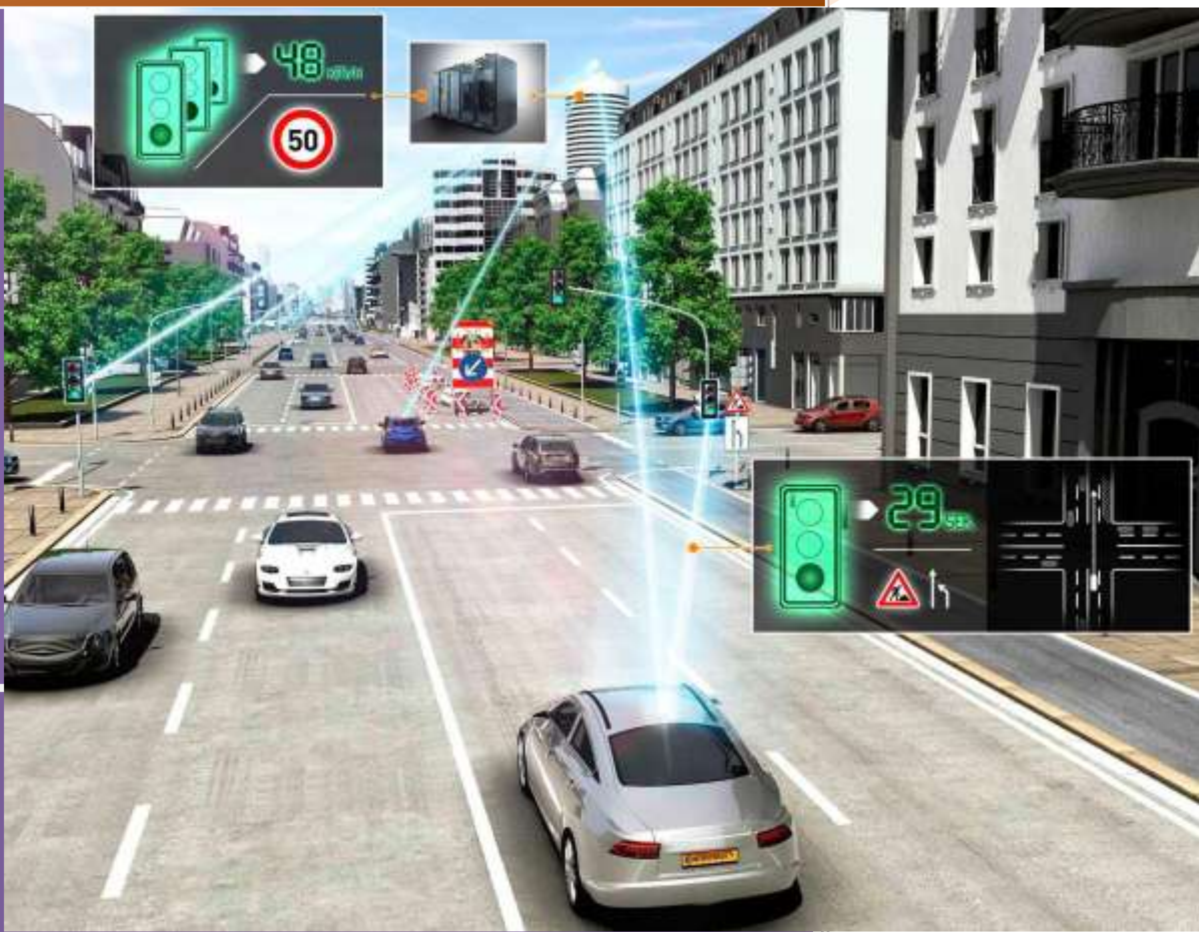
Autonomous Car-Control Mechanism



An autonomous car (driverless car, self-driving car, robotic car) is a vehicle that is capable of sensing its environment and navigating without human input.

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Introduction

An autonomous car (driverless car, self-driving car, robotic car) is a vehicle that is capable of sensing its environment and navigating without human input. Autonomous vehicles detect surroundings using radar, LIDAR, GPS, Odometry, and computer vision. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage. Autonomous cars have control systems that are capable of analyzing sensory data to distinguish between different cars on the road, which is very useful in planning a path to the desired destination

General Motor's Cadillac division expects to produce partially autonomous cars on a large scale by 2015, and the car manufacturer also predicts it will have fully autonomous cars available by the end of the decade. Audi and BMW have also shown self-driving car concepts, with the former working with Stanford University to pilot a modified TT up Pikes Peak.

A fully autonomous car can be defined as a car which is able to perceive its environment, decide what route to take to its destination, and drive it. The development of this could allow significant changes to travel – without the need for human supervision or operation, everyone in the car could be a passenger, or it could even drive with no occupants at all. This could allow productivity and leisure time to be reclaimed from commutes, transport accessibility to be widened for those previously unable to drive, and greater traffic efficiency. Autonomous cars could have a positive environmental impact. Driving at more consistent speeds, with less accelerating and braking, as well as more efficiently chosen routes could result in lower carbon emissions from driving.

This report analyzes the innovation in the field of autonomous cars with respect to the different control mechanisms, braking technologies and anti-collision systems used.

NOTE: All analysis in this report has been done on INPADOC Families (Extended Families) and so the data in the charts should be construed accordingly.

Patent Search Strategy

Using PatSeer following search query was used to create patent set.

TAC- Title, Abstract, Claims

TACD- Full Text

IC- International Class

CPC- Cooperative Patent Classification

(((TAC: (((autonomous* OR driver_less OR self_driv* OR autonomic* OR robotic) w3 (car OR vehicle)) OR ((collision_avoid* OR pre_crash system OR parking_assist* OR adapt*_brak* OR control*_brak* OR automatic*_brak* OR cruise_control*) AND (vehicle OR car)) OR (vehicle controls ECU))

AND

(IC:(B60W* OR B62D101/00 OR B62D109/00 OR B62D133/00 OR G07B15/02 OR G08G1/0955 OR G08G1/16 OR B60R21/00 OR B60K31/00 OR G01S13/93 OR B60T7/22 OR B62D6/00 OR B60T7/12 OR G05D1/0* OR B60R21/01 OR B60R21/013 OR B60T8/32 OR B62D101/00 OR B62D113/00 OR G01C22/00 OR G08G1/16 OR G01S17* OR G01C21/00 OR G08G1* OR B60L11/14 OR B60L15/20 OR B60L15/32 OR B60L15/40 OR B60L15/42 OR B60L11/18 OR B60L3* OR B60L7*)

OR

CPC:(B60K31* OR B60L11/14 OR B60L11/18 OR B60L15/20 OR B60L15/32 OR B60L15/40 OR B60L15/42 OR B60L3* OR B60L7* OR B60R19/483 OR B60R21/00 OR B60R21/01 OR B60R21/013 OR B60T7/12 OR B60T7/22 OR B60T8/32 OR B60W* OR B62D101/00 OR B62D109/00 OR B62D113/00 OR B62D133/00 OR B62D15* OR B62D6/00 OR G01C21* OR G01C22/00 OR G01S13/93 OR G01S13/931 OR G01S15/88 OR G01S15/93 OR G01S15/931 OR G01S17* OR G01S2013/9314 OR G01S2013/9317 OR G01S2013/9321 OR G01S2013/9325 OR G01S2013/9332 OR G01S2013/9339 OR G01S2013/9342 OR G01S2013/9346 OR G01S2013/935 OR G01S2013/9353 OR G01S2013/9357 OR G01S2013/936 OR G01S2013/9364 OR G01S2013/9367 OR G01S2013/9371 OR G01S2013/9375 OR G01S2013/9378 OR G01S2013/9382 OR G01S2013/9385 OR G01S2013/9389 OR G01S2015/938 OR G05D1/00 OR G05D1/0005 OR G05D1/0011 OR G05D1/0016 OR G05D1/0022 OR G05D1/0027 OR G05D1/0033 OR G05D1/0038 OR G05D1/0044 OR G05D1/005 OR G05D1/0055 OR G05D1/0061 OR G05D1/0066 OR G05D1/0072 OR G05D1/0077 OR G05D1/0088 OR G05D1/0094 OR G05D1/02 OR G05D1/021 OR G05D1/0212 OR G05D1/0214 OR G05D1/0217 OR G05D1/0219 OR G05D1/0221 OR G05D1/0223 OR G05D1/0225 OR G05D1/0227 OR G05D1/0229 OR G05D1/0231 OR G05D1/0234 OR G05D1/0236 OR G05D1/0238 OR G05D1/024 OR G05D1/0242 OR G05D1/0244 OR G05D1/0246 OR G05D1/0248 OR G05D1/0251 OR G05D1/0253 OR G05D1/0255 OR G05D1/0257 OR G05D1/0259 OR G05D1/0261 OR G05D1/0263 OR G05D1/0265 OR G05D1/0268 OR G05D1/027 OR G05D1/0272 OR G05D1/0274 OR G05D1/0276 OR G05D1/0278 OR G05D1/028 OR G05D1/0282 OR G05D1/0285 OR G05D1/0287 OR G05D1/0289 OR G05D1/0291 OR G05D1/0293 OR G05D1/0295 OR G05D1/0297 OR G05D1/03 OR G05D1/0891 OR G05D2201/02 OR G05D2201/0212 OR G05D2201/0213 OR G07B15/02 OR G08G1*))

AND NOT

TACD:(saddle*_vehicle OR aerial_vehicle OR underwater OR UAV OR AUV OR ROV OR tripod OR autonomous_underwater_vehicles OR unmanned_underwater_vehicles))

AND

TAC:(vehicle_propel* OR (adapt* w2 control*) OR vehicle_speed OR vehicle_steer* OR vehicle_stability OR (collision* w2 (detect* OR response*)) OR ((adaptive OR automatic*) w2 brak*) OR ((cruise* OR park*) w2 assist*) OR warning_system* OR alarm_system* OR (lane* w2 keep*) OR lane_keep* OR automatic_park*)))

- The query was directed to search through the title, abstract and claims. The individual results were collapsed to one publication per family which was then exported from PatSeer and imported in Patent iNSIGHT Pro.
- After reviewing few results across different publication years, we came across some similar but irrelevant terms which we then excluded from the data set manually.
- Result set of 7724 records was analyzed using the software.
- Class Definitions are mentioned at the end of the report under Appendix section.

The publications included in the report are updated as of 28th March, 2016

Evolution of Driverless Cars over the Years

1920-1930

- In 1925, Houdina Radio Control demonstrated the radio-controlled driverless car "linrrican Wonder" on New York City streets, traveling up Broadway and down Fifth Avenue through the thick of the traffic jam
- An early representation of an automated guided car was Norman Bel Geddes's Futurama exhibit sponsored by General Motors at the 1939 World's Fair, which depicted radio-controlled electric cars that were propelled via electromagnetic fields provided by circuits embedded in the roadway.

1950-1980

- Special radio receivers and audiovisual warning devices,Electronically Controlled Highways, Relaying Computer Messages
- Laser Radar, Computre Vision, Autonomous Robotic Control,demonstration of the first off-road map and sensor-based autonomous navigation on the Automatic Land Vehicle(ALV).

1990-2010

- Demonstrations of close-headway platooning intended to operate in segregated traffic, as well as "free agent" vehicles intended to operate in mixed traffic
- autonomous driving in free lanes, convoy driving, and lane changes with autonomous passing of other cars
- Carnegie Mellon University's Navlab project completed a 3,100 miles (5,000 km) cross-country journey, of which 98.2% was autonomously controlled, dubbed "No Hands Across America
- RFID Tags and Real Time Control Systems
- Artificial Intelligence and emergance of LIDAR technology ,Sensors, Global Positioning Systems, 3-D Maps, Stereo vision and Mono vision Camaras

2011-2016

- Freie Universität Berlin developed two autonomous cars to drive in the innercity traffic of Berlin in Germany
- VisLab conducted another pioneering test of autonomous vehicles, during which a robotic vehicle drove in downtown Parma with no human control, successfully navigating roundabouts, traffic lights, pedestrian crossings and other common hazards
- Infiniti Q50 uses cameras, radar and other technology to deliver various lane-keeping, collision avoidance and cruise control features
- First self-driving vehicle to be available for commercial sale
- Google announced plans to unveil 100 autonomous car prototypes built from scratch inside Google's secret X lab
- Tesla Motors announced its first version of AutoPilot. Model S cars equipped with this system are capable of lane control with autonomous steering, braking and speed limit adjustment based on signals image recognition. The system also provide autonomous parking and is able to receive software updates to improve skills over time
- A car designed by Delphi Automotive became the first automated vehicle to complete a coast-to-coast journey across North America
- Google announced that the test vehicles in its driverless car project had been involved in 14 minor accidents since the project's inception in 2009.All of the accidents were caused by humans driving other cars, and that 11 of the mishaps were rear-end collisions

Technical Segmentation (Patent Categorization)

Control Mechanisms	Anti-Collision System	Breaking Mechanism
• Blind Spot Detection • Cruise Control • Lane Keeping • LIDAR • Parking Assist • Propulsion • Stability • Steering • Traffic Jam Assist • Warning System • Wheel Speed Sensor	• Collision Detection • Obstacle Detection	• Adaptive Braking • Automatic Braking

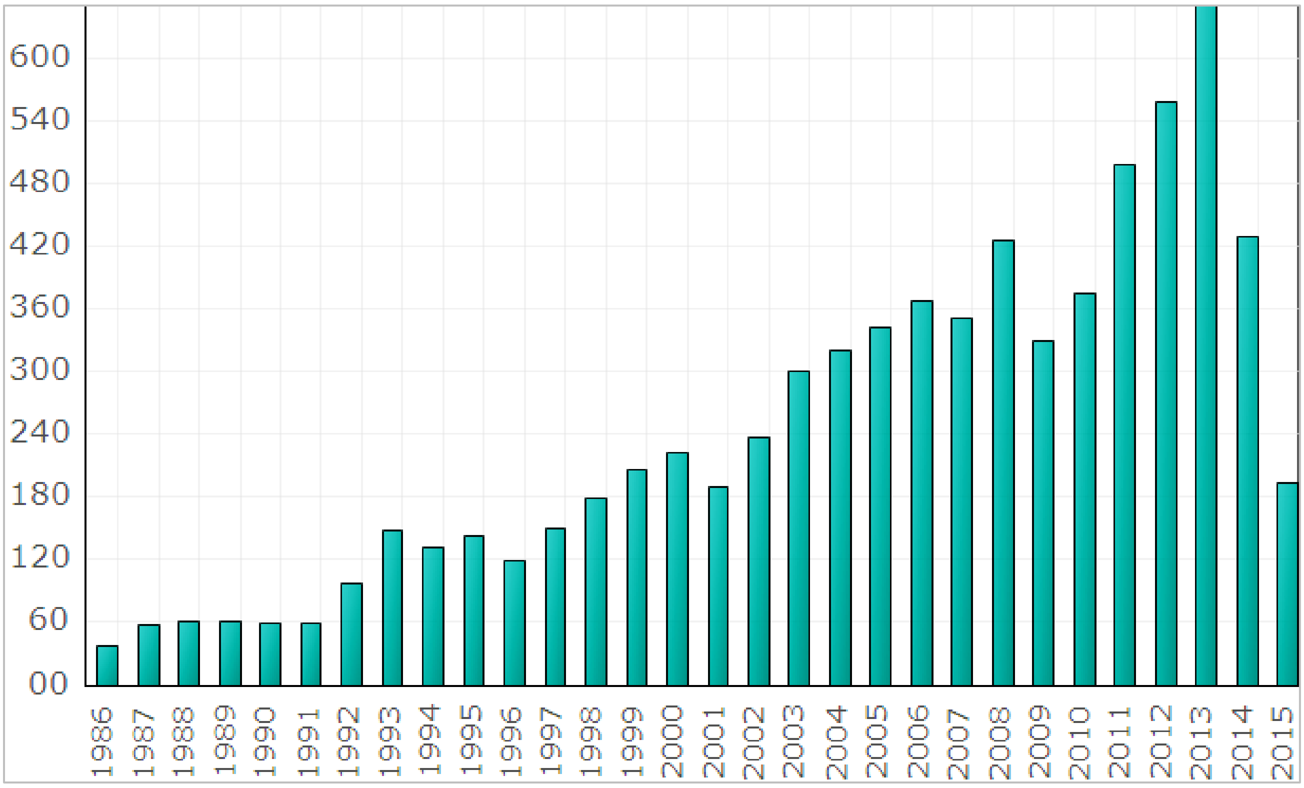
The categorization involved defining a search strategy for each topic and then conducting the search using the Advanced Searching capability in Patent iNSIGHT Pro. Details of search strings used for each category are given in Appendix.

Filing Trend

The chart below shows number of filings for driverless cars during the last 30 years. The number of filings has steadily increased since 2000 with a minor fall in the number of filings during 2008-2009.

The overall trend has seen constant rise in the number of filings with sudden rise from the year 2011. From 40 filings in the year 1986 to nearly 700 in 2013, driverless cars have seen tremendous increase.

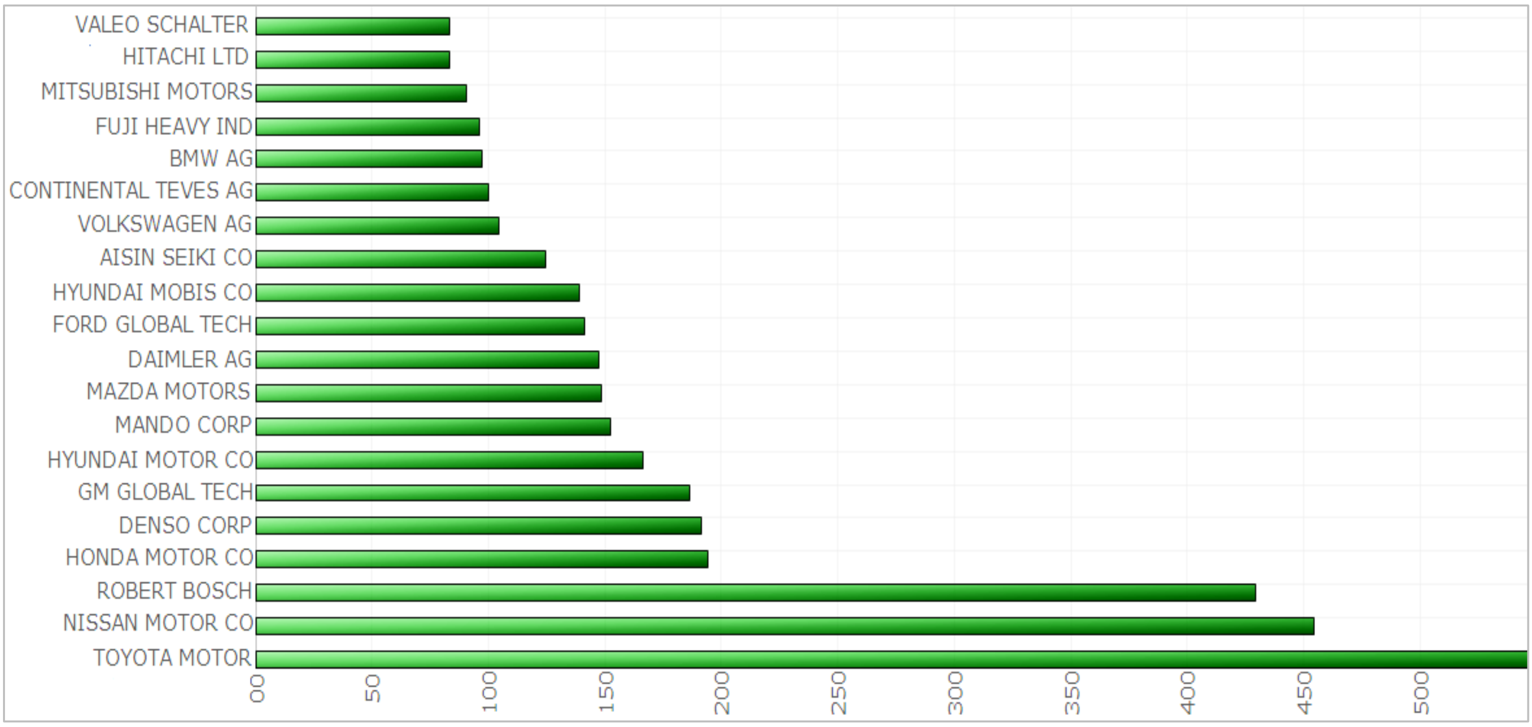
It's clear the current activity around these technologies is likely to continue seeing more innovation in the near future.



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 Companies



The top companies in Autonomous Car are:

1. TOYOTA MOTOR CORP
2. NISSAN MOTOR CO LTD
3. ROBERT BOSCH GMBH
4. HONDA MOTOR CO LTD
5. DENSO CORP
6. GM GLOBAL TECHNOLOGIES
7. HYUNDAI MOTOR CO
8. MANDO CORP
9. MAZDA MOTORS
10. DAIMLER AG
11. FORD GLOBAL TECH LLC
12. HYUNDAI MOBIS CO LTD
13. AISIN SEIKI CO LTD
14. VOLKSWAGEN AG
15. CONTINENTAL TEVES AG
16. BMW AG
17. FUJI HEAVY INDUSTRIES
18. MITSUBISHI MOTORS
19. HITACHI LTD
20. VALEO SCHALTER UND SENSOREN GMBH

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:

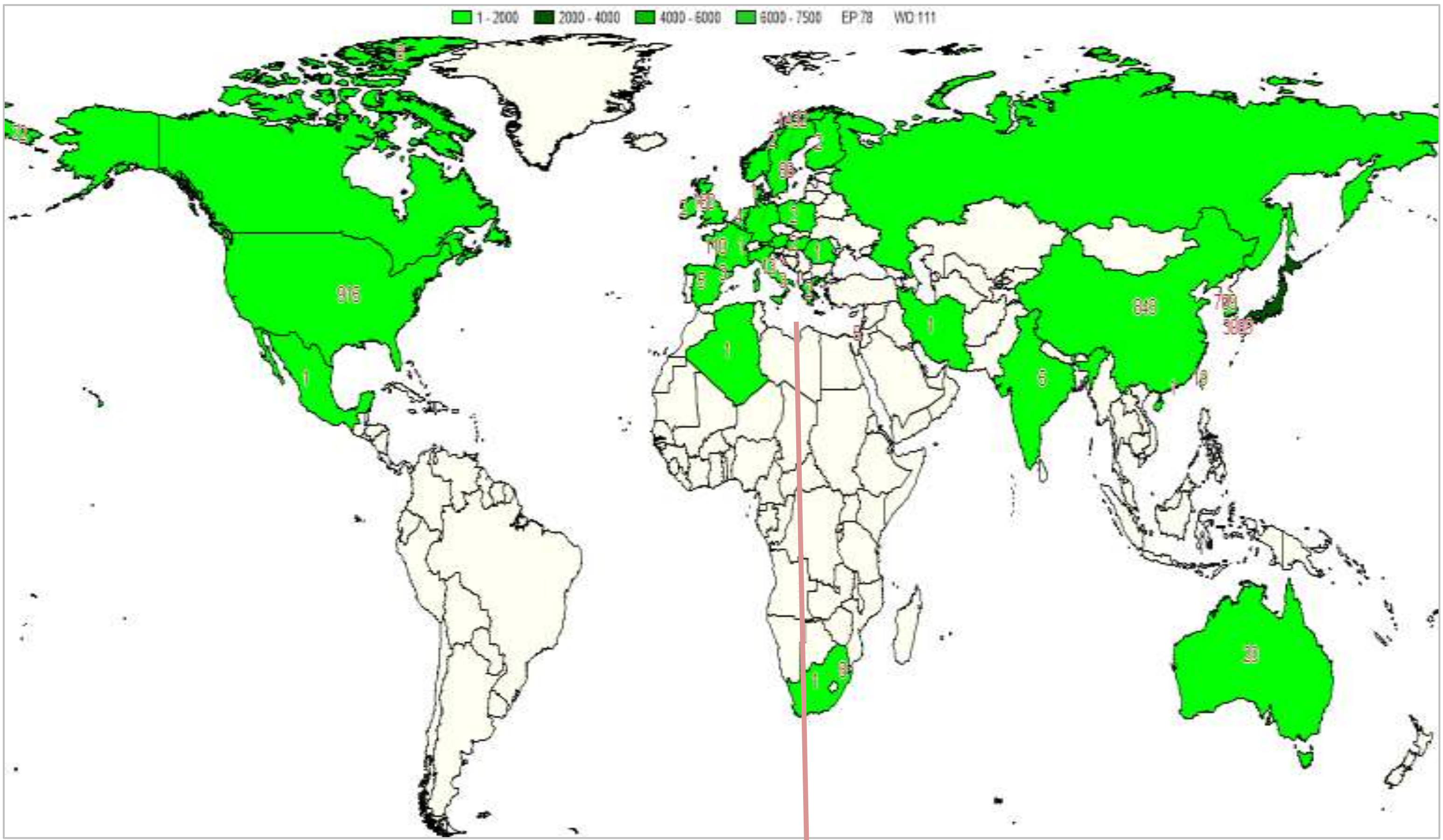
- To locate assignees for unassigned records
- To clean up records having multiple assignees
- To locate the correct assignee names for US records using the US assignments database
- To merge assignees that resulted from a merger or acquisition or name change.

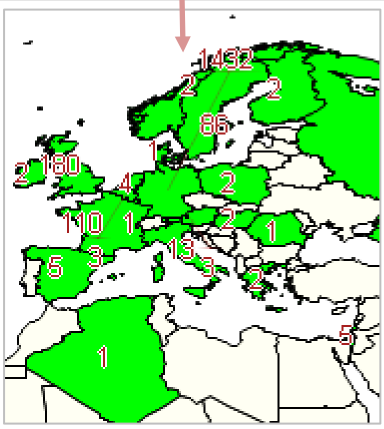
The dashboard tool within Patent iNSIGHT Pro was used to find the top 20 assignees within the given patent set. A visual graph was created based on the results of the top assignees with the number of patents alongside each one.

The complete Assignee table in available in the following Excel file:
http://www.patentinsightpro.com/techreports/0416/List%20of%20Assignees.xls

Research activity around the world

The below map represents the geographical filing of patents relating to driverless car technology. The table below ranks top priority countries and helps provide an indication of where innovation in this area is originating.
Toyota which is the leading entity in driverless car technology makes Japan the leading country in this field with 3089 families followed by Germany (1432) and US (915). The strength of the coloring represents the proportion of patent publications.





Country Code	Total
JP	3089
DE	1432
US	915
CN	843
KR	709
GB	180

How we did it?

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

Companies - Key Statistics

Here we summarize key parameters of Top 15 companies such as filing trend, Top inventors in each company and Coverage of underlying patent families

Assignee	Total No. of Records	Avg. No. of Fwd Cites per Patents	Key Inventor (Top 5)	Co-Assignees	Coverage(Includes families)								
					US	EP	WO	JP	DE	FR	CN	KR	IN
TOYOTA MOTOR CORP	546 (7.1%)	4.13	ENDO TOMOHIKO KUBOTA YUICHI SATONAKA HISASHI MAKINO YASUSHI IWAKIRI HIDEYUKI	AISIN SEIKI CO LTD ADVICS CO LTD DENSO CORP TOYOTA CENTRAL RESEARCH & DEVELOPMENT LAB INC AISIN AW CO LTD	195	116	131	502	106	4	123	36	11
NISSAN MOTOR CO LTD	454 (5.9%)	6.11	SETO YOJI YAMAMURA YOSHINORI TAMURA MINORU INOUE HIDEAKI SUZUKI TATSUYA	JATCO CO LTD NAT INST OF ADV IND & TECHNOL UNIV KYUSHU	148	76	20	426	82	1	35	8	1
ROBERT BOSCH GMBH	429 (5.6%)	4.18	WINNER HERMANN NIEMZ VOLKER UHLER WERNER SCHNEIDER MARCUS SCHERL MICHAEL	ROBERT BOSCH ENG & BUSINESS SOLUTIONS LTD	225	245	210	148	393	48	109	31	16
HONDA MOTOR CO LTD	194 (2.5%)	3.97	SEKINE HIROSHI URAI YOSHIHIRO SAKAI KATSUHIRO ARAI TOSHIAKI SHIMIZU YASUO	No Co-Assignee Present	69	28	11	181	32	0	23	5	1

DENSO CORP	191 (2.5%)	5.17	ISOGAI AKIRA TERAMURA EIJI TSURU NAOHIKO ITO YOSUKE SHIMIZU HIROAKI	NIPPON SOKEN INC TOYOTA MOTOR CORP ADVICS CO LTD HINO MOTORS LTD DENSO IT LAB INC	71	13	6	180	47	3	24	4	0
GM GLOBAL TECHNOLOGY OPERATIONS INC	186 (2.4%)	7.19	LEE JIN-WOO ZAGORSKI CHAD T CHEN SHIH-KEN LITKOUHI BAKHTIAR BRIAN MOSHCHUK NIKOLAI K	No Co-Assignee Present	168	7	13	5	141	1	107	0	7
HYUNDAI MOTOR CO LTD	166 (2.1%)	1.3	LEE CHAN KYU KIM JONG CHUL KIM SANG JOON KIM JEE YOUNG JEON JAE HWAN	KIA MOTORS CORP	52	2	0	23	29	0	35	162	0
MANDO CORP	152 (2%)	0.85	NOH TAE BONG KIM JAE SUK YOU KWAN SUN YOO JE HONG PARK MAN BOK	No Co-Assignee Present	29	1	0	1	28	0	23	152	0
MAZDA MOTORS CORP	148 (1.9%)	7.27	ADACHI TOMOHIKO YAMAMOTO YASUNORI NIIBE TADAYUKI KAMIMURA HIROKI ISHIKAWA TOSHIHIRO	NALDEC KK	30	5	1	140	19	0	1	3	0
DAIMLER AG	147 (1.9%)	6.08	STEINER MANFRED KNOFF BERND RUMP SIEGFRIED ECKL ALBRECHT REUTTER DOMINIC	No Co-Assignee Present	62	19	24	69	121	32	4	0	0

FORD GLOBAL TECH LLC	141 (1.8%)	6.39	ENGELMAN GERALD H TELLIS LEVASSEUR PILUTTI THOMAS EDWARD LU JIANBO STEFAN FREDERIC	No Co-Assignee Present	129	20	5	6	89	0	75	0	0
HYUNDAI MOBIS CO LTD	139 (1.8%)	0.18	LEE SEONG SOO KIM IL HAN KIM HYE RIM KIM JEONG KU HAM JUN HO	No Co-Assignee Present	19	3	0	0	8	0	53	137	0
AISIN SEIKI CO LTD	124 (1.6%)	6.66	WATANABE KAZUYA SATONAKA HISASHI IWATA YOSHIFUM ENDO TOMOHIKO TANAKA YUU	TOYOTA MOTOR CORP	67	38	23	114	31	2	29	10	0
VOLKSWAGEN AG	104 (1.3%)	6.78	WUTTKE ULRICH HUEGER PHILIPP ROHLFS MICHAEL TERKES MEHMET MAI RUDOLF	AUDI AG VALEO SCHALTER UND SENSOREN GMBH	26	40	24	6	94	1	15	4	0
CONTINENTAL TEVES AG & CO OHG	100 (1.3%)	3.57	STAEHLIN ULRICH ECKERT ALFRED GRONAU RALPH LUEKE STEFAN BAYER RONALD	No Co-Assignee Present	48	54	60	28	83	0	17	23	0

How we did it?

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, key associated companies and top 5 co-inventors.

Inventor	Total No. of Records	Avg. No. of Fwd Cites per Patents	Filing Year Range	Key Assignees (Top 5)	Co-Inventors
ENDO TOMOHIKO	47 (0.6%)	6.3	2003 - 2010	TOYOTA MOTOR CORP AISIN SEIKI CO LTD	KUBOTA YUICHI IWAKIRI HIDEYUKI SATONAKA HISASHI KATAOKA HIROAKI KAWAKAMI SEIJI
SATONAKA HISASHI	41 (0.5%)	6.51	1995 - 2013	TOYOTA MOTOR CORP AISIN SEIKI CO LTD	ENDO TOMOHIKO KATAOKA HIROAKI KAWAKAMI SEIJI IWAKIRI HIDEYUKI IWATA YOSHIFUMI
KUBOTA YUICHI	37 (0.5%)	6.86	1998 - 2013	TOYOTA MOTOR CORP AISIN SEIKI CO LTD	ENDO TOMOHIKO IWAKIRI HIDEYUKI SATONAKA HISASHI KATAOKA HIROAKI KAWAKAMI SEIJI
SETO YOJI	36 (0.5%)	7.06	1995 - 2008	NISSAN MOTOR CO LTD	YAMAMURA YOSHINORI NAKAMURA MASAHIDE TAMURA MINORU INOUE HIDEAKI KOBAYASHI YOSUKE
SHIMAZAKI KAZUNORI	34 (0.4%)	5.97	2001 - 2010	TOYOTA IND CORP TOYOTA MOTOR CORP LOREAL SA	KIMURA TOMIO YAMADA SATOYUKI NAKASHIMA YUTAKA HIKA KOJI YAMADA SATOSHI

WINNER HERMANN	34 (0.4%)	6.24	1997 - 2011	ROBERT BOSCH GMBH CONTINENTAL TEVES AG & CO OHG VOLKSWAGEN AG UNIV DARMSTADT TECH HONDA MOTOR CO LTD	HELLMANN MANFRED UHLER WERNER IRION ALBRECHT LUEDER JENS WEILKES MICHAEL
KIMURA TOMIO	32 (0.4%)	6.25	2001 - 2010	TOYOTA IND CORP TOYOTA MOTOR CORP	SHIMAZAKI KAZUNORI YAMADA SATOYUKI NAKASHIMA YUTAKA HIKA KOJI HIGA KOJI
IWAKIRI HIDEYUKI	31 (0.4%)	6.81	2003 - 2008	TOYOTA MOTOR CORP AISIN SEIKI CO LTD	ENDO TOMOHIKO KUBOTA YUICHI SATONAKA HISASHI KATAOKA HIROAKI KAWAKAMI SEIJI
KAWAKAMI SEIJI	28 (0.4%)	7.64	1993 - 2007	TOYOTA MOTOR CORP AISIN SEIKI CO LTD	KATAOKA HIROAKI ENDO TOMOHIKO SATONAKA HISASHI IWATA YOSHIFUMI IWAZAKI KATSUHIKO
OKUYAMA HIROKAZU	28 (0.4%)	2.71	1997 - 2008	HINO MOTORS LTD	EZOE TOSHIKI OKAMOTO KOICHI ICHINOSE SUNAO NARATA SHUJI KAGAWA MASAKATSU
EZOE TOSHIKI	27 (0.3%)	1.93	2006 - 2014	HINO MOTORS LTD	ICHINOSE SUNAO OKUYAMA HIROKAZU OKAMOTO KOICHI NARATA SHUJI HOKARI SATOSHI
KATAOKA HIROAKI	27 (0.3%)	7.89	2002-2007	TOYOTA MOTOR CORP AISIN SEIKI CO LTD	KAWAKAMI SEIJI ENDO TOMOHIKO SATONAKA HISASHI IWATA YOSHIFUMI IWAZAKI KATSUHIKO

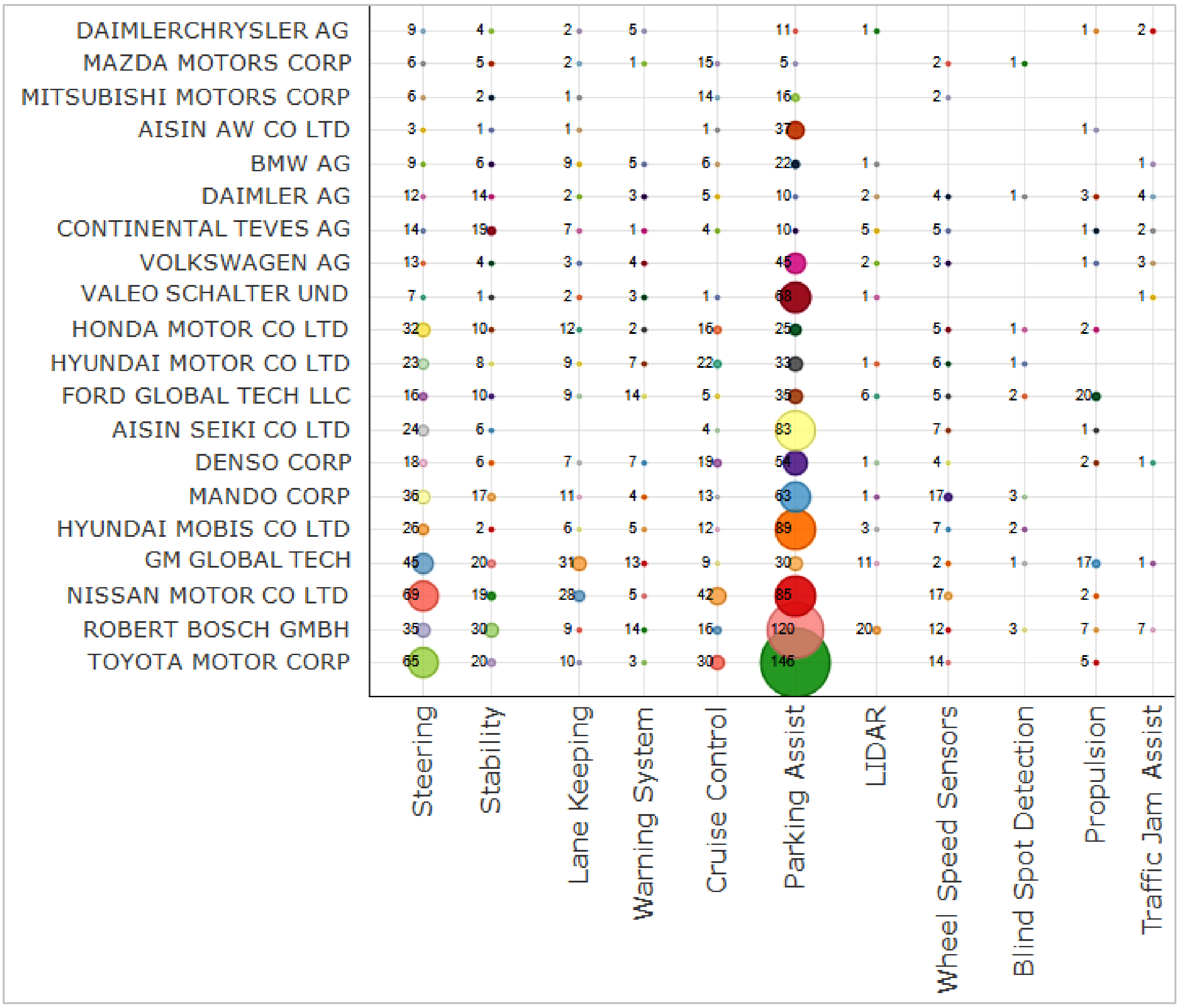
IWATA YOSHIFUMI	26 (0.3%)	7.96	2001-2007	AISIN SEIKI CO LTD TOYOTA MOTOR CORP	ENDO TOMOHIKO KATAOKA HIROAKI KAWAKAMI SEIJI SATONAKA HISASHI TANAKA YUU
YAMAMURA YOSHINORI	26 (0.3%)	10.5	1997-2007	NISSAN MOTOR CO LTD	SETO YOJI TAMURA MINORU NAKAMURA MASAHIDE TAKAHASHI MASAKI KOBAYASHI YOSUKE
JOHANSSON OSKAR	25 (0.3%)	0.36	2010-2013	SCANIA CV AB	ROOS FREDRIK SÖDERGREN MARIA SOEDERGREN MARIA ÖGREN MIKAEL EVALDSSON MARTIN

How we did it?

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 was then exported to Excel using the option provided for the same.

Company activity across Control Mechanisms

- The chart below shows research activity of companies across different Control mechanisms used in driverless car
- Toyota has the most number of records for Parking Assist followed by Robert Bosch and Nissan Motors
- GM Global has the maximum number of records for Lane Keeping and Warning Systems

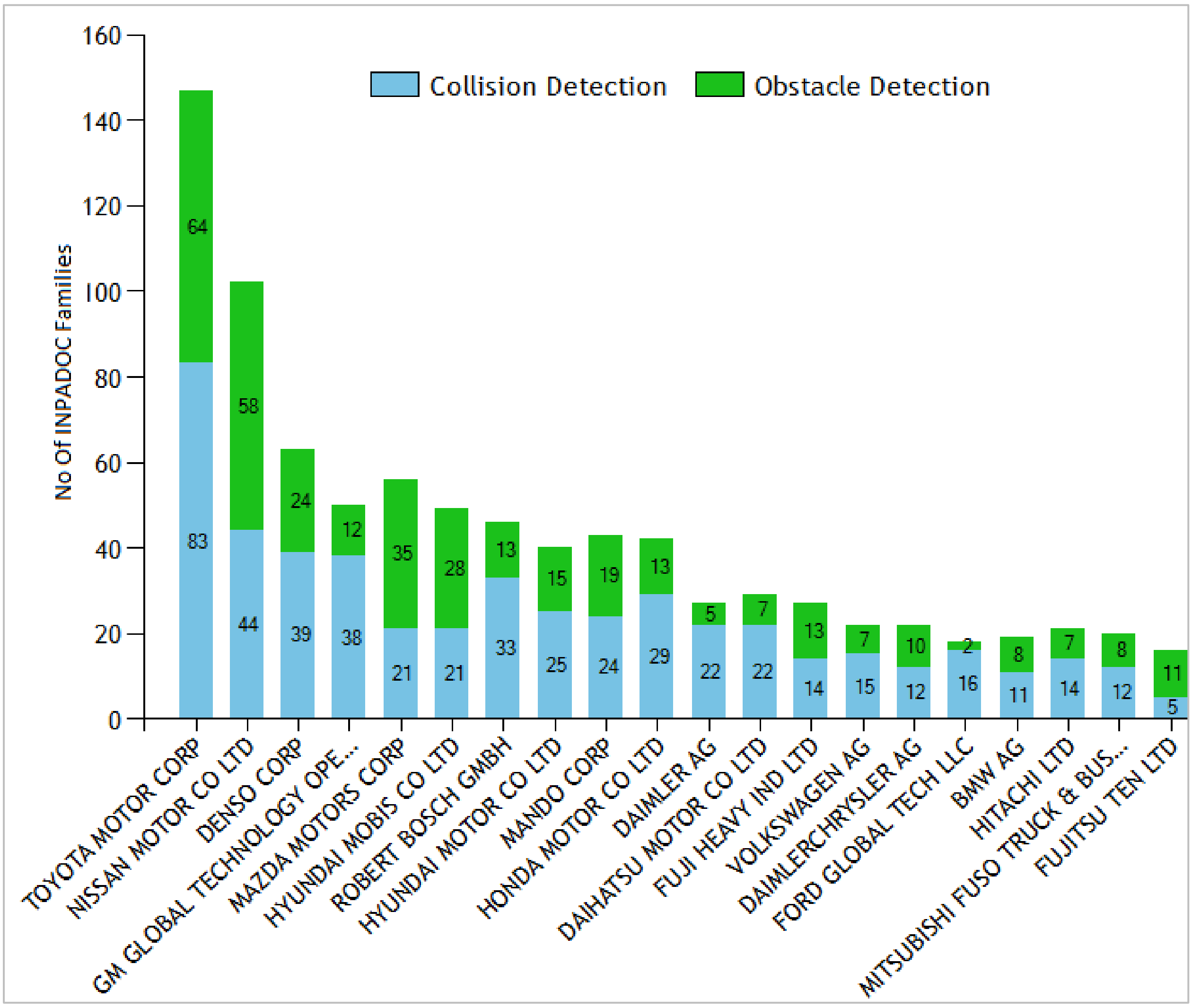


How we did it?

First various mechanisms used for driverless cars were identified by manual research. Then by using a combination of semantic analysis tools such as clustering tools and searching tools available in Patent iNSIGHT Pro, records were categorized under different mechanisms. A co-occurrence matrix was generated using the co-occurrence analyzer to map the different mechanisms with assignees. The matrix was filtered for the top 20 assignees and was converted into bubble column chart using the option provided in software for the same.

Company activity across Anti-Collision Systems

- The chart below shows research activity of companies across the types of anti-collision systems used
- Collision Detection has more number of records filed as compared to Obstacle Detection
- Toyota has the largest number of patents pertaining to Collision Detection followed by Nissan

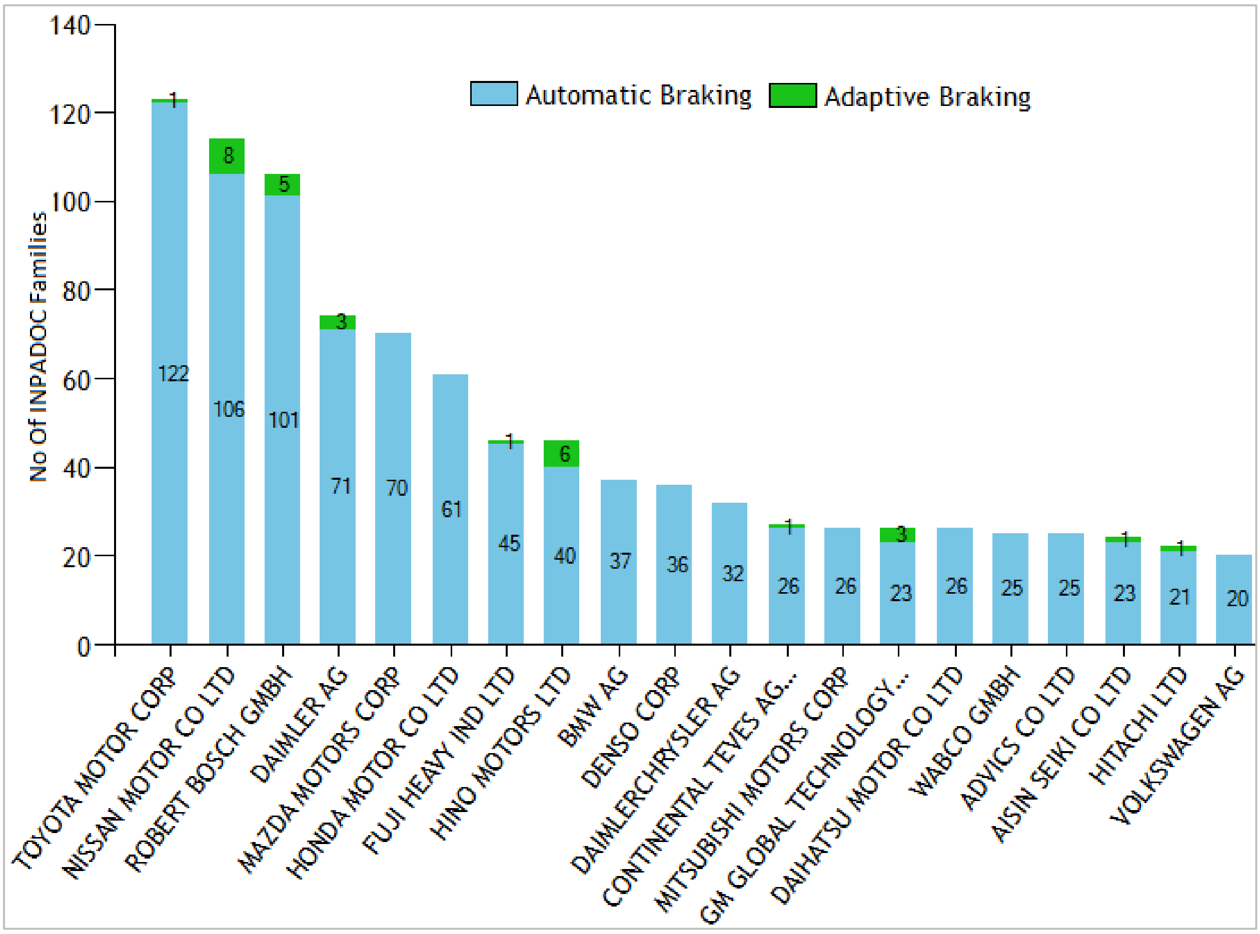


How we did it?

First various types of anti collision systems were identified by manual research. Then by using a combination of semantic analysis tools such as clustering tools and searching tools available in Patent iNSIGHT Pro, records were categorized under various anti collision systems. A co-occurrence matrix was generated using the co-occurrence analyzer to map the anti collision systems with assignees. The matrix was filtered for the top 20 assignees and types and converted into Stacked Column chart using the option provided in software for the same.

Company activity across Braking Mechanisms

- The chart below shows research activity of companies across different braking mechanisms used in a driverless car
- Automatic Braking seems to be the most widely used braking mechanism with nearly 2100 families
- Toyota lies at the top for patents relating to automatic braking closely followed by Nissan and Robert Bosch
- Nissan and Hino have some research interest in adaptive braking



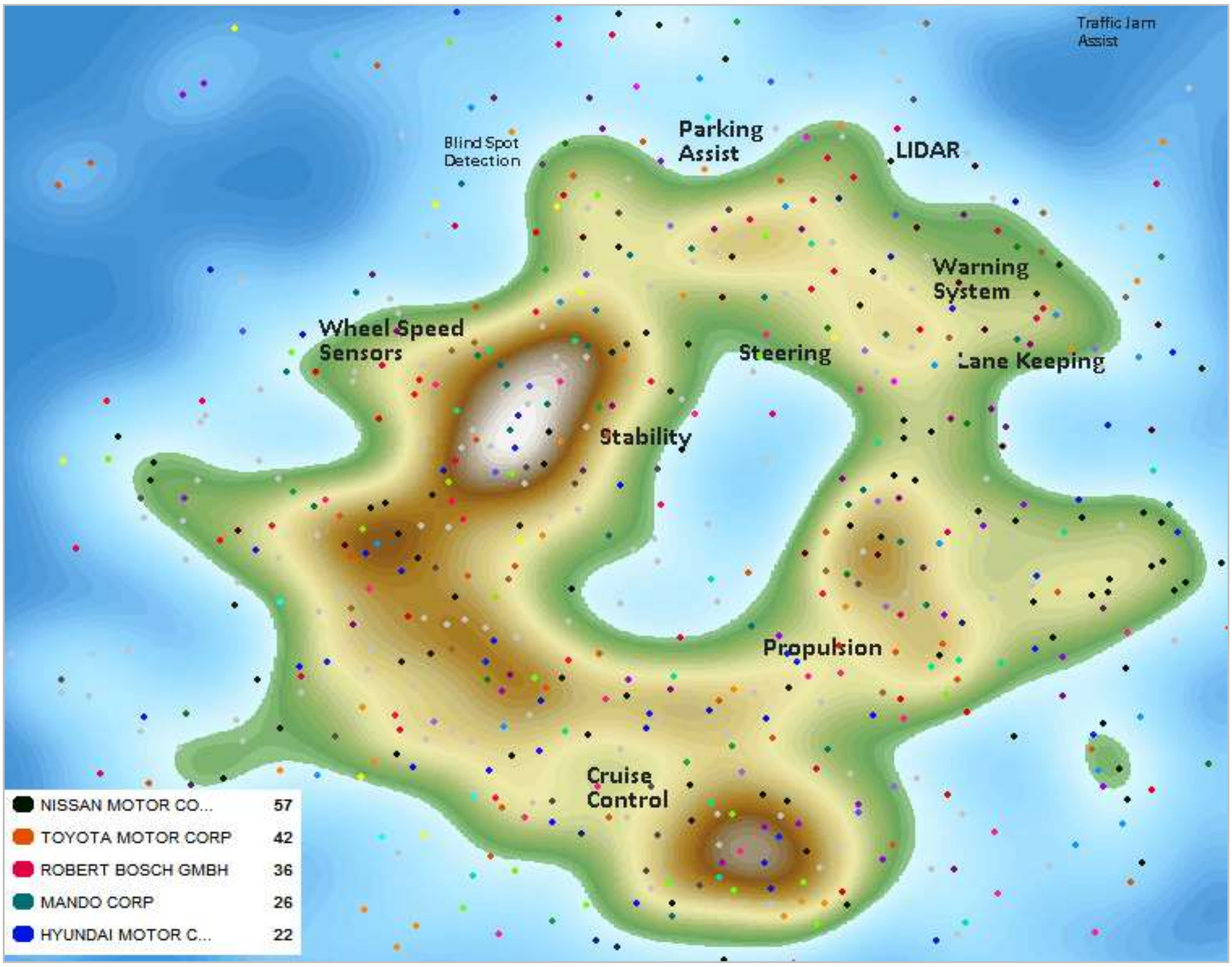
How we did it?

First various braking mechanisms were identified by manual research. Then by using a combination of semantic analysis tools such as clustering tools and searching tools available in Patent iNSIGHT Pro, records were categorized under different braking mechanisms. A co-occurrence matrix was generated using the co-occurrence analyzer to map the different braking mechanisms and assignees. The matrix was filtered for the top 20 assignees and was converted into Stacked Column chart using the option provided in software for the same.

Technology Landscape for different mechanisms used by a driverless car

The contour map below represents key concepts for different companies across various mechanisms used in a driverless car.

Clusters for Cruise Control and Propulsion and the records relating speed of the vehicle namely Wheel Speed Sensor and Steering are close to each other as there is high degree of relevance between the records present in those types of methods. The patents represented by dots were coloured by company.



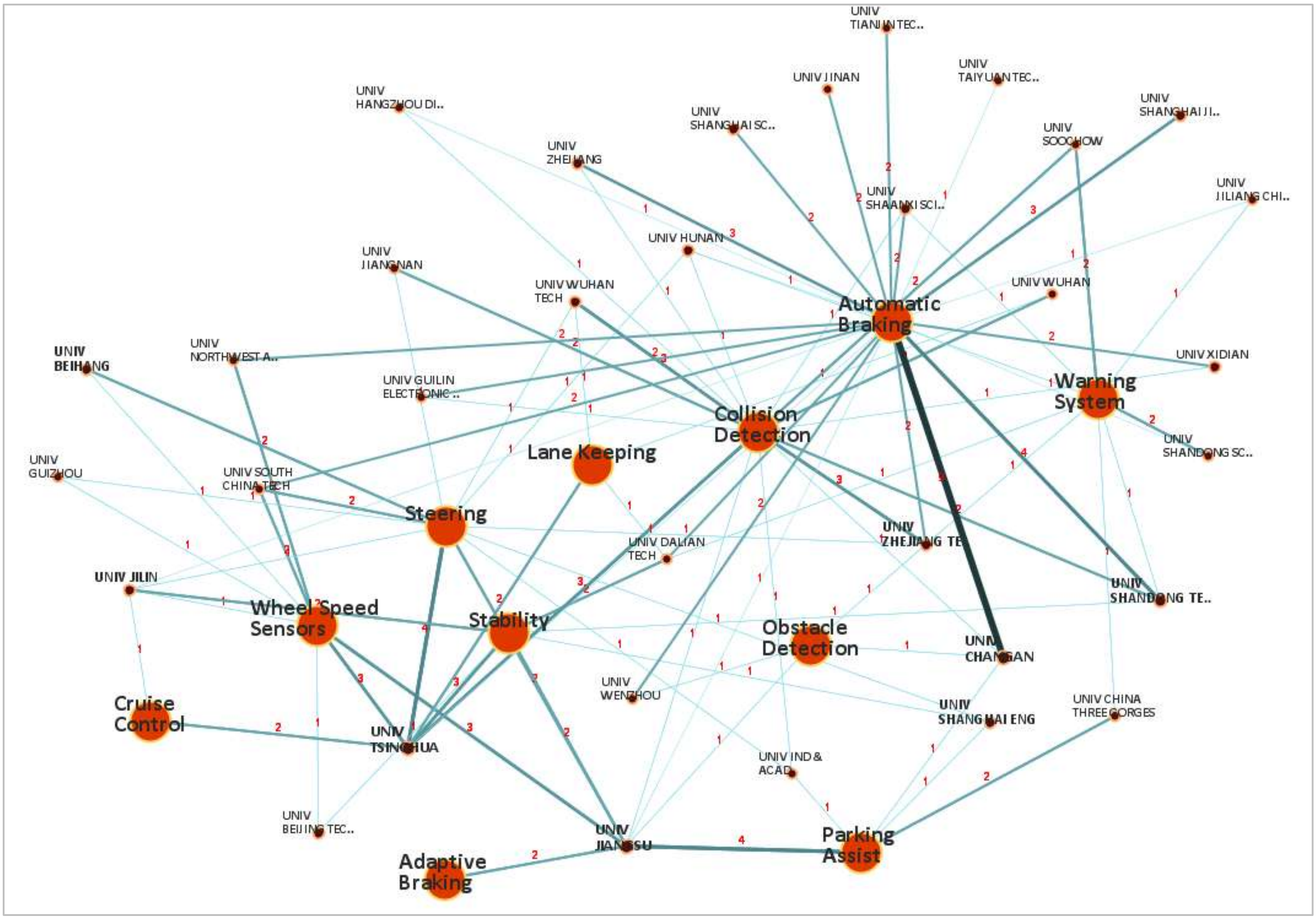
How we did it?

The VizMAP tool in Patent iNSIGHT Pro was used for this analysis. First the clusters for different mechanisms were loaded on the map. They were analyzed on basis of their contextual similarity using title, abstract and claims as Text and technology as UDC from the 'Context mode' option. We removed unrelated patents using the "Hide Unrelated records" option and one patent assignee using the options available in VizMAP.

Universities and their research interest across different technology segmentations

In the map, each company is connected to particular technology area through links whose thickness and color intensity is directly proportional to the number of records relating them. The number (in red) next to each line represents the number of records held by Universities present in a particular technology area.

It can be seen that Univ Changan is mainly into Automatic Braking and Univ Jiangsu focuses more on Parking Assist as compared to other segmentations.



How we did it?

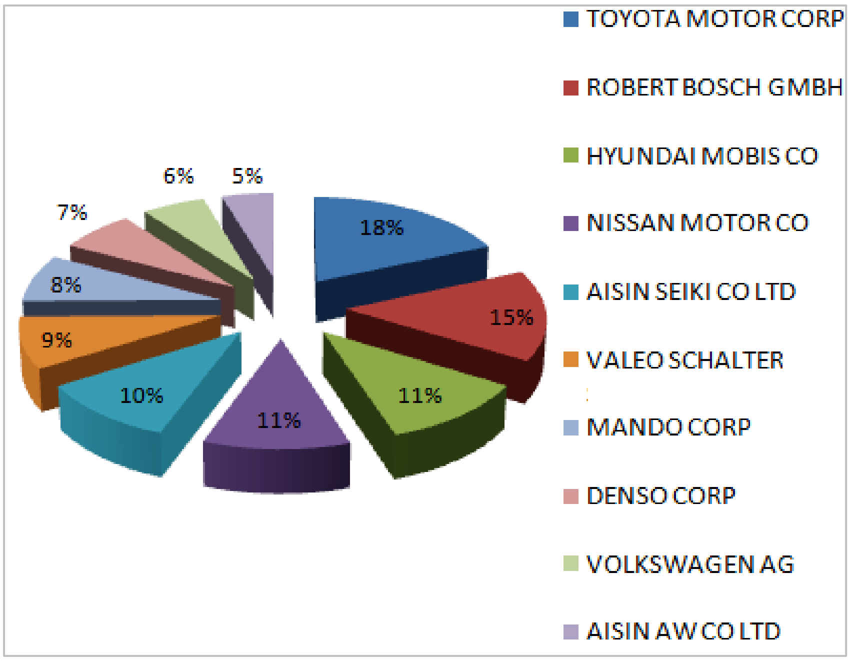
We first filtered all the universities having research interest in driverless car technology from 'Analyze by' option available in VIZMAP. These were then correlated with all the technological segmentations and a correlation map was generated. Inter member links were hidden using the 'Hide Member Links' option available.

Analysis for key mechanisms used by driverless cars

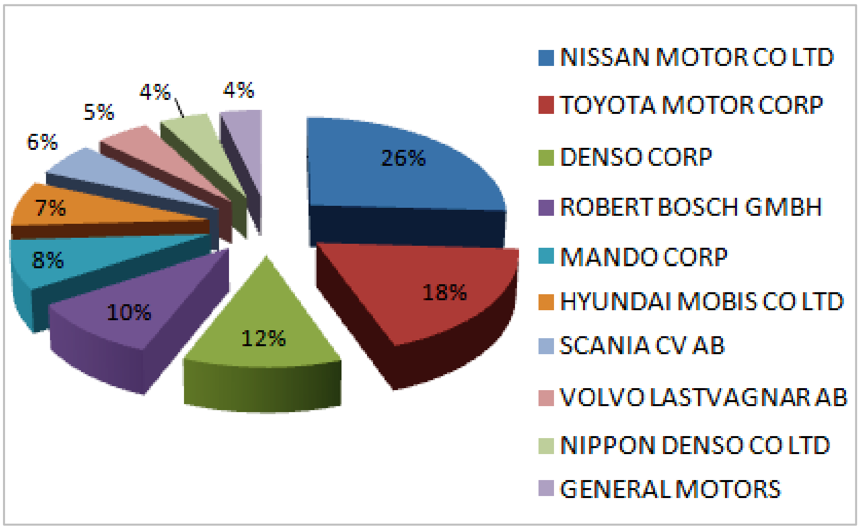
This section focuses on key mechanisms used by various companies.

- Parking Assist
- Cruise Control
- Lane Keeping
- LIDAR

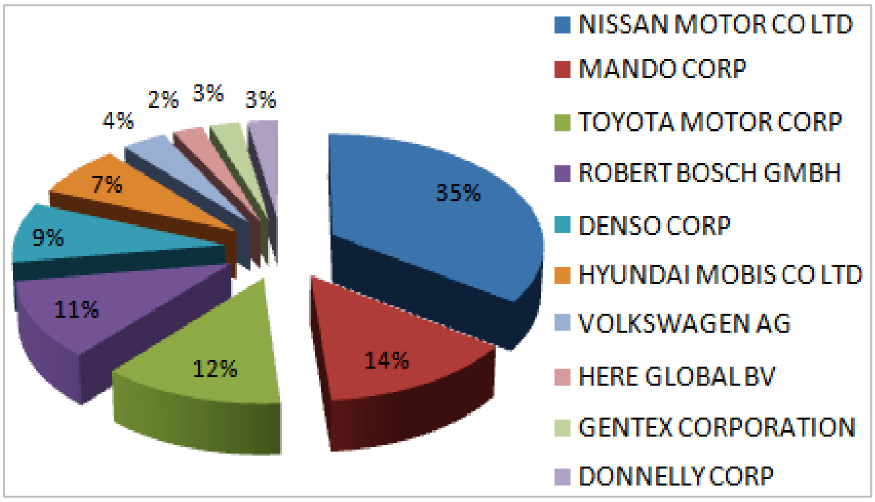
The pie chart below displays Top 10 Companies in the field of **Parking Assist** (1504 Families). Some of the companies which are a part of this list are Toyota, Robert Bosch, Hyundai.



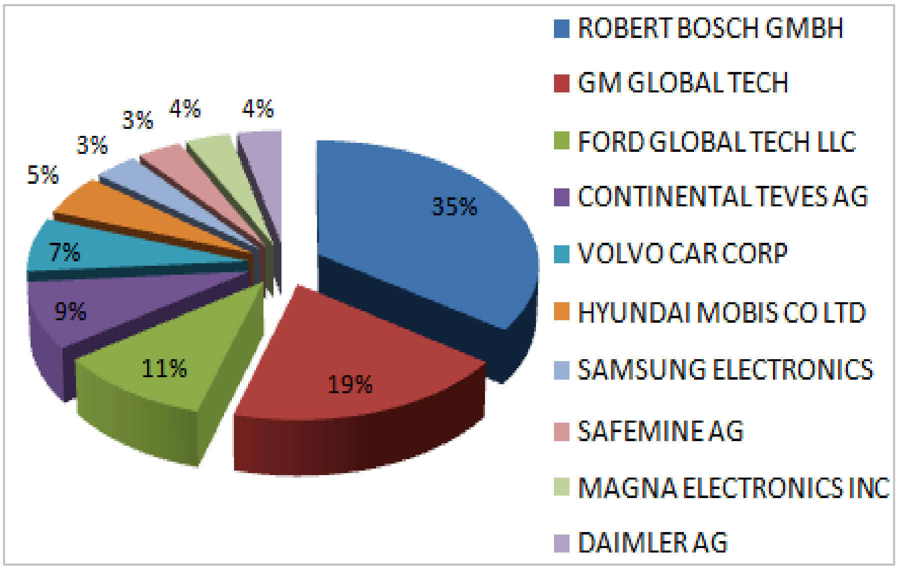
The pie chart below displays Top 10 Companies in the field of **Cruise Control** (500 Families). Some of the companies which are a part of this list are Nissan, Denso, and Toyota, etc.



The pie chart below displays Top 10 Companies in the field of **Lane Keeping** (295 Families). Some of the companies which are a part of this list are Mando, Nissan, Robert Bosch.



The pie chart below displays Top 10 Companies in the field of **LIDAR** (92 Families). Some of the companies which are a part of this list are GM Global, Volvo. Some of the lesser known companies Safemine AG, Magna are also a part of the top 10 filers for LIDAR.



How we did it?

We identified some key mechanisms used in driverless cars. These mechanisms were analyzed using co-occurrence analyzer with respect to assignees, the generated matrix was exported to excel and pie chart was generated for the same.

Appendix: Search Strings Used for Categorization

Mechanisms:

Mechanisms	Search Query	Results
Blind Spot Detection	(TAC) contains ((blind* w/2 (detect* OR assist*)) OR BSD)	31
Cruise Control	(TAC) contains ((vehicle* OR car*) w/3 (speed* AND cruis*) OR CCVS OR crusing OR (cruise* w/2 (control* OR assist*)) OR ACC)	500
Lane Keeping	(TAC) contains ((lane* w/2 (keep* OR chang* OR depart*)) OR LKAS)	295
LIDAR	(TAC) contains ((Light* w/3 Rang*) OR LIDAR)	92
Parking Assist	(TAC) contains ((park* w/2 assist*) OR (self w/2 park*)	1504
Propulsion	(TAC) contains ((vehicle* OR car*) w/3 (propul* OR propeller* OR propelled OR propel*))	177
Stability	(TAC) contains ((vehicle* OR car* OR electronic* OR dynamic* OR electric*) w/3 (stability OR stabilization OR stabilized OR stabilizing) OR ESC OR ESP OR DSC OR skidding OR (vehicle* w/2 dynamic*))	344
Steering	(TAC) contains ((vehicle* OR car*) w/3 (steer*) OR oversteer* OR (active* w/2 steer*))	866
Traffic Jam Assist	(TAC) contains (traffic* w/3 (assist* OR recogni*))	43
Warning System	(TAC) contains ((warn* OR alarm*) w/2 system*)	318
Wheel Speed Sensor	(TAC) contains (wheel* w/3 speed w/3 sens*)	221

Anti-Collision System:

Anti-Collision System	Search Query	Results
Collision Detection	(TAC) contains ((collision*) w/3 (detect* OR avoid*) OR (time* w/2 colli*))	1063
Obstacle Detection	(TAC) contains ((obstacle*) w/3 (detect* OR avoid*))	632

Braking Control Mechanism:

Methods	Search Query	Results
Adaptive Braking	(TAC) contains ((adaptive* w/3 brak*) OR (anti* w/2 skid*) OR (anti* w/2 lock*))	82
Automatic Braking	(TAC) contains (automatic* w/2 brak*)	2118

Definitions of Classes referred to in search query

IPC:

IPC	Description
B60W	Conjoint control of vehicle sub-units of different type or different function
B62D 101/00	Road speed
B62D 109/00	Presence, absence or inactivity of driver or operator
B60L 7/00	Electrodynamic brake systems for vehicles in general
B60L 3/00	Electric devices on electrically-propelled vehicles for safety purposes
B60L 11/18	Electric propulsion with power supplied within the vehicle -using power supplied from primary cells, secondary cells, or fuel cells
B60L 15/42	Adaptation of control equipment on vehicle for actuation from alternative parts of the vehicle
B60L 15/40	Adaptation of control equipment on vehicle for remote actuation from a stationary place
B60L 15/32	Control or regulation of multiple-unit electrically-propelled vehicles
B60L 15/20	Methods, circuits or devices for controlling the propulsion of electrically-propelled vehicles
B60L 11/14	Electric propulsion with power supplied within the vehicle with provision for direct mechanical propulsion
G08G 1/0955	Traffic control systems for road vehicles
G08G1/16	Anti-collision systems
B60K 31/00	Vehicle fittings, acting on a single sub-unit only, for automatically controlling vehicle speed
B60T 7/22	Brake-action initiating means
B62D 113/00	Position of parts of the steering mechanism
B60R21/01	Electrical circuits for triggering safety arrangements in case of vehicle accidents or impending vehicle accidents
B60T8/32	Arrangements for adjusting wheel-braking force to meet varying vehicular or ground-surface conditions responsive to a speed condition, e.g. acceleration or deceleration
B60R21/013	means for detecting collisions, impending collisions or roll-over
B60R 21/01	Electrical circuits for triggering safety arrangements in case of vehicle accidents or impending vehicle accidents
G01S 17/00	Systems using the reflection or reradiation of electromagnetic waves other than radio waves, e.g. lidar systems
G01C 21/00	Navigational instruments for measuring distance traversed on the ground by a vehicle
G01C 21/26	Navigational instruments adapted for navigation in a road network
G01C 22/00	Measuring distance traversed on the ground by vehicles, persons, animals or other moving solid bodies, e.g. using odometers or using pedometers
G01S 13/93	Systems using the reflection or reradiation of radio waves, e.g. radar systems for anti-collision purposes
G05D1/0	Control of position, course, altitude, or attitude of land, water, air, or space vehicles, e.g. automatic pilot (radio navigation systems or analogous systems using other waves G01S)
B60T 7/12	automatic initiation; for initiation not subject to will of driver or passenger
B62D 6/00	Arrangements for automatically controlling steering depending on driving conditions sensed and responded to
G08G 1/00	Traffic control systems for road vehicles
B60R 21/00	Arrangements or fittings on vehicles for protecting or preventing injuries to occupants or pedestrians in case of accidents or other traffic risks
B62D 133/00	Trim or inclination, including road gradient
B60L 11/14	Electric propulsion with provision for direct mechanical propulsion

Summary

This report categorizes and graphically analyzes research trends around the mechanisms, ant-collision system and braking technologies used by a driverless car from various perspectives and highlights the key companies involved.

In the United States, the National Highway Traffic Safety Administration (NHTSA) has proposed a formal classification system: The following pertains to automated vehicles.

Level 0: The driver completely controls the vehicle at all times.
Level 1: Individual vehicle controls are automated, such as electronic stability control or automatic braking.
Level 2: At least two controls can be automated in unison, such as adaptive cruise control in combination with lane keeping. Example: Tesla Model S
Level 3: The driver can fully cede control of all safety-critical functions in certain conditions. The car senses when conditions require the driver to retake control and provides a "sufficiently comfortable transition time" for the driver to do so.
Level 4: The vehicle performs all safety-critical functions for the entire trip, with the driver not expected to control the vehicle at any time. As this vehicle would control all functions from start to stop, including all parking functions, it could include unoccupied cars.

Some of the driverless technologies which are already being used by semi-autonomous cars are parking assist, cruise control and automatic braking. Others such as blind spot detection, traffic jam detection are still in the early stages of development. Key factors that would impact producer deployment of autonomous vehicles include technological feasibility, digital infrastructure, producer liability, regulation, diverging business models, and profitability.

According to a new report covered by the IEEE, driverless car-compliant microcontroller and processor units will be a $500 million market by 2020, up from $69 million last year

Looking at the pace at which records are being file in the field of driverless cars, we can have self driving cars on the roads in the near future. Some of the advantages of self driving vehicles are fewer accidents, congestion reduction and increased roadway capacity, reduction of physical read signage, smoother traffic and improved fuel efficiency

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Sources & References

en.wikipedia.org/wiki/History_of_autonomous_car
en.wikipedia.org/wiki/Autonomous_car
wired.co.uk/news/archive/2012-09/19/no-drivers-licences-by-2040
electronicproducts.com/Digital_ICs/Microprocessors_Microcontrollers_DSPs/Google_s_driverless_car_to_boost_revenue_for_semiconductors.aspx
e2e.ti.com/blogs_/b/tilive/archive/2015/03/17/lidar-cameras-radars-action-the-road-to-autonomous-vehicles
auto.howstuffworks.com/under-the-hood/trends-innovations/driverless-car2.htm
ikhlaqsidhu.files.wordpress.com/2013/06/self_driving_cars.pdf
googleblog.blogspot.in/2010/10/what-were-driving-at.html
engadget.com/2012/12/03/volvo-self-driving-cars-2014/
en.wikipedia.org/wiki/Collision_avoidance_system
en.wikipedia.org/wiki/Automatic_braking
en.wikipedia.org/wiki/Anti-lock_braking_system
en.wikipedia.org/wiki/Emergency_brake_assist
en.wikipedia.org/wiki/Autonomous_cruise_control_system
en.wikipedia.org/wiki/Cooperative_Adaptive_Cruise_Control
en.wikipedia.org/wiki/Lidar
forbes.com/sites/zacharyhamed/2015/01/21/driverless-stocks/#6f7ce88734f9
bankrate.com/finance/auto/companies-testing-driverless-cars-1.aspx