# Recent Trends in AI-related Inventions – Report

July 2020

Patent Examination department (Electronic Technology),
Japan Patent Office

In recent years, Artificial Intelligence (AI) -related technology has shown remarkable development centering on deep learning. Accordingly, AI-related patent applications are increasing across technological fields. As growth of AI-related technology developments and patent applications is expected to continue in the future, the JPO researches the current status of AI related applications in Japan and overseas.

＜Contents＞



＜Annex＞



Contact for this report
Examination Research Office,
Patent Examination department (Electronic Technology),
Japan Patent Office
Tel +81-3-3580-6917
Mail : PA5Y00@jpo.go.jp

# 1. Introduction

## 1-1. Definition of AI-related Invention and Research Target

○ Although AI can be defined in various ways, here, we define ①AI core invention and ② AI-applied Invention as "AI-related invention" [1] and have made it a research target, as shown in Figure 1.

① AI core invention:

Inventions characterized by mathematical or statistical information processing technology that forms the basis of AI, such as various machine learning methods including neural network, deep learning, support vector machines, reinforcement learning, in addition to knowledge-based models and fuzzy logic, etc. (The FI[2] to be assigned is mainly G06N[3].)

② AI-applied Invention:

Inventions characterized by applying ①AI core invention to various technical fields such as image processing, speech processing, natural language processing, device control/robotics, various diagnosis / detection / prediction / optimization system, etc. (A number of FI would be assigned.)

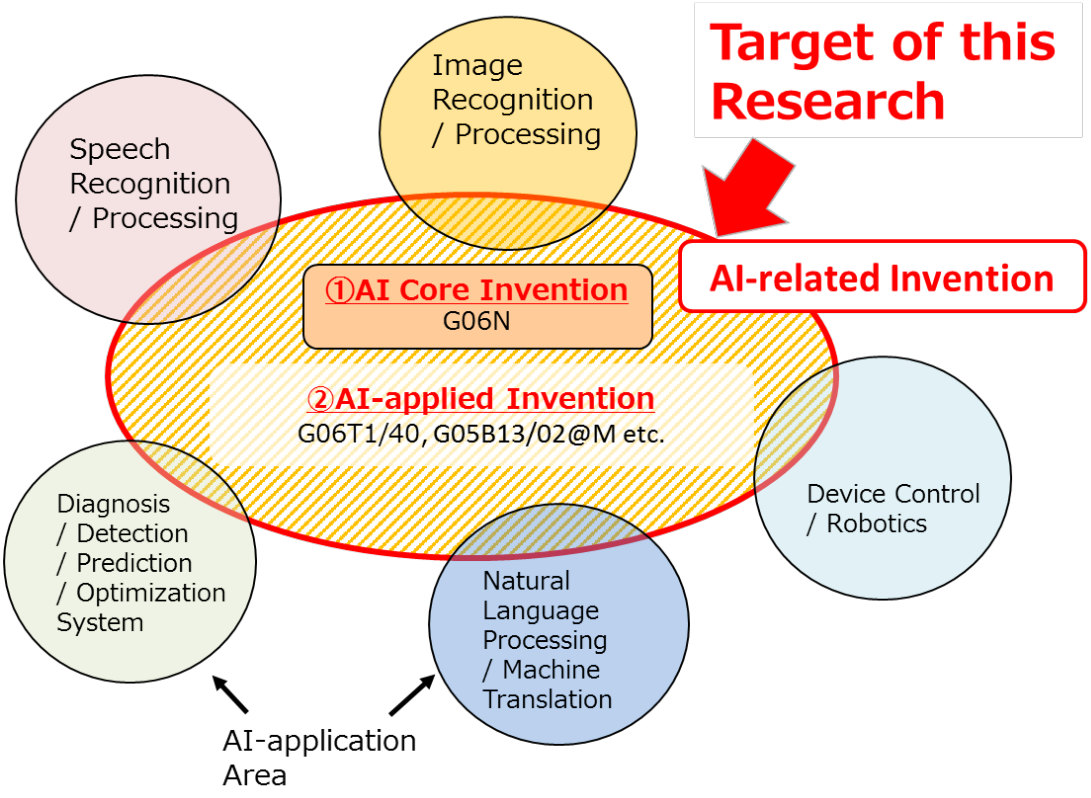


**Figure 1 Target of this research (scope of AI-related invention)**

[1] The above definition of "AI related invention" is used only in this research, and does not express an official definition from the Japan Patent Office.

[2] It is a classification unique to the Japan Patent Office that has been expanded based on IPC. For details, see J-PlatPat.

[3] "Computer systems based on specific calculation model", including G06F15/18 before FI revision.

## 1-2. Research Method

- The union of the domestic patent applications from Sets A to C below are extracted as "AI-related invention".
  - Set A : Patent applications classified into G06N as FI
    (In order to capture ①AI core invention)
  - Set B : Patent applications classified into any of AI-related FI listed in Annex 1.
    (In order to capture ②AI-applied invention by using patent classification).
  - Set C : Patent applications of which application documents are including any of AI core keywords listed in Annex 2 in any place of the "Abstract", "Problems to be Solved by the Invention", or "Means for Solving the Problems".
    (In order to capture ②AI-applied invention by using keywords)
- AI-related FI and AI core keywords are based on classifications and keywords used in "Methodology" of WIPO Technology Trends - Artificial Intelligence. Further, they are carefully selected and modified to properly extract "AI-related inventions" from domestic patent documents.
- The targets of this research are domestic applications and international applications based on PCT (Patent Cooperation Treaty) and transferred into the national phase in Japan, and for which the application year[4] is 1988-2018.
- The above-mentioned sets A-C include 14,667, 16,122 and 30,730 patent applications respectively, and totally 46,204 applications are the target of this research. The overlapping relationship of above sets A-C is shown in Figure 2.
- Please notice that the research results described below are based on the analysis of the bibliographical information of patent documents including classifications and applicants, etc., not based on manual reading of patent documents.

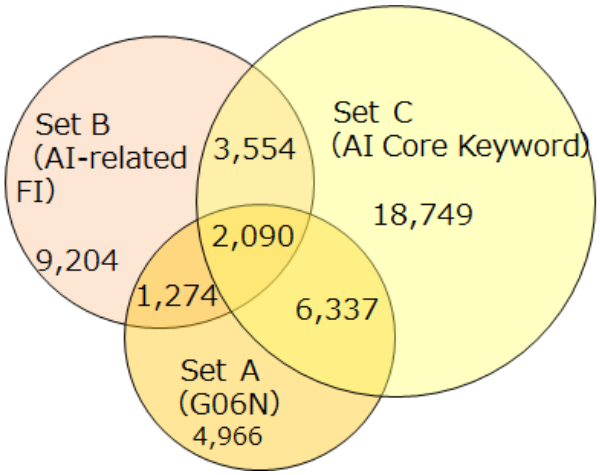


**Figure 2 Overlapping relations of AI-related inventions to be researched (46,204 in total)**

[4] "Application year" is determined based on the actual filing date as for domestic applications and the receiving date for domestic documents as for international patent applications.

## 2. Application trends in AI-related invention

### 2-1. Overall Trends in Application, Examination and Technology

○ The transition of the number of domestic applications for AI-related inventions is shown in Figure 3. AI-related inventions have increased sharply since 2014, with about 4,700 in 2018 (of which about 1,500 are classified into G06N). Also, it can be seen from the graph in Figure 3 that AI-related inventions (the pink bar) have increased and decreased in accordance with the applications classified into G06N (the yellow bar).

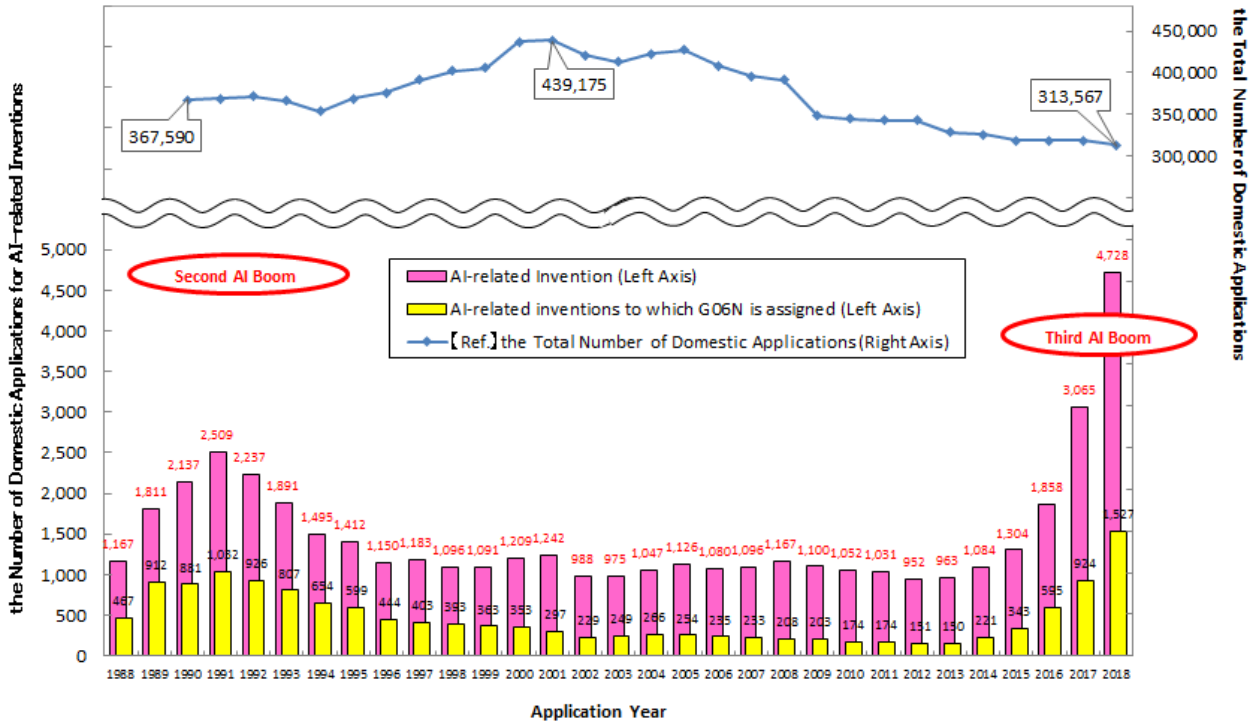


**Figure 3 The number of domestic applications for AI-related inventions**

【Remarks】

- "The number of applications" includes undisclosed applications for which a decision of refusal, (deemed) withdrawal, or abandonment was made prior to publish.

○ For AI-related inventions, the application boom occurred once in the early 1990s due to the so-called second AI boom, but the number of applications has been sluggish for nearly 20 years thereafter.

○ The second AI boom, in which technologies such as knowledge-based models and expert systems were popular, came to an end due to the difficulty in teaching computers the complete rules in advance. In addition, a neural network was actively researched at that time, but the boom was also temporary because performance limitations had arisen.

○ Figure 4, which shows the number of applications classified into G06N subclass, also supports that. In the first half of the 1990's, all applications classified into any of

G06N3/02-3/10 (neural network), G06N5/ (knowledge base), G06N7/ (fuzzy logic etc.) and G06N20/ (machine learning; G06N99/00, 150-159 before FI revision. Same below.) increased, but then began to decline, and as for G06N5/ and G06N7/, the number of applications remains low today.

- Application growth after 2014 is considered to be the influence of the so-called the third AI boom, and machine learning including neural networks plays a leading role (Especially, deep learning roles a major position. The detail is described in 2-3.). It can be seen from Figure 4 that the factors pushing up the number of applications for the third AI boom are G06N3/02-3/10 and G06N20/.
- Figure 5 shows the transition in machine learning rates defined as the ratio of the applications with G06N3/02-3/10 or G06N20/ to the applications with G06N. The machine learning rate, which has been around 50 to 60% for long term, has risen from around 2013 and has reached 85% in 2018. Recent AI-related inventions are usually realized by machine learning.
- The third AI boom is considered to be caused because that methods to suppress over-learning in machine learning have developed and that the improvement of computer performance and the increase of available data volume have made it possible to put AI-related "theories" into "practical use". For example, the idea of multi-layered neural network, which was the heart of deep learning, had been proposed for decades, but research on it had not progressed so far due to enormous computational cost. However, in 2012, a team at University of Toronto in Canada overwhelmed[5] the others by using deep learning in the global image recognition contest "ILSVRC (ImageNet Large Scale Visual Recognition Competition)", which had become one of the occasions causing the third AI boom.
- The grant rate for AI-related inventions has been rising year by year since 2004, and has been steady at around 80% in recent years (Figure 6).

[5] See "ImageNet Classification with Deep Convolutional Neural Networks, A. Krizhevsky et al., NIPS 2012" for the detail of the method.

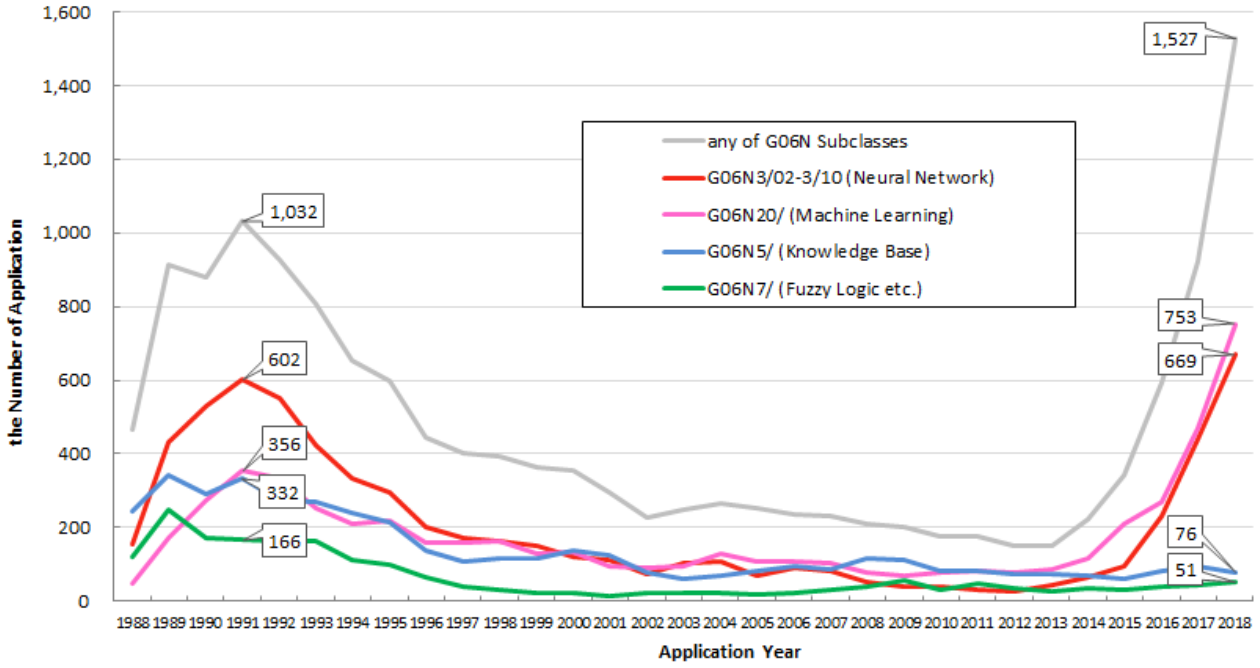


Figure 4 The number of applications classified into G06N subclass
(showing the number in 1991 and 2018)

【Remarks】

As one application may be classified into multiple G06N subclasses, the total of G06N subclasses does not match "any of G06N subclasses".

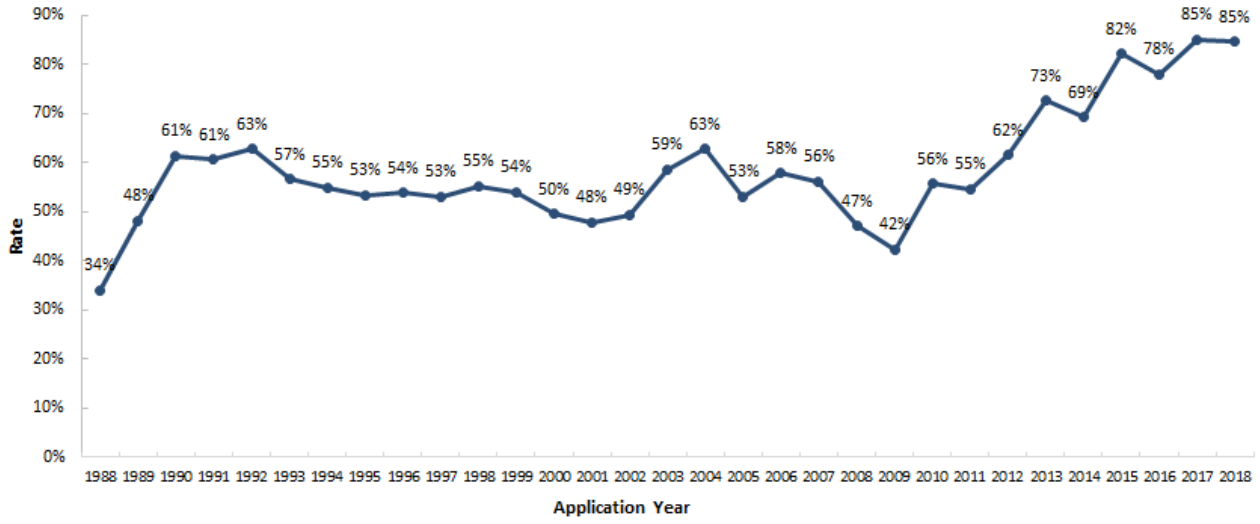


Figure 5 The machine learning rate
(Rate of the applications classified into G06N3/02-3/10 or G06N20/
to the applications classified into G06N)

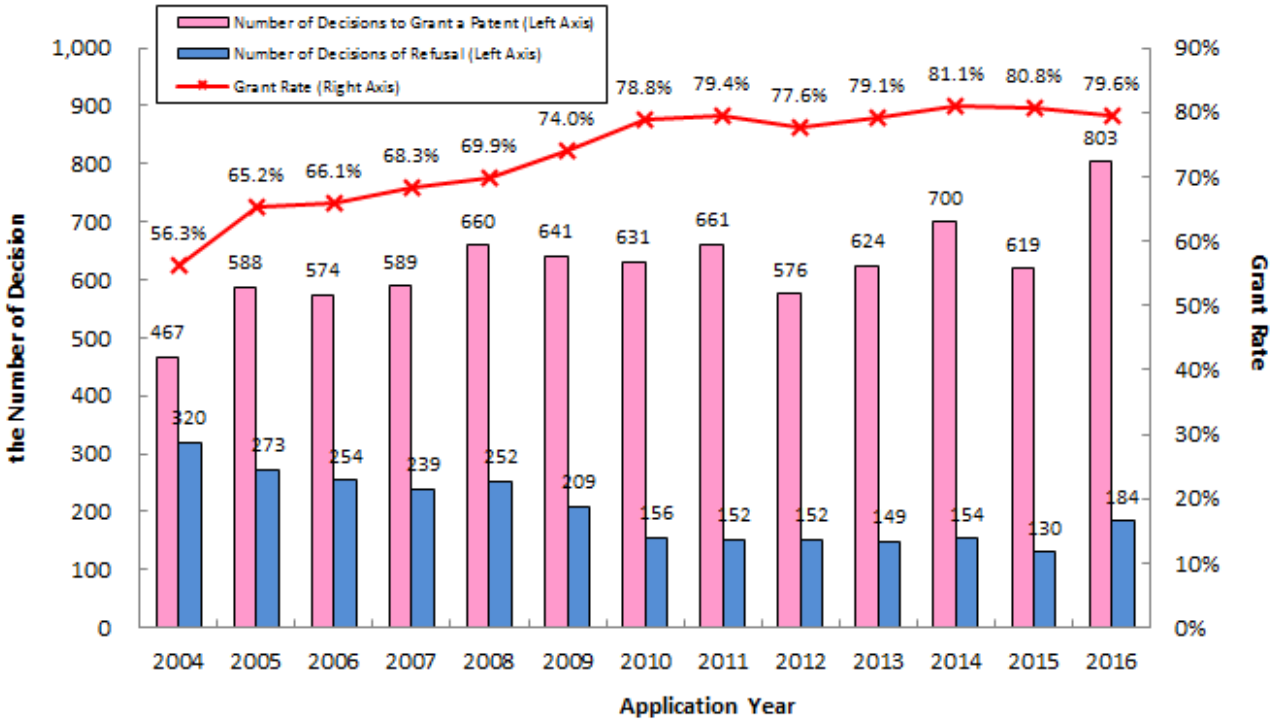


Figure 6 the Grant Rate for AI-related Inventions

【Remarks】

- Grant rate = number of decisions to grant a patent / (number of decisions to grant a patent + number of decisions of refusal + number of withdrawals or abandonment after FA)

## 2-2. Trends in AI-application Area

- We researched the main classifications of all AI-related inventions in order to find overall trends in the application area of AI-related inventions (Figure 7). We have extracted FI subclasses (Upper 4-digit subclass unit; only for G06F, 16/ and 17/20-28 were extracted) with more than 50 applications in 2018.
- It shows that G06T (image processing technology) and G06F16/ (information retrieval / recommendation; including G06F17/30 before FI revision) have been particularly major as main classifications assigned other than G06N.
- In addition, G06Q (business; including G06F17/60 before FI revision), A61B (medical diagnosis), G05B (control system and adjustment system in general), G01N (material analysis), G10L (speech processing), G06F17/20-28 (natural language processing / machine translation) and so on are also major AI-application area.
- Note that the scale of other G06F (information in general) is also large, including the major AI-application area such as G06F3/ (man machine interface) and G06F21/ (security).

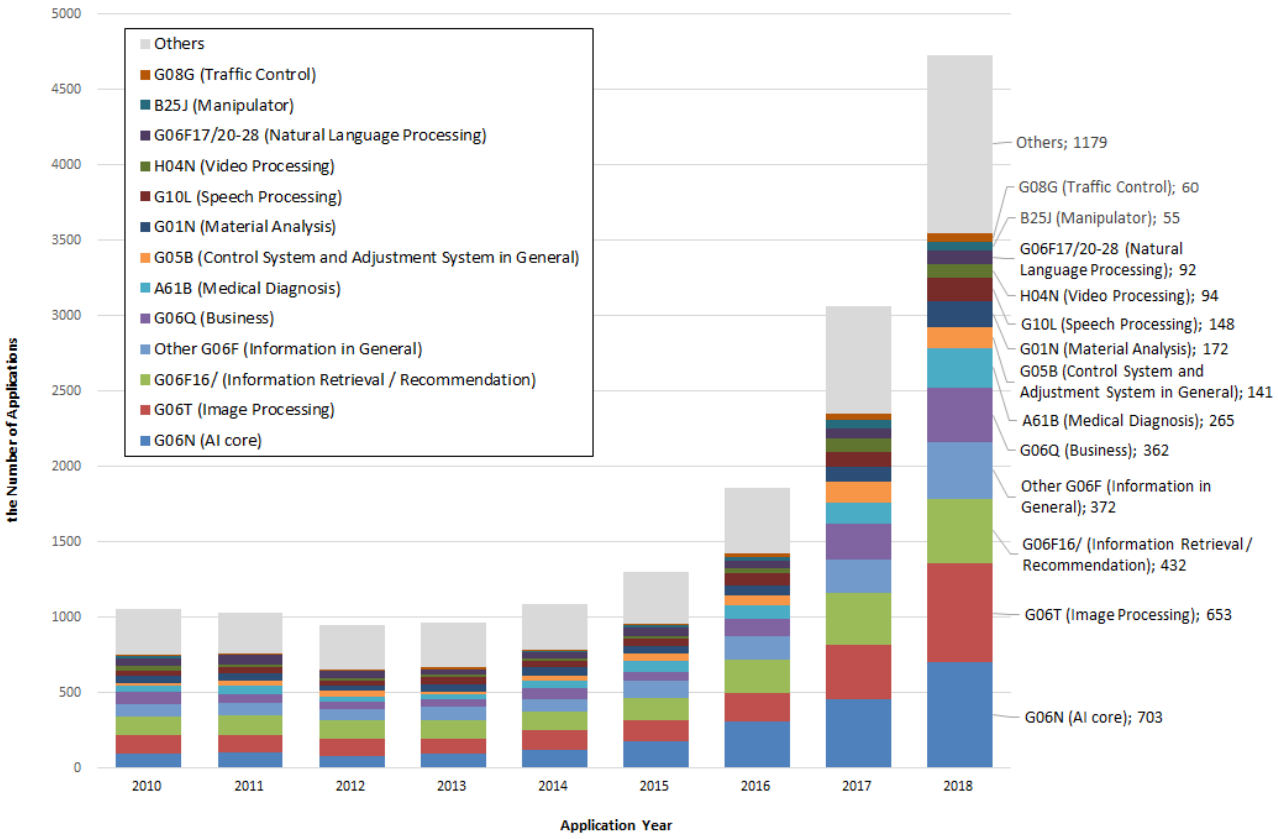


Figure 7 Composition of main classification of AI-related invention (showing the number in 2018)

○ Furthermore, Figure 8 shows the growth rate for each main classification with the number of applications in 2010 as 100%. As for almost all main classifications, the number of applications in 2018 is more than double that in 2010. Especially, classifications such as A61B (medical diagnosis), G05B (control system and adjustment system in general), G08G (traffic control) and G06T (image processing) show a high growth rate. It can be seen that the application of AI has been spreading rapidly in those fields in recent years.

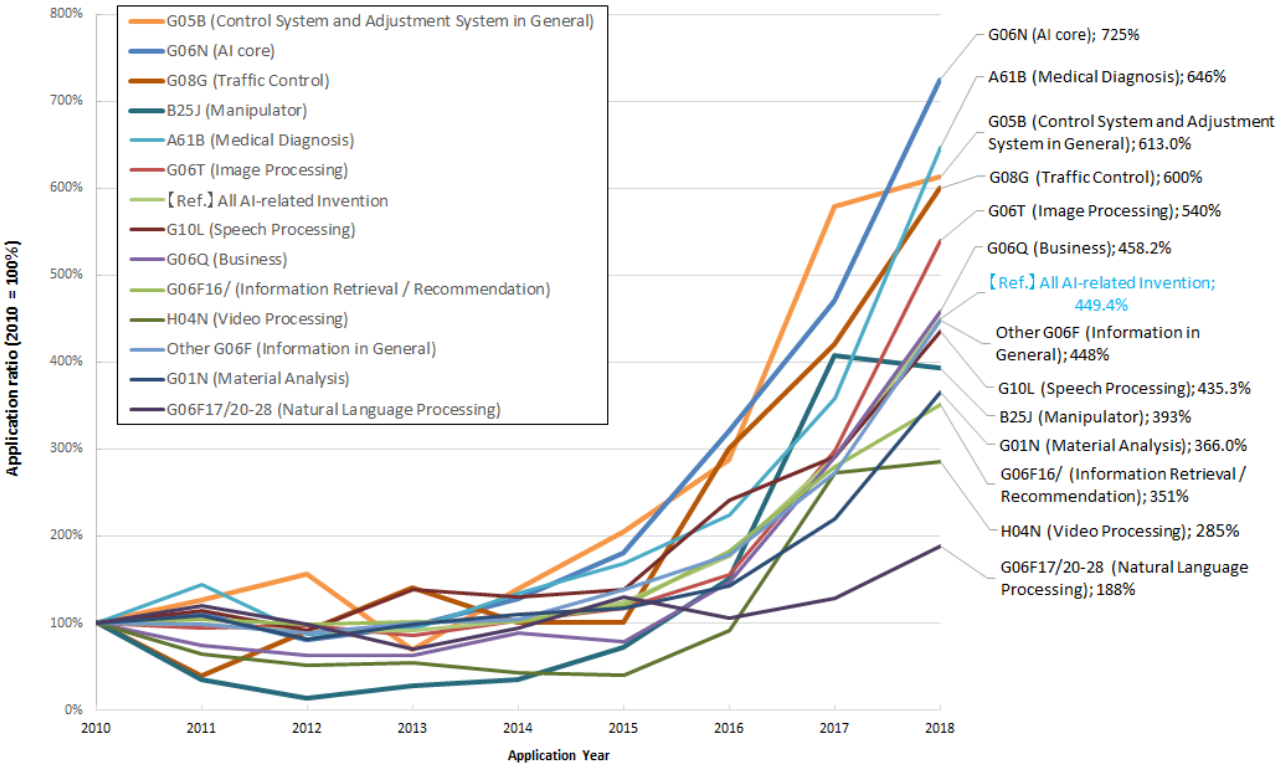


Figure 8 The growth rate for each main classification with the number of applications in 2010 as 100%

## 2-3. Status of Application for Deep Learning

- We researched the application trends in deep learning which is the biggest factor in the increase of applications for AI-related inventions in recent years. Among AI-related inventions, an application of which application documents (abstract, claim or specification) include any of deep-learning-related keywords listed in Annex 3 is defined as "AI-related invention referring to deep learning", and Figure 9 shows the number of the applications.
- AI-related inventions referring to deep learning have become prominent since 2014 and have rapidly increased in recent years. In 2018, more than half of AI-related inventions are referring to deep learning in the application documents.

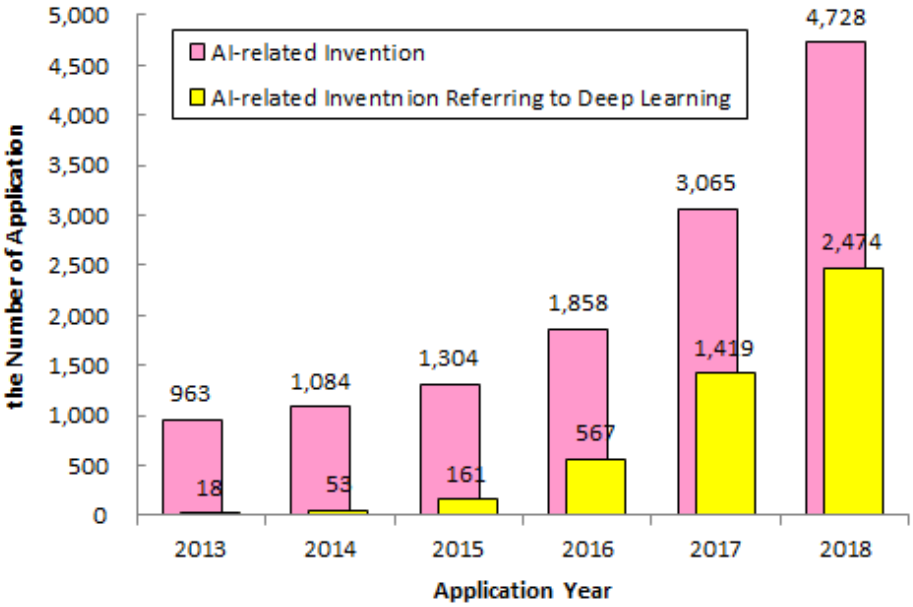


Figure 9 The number of application of AI-related invention referring to deep learning

- Figure 10 shows the number of applications for AI-related inventions that refer to the following three methods, which are important and frequently used deep learning methods. (Extracting by using the keywords in Annex 3)
  (1) Convolutional Neural Network; CNN
  (2) Recurrent Neural Network; RNN, or Long Short Term Memory; LSTM which is an extension of RNN
  (3) Deep Reinforcement Learning
- Figure 10 highlights the number of CNNs frequently used in the image processing, but the number of applications for all methods has increased rapidly in the last few years.

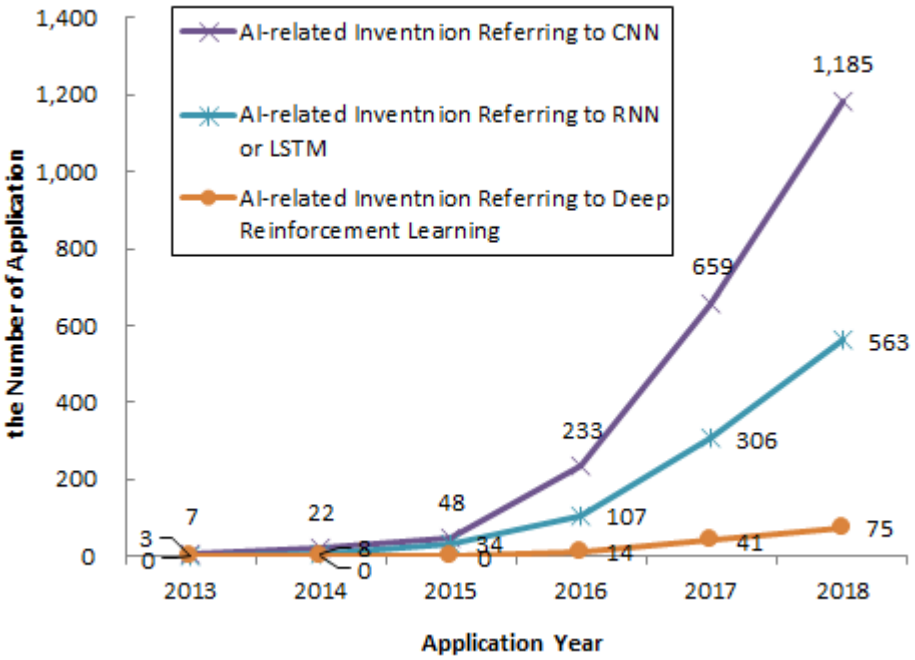


Figure 10 The number of application of AI-related invention referring to the specific deep learning method

| |
|---|
| ○ Figures 11-1 to 11-3 show the composition ratio of the main classifications in each AI-related invention referring to (1)CNN, (2)RNN or LSTM, and (3)Deep Reinforcement Learning. |
| ○ It is well-known that CNN is suitable for video or image recognition processing, RNN and LSTM for speech recognition and text processing, and deep reinforcement learning for system control and optimization. Those technical characters are reflected in the configuration of each main classification shown in Figures 11-1 to 11-3. As for CNN, the classification of G06T (image processing) and H04N (video processing) are prominent, and as for RNN and LSTM, the classification of G10L (speech processing) and G06F17/20-28 (natural language processing) are prominent. Deep Reinforcement Learning is actually small in the number of applications per se, but it is often used in control-related technologies such as G05B (control system and adjustment system in general) and B25J (manipulator). |
| ○ It is important to continue to select and adopt appropriate deep learning methods (or other AI methods) according to the purpose and application of the system. |

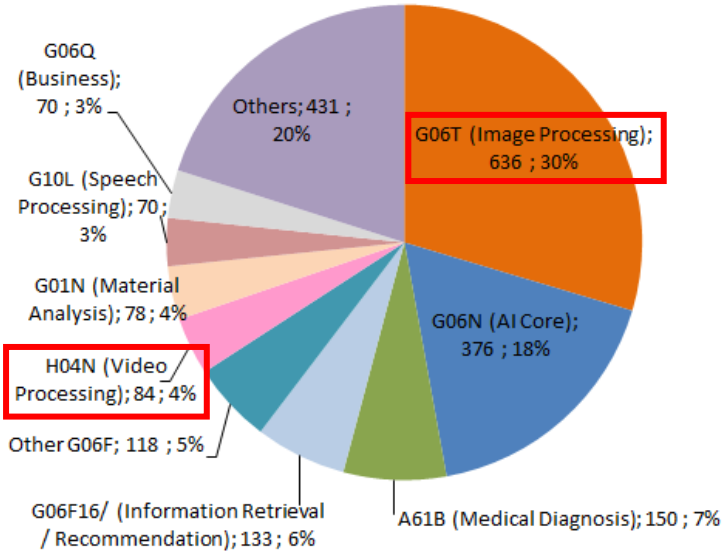


Figure 11-1 Configuration of main classifications of AI-related inventions referring to CNN (applications in 2013-18)

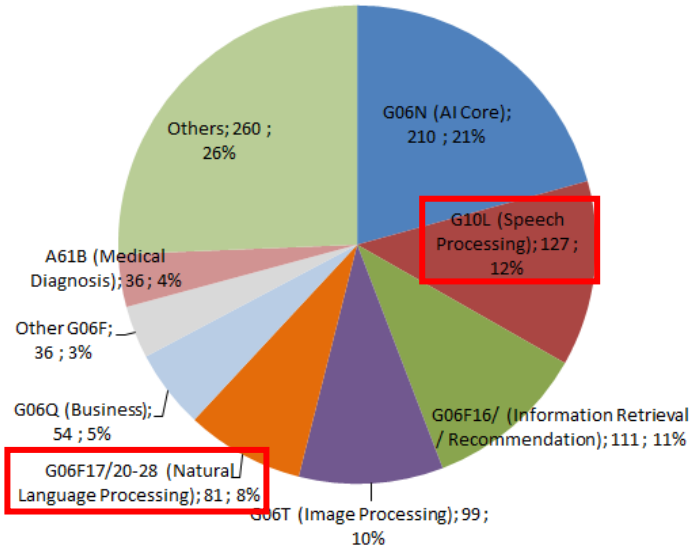


Figure 11-2 Configuration of main classifications of AI-related inventions referring to RNN or LSTM (applications in 2013-18)

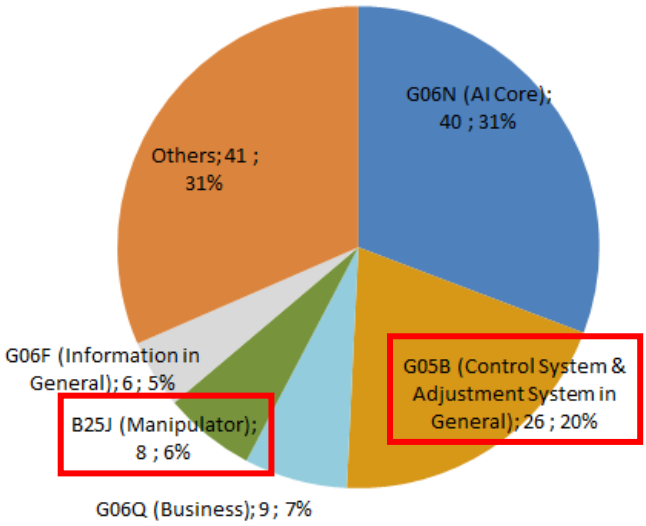


Figure 11-3 Configuration of main classifications of AI-related inventions referring to Deep Reinforcement Learning (applications in 2013-18)

## 2-4. Applicants Trends

- ○ Figure 12 shows the applicants with the highest number of applications for AI-related inventions in recent years. Figure 12 also shows the number of applications for AI-related inventions referring to deep learning. The target is applications in 2014 or later for which the patent publication had been issued by April 2020.
- ○ Because this research targets domestic applications, Japanese companies occupy the top position, but some foreign companies are also prominent.

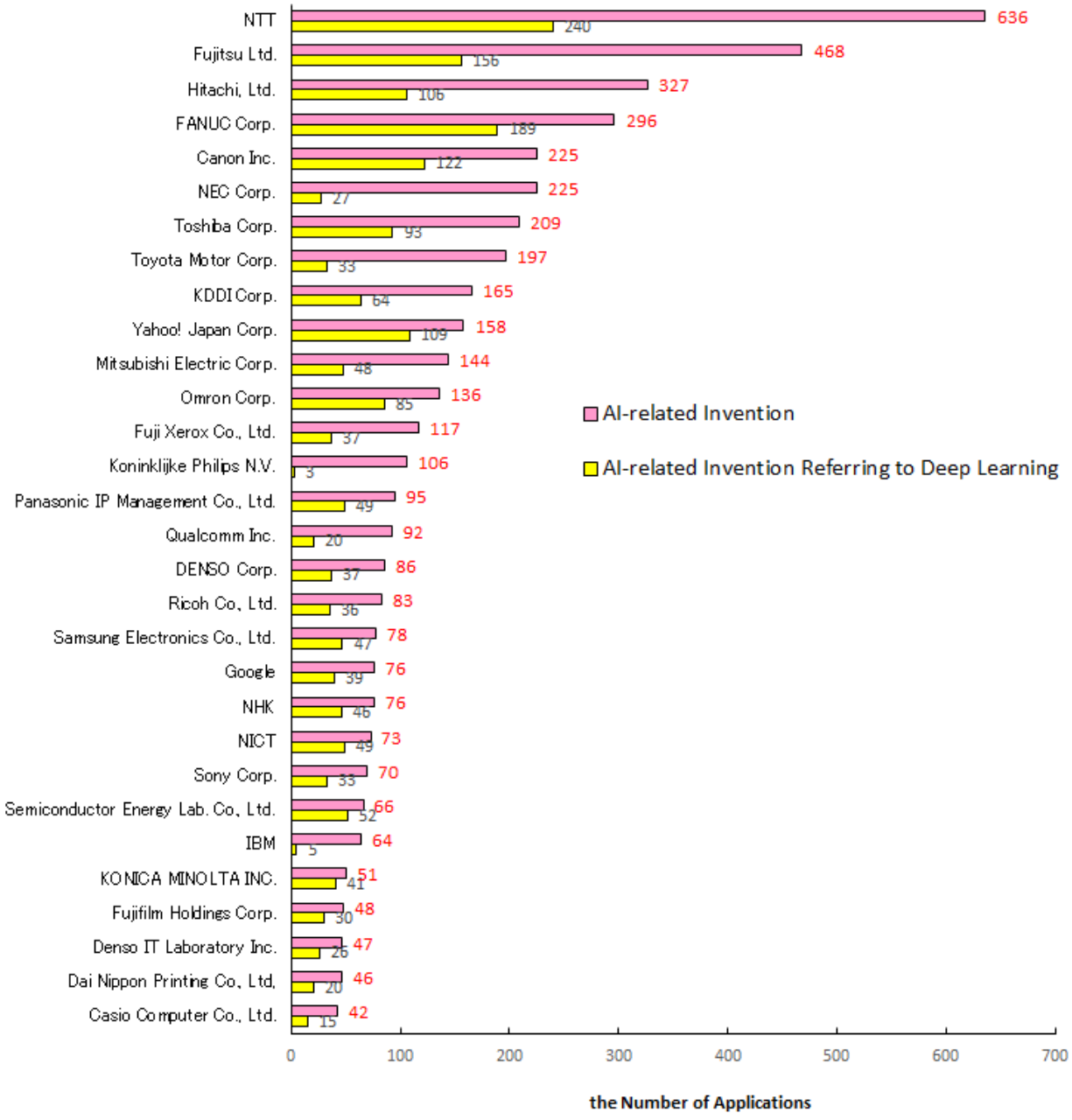


Figure 12 The number of applications for AI-related inventions by applicants (Applications since 2014 and published by April 2020)

- ○ Figure 13 shows the composition ratio of the main classifications of the applications for AI-related inventions by the above applicants. As described in Figure 13, here, several main classifications are grouped and displayed as "video or image processing", "control / robotics" and so on.
- ○ It can be seen that each applicant is using AI for a technical fields closely related to their own business.

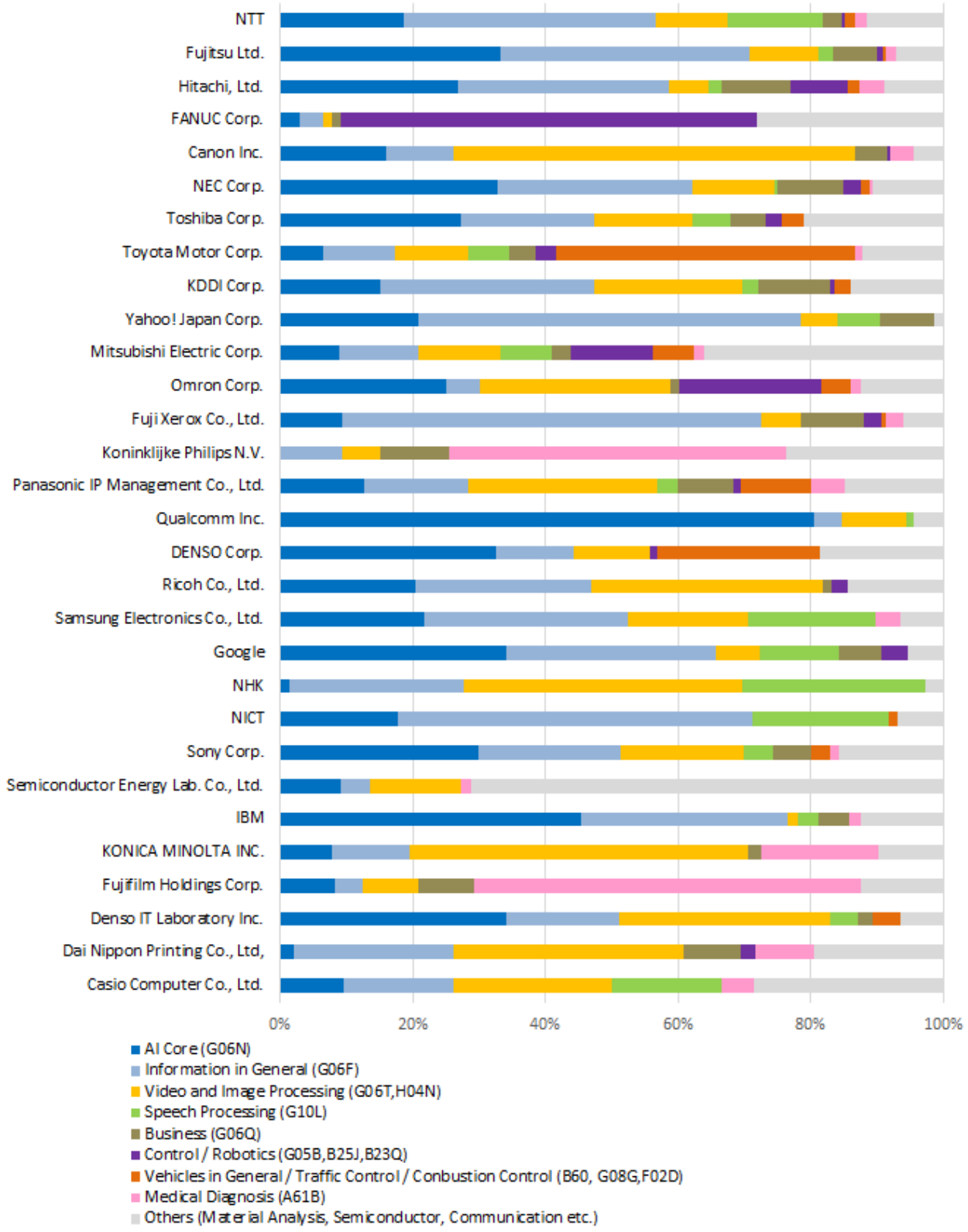


**Figure 13 The composition ratio of main classifications for AI-related inventions by applicants**

【Remarks】

- The term “number of applications” in Figures 12 and 13 refers to the number of applications

in 2014 or later for which any of (1) publication of unexamined patent application, (2) publication of PCT application, (3) publication of granted patent application or (4) JP domestic re-publication text of PCT publication has been issued by April 2020.

- As for joint application, the first applicant is counted.
- "NTT" stands for "Nippon Telegraph and Telephone Corp.".
- "Qualcomm Inc." is a generic term for "Qualcomm Inc." and "Qualcomm Technologies Inc.".
- "Panasonic IP Management Co., Ltd." stands for "Panasonic Intellectual Property Management Co., Ltd.".
- "Google" is a generic term for "Google LLC" and "Google Inc.".
- "IBM" stands for "International Business Machines Corp.".
- "NHK" stands for "Japan Broadcasting Corp.".
- "NICT" stands for "National Institute of Information and Communications Technology".
- "Microsoft" stands for "Microsoft Technology Licensing, ELC".

## 3. Application Status in each Country

- ○ Figure 14 shows the number of national applications to the Five IP Offices and PCT classified into IPC: G06N. Similar to the situation in Japan, the number of applications for AI-related technology is increasing in each country. The United States and China are the major application destinations in the world.
- ○ Furthermore, as a trend of applications related to neural networks, Figure 15 shows the number of applications classified into IPC: G06N3/02-3/10 (neural network). As for this, the number of applications in China is higher than the US, and it is also on the rise worldwide.
- ○ Figure 16 shows, the ratio of the applications including the deep-learning-related keywords listed in Annex 4 in its application documents (abstract, claim or specification) among applications to the five offices classified into G06N3/02-3/10. Although this ration alone cannot measure technical levels of deep learning in each country, it can be seen the trend that the ratio is growing in all countries as well, which suggests that deep learning has been rapidly spreading in AI technology development around the world since 2014.

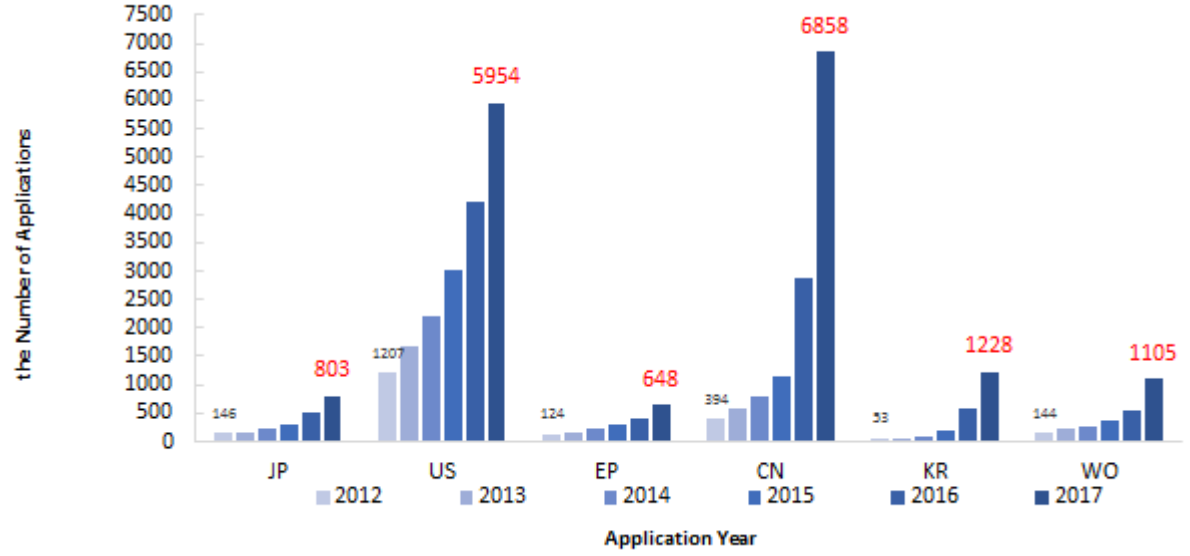


**Figure 14 The number of applications to each country classified into G06N (showing the number of applications in 2012 and 2017)**

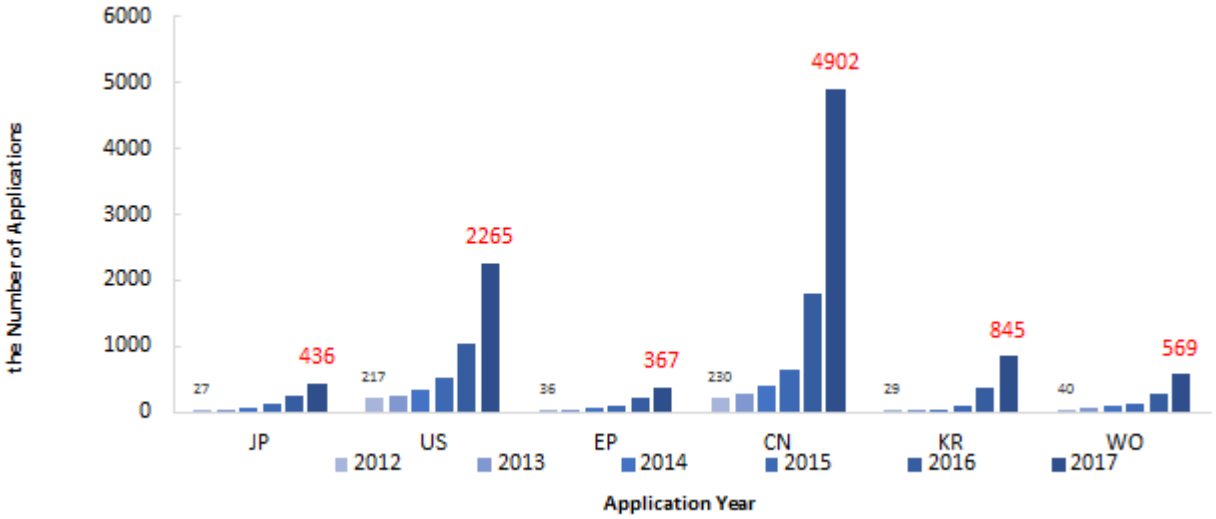


Figure 15 The number of applications
classified into G06N3/02-3/10 (neural network)
(showing the number of applications in 2012 and 2017)

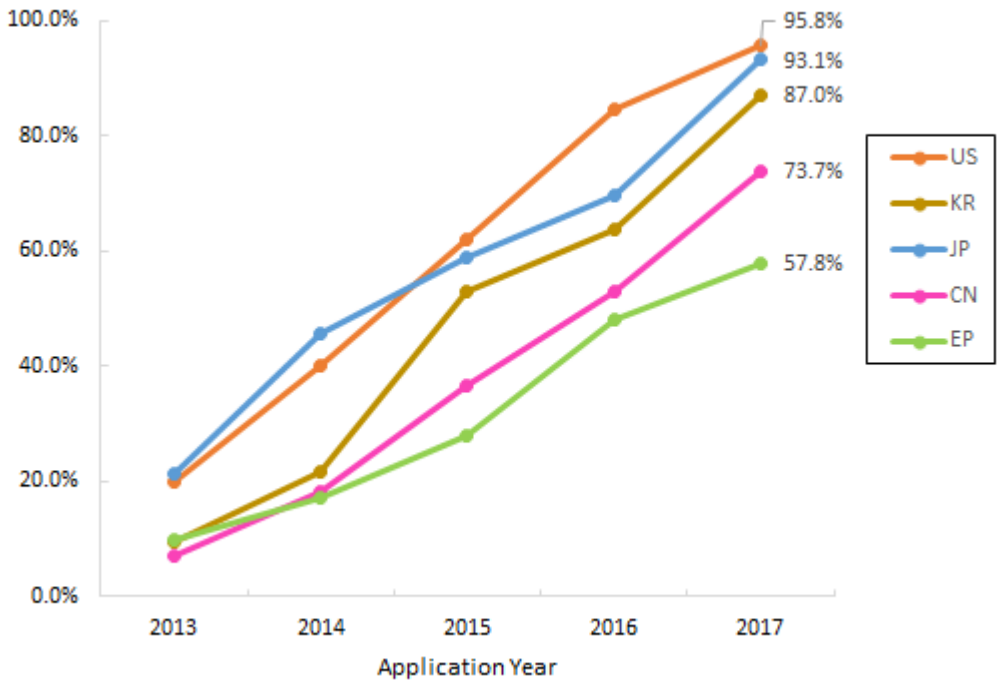


Figure 16 the ratio of the applications including deep-learning-related keywords in its application documents among applications classified into G06N3/02-3/10

【Remarks】

- Figures 14-16 are made based on WIPO Patentscope (searched on April 15, 2020). As the searched databases are different, the number of JP applications does not match the number of domestic

applications in Figure 3.

- "Application year" follows the definition in WIPO Patentscope.
- For Japan, China, and Korea, the number of applications includes utility models.

## 4. Reference Information about AI-related Invention

① WIPO Technology Trends - Artificial Intelligence (This is a report on the application and research trends in each country regarding AI technology, published by WIPO in January 2019. This report is detailed on trends in AI-related technologies from a global perspective. When selecting the FI codes and keywords defining the scope of AI-related inventions in our research, we carefully referred to "Methodology" attached to this report.)

② J-PlatPat PMGS (See here for details on FI and IPC.)

③ Patent Examination Case Examples pertinent to AI-related technologies

【Annex 1】AI-related FI

| AI-related FI | Description | 【Ref.】Description of upper subclass |
|---|---|---|
| A61B1/045,614 | conducting machine learning, data mining or statistical analysis, e.g. extracting lesion parts by using AI; extracting lesion parts by cluster analysis | A61B：DIAGNOSIS; SURGERY; IDENTIFICATION |
| B23Q15/00,301@C | Programme creation by knowledge accumulation and inference | B23Q：DETAILS, COMPONENTS, OR ACCESSORIES FOR MACHINE TOOLS |
| B60T8/174 | characterised by using special control logic, e.g. fuzzy logic | B60T：VEHICLE BRAKE CONTROL SYSTEMS OR PARTS THEREOF; BRAKE CONTROL SYSTEMS OR PARTS THEREOF, IN GENERAL; ARRANGEMENT OF BRAKING ELEMENTS ON VEHICLES IN GENERAL; PORTABLE DEVICES FOR PREVENTING UNWANTED MOVEMENT OF VEHICLES; VEHICLE MODIFICATIONS TO FACILITATE COOLING OF BRAKES |
| F02D41/14,310@H | Learning control | F02D：CONTROLLING COMBUSTION ENGINES |
| F24H1/10,302@N | Fuzzy control(Including neural net) | F24H：FLUID HEATERS, e.g. WATER OR AIR HEATERS, HAVING HEAT-GENERATING MEANS, IN GENERAL |
| G05B13/02@L | Learning control | G05B：CONTROL OR REGULATING SYSTEMS IN GENERAL; FUNCTIONAL ELEMENTS OF SUCH SYSTEMS; MONITORING OR TESTING ARRANGEMENTS FOR SUCH SYSTEMS OR ELEMENTS |
| G05B13/02@M | using AI and inference method | |
| G05B13/02@N | Fuzzy control | |
| G05B19/4155@V | inferencing or learning | |
| G06F7/02,630 | adaptation, e.g. self study | G06F：ELECTRIC DIGITAL DATA PROCESSING |
| G06F11/14,676 | in neural net | |
| G06F11/22,657 | using expert system | |
| G06F11/22,663 | using neural network | |
| G06F16/36 | Creation of semantic tools, e.g. ontology or thesauri | |

| | | |
|---|---|---|
| G06F16/90,100 | knowledge database | |
| G06F17/22,682 | automatically learn conversion rule, e.g. learning by examples | |
| G06F17/27,615 | statistical method | |
| G06F17/28,618 | statistical method, e.g. probability model | |
| G06F17/30,180@A | knowledge database | |
| G06F17/30,180@B | expert system | |
| G06F17/30,180@C | fuzzy searching | |
| G06F17/50,604@D | using AI, inference | |
| G06K7/14,082 | step using fuzzy logic solution or solution taking natural phenomenon as model such as neural network, genetic algorithm, simulated annealing | G06K：RECOGNITION OF DATA; PRESENTATION OF DATA; RECORD CARRIERS; HANDLING RECORD CARRIERS |
| G06T1/40 | Neural networks | G06T：G06T IMAGE DATA PROCESSING OR GENERATION, IN GENERAL |
| G06T3/40,725 | uses neural network | |
| G06T7/00,350@B | recognition by learning algorithm | |
| G06T7/00,350@C | using neural network | |
| G06T7/00,350@D | by heriditical algorithm | |
| G06T7/143 | involving probabilistic approaches, e.g. Markov random field [MRF] modelling | |
| G06T9/00,200 | using neural networks | |
| G08B31/00@A | for example, analyzing the cause of anomaly by the use of reasoning or fuzzy theory, or showing the measures and methods | G08B：SIGNALLING OR CALLING SYSTEMS; ORDER TELEGRAPHS; ALARM SYSTEMS |
| G10L15/10,300@J | characterized by calculation of the degree of resemblance or the distance by using the fuzzy theory or the chaos theory | G10L：SPEECH ANALYSIS OR SYNTHESIS; SPEECH RECOGNITION; SPEECH OR VOICE PROCESSING; SPEECH OR AUDIO CODING OR DECODING |
| G10L15/14 | using statistical models, e.g. Hidden Markov Models [HMM] (G10L 15/18takes precedence) | |
| G10L15/16 | using artificial neural networks | |
| G10L17/10 | Multimodal systems, i.e. based on the integration of multiple recognition engines or fusion of expert systems | |
| G10L17/16 | Hidden Markov models [HMMs] | |
| G10L17/18 | Artificial neural networks; Connectionist approaches | |
| G10L25/30 | using neural networks | |
| G10L25/33 | using fuzzy logic | |

| | | |
|---|---|---|
| G10L25/36 | using chaos theory | |
| G10L25/39 | using genetic algorithms | |
| G16B40/00 | ICT specially adapted for biostatistics; ICT specially adapted for bioinformatics-related machine learning or data mining, e.g. knowledge discovery or pattern finding | G16B：BIOINFORMATICS, i.e. INFORMATION AND COMMUNICATION TECHNOLOGY [ICT] SPECIALLY ADAPTED FOR GENETIC OR PROTEIN-RELATED DATA PROCESSING IN COMPUTATIONAL MOLECULAR BIOLOGY |
| G16C20/70 | Machine learning, data mining or chemometrics | G16C：COMPUTATIONAL CHEMISTRY; CHEMOINFORMATICS; COMPUTATIONAL MATERIALS SCIENCE |
| G16H50/20 | for computer-aided diagnosis, e.g. based on medical expert systems | G16H：HEALTHCARE INFORMATICS, i.e. INFORMATION AND COMMUNICATION TECHNOLOGY [ICT] SPECIALLY ADAPTED FOR THE HANDLING OR PROCESSING OF MEDICAL OR HEALTHCARE DATA |
| H01M8/04992 | characterised by the implementation of mathematical or computational algorithms, e.g. feedback control loops, fuzzy logic, neural networks or artificial intelligence | H01M：PROCESSES OR MEANS, e.g. BATTERIES, FOR THE DIRECT CONVERSION OF CHEMICAL ENERGY INTO ELECTRICAL ENERGY |

【Annex 2】AI core keywords (Hereinafter, ○C or ○N respectively means ○ characters neighborhood search with or without specifying word order.)

- 機械学習
- (マシン+machine),2C,(ラーニング+learning)
- (学習アルゴリズム+学習モデル)
- (教師あり+教師有+教師付+教師つき),2C,(学習+トレーニング+訓練)
- (教師なし+教師無),2C,(学習+トレーニング+訓練)C,
- (半教師あり+半教師有+半教師付+半教師つき),2C,(学習+トレーニング+訓練)
- (ニューラル+neural),2C,(ネット+network)
- 多層,2C,パーセプトロン
- ネオコグニトロン
- (コネクショニスト+コネクショニズム)
- バック,2C,プロパゲーション
- 誤差逆伝播
- (過剰適合+過剰学習+過適合+過学習)
- (シグモイド+活性化),2C,関数
- (深層+ディープ+deep),2C,(学習+ラーニング+learning)
- (deep+ディープ+深層),2C,(強化+reinforcement+Q+信頼+ビリーフ+belief)
- オートエンコ
- 自己符号化
- ボルツマンマシン
- 潜在表現
- 次元削減
- (強化+レインフォースメント+リインフォースメント),2C,(学習+ラーニング)
- Q,1C,(学習+ラーニング+learning)
- long,2C,short,2C,term
- 長,2C,短期記憶
- (敵対+generative),2C,(生成+adversarial),2C,(ネット+network)
- 表現学習
- 転移学習
- アンサンブル学習
- ファイン,2C,チューニング
- (アクティブ+能動),2C,(ラーニング+学習)
- セルフ,2C,ラーニング
- 自己学習
- 遺伝,2C,(アルゴリズム+モデル+モデリ)
- 群知能

- スワーム,2C,インテリ
- サポート,2C,ベク,3C,マシン
- SVM
- ランダム,2C,フォレスト
- (決定+ディシジョン),2C,(木+トリー+ツリー)
- (ベイズ+ベイジアン),2C,(ネット+モデル+モデリ+推定)
- (決定+ディシジョン),2C,(モデル+モデリ)
- (勾配+gradient),2C,(ブースト+ブースティング+boost)
- XG,2C,(ブースト+ブースティング+boost)
- (ADA+エイダ+アダ),2C,(ブースト+ブースティング+boost)
- (RANK+ランク+ランキング),2C,(ブースト+ブースティング+boost)
- ロジスティ,3C,回帰
- 確率,2C,勾配,2C,降下
- (潜在+latent),2C,(意味+セマンティ+概念+semantic)
- (潜在+latent),2C,(ディリクレ+ディレクレ+dirichlet)
- (隠+確率+モデル+モデリ+ネット+過程),2N,マルコフ
- (コンピュー+コンピュテ),7C,クリエイティ
- 記述,2C,(モデル+モデリ)
- 特徴選択
- (ワード+単語),3n,(分散表現+埋め込+埋めこ+埋込+エンベッド+エンベッディング+エンベディング)
- 確率,2C,(アプローチ+テクニック+手法+方法+アルゴリズム)
- ファジ,2C,(論理+理論+ロジック+制御)
- カオス,2C,(モデル+モデリ+理論)
- 混合ガウス
- トピック,2C,(モデル+モデリ+分析+ラベ+抽出)
- (チャット+AI),2C,ボット
- ロボ,2C,アドバイ
- エキスパート,2C,システム
- マルチ,2C,エージェント,2C,システム
- (帰納+論理),2C,プログラミング
- オントロジ
- (概念+セマンティック+意味論),2C,(モデル+モデリ)
- (知識ベース+知識モデル)
- (人工知能+計算知能)
- artificial,2C,intelligence

【Annex 3】Deep-Learning-related keywords (Hereinafter, ○C or ○N respectively means ○ characters neighborhood search with or without specifying word order.)

① (深層+ディープ+deep),2C,(学習+ラーニング+learning)
② (deep+ディープ+深層),2C,(ニューラル+neural+信頼+ビリーフ+belief)
③ (オートエンコーダ+オート・エンコーダ+自己符号化)
④ (制限+制約),2c,ボルツマン
⑤ (畳み+畳込+たたみ+convolutional+convolution+コンボリューション+コンボリューショナル),3C,(ニューラル+neural)
⑥ (リカレント+再帰+recurrent),2C,(ニューラル+neural)
⑦ long,2C,short,2C,term
⑧ 長,2C,短期記憶
⑨ (deep+ディープ+深層),2C,(強化+reinforcement+Q),2C,(ネット+学習+ラーニング+network+learning)
⑩ (敵対+generative),2C,(生成+adversarial),2c,(ネット+network)

・CNN-related keywords → ⑤
・RNN-or-LSTM-related keywords → ⑥⑦⑧
・Deep-Reinforcement-Learning-related keywords → ⑨

【Annex 4】Deep-Learning-related keywords in different languages

| English | Japanese | Chinese | Korean |
|---|---|---|---|
| "deep learning" | "ディープラーニング" OR "ディープ・ラーニング" OR "深層学習" | "深度学习" | "딥러닝" OR "심층학습" |
| "deep neural net*" | "ディープニューラル" OR "ディープ・ニューラル" OR "深層ニューラル" | "深度神经网络" | "심층신경망" OR "딥신경망" |
| "deep belief net*" | "ディープ信頼ネット" OR "ディープビリーフネット" OR "ディープ・ビリーフ・ネット" | "深度信仰网络" | "딥 빌리프 네트워크" |
| "auto encoder" OR "autoencoder" | "自己符号化" OR "オートエンコーダ" OR "オート・エンコーダ" | "自编码器" | "오토인코더" |
| "restricted boltzmann" | "制限ボルツマン" OR "制約ボルツマン" OR "制限付きボルツマン" OR "制約付きボルツマン" | "受限玻尔兹曼机" | "제한된 볼츠만 머신" |
| "convolutional neural net*" | "畳み込みニューラル" OR "畳込みニューラル" OR "畳みこみニューラル" OR "畳み込ニューラル" OR "畳込ニューラル" OR "たたみ込みニューラル" OR "たたみこみニューラル" OR "コンボリューショナルニューラル" OR "コンボリューショナル・ニューラル" | "卷积神经网络" | "합성곱신경망" OR "콘볼루션신경망" |
| "recurrent neural net*" | "リカレントニューラル" OR "リカレント・ニューラル" OR "リカレント型ニューラル" OR "再帰型ニューラル" | "循环神经网络" | "순환신경망" |
| "long short term memory" | "長短期記憶" OR "長・短期記憶" | "長短期記憶" | "장단기메모리" |
| "deep reinforcement" | "ディープ強化" OR "深層強化" | "深度强化" | "심층강화" OR "딥강화" |
| "generative adversarial net*" | "敵対的生成ネット" | "生成对抗网络" | "생성적 적대 신경망" |

●Query used in WIPO Patentscope (Set one of JP, US, EP, CN, KR, WO to **XX** of CTR and set a range of application year to **YY** of AD.)

CTR:**XX** AND AD:([01.01.20**YY** TO 31.12.20**YY**]) AND (IC:G06N3/02 OR IC:G06N99/00) AND (EN_ALLTXT:("deep learning" OR "deep neural net*" OR "deep belief net*" OR "autoencoder" OR "auto encoder" OR "restricted boltzmann" OR "convolutional neural net*" OR "recurrent neural net*" OR "long short term memory" OR "deep reinforcement" OR "generative adversarial net*") OR JA_ALLTXT:("deep learning" OR "ディープラーニング" OR "ディープ・ラーニング" OR "深層学習" OR "deep neural net*" OR "ディープニューラル" OR "ディープ・ニューラル" OR "深層ニューラル" OR "deep belief net*" OR "ディープ信頼ネット" OR "ディープビリーフネット" OR "ディープ・ビリーフ・ネット" OR "autoencoder" OR "auto encoder" OR "自己符号化" OR "オートエンコーダ" OR "オート・エンコーダ" OR "restricted boltzmann" OR "制限ボルツマン" OR "制約ボルツマン" OR "制限付きボルツマン" OR "制約付きボルツマン" OR "convolutional neural net*" OR "畳み込みニューラル" OR "畳込みニューラル" OR "畳みこみニューラル" OR "畳み込ニューラル" OR "畳込ニューラル" OR "たたみ込みニューラル" OR "たたみこみニューラル" OR "コンボリューショナルニューラル" OR "コンボリューショナル・ニューラル" OR "recurrent neural net*" OR "リカレントニューラル" OR "リカレント・ニューラル" OR "リカレント型ニューラル" OR "再帰型ニューラル" OR "long short term memory" OR "長短期記憶" OR "長・短期記憶" OR "deep reinforcement" OR "ディープ強化" OR "深層強化" OR "generative adversarial net*" OR "敵対的生成ネット") OR ZH_ALLTXT:("deep learning" OR "深度学习" OR "deep neural net*" OR "深度神经网络" OR "deep belief net*" OR "深度信仰网络" OR "autoencoder" OR "auto encoder" OR "自编码器" OR "restricted boltzmann" OR "受限玻尔兹曼机" OR "convolutional neural net*" OR "卷积神经网络" OR "recurrent neural net*" OR "循环神经网络" OR "long short term memory" OR "長短期記憶" OR "deep reinforcement" OR "深度强化" OR "generative adversarial net*" OR "生成对抗网络") OR KO_ALLTXT:("deep learning" OR "딥러닝" OR "심층학습" OR "deep neural net*" OR "심층신경망" OR "딥신경망"  OR "deep belief net*" OR "딥 빌리프 네트워크" OR "autoencoder" OR "auto encoder" OR "오토인코더" OR "restricted boltzmann" OR "제한된 볼츠만 머신" OR "convolutional neural net*" OR "합성곱신경망" OR "콘볼루션신경망" OR "recurrent neural net*" OR "순환신경망" OR "long short term memory" OR "장단기메모리" OR "deep reinforcement" OR "심층강화" OR "딥강화" OR "generative adversarial net*" OR "생성적 적대 신경망"))