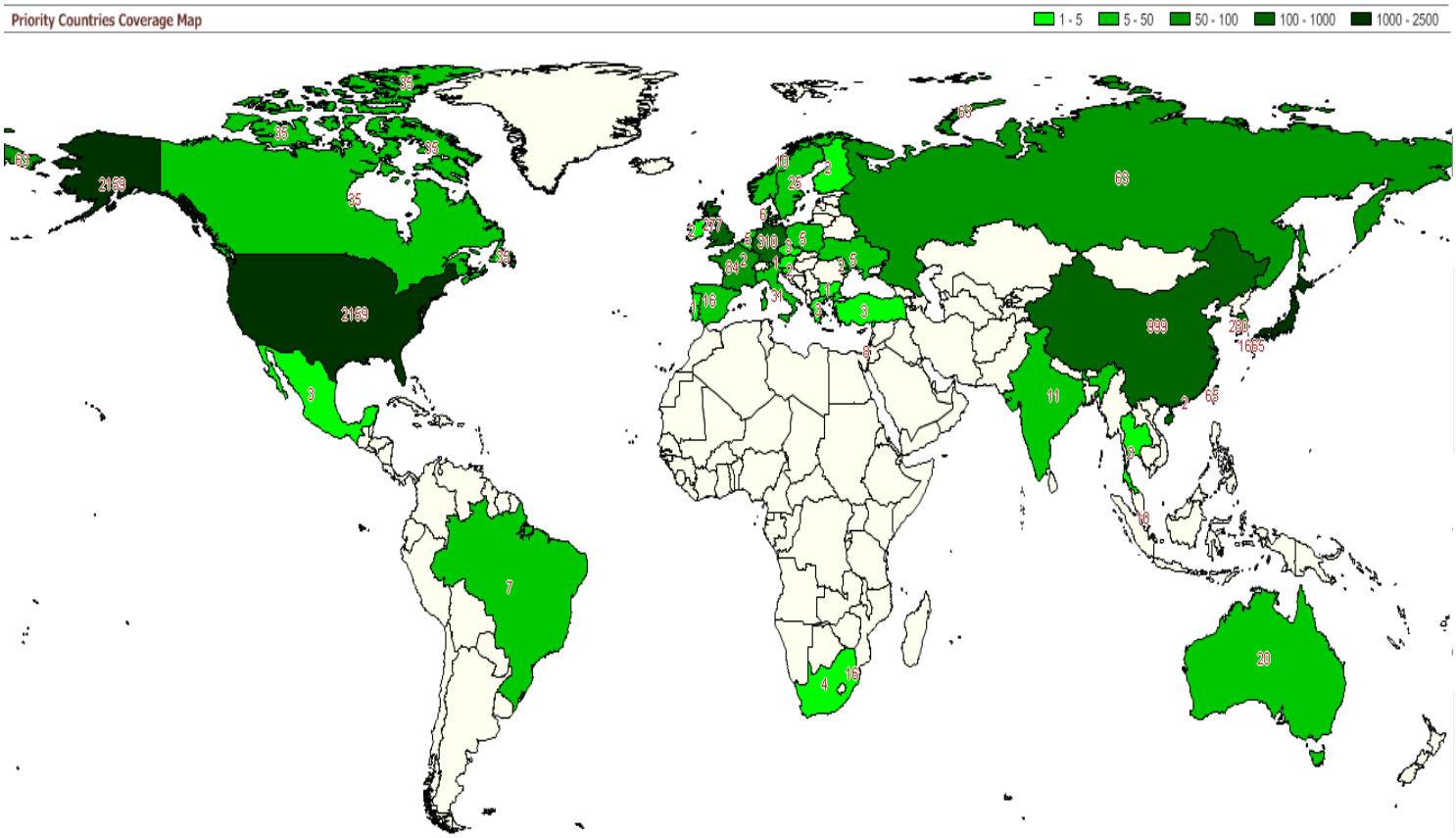
Once the Assignee names were cleaned up, the dashboard tool within Patent iNSIGHT Pro was used to find the top 20 assignees within the given patent set. A visual graph was created based on the results of the top assignees with the number of patents alongside each one.

The complete Assignee table in available in the following Excel file:
http://www.patentinsightpro.com/techreports/0811/List%20of%20Assignees.xls

Top Countries

How is research in Fiber Optic Sensors spread across different countries?

In terms of regional pockets where patent protection is being sought most frequently for these technologies, the US is in the lead, followed by JP and AU. The map below breaks down fiber optic sensor patenting activity priority country wise from 1960. The table below ranks top priority countries and helps provide an indication of where innovation in this area taking place:



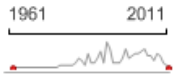
Country Code	Total
US	2159
DE	310
CN	999
JP	1665
RU	63
KR	280
GB	277

How we did it?

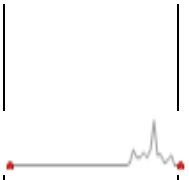
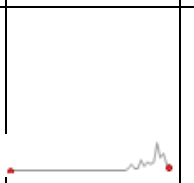
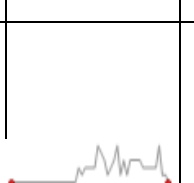
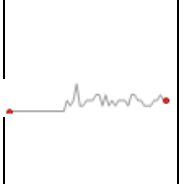
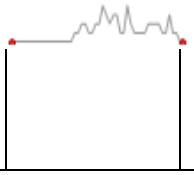
The map was generated using the Priority country coverage map option provided in the dashboard tool within Patent iNSIGHT Pro.

Assignee - Key Statistics

Here we summarize key parameters of Top 15 Assignees such as filing trend, Avg. number of Forward citations per record, Top inventors in each Assignee, Top Co-Assignees and Coverage of underlying patent families

Assignee	Total No. of Records	Average No. of Fwd Cites per Patents	Filing Trend (Absolute)	Filing Year Range	Key Inventor (Top 5)	Co-Assignees	Coverage (Includes families)					
							US	EP	WO	JP	DE	AU
HITACHI LTD	137 (2.2%)	2.09		1976-2010	YAMAMOTO SATORU(15) KOBAYASHI KAZUNAGA(13) KUMAGAI TATSUYA(13) SUZUKI FUMIO(11) HISHIDA YASUYUKI(10)	TOKYO DENRYOKU KK(4) DENSO CORP(3) EAST JAPAN RAILWAY CO(3) FOUNDATION OF RIVER AND BASIN INTEGRATED COMMUNICATIONS JAPAN(2) TOKYO ELECTRIC POWER CO INC(2)	11	5	1	130	5	0
FUJIKURA LTD	132 (2.1%)	0.61		1980-2011	SHIODA TAKAO(28) SHIMOMICHI TAKESHI(22) KURII MASATO(21) OGATA KAZUYA(20) TANAKA YUKIAKI(16)	NEUBREX CO LTD(6) OYO CORP(6) OHBAYASHI CORP(3) SAKATA DENKI(3) CHUBU DENRYOKU KK(2)	6	1	2	130	0	1
MITSUBISHI GROUP	119 (1.9%)	1.4		1979-2010	HISAMA KAZUO(12) TAI SHUICHI(12) YAMAURA TSUYOTOSHI(12) KAWASHIMA TAKAO(12) ITO HIROMASA(11)	RAILWAY TECHNICAL RES INST(7)	9	3	3	115	4	0
NORTHROP GRUMMAN CORP	117 (1.9%)	9.89		1977-2009	CORDOVA AMADO(15) HALL DAVID B(15) FREDERICK DONALD A(10) FERSHT SAMUEL N(8) LAYTON MICHAEL R(8)	No Co-Assignee Present	45	11	6	7	6	2

SUMITOMO ELECTRIC INDUSTRIES LTD.	101 (1.6%)	1.11		1980-2007	KAKUZEN HIDEO(12) MURATA YOSHIKAZU(9) WAKAMI TOSHINORI(9) MIYAMOTO TOSHIHARU(9) FUJIEDA TAKASHI(9)	SUMIDEN BIJITORONIKUSU KK(7) AGENCY OF IND SCIENCE AND TECHNOL(3) ELECTRIC POWER DEV CO LTD(2) KANSAI ELECTRIC POWER CO INC(2) CHUBU ELECTRIC POWER CO INC(1)	9	9	6	99	3	4
US NAVY	92 (1.5%)	14.24		1976-2010	KERSEY ALAN D(16) BUCARO JOSEPH A(15) LAGAKOS NICHOLAS(11) DANDRIDGE ANTHONY(9) BOBB LLOYD C(7)	No Co-Assignee Present	81	1	6	0	0	1
HONEYWELL INC.	73 (1.2%)	9.19		1978-2010	SANDERS GLEN A(9) STRANDJORD LEE K(7) BLAKE JAMES N(6) FETH JOHN R(5) SZAFRANIEC BOGDAN(5)	SANDIA CORP(1)	23	4	7	3	2	3
BAKER HUGHES INC.	63 (1%)	7.02		1984-2010	JOHN W HARRELL(21) PAULO S TUBEL(21) JOHNSON MICHAEL H(14) KURT A HICKEY(9) VOLL BENN(8)	No Co-Assignee Present	22	3	12	0	0	8
OKI ELECTRIC INDUSTRY CO LTD	60 (1%)	0.35		1984-2009	SATOU RIYOUTAKU(15) SHINDO YUGO(11) DOBASHI KOJI(10) ARAI HIROSHI(7) TSUCHIDA NORIHIRO(7)	TECHNICAL RESEARCH AND DEVELOPMENT INSTITUTE MINISTRY OF DEFENCE(2)	0	0	0	60	0	0
SIEMENS AG	56 (0.9%)	3.82		1975-2010	HAPPEL TOBIAS(4) WILLSCH MICHAEL(4) SICHLING GEORG H(4) SCHOBER HERBERT(4) BOSSELMANN THOMAS(3)	SCHOBER HERBERT(3) BOSSELMANN THOMAS(1) FRANKE MARTIN(1) FRENZEL HENRYK(1) GAMULESCU TUDOR ION(1)	9	9	5	3	27	0

WEATHERFORD INC.	56 (0.9%)	10.2		1996-2008	GYSLING DANIEL L(11) KERSEY ALAN D(9) MARON ROBERT J(5) OGLE PETER C(4) DAVIS ALLEN R(4)	No Co-Assignee Present	12	1	4	1	1	3
SCHLUMBERGER HOLDINGS LIMITED	55 (0.9%)	4.4		1998-2011	RAMOS ROGERIO T(11) SCHROEDER ROBERT J(9) YAMATE TSUTOMU(9) HARTOG ARTHUR H(8) PEIRCE IAN(4)	PRAD RESEARCH AND DEVELOPMENT LIMITED(6) SERVICES PETROLIERS SCHLUMBERGER(3) PEIRCE IAN(2) RAMOS ROGERIO TADEU(2) ROBERTS DAMON(2)	24	10	25	2	3	7
TOSHIBA CORP	52 (0.8%)	1.96		1982-2010	TAKAHASHI MASASHI(7) TAKAHASHI HIROYUKI(7) TATSUNO KYOICHI(6) UMEDA TOSHIYA(6) SASAKI KEIICHI(6)	LAZOC INC(1)	9	2	2	51	2	0
ABB GROUP	49 (0.8%)	8.65		1979-2011	BOHNERT KLAUS(28) BRAENDLE HUBERT DR(12) FRANK ANDREAS(6) BROGARDH TORGNY(6) GABUS PHILIPPE(5)	BOHNERT KLAUS(2) BRAENDLE HUBERT(1) FRANK ANDREAS(1) WUEST ROBERT(1)	11	9	1	8	9	0
THE BOEING COMPANY	45 (0.7%)	16.47		1979-2009	UDD ERIC(15) CAHILL RICHARD F(6) THERIAULT JOHN P(4) HAAKE JOHN M(3) BUTTRICK JR JAMES N(3)	No Co-Assignee Present	28	1	1	0	0	0

How we did it?

In order to compress all the information into a single report, we used the 360 ° series of reports available in the software.

From the Assignee 360° report options, we selected Top 15 Assignees and the different pieces of information we wanted to include in the singular display and then ran the report. The generated report was then exported to Excel using the option provided for the same.

Inventor - Key Statistics

Here we summarize key parameters of Top 15 Inventors such as filing trend, average number of forward citations per record, key associated companies and top 5 co-inventors.

Inventor	Total No. of Records	Average No. of Fwd Cites per Patents	Filing Trend (Absolute)	Filing Year Range	Key Assignees (Top 5)	Co-Inventors
YUAN LIBO	285 (4.6%)	0		1985-2010	HARBIN ENGINEERING UNIVERSITY(12) INSTITUTE OF SEMICONDUCTORS CAS(12) CHONGQING UNIVERSITY(6) NORTHWESTERN POLYTECHNICAL UNIVERSITY(5) CHINA NATIONAL PETROLEUM CORPORATION(5)	LIU YULIANG(59) JIANG QI(31) LI FANG(25) LEE KYU WAN(19) LI WEI(15)
LIU YULIANG	146 (2.3%)	0		1985-2010	INSTITUTE OF SEMICONDUCTORS CAS(18) SHANDONG UNIVERSITY(6) QIN YITAO(4) UNIVERSITY OF ELECTRONIC SCIENCE AND TECHNOLOGY OF CHINA(4) TIANJIN UNIVERSITY(3)	YUAN LIBO(59) LI FANG(25) JIANG QI(11) LI WEI(7) LEE KYU WAN(5)
JIANG QI	107 (1.7%)	0		1987-2010	SHANDONG UNIVERSITY(9) ZHEJIANG UNIVERSITY(6) NORTHWESTERN POLYTECHNICAL UNIVERSITY(5) WUHAN RENTIAN PACKAGING TECHNOLOGY CO(3) CHEN JEN CHUAN(3)	YUAN LIBO(31) LEE KYU WAN(11) LIU YULIANG(11) LI WEI(5) CHEN JEN CHUAN(4)

LEE KYU WAN	62 (1%)	0		1990-2010	KAISEN CO LTD(5) ZHEJIANG UNIVERSITY(5) KOREA INSTITUTE OF CONSTRUCTION TECHNOLOGY(4) SHANDONG UNIVERSITY(4) KOREA MAINTENANCE AND CONTROL CO(3)	YUAN LIBO(19) JIANG QI(11) SHU XIAOWU(6) LIU YULIANG(5) CHEN KAN(4)
LI FANG	56 (0.9%)	0		1987-2010	INSTITUTE OF SEMICONDUCTORS CAS(18) SHANDONG UNIVERSITY(3) TIANJIN POLYTECHNIC UNIVERSITY(3) DALIAN SCIENCE AND ENGINEERING UNIV(2) CHANG AN UNIVERSITY(2)	LIU YULIANG(25) YUAN LIBO(25) JIANG QI(4) LEE KYU WAN(4) WANG YONGJIE(4)
SUZUKI FUMIO	55 (0.9%)	0		1981-2010	FUJIKURA LTD(13) HITACHI LTD(11) NKK CORP(3) WATANABE KAZUHIRO(2) PANASONIC CORP(2)	KIKUCHI YOSHIO(8) YAMAUCHI RYOZO(7) FUKUDA TAKERU(5) KOBAYASHI KAZUNAGA(5) SHIODA TAKAO(5)
TANAKA YUKIAKI	54 (0.9%)	0		1982-2009	FUJIKURA LTD(16) NIPPON DENKI KK(5) FUJITSU LIMITED(5) FUJI HEAVY IND LTD(4) ISHIKAWAJIMA HARIMA HEAVY INDUSTRIES CO LTD(3)	SHIMOMICHI TAKESHI(16) KOBAYASHI KAZUNAGA(5) OTA JUNICHI(5) ASAKI YUTAKA(5) SAYAMA TADAYOSHI(5)
LI WEI	53 (0.9%)	0		1985-2010	DAQING OIL FIELD CO(4) BEIJING UNIVERSITY OF AERONAUTICS AND ASTRONAUTICS(3) CHINA PETROLEUM PIPELINE BUREAU(2) SHENYANG INSTITUTE OF ENGINEERING(2) WUHAN BRIDGE RESEARCH INSTITUTE CO(1)	YUAN LIBO(15) LIU YULIANG(7) SUN XIAOHAN(6) YAO HONGTIAN(6) JIANG QI(5)

JOHNSON MICHAEL H	49 (0.8%)	0		1978-2009	BAKER HUGHES INC.(14) NORTHROP GRUMMAN CORP(2) UNIVERSITY OF WASHINGTON(2) OPTICAL SENSORS INC(2) JOHNSON DOUGLAS M(2)	JOHN W HARRELL(11) PAULO S TUBEL(11) BIDIGARE BRIAN(7) VOLL BENN(7) KURT A HICKEY(6)
SHIODA TAKAO	46 (0.7%)	0		1980-2005	FUJIKURA LTD(28) FUJIKURA DENSEN KK(6) CHUBU ELECTRIC POWER CO INC(5) HITACHI LTD(2) NEC CORP(2)	FUKUDA TAKERU(19) WADA FUMIO(12) HIDAKA HIROMI(10) KATO MASAMI(9) KIKUCHI YOSHIO(7)
KOBAYASHI KAZUNAGA	45 (0.7%)	0		1983-2010	HITACHI LTD(13) FUJIKURA LTD(9) TOBISHIMA CORP(5) TOYOTA MOTOR CORP(4) ISHIKAWAJIMA HARIMA HEAVY INDUSTRIES CO LTD(3)	HISHIDA YASUYUKI(6) YAMAMOTO SATORU(6) KUMAGAI KOJU(5) SUZUKI FUMIO(5) TANAKA YUKIAKI(5)
KAWAMURA TAKESHI	43 (0.7%)	0		1983-2009	SUMITOMO ELECTRIC INDUSTRIES LTD.(5) PANASONIC CORP(4) FURUKAWA ELECTRIC CO LTD (3) ANRITSU CORP(3) KAJIMA CORP(2)	AGATA KATSUSHI(2) ENOMOTO YOSHITAKA(2) FUJIWARA KUNIHIKO(2) IIKE MASANORI(2) IKEDA HIROSHI(2)
SUN XIAOHAN	42 (0.7%)	0		1990-2010	SOUTHEAST UNIVERSITY(6) DAQING OIL FIELD CO(4) DONGNAN UNIV(2) GENERAL ELECTRIC COMPANY(2) AEGIS SEMICONDUCTOR INC.(2)	YUAN LIBO(10) LI WEI(6) LIN FAZHI(4) LIU YULIANG(4) WANG QINGPING(4)
TAKAHASHI HIROYUKI	34 (0.5%)	0.9		1986-2010	TOSHIBA CORP(7) HITACHI LTD(4) FUJIKURA LTD(4) MITSUBISHI GROUP(4) TOYOTA MOTOR CORP(3)	TERAI KIYOHISA(6) KATO MASAMI(5) SHIODA TAKAO(5) FUKUSHI MORIHISA(4) IKUTA SAKAE(4)

KIM KI SOO	33 (0.5%)	0.8		1989-2010	KOREA ADVANCED INSTITUTE OF SCIENCE AND TECHNOLOGY(4) INDUSTRY FOUNDATION OF CHONNAM NATIONAL UNIVERSITY(3) ICES CO LTD(3) HUTECH 21(2) KRRI(2)	LEE JUNG JU(6) LEE KYU WAN(3) YUN CHUNG BANG(3) AN TAE KI(2) CHIN WON JONG(2)

How we did it?

In order to compress all the information into a single report, we used the 360 ° series of reports available in the software. From the Inventor 360° report options, we selected the different pieces of information we wanted to include in the singular display and then ran the report. The generated report as then exported to Excel using the option provided for the same.

Assignee portfolio across different sensor types and application areas

Categories	Intrinsic Fiber Optic Sensors				Extrinsic/Hybrid Fiber Optic Sensors		Industrial Applications					Infrastructure							Transportation		
												Bridges									
Key Assignees	Interferometric Sensors	Distributed Sensors	Microbend Sensors	Intrinsic Fabry-Perot Fiber Sensors	Bragg Grating Sensors	Extrinsic Fabry-Perot Fiber Sensors	Humidity	Defense	Youngs Modulus	Chemical/ Bio-detection	Oil and Gas	Truss	Suspension Bridges	Buildings	Tunnels	Mode Coupling	Raman Scattering	Rayleigh Scattering	Acoustic Sensors	Fire Detection	Automobiles
WEATHERFORD INC.	7	3			37		2		1		11			1	1		1	2	9		
NORTHROP GRUMMAN CORP	26	1			5		2	4	3	1	3					1	1		13		
US NAVY	17	1			12	1		2	8	1	1						1	3	9		
SCHLUMBERGER HOLDINGS LTD.		10			20			1	1		20		1			1	6	7	1		
BAKER HUGHES INC.		18			6					12	20						2	1	12		
OPTOPLAN AS	2	2			10						7										
GENERAL ELECTRIC CO					10		1	2			5				1		1	1	2		
THE BOEING CO	2	5	1		2		1	7			5	1							1		1
FUJIKURA LTD	1	4			3		2				3			3	1		3	3	3	1	
HITACHI LTD		2			5		3										8	1			
ABB GROUP	3				4		1	1			9			1							
THE BOARD OF TRUSTEES OF THE LELAND STANFORD JUNIOR UNIV	4	2														1		1	4		
SENSOR DYNAMICS LTD	1	2			2	1					5								2		

In the above matrix leading patent holdings within each category of sensor types and application areas have been highlighted with stronger shades of orange for larger number of patents within that category. Northrop Grumman has a significant number of patents for interferometric sensors. Baker Hughes Inc. and Schlumberger Holdings have an edge when it comes oil and gas exploration and drilling with 20 patents each.

How we did it?

The clusters of types and application areas that were created for the previous analysis were correlated using the co-occurrence analyzer and then the resulting matrix was exported to Excel using the option provided for the same.

Keywords vs. Fiber Optic Technologies – White Space Analysis

Patent iNSIGHT Pro
Transform Patents to Intelligence

What are the top keywords in Fiber Optic technologies and how do they vary across the different fiber optic sensor types? For this a cleaned list of keywords that were generated from the Title, Abstract and Claims. Such a table can be used for preliminary insights toward White Space Analysis. (White-spaces are gaps in a technology landscape that have potential for attaining exclusivity.)

As can be seen in the table below the concept of "Elongate Optical Fiber Sensor" hasn't been used in any of the Intrinsic and Extrinsic Fiber Optic Sensors. Such an indication can be further verified via patent search to confirm existence of a white space.

Fiber Optic Technologies across different Sensor Types (Columns) / Top Keywords (Rows)	Total	Intrinsic Fiber Optic Sensors					Extrinsic/Hybrid Fiber Optic Sensors		
		Total	Interferometric Sensors	Distributed Sensors	Intrinsic Fabry-Perot Fiber Sensors	Microbend Sensors	Total	Bragg Grating Sensors	Extrinsic Fabry-Perot Fiber Sensors
Total	704	359	180	162	18	16	413	396	26
OPTICAL FIBER	515	238	111	115	15	7	321	312	14
FIBER OPTIC	364	215	115	87	10	13	186	172	18
FIBER OPTIC SENSOR	188	113	59	48	3	9	96	86	13
FIBER SENSOR	178	75	24	47	3	3	122	120	4
FIBER BRAGG GRATING	164	20	7	11		4	164	164	2
STRAIN SENSOR	49	20	7	11	1	4	41	38	5
OPTICAL SENSORS	37	20	10	7		4	25	23	4
FABRY-PEROT INTERFEROMETER	30	22	19			8	19	11	12
ACOUSTIC SENSOR	26	20	11	9			10	9	1
PRESSURE SENSORS	22	12	3	10			11	11	
FIBER OPTIC INTERFEROMETRIC SENSOR	22	22	22	1			3	3	
MICHELSON INTERFEROMETER	21	18	15	3		3	7	7	3
FIBER OPTIC PRESSURE SENSOR	18	9	5	1		4	15	10	5
ACOUSTIC SIGNALS	18	12	8	4			8	8	
ACOUSTIC PRESSURE	16	13	13				4	4	1
COHERENCE LENGTH	15	15	13	3			1	1	
OPTICAL FIBER INTERFEROMETER	14	10	9	1			4	4	
INTERFEROMETRIC FIBER OPTIC SENSOR	13	13	13			2	3	2	2
FIBER LENGTH	13	7	3	3		1	8	7	1

SAGNAC INTERFEROMETER	12	11	8	5			1	1	
COHERENT LIGHT	12	9	9	1			3	3	
OPTICAL INTERFEROMETER	11	8	5	3			5	5	1
FIBER OPTIC ACOUSTIC SENSOR	11	8	5	3			5	5	
VIBRATION SENSOR	10	9	2	7			1	1	
RESPECTIVE SENSOR	8	5	3	2			4	4	
NOISE RATIO	8	6	1	5			3	3	
FIBER OPTIC STRAIN SENSOR	8	4	1	1	1	1	5	4	1
YOUNGS MODULUS	7	3	2	1			4	4	
DISPLACEMENT SENSOR	7	5	4		1		2	2	
ACOUSTIC WAVES	7	6	6				2	2	
INTRINSIC FIBER OPTIC SENSOR	6	2		2			6	6	
FIBER OPTIC CHEMICAL SENSOR	6	6		6					
SCALE FACTOR	5	4	4				1	1	
PRESSURE TRANSDUCER	5	2		1	1		3	3	
OUTPUT OPTICAL SIGNAL	5	4	4				1	1	
MEASURING SENSOR	5	3		3			2	2	
OUTPUT OPTICAL FIBER	4	3	2			1	2	1	1
OPTICAL SPECTROMETRIC SENSORS	4	4		4					
MULTIPLE SENSOR	4	2	2	2			2	2	
LIGHT SENSOR	4	2	1	1			2	2	
ATMOSPHERIC PRESSURE	4	1	1			1	4	4	1
ACOUSTIC EMISSION	4	4	2	2		1	3	3	1
POLARIZATION BEAM SPLITTER	3	2	1	1			1	1	

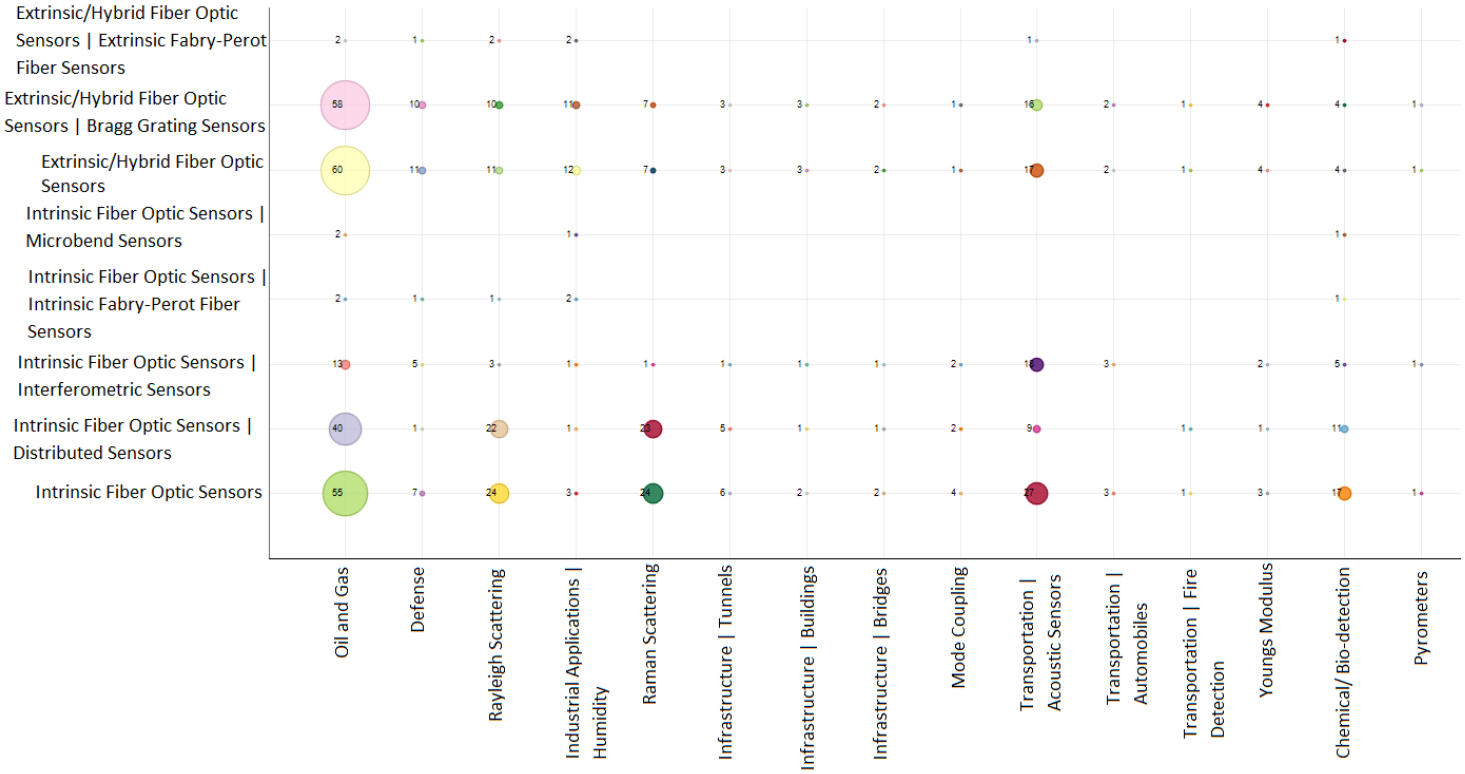
PIEZOELECTRIC TRANSDUCER	3	2	1	1			1	1	
MULTIMODE OPTICAL FIBER	3	3	1	1	1				
MAGNETIC SENSOR	3	1	1				2	2	
FIBER OPTIC ROTATION SENSOR	3	2	2				1	1	
POLARIZATION COMPONENTS	2	2	1	1					
MONOMODE FIBER	2	1			1		1	1	
LASER SENSOR	2						2	2	
ELECTROMAGNETIC SENSOR	2						2	2	
BIREFRINGENT OPTICAL FIBER	2	2	2				1	1	
ACOUSTIC TRANSDUCER	2						2	2	
PROXIMITY SENSORS	1						1	1	
POSITIONING SENSOR	1	1	1						
PIEZOELECTRIC SENSORS	1						1	1	
OPTICAL RESONATOR	1						1	1	
OPTICAL FIBER PRESSURE SENSOR	1						1	1	
OPTICAL CURRENT SENSOR	1	1	1						
INPUT OPTICAL FIBER	1	1	1						
HUMIDITY SENSOR	1						1	1	
FIBER-OPTIC CURRENT SENSOR	1	1	1						
ELONGATE OPTICAL FIBER	1						1	1	
COUPLED OPTICAL SIGNAL	1						1	1	
COUNTERPROPAGATING WAVES	1	1	1						
ACOUSTIC PRESSURE SENSORS	1						1	1	

How we did it?

First the various types of Fiber Optic Sensors were identified by online research. Then by using a combination of semantic analysis tools such as the clustering tools and searching tools available in Patent iNSIGHT Pro, patents were categorized under the different types. A clean set of keywords was generated using Patent iNSIGHT Pro using a combination of keyword list Cleanup and Auto Custer features. A co-occurrence matrix was generated to map the keywords with types. The generated matrix was exported to Excel.

Fiber Optic Sensor types vs. Key Application Areas

How do various fiber optic sensors compare across key application areas?



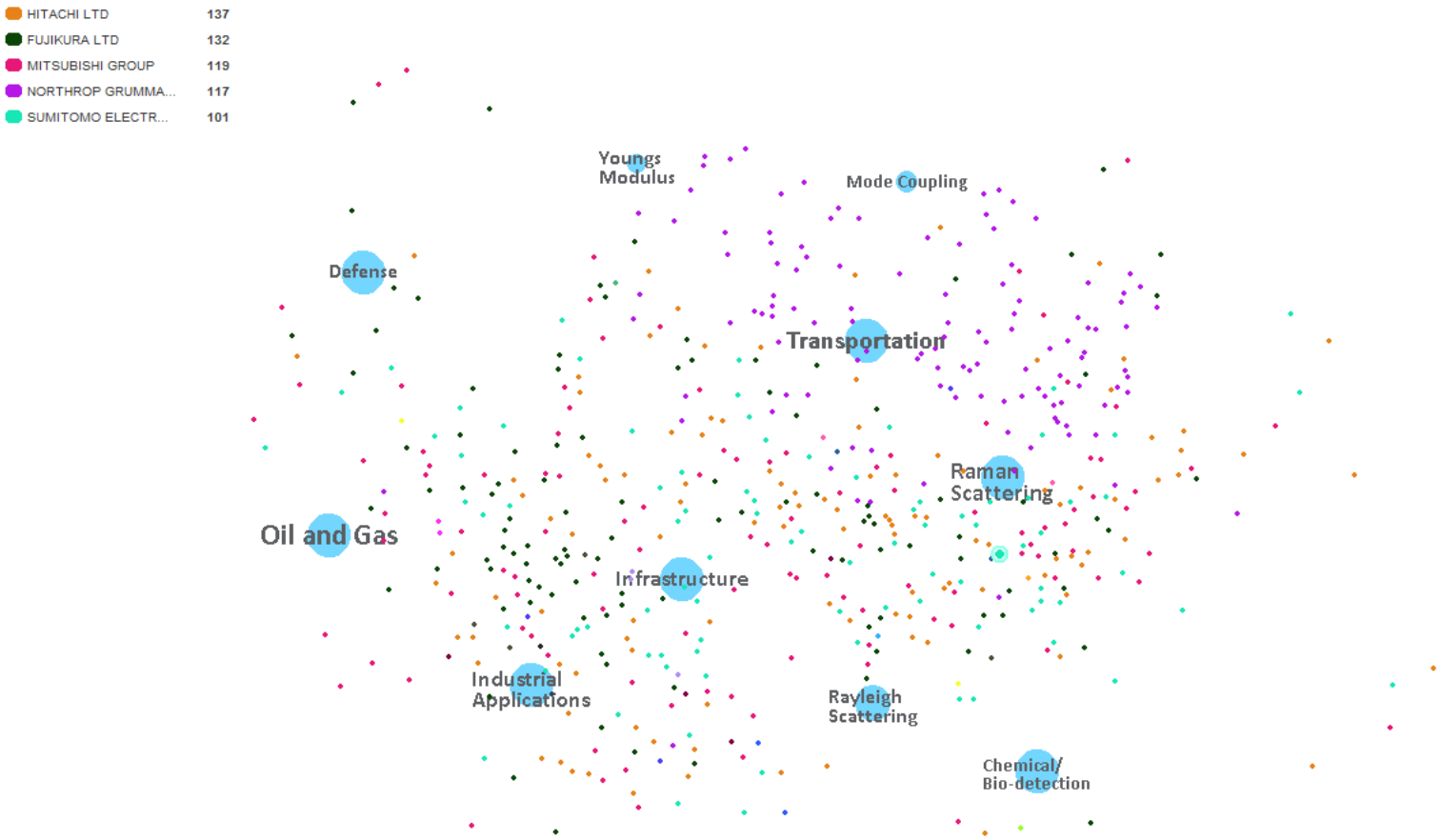
In the chart below "Bragg Grating Sensors" are extensively used in Oil and Gas with 58 records. Distributed sensors are used in Raman Scattering with 23 records.

How we did it?

The clusters of types and application areas that were created for the previous analysis were correlated using the co-occurrence analyzer and then the resulting matrix for converted into a bubble chart.

Sample Portfolio Comparison of Hitachi Ltd vs. other top Assignees

How does the portfolio landscape of Hitachi Ltd compare with other companies? What are the overlaps in the portfolios?



The map shows patents of top five assignees clustered together based on the basis of application areas. The map also shows the overlapping areas and patents in respective categories.

How we did it?

The VizMAP tool in Patent iNSIGHT Pro was used for this analysis. First the patents of the top five assignees were loaded on the map. The map was then analyzed in the context mode wherein each patent record is placed across to the contextual similarity with other records. The contextual similarity was calculated over Title, Abstract and Claims.

Appendix A: Key Assignee Normalization Table

Note: The tables below include normalization from US Assignments database and so some assignees may appear under multiple normalized names.

HITACHI LTD

HITACHI LTD
HITACHI SHIPBUILDING ENG CO
HITACHI DENSEN KK
HITACHI CABLE
HITACHI KEIYO ENG
IZUTSU MASAYUKI, SUEDA TADASHI

FUJIKURA LTD.

FUJIKURA LTD
OHBAYASHI CORP, SAKATA DENKI

MITSUBISHI GROUP

MITSUBISHI ELECTRIC CORP
MITSUBISHI CABLE IND LTD
MITSUBISHI HEAVY IND LTD

NORTHROP GRUMMAN CORP

LITTON SYSTEMS INC
LITTON SYSTEMS INC US
NORTHROP GRUMMAN GUIDANCE AND
GRUMMAN AEROSPACE CORP
NORTHROP CORP
GRUMMAN AEROSPACE CORP
LITTON SYSTEMS CANADA
SPERRY MARINE INC
TELEDYNE RYAN AERONAUTICAL DIV
NORTHROP GRUMMAN CORP
LITEF GMBH

Appendix B: Search Strings Used for Categorization

Categorization: Types of Fiber Optic Sensors

1. Extrinsic/Hybrid Fiber Optic Sensors
   a) Bragg Grating Sensors

Bragg Grating Sensors	
(TAC) contains ((Bragg w/3 grating*) or FBG)	411 results

b) Extrinsic Fabry Perot Fiber Sensors

Extrinsic Fabry Perot Fiber Sensors	
(TAC) contains (fabry-perot and (extrinsic or external or hybrid))	27 results

2. Intrinsic Fiber Optic Sensors
   a) Distributed Sensors

Distributed Sensors	
(TAC) contains (distributed w/3 sensor*)	182 results

b) Interferometric Sensors

Interferometric Sensors	
(TAC) contains (interferomet* w/3 sensor*)	193 results

c) Intrinsic Fabry Perot Fiber Sensors

Intrinsic Fabry Perot Fiber Sensors	
(TAC) contains (fabry-perot and (intrinsic or internal))	16 results

d) Microbend Sensors

Microbend Sensors	
(TAC) contains(microbend w/3 sensor*)	18 results

Categorization: Applications

1. Chemical/ Bio Detection

Chemical/ Bio Detection	
(TAC) contains ((chem* or bio*) w/5 (detect* or monitor*))	123 results

2. Defense

Defense	
(TAC) contains (defense or aerospace or aeronautic* or aerodynamic* or navy or naval* or army or airforce or aircraft or airplane or aerosystems or military or weapon* or submarine* or missile*)	85 results

3. Encoder Plates/ Disks

Encoder Plates/ Disks	
(TAC) contains (encode* w/3 (plate* or disk*))	2 results

4. Industrial Applications
a) Humidity

Humidity	
(TAC) contains (humid* or dampness or moist*)	117 results

b) Induction Heating

Induction Heating	
(TAC) contains (induction w/3 heat*)	6 results

c) Plastic Film

Plastic Film	
(TAC) contains (plastic pre/3 film*)	3 results

5. Mode Coupling

Mode Coupling	
(TAC) contains (mode w/3 coupl*)	24 results

6. Infrastructure
a) Bridges
i) Suspension Bridges

Suspension Bridges	
(TAC) contains (suspension w/3 (line* or cable* or wire*))	6 results

ii) Truss

Truss	
(TAC) contains truss*	4 results

b) Buildings

Buildings	
(TAC) contains building*	58 results

c) Tunnels

Tunnels	
(TAC) contains tunnel*	50 results

7. Oil and Gas

Oil and Gas	
(TAC) contains (oil* or gas or petro* or refin*)	532 results

8. Pyrometer

Pyrometer	
(TAC) contains pyrometer*	14 results

9. Raman Scattering

Raman Scattering	
(TAC) contains Raman	90 results

10. Rayleigh Scattering

Rayleigh Scattering	
(TAC) contains (rayleigh or CRN)	59 results

11. Transportation

a) Acoustic Sensors

Acoustic Sensors	
(TAC) contains (acoustic w/3 sensor*)	140 results

b) Automobiles

Automobiles	
(TAC) contains ((traffic or vehic*) w/3 control* or monitor*)	15 results

c) Fire Detection

Fire Detection	
(TAC) contains (fire w/3 detect*)	21 results

Youngs Modulus	
(TAC) contains ("youngs modulus")	20 results

Summary

Fiber optic sensors began as a by-product of optical fiber research and development. The first sensors were designed to measure the performance and status of an optical network.

This report graphically analyzes fiber optic sensor markets from many perspectives, categorizes and highlights the key companies involved, defines unique keywords.

This report also covers the global fiber optic sensors marketplace. It focuses particularly on the markets and opportunities for fiber optic sensors in defense, oil and gas exploration and drilling, medical, and industrial markets. The study considers future opportunities for new application markets.

About Patent iNSIGHT Pro

Patent iNSIGHT Pro™ is a comprehensive patent analysis platform that allows you to accelerate your time-to-decision from patent analysis activities. Designed from inputs by experienced patent researchers, Patent iNSIGHT Pro easily blends into your existing Research workflow. Patent iNSIGHT Pro is used by leading legal services, Pharmaceutical & biotech, electronics companies and research organization across US, Europe, South America and India with more than 400 end users. Patent iNSIGHT Pro is developed and marketed by Gridlogics, a research driven IT Company specializing in providing intellectual property analysis and visualization solutions to aid R&D and corporate strategy.

Gridlogics is headquartered in Pune, India and has a sales presence in Delhi, Mumbai and USA.

For more information:

Visit us at: www.patentinsightpro.com
Or call us at: 1-408-786-5524
Or mail us at: contact@patentinsightpro.com

Have a comment on this report? Mail us at feedback_tr@patentinsightpro.com

Sources & References

- http://en.wikipedia.org/wiki/Fiber_optic_sensor
- http://www.rp-photonics.com/fiber_optic_sensors.html
- http://www.eaeeie.org/theiere_bratislava/1.html
- http://www.wikid.eu/index.php/Fiber_optic_sensing#Two_Main_Types_of_Optical_Sensors
- http://www.sensorwiki.org/doku.php/sensors/fibre_optic