



Autonomous Vehicles Inventive Energy

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AUTONOMOUS VEHICLES INVENTIVE ENERGY 2018

INTERNATIONAL PATENT CLASSES (IPC): Autonomous Vehicles

Autonomous vehicles are a rapidly evolving technology which only a few years ago was still considered as science fiction. An autonomous vehicle (sometimes called a *driverless car*, a *self-driving car*, or an *automated car*) is a *robotic vehicle* that is designed to travel between destinations without a *human driver*. Car manufacturing companies are joining with tech giants like Google, Uber, and prominent start-ups to develop next-generation autonomous vehicles that will alter the roads, thoroughways and lay the groundwork for the future smart cities. Car manufacturers are harnessing technological advances such as an machine learning, image processing, Internet of Things (IoT), and the cloud computing to accelerate the

IPC Domain	Description
B60W10/06	Conjoint control of vehicle sub-units of different type or different function;including control of combustion engines
B60W10/10	including control of change-speed gearings
B60W10/18	including control of braking systems
B60W10/20	including control of steering systems
B62D15/02	Steering position indicators
B60R11/04	Mounting of cameras operative during drive; Arrangement of controls thereof relative to the vehicle
G05D1/02	Control of position or course in two dimensions
G05D1/10	Simultaneous control of position or course in three dimensions (G05D 1/12 takes precedence)
G08G1/09	Arrangements for giving variable traffic instructions
G06K9/62	Methods or arrangements for recognition using electronic means

development. More significantly, autonomous vehicles will advance the industry disruption set in motion by popular ride-sharing services like Uber, Lyft, Ola etc. Organizations, developers, and researchers are coming together to create a world where intelligent, driverless vehicles become the future of transportation.

We identified following top 10 *International Patent Classification classes in autonomous vehicle domain through the study of key patents*. The overall number of Applications published in the United States Patent and Trademark Office (USPTO) and Patents granted by USPTO are given in the table below (from the year 2010 till 2017). These are total numbers granted and published by the world at large at USPTO in that specific year.

S.No	IPC Domain	Year								
		2010	2011	2012	2013	2014	2015	2016	2017	
1	B60W10/06	2010	2011	2012	2013	2014	2015	2016	2017	
		Application	53	147	183	280	337	537	464	474
		Granted	37	39	69	59	116	506	618	654
2	B60W10/10	2010	2011	2012	2013	2014	2015	2016	2017	
		Application	98	85	109	83	66	113	99	85
		Granted	39	50	70	65	69	106	122	123
3	B60W10/18	2010	2011	2012	2013	2014	2015	2016	2017	
		Application	48	54	52	45	48	106	170	224
		Granted	16	18	18	26	25	31	81	132
4	B60W10/20	2010	2011	2012	2013	2014	2015	2016	2017	
		Application	10	14	11	27	22	68	139	220
		Granted	1	1	1	4	8	58	94	140
5	B62D15/02	2010	2011	2012	2013	2014	2015	2016	2017	
		Application	30	28	10	24	37	109	183	307
		Granted	1	2	6	4	11	106	228	282
6	B60R11/04	2010	2011	2012	2013	2014	2015	2016	2017	
		Application	4	1	2	5	70	113	174	272
		Granted	1	1	1	1	1	2	30	95
7	G05D1/02	2010	2011	2012	2013	2014	2015	2016	2017	
		Application	1	44	34	78	87	310	506	630
		Granted	1	46	135	133	151	267	463	1137
8	G05D1/10	2010	2011	2012	2013	2014	2015	2016	2017	
		Application	5	13	20	15	10	31	95	238
		Granted	8	10	10	3	18	44	87	161
9	G08G1/09	2010	2011	2012	2013	2014	2015	2016	2017	
		Application	48	62	27	16	15	27	34	64
		Granted	24	17	31	54	55	54	68	108
10	G06K9/62	2010	2011	2012	2013	2014	2015	2016	2017	
		Application	483	319	509	523	530	1185	1815	1940
		Granted	225	233	374	385	410	794	1247	1711

STATE OF ART OF ANY TECHNOLOGY USING CRAFITTI's INVENTIVE ENERGY

CRAFITTI's **INVENTIVE ENERGY** measures the pace and intensity of **inventive activity** in a particular technological field. Inventive Energy provides a true picture of the state of the art of technology as it is a **composite metric** of Patents Granted and Patent Applications published in specific technology domains annually for a period of five years.

Inventive Energy in specific technology domains can be utilized by existing technology players, start-ups, new players, investors, VCs, Research and Development teams and technology and Product Strategy Teams to design more informed future.

Inventive Energy (IE) is a yearly metric of the trend of last five years of invention activity in the specific technological domain such as autonomous vehicle calculated based on a number of patent applications published and a number of patents granted in the respective technological domain. **Inventive energy is a composite metric of two indices – Patent Intensity Index and Patent Activity Index.**

Patent Intensity Index of a year is measured in terms of the yearly average of a number of total patents granted and patent applications published in last 5 years. *As an analogy, the Patent Intensity Index is denoted as the Mass which is reflected as a number of Patents and Applications granted and published respectively in the preceding 5 years.*

Patent Activity Index is measured in terms of the yearly average of *relative* pace of patent applications and granted patents in the IPC domain. *As an analogy, the Patent Activity Index denotes the Velocity or relative pace of Patents and Applications, granted and published respectively in the preceding 5 years, with higher*

weightage assigned to recent years.

For any year, the two indices include a measure of yearly averages of **last five years of number of applications published and patents granted**. For example, for 2017, these indices use data from years 2013-2017.

Patent Activity Index of top 10 autonomous vehicle IPC classes for years 2014-2017

A value of **Patent Activity Index** less than 1.0 indicates that relative average number of applications filing is reducing compared to a number of patents being granted. **The index also gives a red, amber and green signal.** **Red** indicates the value of the index is less than 1.0. **Amber** indicates it is between 1.0 and 2.0 and **green** indicates it is above 2.0, i.e., *the number of applications being published every year on an average is more than 2 times the number of patents being granted on an average.* A higher value of patent activity index is an indication of more recent **inventive activity** in the domain or the specific IPC

class. In turn, a higher activity index will signify a *higher Inventive Energy*. *Activity Index is analogous to the velocity of the particle*. The PAI (Patent Activity Index) of top 10 autonomous vehicle IPCs for years 2014-2017 are given below.

IPC Domain	Description	BM-PAI 2014	BM-PAI 2015	BM-PAI 2016	BM-PAI 2017
B60W10/06	Conjoint control of vehicle sub-units of different type or different function;including control of combustion engines	● 3.24	● 2.41	● 1.74	● 1.37
B60W10/10	including control of change-speed gearings	● 1.33	● 1.18	● 1.00	● 0.85
B60W10/18	including control of braking systems	● 2.23	● 2.75	● 2.39	● 2.06
B60W10/20	including control of steering systems	● 6.70	● 4.53	● 3.01	● 2.08
B62D15/02	Steering position indicators	● 7.19	● 3.47	● 1.87	● 1.70
B60R11/04	Mounting of cameras operative during drive; Arrangement of controls thereof relative to the vehicle	● 32.50	● 41.11	● 25.85	● 18.87
G05D1/02	Control of position or course in two dimensions	● 0.61	● 0.83	● 0.90	● 0.77
G05D1/10	Simultaneous control of position or course in three dimensions (G05D 1/12 takes precedence)	● 1.83	● 1.49	● 1.44	● 1.49
G08G1/09	Arrangements for giving variable traffic instructions	● 0.89	● 0.74	● 0.48	● 0.50
G06K9/62	Methods or arrangements for recognition using electronic means	● 1.40	● 1.40	● 1.42	● 1.29

*BM-PAI – *Bhushan Mishra Patent Activity Index* – named after its creators

As can be seen in the above table, the PAI for IPC classes B60W10/18 (Conjoint control of vehicle sub-units of different type or different function; including control of braking systems), B60W10/20 (including control of steering systems), and B60R11/04 (Mounting of cameras operative during drive; Arrangement of controls thereof relative to the vehicle) are **above 2.0** for years 2014, 2015, 2016 and 2017, indicated in **green**.

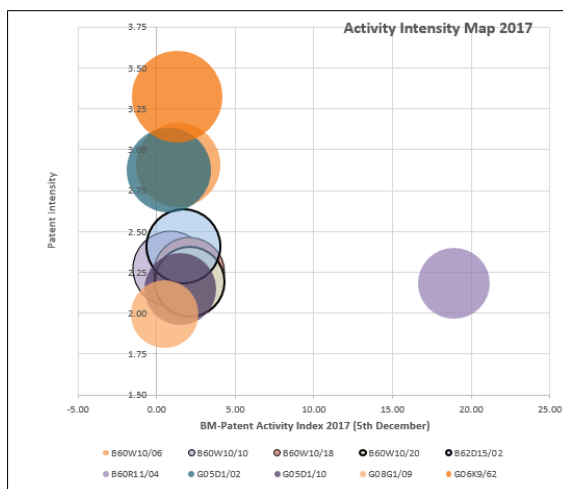
The PAI for B60W10/06 (Conjoint control of vehicle sub-units of different type or different function; including control of combustion engines), and B62D15/02 (Steering position indicators) is above 2.0 for years 2014-2015, indicated in **green**, and below 2.0 for the year 2016-2017, indicated in **amber**. Similarly, for the IPC class G05D1/10 (Simultaneous control of position or course in three dimensions (G05D 1/12 takes precedence)), and G06K9/62 (Methods or arrangements for recognition using electronic means) the PAI is below 1.0 for years 2014, 2015, 2016 and 2017, indicated by **amber**.

Furthermore, the PAI for B60W10/10 (including control of change-speed gearings) is **amber** (below 2.0) for the years 2014-2016, other than the year 2017 **red** (below 1.0).

Further, the PAI for G05D1/02 (Control of position or course in two dimensions), and G08G1/09 (Arrangements for giving variable traffic instructions) is **red** (below 1.0) for the years 2014-2017. This implies that the number of Patent Applications being published in the preceding 5 years (inclusive of current year) *remains less* than the number of Patents being granted. This indicates a reducing Invention activity in the specific domain. **Thus, it can be concluded that IPC domains G05D1/02, and G08G1/09 are seeing reducing Invention Activity and has low invention velocity from 2010 to 2017.**

B60W10/18, B60W10/20, and B60R11/04 are the prominent IPC classifications in the Autonomous vehicle technology which talks about **braking systems, steering systems, and mounting of cameras operative during drive** respectively. The inventive activity in B60W10/20 was higher in the year 2014, since then the patent activity has been reducing as the number of Patents being granted has started increasing. Further, the inventive activity in B60R11/04 was higher in the year 2015, since then the patent activity has been reducing. However, the inventive activity is still higher in this IPC than other key IPC classes.

Activity Intensity Maps of Top 10 Autonomous vehicle IPC classes in the year 2014 and 2017



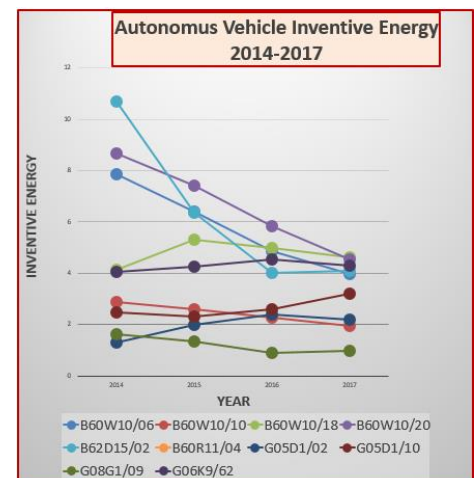
Activity Intensity Map (AIM) of a set of IPC classes is a Crafitti proprietary visualization of intensity in terms of a number of patents granted and patent applications published, and inventive activity in terms of relative pace of patent applications and granted patents in any IPC domain. For any year say 2014, these indices include a measure of yearly averages of last five years of a number of applications published and patents granted. For example, for 2014, these indices use data from years 2010, 2011, 2012, 2013 and 2014.

Autonomous vehicle Inventive Energy of Top 10 IPC classes

Inventive Energy for the year 2014 for IPC class B60W10/06 is simply a product of Patent Activity Index for the year 2014 (in this case a value of 3.24) and Patent Intensity for the year 2014 (in this

IPC Domain	Patent Activity Index				Patent Intensity				INVENTIVE ENERGY			
	BM-PAI 2014	BM-PAI 2015	BM-PAI 2016	BM-PAI 2017	2014	2015	2016	2017	2014	2015	2016	2017
B60W10/06	3.24	2.41	1.74	1.37	2.42	2.66	2.80	2.91	7.84	6.42	4.87	3.99
B60W10/10	1.33	1.18	1.00	0.85	2.17	2.21	2.26	2.27	2.89	2.62	2.27	1.94
B60W10/18	2.23	2.75	2.39	2.06	1.85	1.93	2.08	2.25	4.12	5.30	4.97	4.64
B60W10/20	6.70	4.53	3.01	2.08	1.30	1.63	1.94	2.19	8.68	7.39	5.83	4.55
B62D15/02	7.19	3.47	1.87	1.70	1.49	1.83	2.16	2.41	10.68	6.35	4.04	4.09
B60R11/04	32.50	41.11	25.85	18.87	1.24	1.60	1.90	2.18	40.32	65.59	49.17	41.21
G05D1/02	0.61	0.83	0.90	0.77	2.15	2.41	2.64	2.88	1.31	2.00	2.38	2.20
G05D1/10	1.83	1.49	1.44	1.49	1.35	1.54	1.82	2.15	2.47	2.30	2.62	3.20
G08G1/09	0.89	0.74	0.48	0.50	1.84	1.85	1.88	2.00	1.63	1.37	0.90	0.99
G06K9/62	1.40	1.40	1.42	1.29	2.90	3.02	3.19	3.32	4.06	4.24	4.53	4.30

case a value of 2.42). The Inventive Energy for the year 2014 for IPC domain B60W10/06 comes out to be $3.24 \times 2.42 = 7.84$, as shown in the Table. In general, the Inventive Energy of IPC class B60R11/04 (Mounting of cameras operative during the drive; Arrangement of controls thereof relative to the vehicle) is highest among these top 10 IPC classes.



Key Findings

Due to its inherent simplicity and utilization of substantial information on published and granted patents, the present study on **the inventive energy** provides a de-facto standard for enterprises active in an **autonomous vehicle** to evaluate the front edge of technology in various applications of the autonomous vehicle.

IPC class on the mounting of cameras operative during the drive; and arrangement of controls thereof relative to the vehicle (B60R11/04 has seen the tremendous inventive energy in the 2015 Index. Other two prominent IPC classes on braking systems (B60W10/18), and steering systems (B60W10/20) have also been quite active among the autonomous vehicle enthusiasts and R&D teams.

One of the findings from the present inventive energy study is a decrease in the patent activity in the Conjoint control of vehicle sub-units of different type or different function; including control of combustion engines which was higher in the year 2014. However, the filing trend in this domain is relatively better than the other autonomous vehicle domain such as *control of position or course in two dimensions; and arrangements for giving variable traffic instructions*

Further, the reduction in Inventive Energy from 2014 value of nearly 3.24 to the value of 1.37 in the year 2017, *indicates the trend of Patents grants has started in the period that typically brings down the Inventive Energy as it is a function of the ratio of applications published and a patent granted for the particular year*. Also, inventors are active in the implementation of the autonomous vehicle technology in the other applications apart from creating maps for self-driving cars, cybersecurity, high-resolution mapping, improved vision systems etc.

IPC classes with high Inventive Energy typically will have higher business potential and growth in the autonomous vehicle technology. The Inventive Energy can be utilized to create **an autonomous vehicle Inventive Strategy** to find problems in high inventive energy IPC classes. This can be a leading indicator for not only any startup or disruptor but also to existing patent owners to expand and strengthen their portfolio through this guidance rather than letting serendipity and opinion about future guide their inventive effort.

As the patent examiner not only evaluate the patentability of the corresponding technology but also assess the legal aspects of the filed patent application at various levels of scrutiny before granting the patent, therefore, patent grant trends identified by the present inventive energy study in the autonomous vehicle technology will enable the decision maker with the due-diligence aspects of the autonomous vehicle technology.

Any organization willing to invest in the autonomous vehicle technology can utilize invention energy metric in general and this study in particular, as it automatically takes care of three major inputs required to understand the state of the art of autonomous vehicle technology – Patent Applications, Granted Patents and Specific IPC classes relevant to autonomous vehicle technology in a composite metric.



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