Machine Learning Inventive Energy

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MACHINE LEARNING INVENTIVE ENERGY 2018

INTERNATIONAL PATENT CLASSES (IPC): Machine Learning

Last few years have seen significant developments in how machine learning continues to be at the forefront of technological innovation, with a number of use cases coming to fruition. Machine learning is a subset of Artificial Intelligence which enables a software system to algorithmically learn from the data and accordingly grow, change, and develop itself. International Data Corporation (IDC) is forecasting spending on artificial intelligence (AI) and machine learning will grow from $8B in 2016 to $47B by 2020. A recent study shows that investments in machine learning will nearly double over the next two years, reaching 64% adoption by 2020. Any field which needs to make sense of data is a potential consumer of the machine learning. Few prominent examples of real-life machine learning applications are self-driving Google car, friend suggestions on Facebook, YouTube showcasing the movies, videos, shows you might like, and "similar items to consider" on Amazon.

IPC Domain	Description
G06N3/04	Computer systems based on biological models; Architecture, e.g. interconnection topology
G06N3/08	Learning methods
G06N5/04	Computer systems utilizing knowledge based models; Inference methods or devices
G06F15/18	in which a program is changed according to experience gained by the computer itself during a complete run; Learning machines (adaptive control systems G05B 13/00; artificial intelligence G06N) [2006.01]
G06F17/28	Processing or translating of natural language
G06F17/30	Information retrieval; Database structures therefore
G06F19/24	For machine learning, data mining or biostatistics, e.g. pattern finding, knowledge discovery, rule extraction, correlation, clustering or classification
G06K9/32	Aligning or centering of the image pick-up or image-field
G06K9/62	Methods or arrangements for recognition using electronic means
G06K9/66	references adjustable by an adaptive method, e.g. learning

We identified following top 10 International Patent Classification classes in machine learning domain through the study of key patents. The overall number of Applications published in 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							
1	G06N3/04	2010	2011	2012	2013	2014	2015	2016	2017
	Application	6	7	15	30	31	91	181	385
	Granted	3	3	7	4	13	78	133	156
2	G06N3/08	2010	2011	2012	2013	2014	2015	2016	2017
	Application	49	32	41	58	82	163	252	574
	Granted	17	16	7	10	30	77	139	177
3	G06N5/04	2010	2011	2012	2013	2014	2015	2016	2017
	Application	84	78	72	76	229	719	655	834
	Granted	20	16	19	21	33	161	356	354
4	G06F15/18	2010	2011	2012	2013	2014	2015	2016	2017
	Application	459	460	386	236	50	3	1	15
	Granted	250	309	352	458	447	319	270	229
5	G06F17/28	2010	2011	2012	2013	2014	2015	2016	2017
	Application	161	128	179	249	327	455	431	510
	Granted	141	144	185	219	229	318	429	456
6	G06F17/30	2010	2011	2012	2013	2014	2015	2016	2017
	Application	7521	6263	5981	6078	7576	10369	11132	11897
	Granted	3948	3728	4259	4576	5696	8008	10552	11002
7	G06F19/24	2010	2011	2012	2013	2014	2015	2016	2017
	Application	0	1	33	30	40	62	135	163
	Granted	0	4	7	6	22	52	77	92
8	G06K9/32	2010	2011	2012	2013	2014	2015	2016	2017
	Application	150	108	92	148	110	154	229	266
	Granted	254	288	367	362	289	380	446	486
9	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
10	G06K9/66	2010	2011	2012	2013	2014	2015	2016	2017
	Application	8	7	6	8	36	70	186	273
	Granted	67	74	92	110	110	85	120	150

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

Inventive Energy (IE) is a yearly metric of the trend of last five years of invention activity in the specific technological domain such as Blockchain 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.**

> 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.*

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 a 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 Machine Learning IPC classes for years 2014-2017

A value of **Patent Activity Index** *is 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 Machine Learning IPCs for years 2014-2017 are given below.

IPC Domain	Description	BM-PAI 2014	BM-PAI 2015	BM-PAI 2016	BM-PAI 2017
G06N3/04	Computer systems based on biological models; Architecture, e.g. interconnection topology	3.43	2.57	2.21	2.47
G06N3/08	Learning methods	3.79	3.19	2.80	2.93
G06N5/04	Computer systems utilizing knowledge based models; Inference methods or devices	5.29	4.85	3.52	3.16
G06F15/18	in which a program is changed according to experience gained by the computer itself during a complete run; Learning machines (adaptive control systems G05B 13/00; artificial intelligence G06N) [2006.01]	0.65	0.35	0.17	0.09
G06F17/28	Processing or translating of natural language	1.21	1.29	1.17	1.17
G06F17/30	Information retrieval; Database structures therefore	1.43	1.35	1.21	1.16
G06F19/24	For machine learning, data mining or biostatistics, e.g. pattern finding, knowledge discovery, rule extraction, correlation, clustering or classification	2.69	2.19	2.25	1.97
G06K9/32	Aligning or centering of the image pick-up or image-field	0.39	0.38	0.44	0.49
G06K9/62	Methods or arrangements for recognition using electronic means	1.40	1.40	1.42	1.29
G06K9/66	references adjustable by an adaptive method, e.g. learning	0.19	0.46	0.92	1.30

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

As can be seen in the above table, the PAI for IPC classes G06N3/04 (Computer systems based on biological models; Architecture, e.g. interconnection topology), G06N3/08 (Learning methods), and G06N5/04 (Computer systems utilizing knowledge-based models; Inference methods or devices) are above 2.0 for years 2014, 2015, 2016 and 2017, indicated in green.

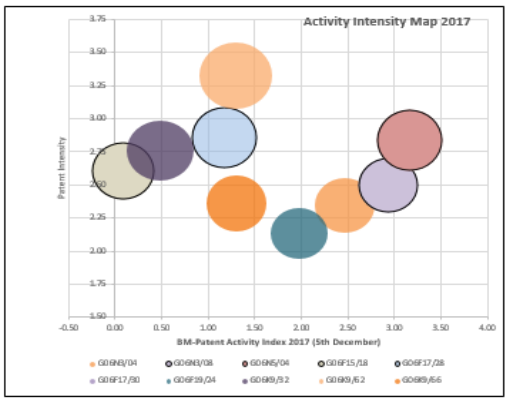
The PAI for G06F19/24 (For machine learning, data mining or biostatistics, e.g. pattern finding, knowledge discovery, rule extraction, correlation, clustering or classification) is above 2.0 for years 2014-2016, indicated in green, and below 2.0 for the year 2017, indicated in amber. Similarly, for the IPC class G06F17/28 (Processing or translating of natural language), G06F17/30 (Information retrieval; Database structures, therefore), 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 G06K9/66 (references adjustable by an adaptive method, e.g. learning) is red (below 1.0) for the years 2014-2016, other than the year 2017 amber (below 2.0).

Further, the PAI for G06F15/18 (in which a program is changed according to experience gained by the computer itself during a complete run; Learning machines (adaptive control systems G05B 13/00; artificial intelligence G06N)), and G06K9/32 (Aligning or centering of the image pick-up or image-field) 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 G06F15/18, and G06K9/32 are seeing reducing Invention Activity and has low invention velocity from 2010 to 2017.

*G06N5/04 and G06N3/08 are the prominent IPC classifications in the Machine Learning technology which talks about utilizing **knowledge-based models, Inference methods; and Learning methods** respectively. The inventive activity in G06N5/04 and G06N3/08 IPC was higher in the year 2014, since then the patent activity has been reducing as the number of Patents being granted has started increasing. However, the inventive activity is still higher than other key IPC classes.*

Activity Intensity Maps of Top 10 Machine Learning IPC classes in the year 2014 and 2017

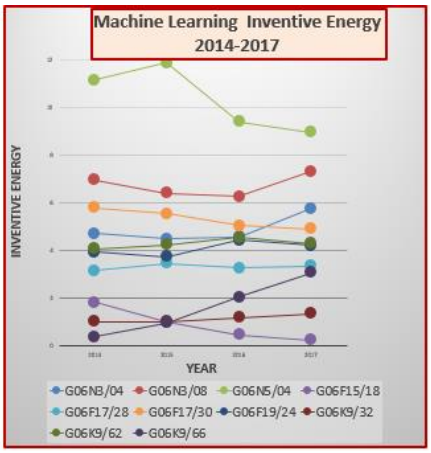


Activity Intensity Map (**AIM**) of a set of IPC classes is a Crafitti proprietary visualization of intensity in terms of a number of patents granted and patent applications published, and inventive activity in terms of relative pace of patent applications and granted patents in any IPC domain. For any 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.

Machine Learning Inventive Energy of Top 10 IPC classes

Inventive Energy for the year 2014 for IPC class G06N3/04 is simply a product of Patent Activity Index for the year 2014 (in this case a value of 3.43) and Patent Intensity for the year 2014 (in this case a value of 1.38). The Inventive Energy for the year 2014 for IPC domain G06N3/04 comes out to be 3.43 x 1.38 = 4.72, as shown in the Table. In general, the Inventive Energy of IPC class G06N5/04 (Computer systems utilizing knowledge based models; Inference methods or devices) is highest among these top 10 IPC classes.

IPC Domain	Patent Activity Index				Patent Intensity				INVENTIVE ENERGY			
IPC	BM-PAI 2014	BM-PAI 2015	BM-PAI 2016	BM-PAI 2017	2014	2015	2016	2017	2014	2015	2016	2017
G06N3/04	3.43	2.57	2.21	2.47	1.38	1.75	2.07	2.34	4.72	4.48	4.56	5.78
G06N3/08	3.79	3.19	2.80	2.93	1.84	2.01	2.24	2.49	6.96	6.42	6.27	7.32
G06N5/04	5.29	4.85	3.52	3.16	2.11	2.45	2.67	2.84	11.17	11.89	9.41	8.98
G06F15/18	0.65	0.35	0.17	0.09	2.83	2.78	2.70	2.61	1.83	0.99	0.47	0.23
G06F17/28	1.21	1.29	1.17	1.17	2.59	2.69	2.78	2.86	3.15	3.46	3.26	3.36
G06F17/30	1.43	1.35	1.21	1.16	4.05	4.10	4.17	4.24	5.78	5.54	5.04	4.90
G06F19/24	2.69	2.19	2.25	1.97	1.46	1.71	1.97	2.13	3.94	3.74	4.44	4.20
G06K9/32	0.39	0.38	0.44	0.49	2.64	2.66	2.71	2.76	1.02	1.01	1.18	1.35
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
G06K9/66	0.19	0.46	0.92	1.30	2.02	2.08	2.22	2.36	0.38	0.95	2.04	3.07



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 machine learning to evaluate the front edge of technology in various applications of the machine learning.

IPC class on knowledge-based models (G06N5/04) has seen the tremendous inventive energy in the 2014 Index. Other two prominent IPC classes on learning methods (G06N3/08), interconnection topology (G06N3/04) and pattern finding, knowledge discovery, rule extraction, correlation, clustering or classification (G06F19/24) have also been quite active among the machine learning enthusiasts and R&D teams.

One of the findings from the present inventive energy study is a decrease in the patent activity in the knowledge-based models and pattern finding which was higher in the year 2014. However, the filing trend in this domain is relatively better than the other machine learning domain such as *translating of natural language, and Information retrieval*.

Further, the reduction in Inventive Energy from 2014 value of nearly 11.17 to the value of 8.98 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 machine learning technology in the other applications apart from knowledge-based models such as virtual Personal Assistants, predictions while commuting, videos surveillance, refining search engine result, online Fraud detection and customer support etc.

IPC classes with high Inventive Energy typically will have higher business potential and growth in the machine learning technology. The Inventive Energy can be utilized to create a machine learning 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 machine learning technology will enable the decision maker with the due-diligence aspects of the machine learning technology.

Any organization willing to invest in the machine learning 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 machine learning technology – Patent Applications, Granted Patents and Specific IPC classes relevant to machine learning technology in a composite metric.

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