Artificial Intelligence: Evolution, Application, and Future Trends

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References

➢ References

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AI Systems in China

➢ AI Systems in China

- AI system development started in China in the 1970s when China's first expert system for the diagnosis and treatment of hepatitis was developed. Since then, AI system activity has been steadily growing in China. Chinese researchers have developed thousands upon thousands of AI systems that have been successfully applied to manufacturing, agriculture, transportation, the environment, scientific research, education and the military.

AI Systems in China

➢ AI Systems in China

- In the mid-1980s, China launched the well-known ‘863 Advanced Technology Project’ under the late leader Deng Xiaoping. This national research project initiated an era of unprecedented development of AI technology. Many of today’s sophisticated expert systems are the results of expansion of AI technology. Since the launching of the ‘863 Project’, we have witnessed the emergence of advanced AI technology including rule-based, model-based, case-based reasoning, neural networks, genetic algorithms, natural language processing, and hybrid intelligent systems.

Overview of Artificial Intelligence

➢ One of the Core Drivers of Industry

- Promoting the integration of emerging technologies, such as Internet of Things (IoT), cloud computing, blockchains, in the era of big data and Industry 4.0.

- Future artificial intelligence will adapt to and interact with humans with natural languages, movements, and even emotions.

(Russell & Norvig, 2016; Goertzel, 2007; Doshi-Velez & Kim, 2017)

Overview of Artificial Intelligence

➢ Definition

- Any theory, method, and technique that helps machines (especially computers) to analyze, simulate, exploit, and explore human thinking process and behavior can be considered as artificial intelligence.

- It is the computation and computing of data in intelligent ways. Artificial intelligence is the study of features of human activities, constructing a certain intelligent system, to make computers complete the tasks that only human is able to do in the past, and to apply computer hardware and software to simulate the underlying theories, approaches and techniques of human behavior.

(Murphy, 2017; Mata, et al., 2018; Došilović, Brčić, & Hlupić, 2018; Tan & Lim, 2018)

Overview of Artificial Intelligence

➢ Development Trend

- Deep Learning plus Big Data has become the mainstream for the development of artificial intelligence.
- Artificial intelligence has gradually entered the stage of technological R&D and industrialization initiated from the experimental research.
- The application of artificial intelligence is gradually expanding from the commercial and service industries to the manufacturing and agricultural sectors, which make the general technology and basic technical features of artificial intelligence more prominent and spreading out.

(Russell & Norvig, 2016; Goertzel, 2007; Doshi-Velez & Kim, 2017; Murphy, 2017; Mata, et al., 2018; Došilović, Brčić, & Hlupić, 2018; Tan & Lim, 2018)

Overview of Artificial Intelligence

- AI **Development in Different Countries**

  - Chinese researchers have constructed different types of artificial intelligent models in petroleum industry (Li, Wang, Wang, & Li, 2018).

  - Multiple artificial intelligence algorithms are applied to analyze rainfall in summer and fall seasons in India. The prediction accuracy is closely related to data, hidden layers, and procedures (Dash, Mishra, & Panigrahi, 2018).

Overview of Artificial Intelligence

➢ AI **Application in Different Countries**

- Artificial intelligence algorithms are employed to assess water level in Morocco and Poland. Practice has proved that the wavelet transform is an efficient pre-processing tool, which can get accurate prediction (Yu, et al., 2018; Baali, 2018; Piasecki, Jurasz, & Adamowski, 2018).

- Artificial neural networks associated with image recognition have been used in forest management in Turkey (Sakici & GünLü, 2018).

Overview of Artificial Intelligence

- AI **Application in Different Countries**

  - In the financial market, AI algorithms have been applied successfully for many years.

Overview of Artificial Intelligence

- AI **Application in Different Countries**

  - Chinese hospital uses AI-based clinical support system to treat patients who have lung cancer (Liu, Liu, et al., 2018).

  - In software and mobile technology, developers adopt specific AI algorithms to program a mobile game.

Goals and of This Talk

- **Briefly introducing the history of artificial intelligence since 1960s**
- **Introducing why deep learning develops so rapidly and its main models**
- **Introducing the current mainstream of artificial intelligence applications**
- **Addressing and discussing the potential challenges and issues facing artificial intelligence**

The Structure of This Survey

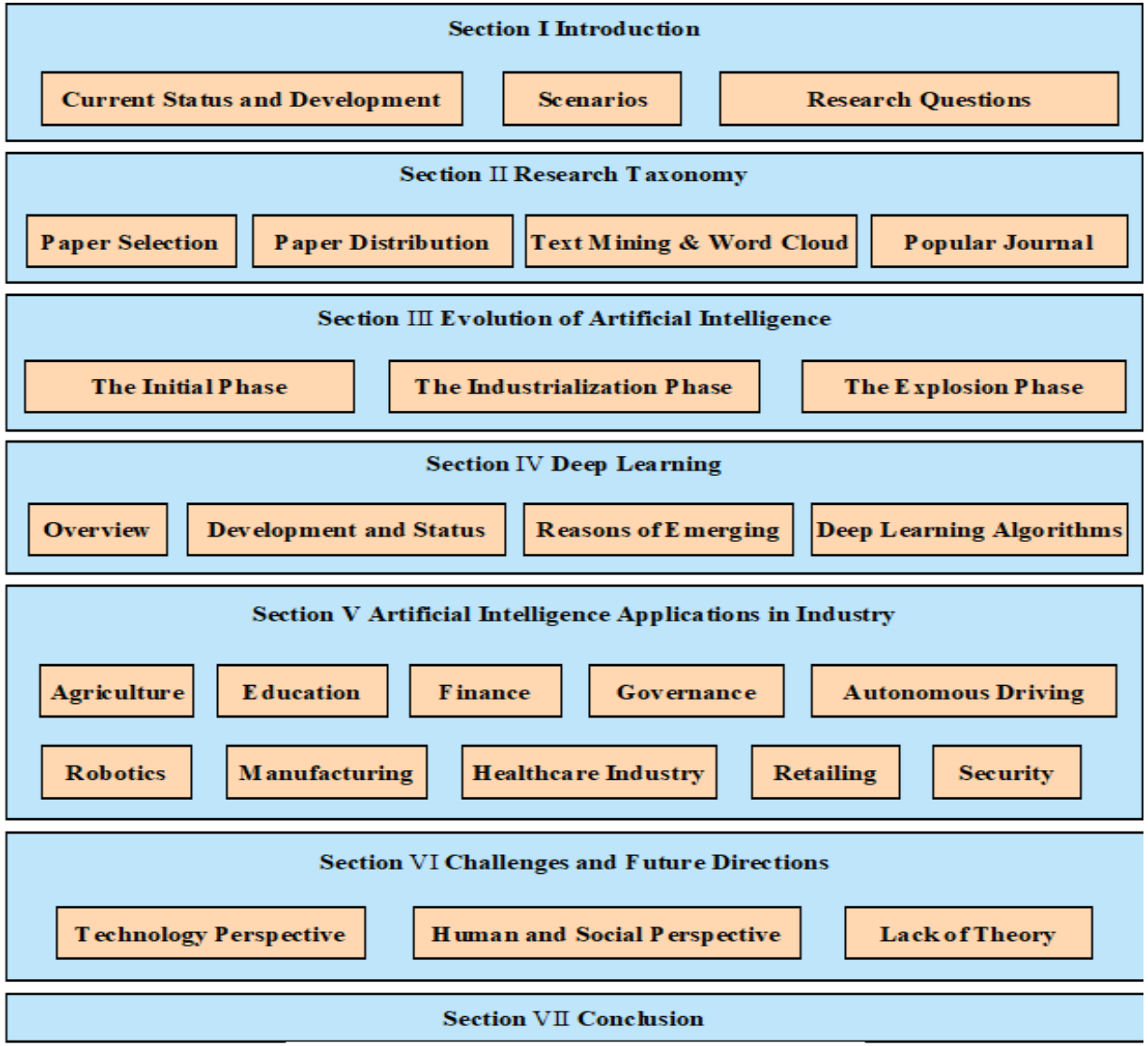
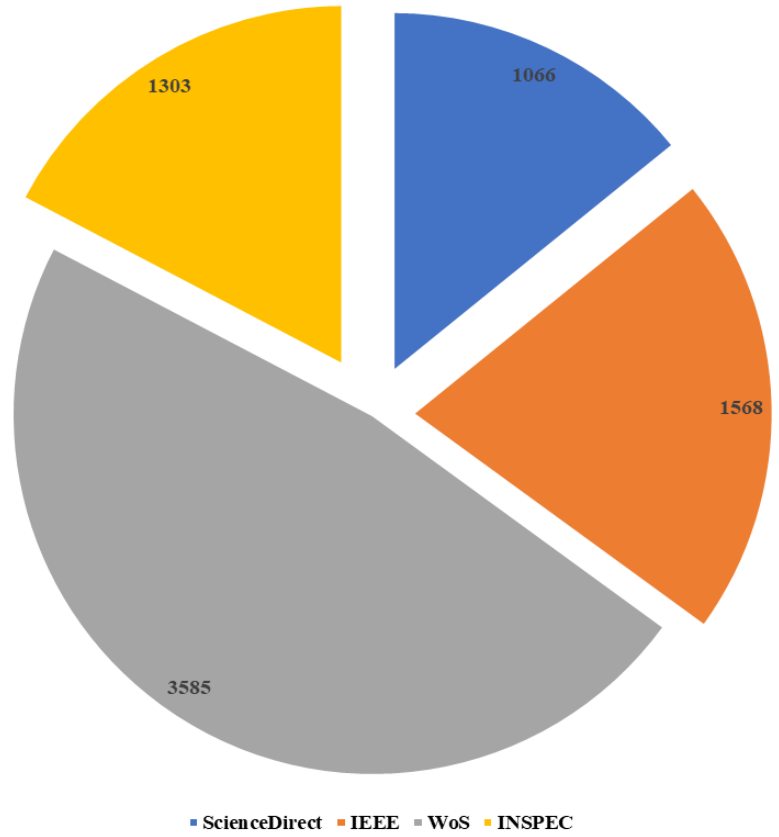


Figure 1. Structure of The Study

Research taxonomy

- **Four Major Databases**
  - WoS (Web of Science), IEEE Xplore, INSPEC, and ScienceDirect
- **The Time Period**
  - Between 1961 and 2018
- **Paper Selected**
  - 7752 papers

Research taxonomy



Fugure 3. Number of Articles from the Four Databases

- **Database:** WoS, IEEE Xplore, INSPEC, ScienceDirect
- **Search Approach:** Searching keywords "artificial intelligence" in Title

First-Round Article Search

- 8599 articles were found in total.
- WoS (3987), IEEE Xplore (1788), INSPEC (1519), ScienceDirect (1305)

Second-Round Article Filtering

- 699 duplicated articles were deleted.

Third-Round Article Filtering

- Text Mining and WordCloud Constructing (The R Project)
- According to the text analysis, current major AI applications were found.
- 378 articles were deleted based on AI application.

Result:

- After the two rounds of filtering procedure, 7522 qualified articles were selected.

Distribution:

- WoS (3585), IEEE Eplore (1568), INSPEC (1303), ScienceDirect (1066)

Article Distribution

(1961 - 2018)

Journal Seeking

26 popular journals (consisting of at least 20 articles directly related with AI)

Figure 2. Research Taxonomy

WordCloud

- **To locate the relevant articles, two criteria were used to examine the title, abstract, and keywords**
  - Word Cloud
  - Word Frequency

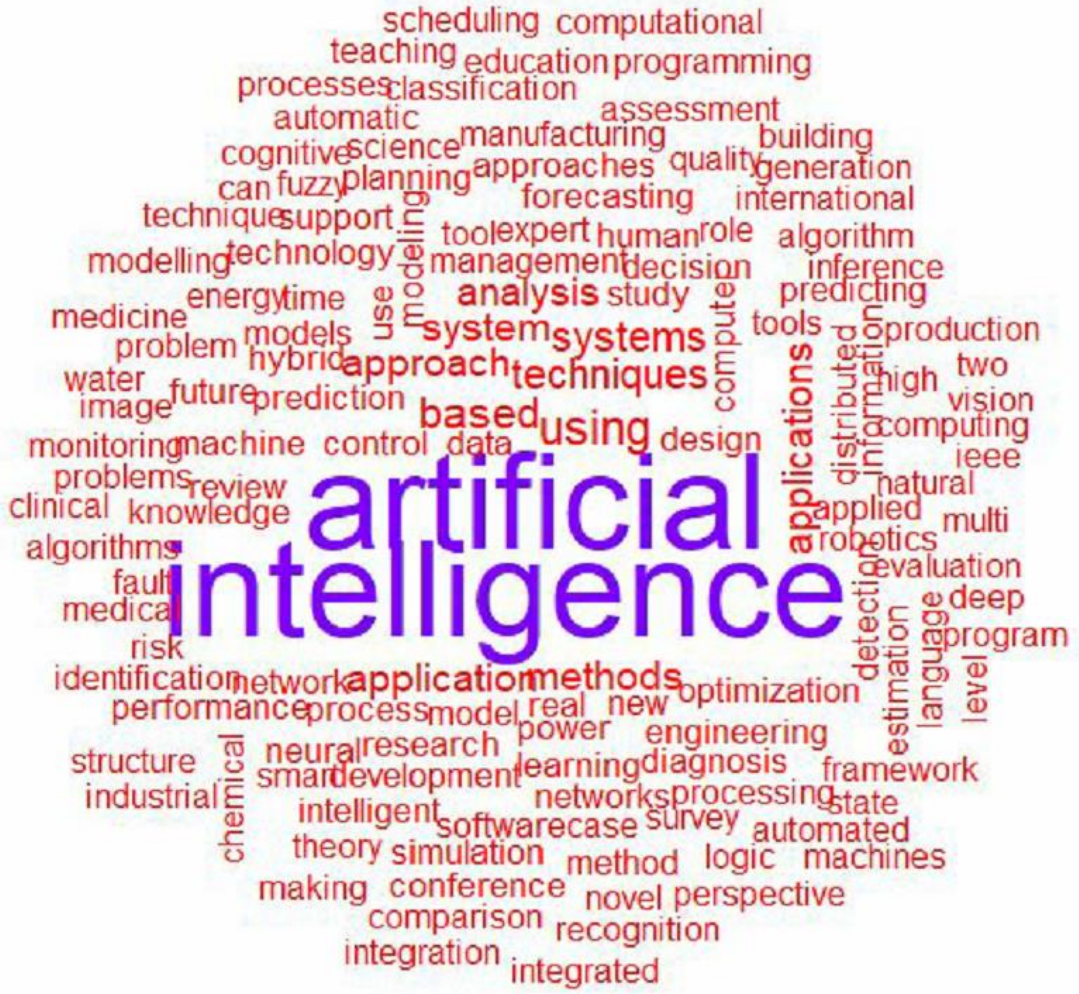


Figure 4. WordCloud of Key Applications In AI

Distribution of Articles

- The overall distribution (red line with light blue dots) clearly shows that the development of artificial intelligence has experienced two summits: the first was between 1985 and 1995, the second started since 2006

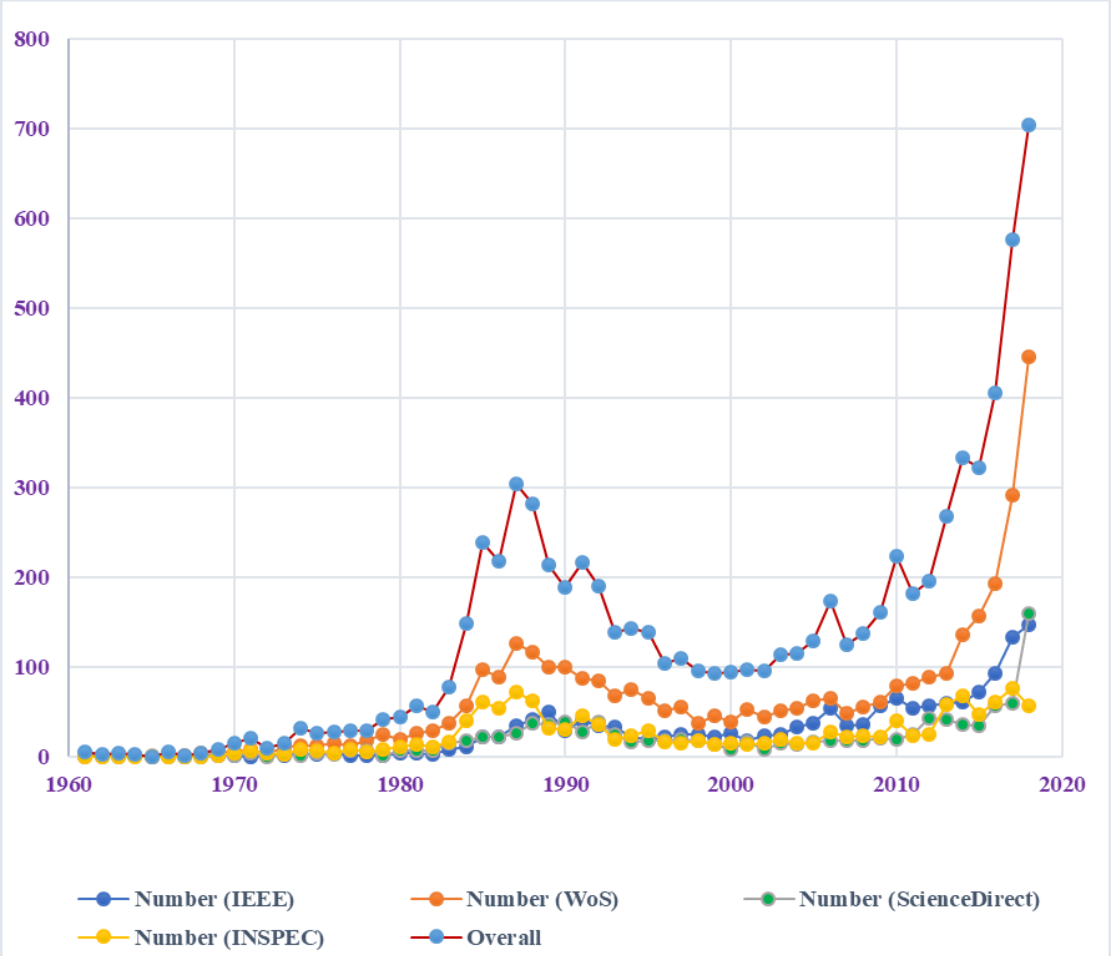


Figure 5. Article (7752) Distribution between 1961 and 2018

Distribution of Publication

- 26 popular journals that published at least 20 directly related artificial intelligence papers
- The top three journals are Expert Systems with applications, AI Magazine, and IFAC Proceedings Volumes

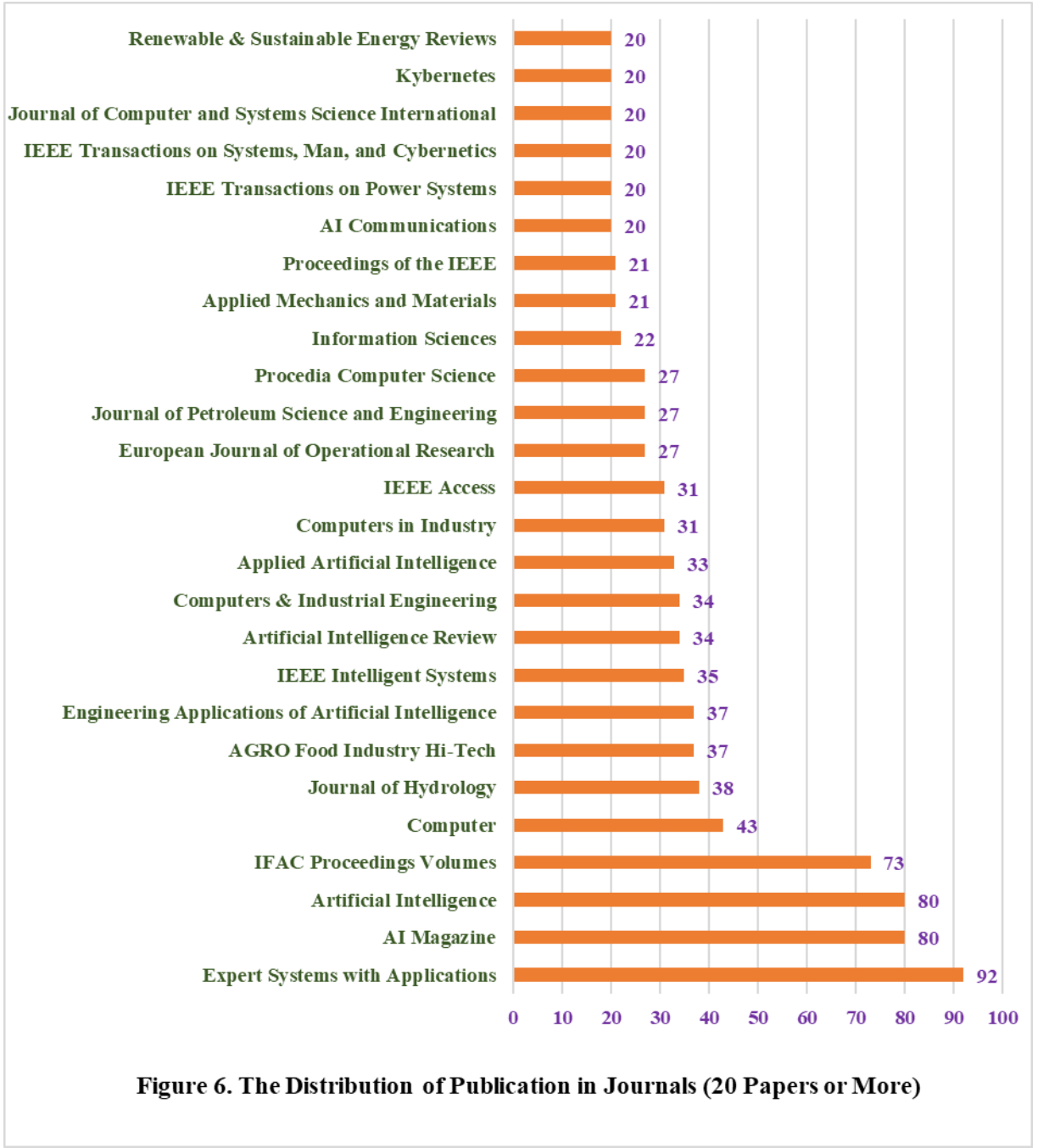


Figure 6. The Distribution of Publication in Journals (20 Papers or More)

Evolution of Artificial Intelligence

- **In terms of time dimension, artificial intelligence has gone through about three steps of development**
  - The initial phase (1956-1980)
  - The industrialization phase (1980-2000)
  - The explosion phase (2000-)

Time	Events	Country
The Initial Phase (1956-1980)		
1950	Alan Turing published a landmark paper indicating that machine was possible to be intelligent. The Turing Test was the first proposal in the philosophy of artificial intelligence.	UK
1956	The Dartmouth Conference in the United States gathered the first researchers to determine the name and mission of artificial intelligence. This event is the starting point for artificial intelligence.	USA
1957	Frank Rosenblatt, a psychologist at Cornell University, implemented a neural network "perceptron."	USA
1957	GPS (General Problem Solving) extended Wiener's feedback principle and solved many problems.	
1958	McCarthy developed LISP (List Processing) language.	USA
1967	Waseda University launched the WABOT project in 1967 and assembled the first full-size smart humanoid robot WABOT-1 in 1972.	Japan
1969	The International Federation of Artificial Intelligence was established in Seattle, USA, and held its first meeting.	USA
1974-1980, because of the limitation of computing and related techniques, AI was under a low level of development.		

The Industrialization Phase (1980-2000)		
1980	Carnegie Mellon University designed an expert system called XCON for DEC and achieved great success.	USA
1982	Japan invested 850 million US dollars to develop artificial intelligence computers. The goal is to enable machines to think in the same way as human, achieving human-computer interaction, language translation and image recognition.	Japan
1982	Physicist John Hopfield invented a neural network that could learn and process information in new ways.	USA
1986	The appearance of multi-layer neural networks and BP response propagation algorithms improved the accuracy of automatic recognition.	
1980-1987, companies around the world have adopted artificial intelligence programs called “expert systems”, and knowledge expression systems have become the focus of mainstream artificial intelligence research.		
1988	The German Artificial Intelligence Research and Center was established. It is the world's largest non-profit artificial intelligence research organization.	Germany
1997	The “Deep Blue” defeated the chess champion. After being influenced by Moore's Law, computing power began to increase dramatically.	USA
1987-1993, AI was under a low level of development for the second time.		

The Explosion Phase (2000-)		
2003	Garry Kasparov ties Deep Junior	USA
2003	Garry Kasparov tied X3D-FRITZ	Germany
2005	Stanford’s robots automatically drove 131 miles on desert roads.	USA
2006	Hinton proposed an unsupervised learning training method based on deep belief network. His doctrine prompted the academic community to begin in-depth research in deep learning.	Canada
2011	IBM Waston defeated human.	USA
2012	Deep learning has begun to be widely used in different fields.	
2014	The "Turing Test 2014" organized by the Royal Society of England passed the test for the first time.	UK
2016	AlphaGo defeated former World Go Champion.	USA

Deep Learning

- Deep learning has opened a window for us to understand the world at a higher level. Deep learning techniques simulate large-scale data, and design complex multi-layer artificial neural network models

- The concept of deep learning is proposed by Hinton in 2006. Based on the deep belief network (DBN), an unsupervised greedy layer-by-layer training algorithm is proposed, which brings hope to solve the optimization problem related to deep structures

- Deep learning establishes a hierarchical model structure similar to the human brain. It extracts input data from the bottom layer to the upper layer and establishes the mapping from the underlying signal to the high-level semantics. (Hinton, Osindero, & Teh, 2006; LeCun, Bengio, & Hinton, 2015)

Deep Learning

- Deep Learning is a method based on data representation and learning process in machine learning. It is a machine learning approach that mimics the neural structure of the human brain. Deep learning stems from the study of artificial neural networks

- The essence of deep learning is to learn more useful features by building machine learning models with many hidden layers and a large amount of training data, and ultimately improve the accuracy of classification or prediction. Therefore, the "depth model" is the approach, and the "feature learning" is the goal

(Bengio, 2009; Goodfellow, Bengio, Courville, & Bengio, 2016)

Deep Learning Algorithms

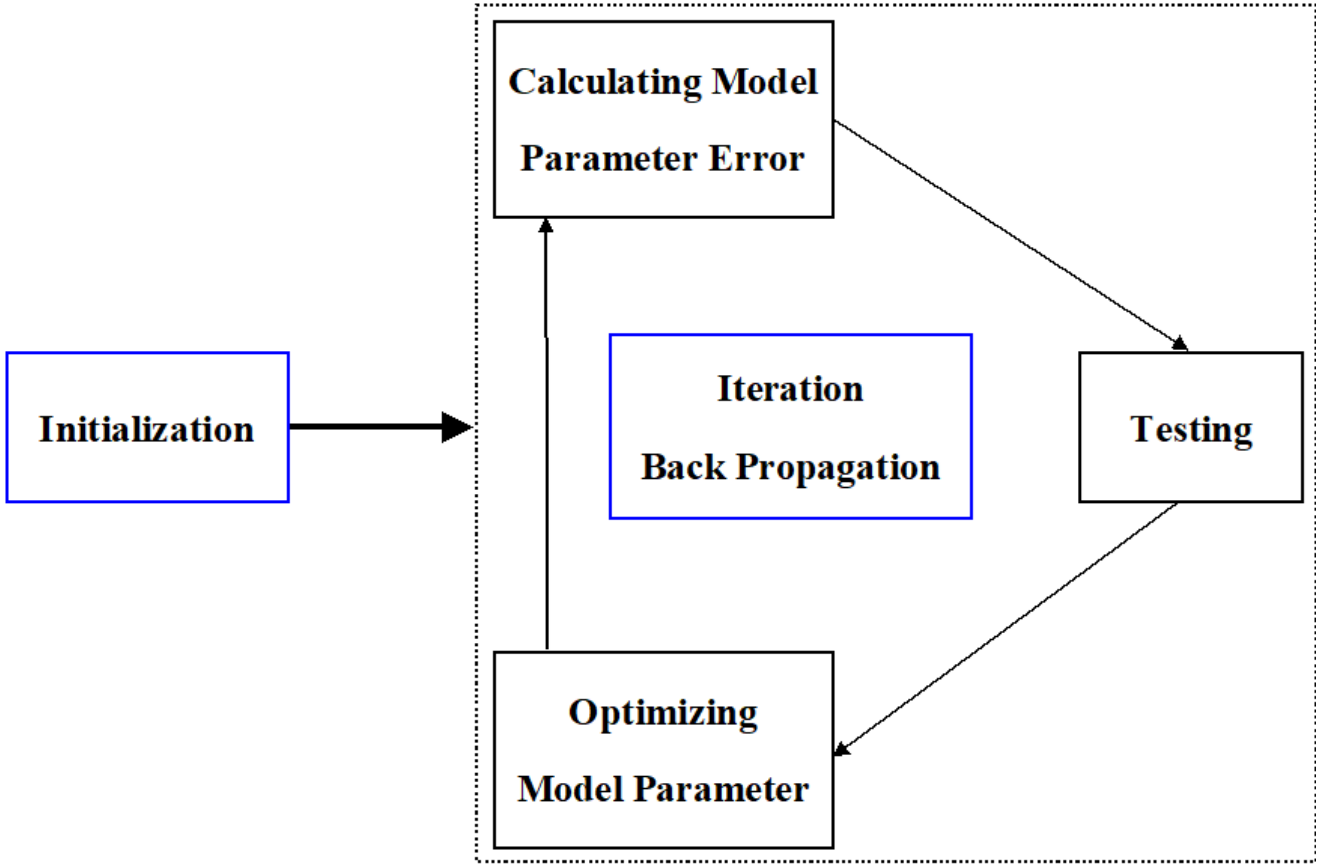


Figure 7. Deep Learning Algorithm Process

Deep Learning Algorithms

- It can be divided into two categories, supervised and unsupervised learning
- Supervised learning can make full use of artificial intelligence prior knowledge to build robust data analysis models. Supervising training and learning models can improve the universality of model applications and improve the accuracy of data analysis
- Unsupervised learning does not require any prior knowledge. Data analysis models can automate information mining and automatically build learning models. Unsupervised learning has been widely used in speech recognition and text retrieval

(Erhan, et al., 2010; Ngiam, et al., 2011; Glorot & Bengio, 2010)

Deep Learning Algorithms

Unsupervised Learning			
Model	Structure	Evaluations	Article
RBM (Restricted Boltzmann Machine)	No connection within a layer, full connection between layers	Provide pre-training for supervised learning models; Unable to calculate the representation effectively	(Nair & Hinton, 2010) (Larochelle & Bengio, 2008)
DBN (Deep Belief Network)	Full connection between the two top layers, directional connection between the other layers	Prevent overfitting; Unable to train effectively	(Hinton, Osindero, & Teh, 2006) (Mohamed, Dahl, & Hinton, 2012)
DBM (Deep Boltzmann Machine)	Full connection with the layers, multiple hidden layers	Provide pre-training for supervised learning models; solving Bayesian variational inference problem; low efficiency	(Salakhutdinov & Larochelle, 2010) (Srivastava & Salakhutdinov, 2012)
AE (Auto-Encoder)	Consisting of encoder and decoder	Used for feature extraction and dimensionality reduction; slow learning	(Bengio, Lamblin, Popovici, & Larochelle, 2007) (Deng, et al., 2010) (Sainath, Kingsbury, & Ramabhadran, 2012)
SAE (Sparse Auto-Encoder)	Consisting of encoder and decoder, sparse restriction	For dimensionality reduction and coding; poorer performance than supervised	(Bengio, Courville, & Vincent, 2013) (Hinton, et al., 2012)
DAE (Denoising Auto-Encoder)	Consisting of encoder and decoder, random noise	Used to predict missing values; robustness	(Vincent, Larochelle, Bengio, & Manzagol, 2008) (Bengio, Yao, Alain, & Vincent, 2013)

Supervised Learning			
CNN (Convolutional Neural Network)	Alternate connection between the convolutional layer the down sampling layer	Used to process image data, to solve overfitting	(Krizhevsky, Sutskever, & Hinton, 2012) (Abdel-Hamid, Deng, & Yu, 2013)
RNN (Recurrent Neural Network)	Directional acyclic structure, directional recurrent in the hidden layer	Focusing on processing sequence data; Strong computational and modeling capabilities	(Martens, & Sutskever, 2011) (Sutskever, Martens, & Hinton, 2011) (Graves & Jaitly, 2014)
DSN (Deep Stacked Network)	Block stacking	Convex optimization problem; Solving overfitting	(Deng, Yu, & Platt, 2012) (He, Zhang, Ren, & Sun, 2016)

Current Status of Deep Learning

- Since 2006 Deep Learning has enabled training data for multi-layer neural networks and built various deep learning models in many areas of artificial intelligence
- Deep learning proposes a method of computer automatic learning mode features, and integrates feature learning into the model building process, thereby reducing the incompleteness caused by artificial design
- Deep learning has realized the recognition or classification performance beyond the existing algorithms in the application scenarios that satisfy certain conditions

(Schmidhuber, 2015; Bengio, Courville, & Vincent, 2013)

The Reasons of Emerging of Deep Learning

- The rise of deep learning depends on the improvement of big data and machine or computing performance. Big data is a generic term for data with a large amount of diversity and low value density

- Deep learning is an effective way to handle big data. And what distinguishes that from previous approaches is the ability to train on very large data sets

(Hinton, et al., 2012; Chen & Lin, 2014; Chen, et al., 2016; Owens, et al., 2008; Gregg & Hazelwood, 2011; Mittal & Vetter, 2015)

Artificial Intelligence Applications in Agriculture

- By simulating the nature of intelligence, artificial intelligence provides a way similar to human intelligence, effectively integrating human knowledge, principles, and experience, studying various problems in the agricultural field through high-speed computing, and applying the results to practice

(Meunkaewjinda, Kumsawat, Attakitmongcol, & Srikaew, 2008; Moskvins, Spakovica, & Moskvins, 2008)

- By simulating human brain neurons, ground-detecting radar imaging techniques are used to detect soil properties and collect signals from electromagnetically-sensing soil sensors. Analysis of soil clay content data can determine which crop is suitable for growing each plot

(Elakkiya, Karthikeyan, & Ravi, 2018; Perea, Poyato, Montesinos, & Díaz, 2018; Patrício & Rieder, 2018)

- Livestock and poultry farming can be achieved remotely and automatically through artificial intelligence. With a remote technology, farmers can film the face and body of animals. The software was used to do image analysis to determine the health and physical condition of each animal. (Soltani-Fesaghandis & Pooya, 2018)

Artificial Intelligence in Autonomous Driving

- Autonomous driving is a robotic system. There are three main technologies involved: perception, path planning, and control decisions
- Autonomous vehicles use deep learning to continually optimize driving behavior, which is considered currently available effective solution
- After a lot of training and learning, you will get the driving experience of your own driving, as well as the learning and training results of other vehicles
- Meanwhile, autonomous driving faces great challenges, such as technical issues, costs, regulations and laws

(Shalev-Shwartz, Shammah, & Shashua, 2016; Marina, Trasnea, & Grigorescu, 2018; Li, Wang, et al., 2018; Li, Lin, et al., 2018)

Artificial Intelligence in Education

- Artificial intelligence and education are deeply integrated, and the form of education has undergone tremendous changes: from artificial intelligence education to educational artificial intelligence. The education focuses on the concept of people-oriented collaborative education
- Educational artificial intelligence research objects become educational activities and educational rules for machines and people
- Educational artificial intelligence is defined as transcending technical limitations, returning to the essence of education, guided by the concept of synergy, using artificial intelligence to understand how learning occurs, how learning is influenced by various external factors, and then to create conditions for learners

(McArthur, Lewis, & Bishary, 2005; Luo & Xie, 2018; Lin, Wooders, Wang, & Yuan, 2018)

Artificial Intelligence in Financial Industry

- The application of artificial intelligence has a very important impact on the development of the financial industry.
- Artificial intelligence is not only analyzing financial data, but also providing services for the financial industry.
- For example, artificial intelligence provides users with comfortable, convenient and safe service, artificial intelligence provides decision support for transactions, credit and analytics in the finance, and artificial intelligence can improve the identification, early warning and prevention and control capabilities of various types of risks in the financial system

(Bahrammirzaee, 2010; Fethi & Pasiouras, 2010)

Artificial Intelligence in Governance

- Artificial intelligence was first applied to areas where data resources are rich, and scenarios are clear.
- Although it is still in its infancy in the field of intelligent governance, with the popularity of artificial intelligence, it has broad application prospects in the fields of virtual government assistant, intelligent conference, robot process automation, document processing and decision-making.
- Artificial intelligence will improve government efficiency and service capabilities and reduce manpower shortages

(Scholl & Scholl, 2014)

Artificial Intelligence in Intelligent Robotics

- Intelligent robots add sensing, pattern recognition, deep learning and autonomous decision making to ordinary robots, enabling them to generate intelligent brains similar to humans. Intelligent robots include industrial robots, service robots, and special robots (Ghahramani, 2015; Jin, et al., 2018)

- A variety of tasks can be accomplished through intelligent behavior in a variety of complex environments.

- For example, medical robot is based on robotic arms, enabling them to perform a variety of clinical operations through intelligent control and real-time tracking. Smart home robot is special robots that serve humans. It is primarily engaged in home services, maintenance and transportation, including smart speaker, sweeping robot, and other equipment.

(Viejo, et al., 2018; Siciliano, & Khatib, 2016; Boyd, & Holton, 2017)

Artificial Intelligence in Manufacturing

- The practice of artificial intelligence and manufacturing integration has increased manufacturing efficiency and economic efficiency, compensated for labor shortages, increased production flexibility, and achieved low cost.
- Mass customization, more accurate market forecasting and matching supply and demand, promote manufacturing service transformation, and improve manufacturing quality control.
- Further promoting the deep integration of artificial intelligence and manufacturing is a complex system engineering.
- For example, intelligent products and facilities, smart plant, intelligent management and service, intelligent supply chain management, intelligent monitoring and decision

(Renzi, Leali, Cavazzuti, & Andrisano, 2014; Li, et al., 2017; Naser, 2018)

Artificial Intelligence in Healthcare Industry

- Artificial intelligence realizes the effective combination of medicine and technology and gives medical science with AI intelligence.
- Intelligent healthcare uses advanced networking technologies, especially the widely used IoT technology, to create regional medical information platforms for health records. It can realize the connection and interaction between patients and doctors, hospitals and medical equipment, and gradually achieve informatization.
- At the same time, through the combination of technology and medicine, the medical process can be digital, electronic, fast and accurate. For example, deep learning for gene prediction, NLP for Electronic Medical Record, and visual technology and image recognition for radiology

(Litjens, et al., 2014; Jiang, et al., 2017; Shen, Wu, & Suk, 2017; Vashistha, et al., 2018; Ranschaert, 2018)

Artificial Intelligence in Retailing Industry

- The advantage of artificial intelligence for the retail industry is to achieve a true customer experience of products.
- The retail industry can make more changes through artificial intelligence, that is, not only during the consumer purchase process and after the service, but also it should be prepared before consumption.
- When a consumer performs each action on a purchasing website, the website records the consumer's preferences. Customers can enjoy convenient services and get a personalized or customized experience. For example, purchasing recommendation, intelligent payment system, intelligent customer service, and intelligent delivery

(Liu, Zhou, et al., 2018; Grewal, Roggeveen, & Nordfält, 2017)

Artificial Intelligence in Security

- On the one hand, artificial intelligence has improved the security protection capabilities; on the other hand, artificial intelligence itself has security issues such as data security, privacy protection, and dynamic environment adaptation.
- Artificial intelligence can quickly detect massive network data and network attacks caused by various security attacks, and can perform adaptive security defense according to changes in the network environment.
- The advantages of artificial intelligence in the field of network security mainly include greatly improving the accuracy of security monitoring. The scale of network traffic is huge, and security devices and systems generate many important security information.
- Artificial intelligence can solve large-scale data processing and analysis, accurately identify network attacks, and reduce security risks.

(Yan, Yu, Gong, & Li, 2016; Grzonka, Jakobik, Kołodziej, & Pllana, 2018; Lu & Xu, 2018; Schneier, 2018)

Challenges and Future Directions

Technology Perspective

- The GPU (Graphic Processing Unit) will replace the CPU (Central Processing Unit) as the next generation computing and calculating terminal (Shi, et al., 2016; Lu, 2018a, Lu, 2018b).
- How to make the machine based on partial data for semi-supervised learning and gradually improve the learning ability in different fields will be the focus of future research (Bengio, 2009; Goodfellow, Bengio, Courville, & Bengio, 2016).
- Deep learning is an important driving force for the development of artificial intelligence, but deep learning is now more focused on processing data, paying less attention to the development of intelligent, such as memory and logical reasoning, predicting and storing information sequences.
- How to quickly realize the direct interaction between human/brain and machine, especially the rapid conversion and exchange of bioelectric signals and digital signals, could become a hot topic in scientific interdisciplinary research

(Bengio, Lamblin, Popovici, & Larochelle, 2007; Matsugu, Mori, Mitari, & Kaneda, 2003)

Challenges and Future Directions

Human and Social Perspective

- The development of artificial intelligence and large-scale application will also bring a problem: more and more intelligent machines are not only high-tech products, but also affect the rules and regulations of human society (Brougham & Haar, 2018; Dasoriya, Rajpopat, Jamar, & Maurya, 2018; Tan, & Lim, 2018)

- The rapid development of artificial intelligence has brought us great convenience and amazing wealth, but on the other hand, we are full of doubts about a series of social problems. Who will ensure that the security of artificial intelligence does not get out of hand? What kind of ethics and responsibilities do artificial intelligence need? (Bengio, 2009; Goodfellow, Bengio, Courville, & Bengio, 2016).

- In terms of security, artificial intelligence can self-correct based on knowledge, automation, and independent decision making. At present, humans cannot fully control it and may lead to unexpected results.

(Albayrak, Özdemir, & Zeydan, 2018; Klinger, Mateos-Garcia, & Stathoulopoulos, 2018)

Challenges and Future Directions

Lack of Theory

- We need to understand the sample complexity of deep learning, that is, how many training samples we need to learn a model of sufficient depth. On the other hand, how much computing resources do we need to get a better model through training. What is the ideal calculation optimization method? (Bengio, Lamblin, Popovici, & Larochelle, 2007; Bengio, 2009; Goodfellow, Bengio, Courville, & Bengio, 2016)

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- There is a lack of in-depth theoretical research behind the success of deep learning. The learning process of deep learning is an end-to-end "black box" operation process. The problem of the network model is mainly solved by adjusting external parameters. It is not conducive to understanding and improving network performance.

(Hinton, Osindero, & Teh, 2006; LeCun, Bengio, & Hinton, 2015; Bengio, 2009)

Conclusion

- Artificial intelligence is an important area of computer applications that adopts advanced machine learning, pattern recognition and data mining techniques to build artificial intelligence models for information preprocessing, processing, refining and value-added services
- Artificial intelligence provides strong support for people's work and life, and more effectively promotes the informatization and automation of smart society
- Artificial intelligence has experienced explosive growth in both techniques and applications
- With the continuous improvement and breakthrough of platforms, algorithms and interaction methods, artificial intelligence will tend to be more extensive and generalized

Thank you**!**