NEW TECHNOLOGY BRINGS NEW OPPORTUNITY FOR TELECOMMUNICATION CARRIERS: ARTIFICIAL INTELLIGENT APPLICATIONS AND PRACTICES IN TELECOM OPERATORS

Wei LIANG[1], Mingjun SUN[2], Baohong HE[2], Mingchuan YANG[1], Xiaoou LIU[1], Bohuan ZHANG[1] and Yuntao WANG[2]
[1]China Telecom, CHINA
[2]CAICT, CHINA

Abstract– In the era of "computational intelligence, perceptional intelligence and cognitive intelligence" as the main direction for the future, telecom operators are on their way to building their own artificial intelligence (AI) ecosystem. In terms of developing AI technology, telecom operators have unique resources and technology advantages: big data resources, superior computing power, lots of investment in AI algorithmic research, broad government and enterprise customer resources. By making full use of these strengths, they have carried out a series of effective practices in the various field and achieved constructive results.
This report will be arranged as follows. In the first part the history and the development status of AI has been introduced, as well as the Chinese powerful policy which was released to support its development. In the second part, the unique advantages for operators to develop AI have been introduced, whilst in the meantime, the AI development idea for telecom operators has been provided. In the third part, in order to be more persuasive, the practice of AI by telecom operators in multiple fields to satisfy internal requirements and meet customer needs, has been described. Finally, based on the current development trends of AI, its future prospects are made by this report. Undoubtedly, in the future, operators will further use their advantages to explore more AI development opportunities.

Keywords –Artificial intelligence, best practice, development idea, telecom operators, unique advantages

1. INTRODUCTION

Artificial intelligence (AI) continues to develop well since it was raised in the US Dartmouth meeting in 1956 [1]. 2017 is its sixtieth anniversary. After more than half a century's development, AI has reached a relatively sophisticated state in terms of both hardware and software, where the potential of industrial application is stimulated. Since 2013, with the rapid development of its related technology such as deep learning and knowledge mapping, the trend of AI technology industrialization has embarked on a fast track. Many giant companies have made remarkable achievements in medical, education as well as Fintech areas. Here are some examples: IBM Watson could diagnose a rare disease within 10 minutes with the help of AI technology, and the accuracy of lung cancer treatments recommendations could be up to 90%. Now AI could make the accuracy of intelligent medical diagnosis comparable to a doctor with years of experience. By proving AI technology can be "trained" to accurately analyze and evaluate test answers, ETS has successfully reviewed the analytical writing test of GRE and SAT, which freed teachers from repetitive work. In the Fintech domain, by taking advantage of AI technology, Google utilized face recognition technology on Android Pay, and facts proved that the security and usability of payment services improved significantly.

At present, the ecological pattern of AI has been established gradually. In the following years, the specialized intelligent application will be the main potential area for the future development of AI. No matter if it is a specialized or generalized application, the enterprise layout of AI will focus on the three basic levels of data and computing layer (base), algorithm layer (technology) and application layer. The Chinese government places a high importance on AI and has released a series of policies to support its development. In May 2016, four Ministries jointly issued "'Internet plus' AI action plans in the next three years". Recently, AI was added in the report on the work of the government at two sessions. On July 20 2017 the state council issued "A new generation of AI development program", which noted AI as one of

the most significant national development strategies. Taking advantage of the above favorable policies, Chinese high-tech industries are devoting to develop AI-related technology and build the AI ecosystem. Telecom operators are no exception. For instance, in 2016, China Telecom proposed the transformation 3.0 strategy in 2016 to be the leading integrated intelligent information service provider. Through the way to AI, they will positively respond to the national development planning in the field of AI, closely keep pace with the emerging forward-looking technology, both domestically and abroad, and dedicated to providing the AI infrastructure. Furthermore, telecom operators are also seeking the entry point for cooperation in the way of the intelligent network, smart operation and business ecology, and to cooperate with the potential industry, push forward the research on AI core technology and promote the development of relevant intelligence applications.

2. THE UNIQUE ADVANTAGES FOR OPERATORS TO DEVELOP AI

In the tide of AI research and development, the operators are also searching for ways to transform themselves from “traditional operator” to “intelligent operator”.

Most of the well-known operators of the world are carrying out AI-related work: 1） France Telecom Orange and Deutsche Telekom AG recently announced that the voice assistant platform Djingo which was based on AI, is being developed. It was expected to compete with the existing voice platforms such as Apple’s Siri and Amazon’s Alexa in the market. 2）Vodafone， the giant European operator also stated that it will launch a customer service robot called "TOBi" to help handle customer service issues and enhance the user experience. 3）Japanese telecom operator NTT has also launched its AI platform. Its main research interests include assistant – AI, echocardiography – AI, environmental AI and network AI.

From the telecom operators’ point of view, there are four key advantages to develop AI: big data resource, superior computing power, lots of investment in AI algorithmic research and a broad customer base. 1) In terms of a big data resource take China Telecom as an example, which has 816,000 mobile base stations and 425 data centers all over China. The mobile subscriber scale has reached 212 million and the broadband subscriber scale has reached 142 million. China Telecom possesses the world's largest data infrastructure and greatest number of subscribers. Characterized by the wide coverage, numerous varieties, large volume and high quality, their data resources will create remarkable value through data mining and analysis. 2) To enhance computing power we have established an advanced infrastructure platform of big data, including the big data management platform, big data applications and operating platform, big data capability platform and enterprise-level big data acquisition system. So far, we have mastered the super-large-scale data processing and analysis capabilities. 3) In the algorithms research area, by combining open source technology and independent research and development ability, telecom operators’ AI teams focus on the direction of natural language processing and has achieved some technical breakthroughs in terms of information extraction, domain knowledge base establishment, information recommendation and filtering and so on. 4) In order to satisfy the internal requirements of operators and meet the needs of customers, by taking full advantage of the above strengths, telecom operators are trying to merge AI technology with innovative technologies such as cloud computing, big data, blockchain and Internet of things, to satisfy the internal and external demands of enterprises. Undoubtedly, this move will shape the characteristic intelligent technology architecture and support intelligent strategies.

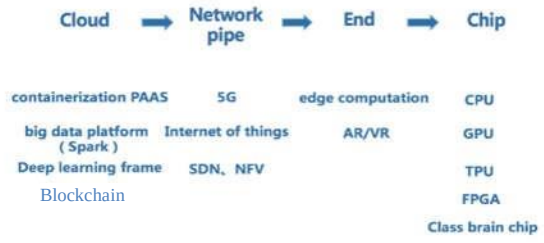

Fig. 1. The road map of AI development of China Telecom

3. TELECOM OPERATORS' PRACTICES IN THE FIELD OF ARTIFICIAL INTELLIGENCE

Based on these unique strengths, telecom operators have implemented a series of effective practices to satisfy the internal and external demands of enterprises. For example, in order to save energy in our internal data centers, by referring to the related algorithms published by Google Corporation, an algorithm based on deep learning has been proposed, which has got great results in energy saving during the tests in the data centers of telecom operator [4]. To help improve public security, by making full use of the “big data resource” advantage, and with a series of

algorithm research, an app named "intelligent police" has been developed, which has been already put into practice. With regard to computing ability advantage, through the effective use of 4G networks, Wi-Fi equipment, cloud storage etc., we also have made fruitful achievements in the field of health management and control. The developments of these applications have gained high-level influence and driven industrial change to some degree.

3.1. AI-based energy saving product in data centers

Telecom operators own a large number of data centers, just take China Telecom for example, it has already constructed 425 data centers all over China. The modern data center (DC) consists of tens of thousands of IT equipment. IT devices and their related service hardware such as air conditioners take up a large percentage of the total power consumption. DCs around the world are all facing the increasing power shortage pressure and cost-efficiency problem. State-of-the-art power-saving technology based on AI such as machine learning works effectively in this tough situation.

As one of the leaders of AI technology, researchers of Google Corporation proposed a novel method based on 5 layers BP neural networks to predict the power consumption trend of the whole DC. The PUE value is selected as the final standard to evaluate the model performance. Meanwhile, 19 features are taken into account to establish a relationship with PUE. This model provides a good idea for realizing data center energy saving.

Based on the model designed by Google, China Telecom Beijing Research Institute (CTBRI) proposes a five-layer neural network to reduce power consumption. DL excels at the feature learning part imitating the signal processing grading mechanism of the human brain. The addition of the convolution layer and the dimension reduction layer allows the deep learning architecture to consider more feature quantities that affect energy consumption. The machine automatically summarizes and learns the characteristics through the actual data. A new method is expected to get a more comprehensive and higher accuracy prediction model performance. In this case, the five-layer neural network uses 50 nodes per hidden layer and 0.001 as the regulation parameter. It has 19 normalized variables as input and the DC PUE as the output. These 19 features represent totals and averages, such as total server IT load, resource usage situation and the environmental index of DC(temperature and humidity). And most of these indexes were derived from individual sensor data. The training process of the five-layer neural network as well as its model are shown as follows:

1) Have the model parameters 8 value randomly initialized between [-1, 1].
2) Do the forward propagation step.
3) Compute the cost function.
4) Do the backward propagation step.
5) Repeat both forward and back propagation until convergence.

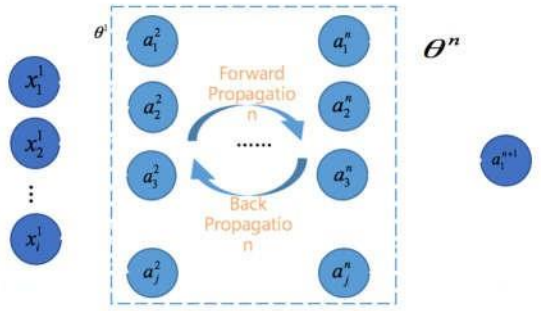

Fig.2. Five-layer neural network model

With the help of the DL framework, CTBRI thinks over the features via different types of services. Potential power-saving capacity is illustrated as the blue areas of part 1 of Fig.3. Each service has one or several power consumption peaks when virtual machines (VMs) work with high loads. However, during the non-peak times, physical devices still consume much energy, with few services running. A predefined strategy is triggered to move the VMs which run fewer jobs to another physical device that still has redundant capacity. Then the former physical machine is turned into idle in which state the device consumes much less energy for about 20W. In contrast with a full load state, i.e. 200~500W, a significant saving is realized.

The DL model does well in predicting the peak load with the support of accumulated data. Some devices will be activated in time and then handle the incoming jobs. Between the gap of peak and non-peak, CTBRIsets a 20% load capacity to handle the unexpected requests. That is to say, if 10 devices are actually needed, 2 devices are required to be ready.

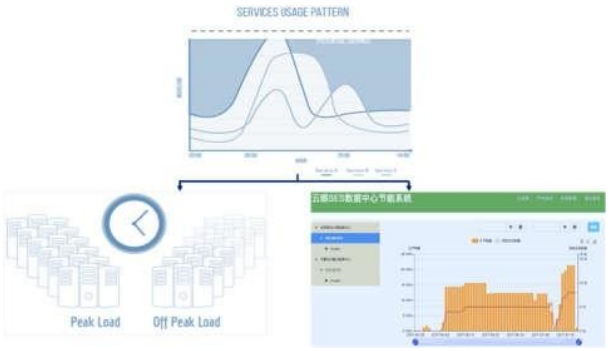

Fig.3. CTBRI data center power saving design based on AI

CTBRI has conducted some tests in the lab and obtained some good results. The lab resource pool consists of 16 physical machines, divided into 120 VMs. During the two months' test period, the total amount of power saving is up to 698 KWh, meaning 11.44 KWh every day. A total of 837 Yuan is saved. A practical test is conducted in Inner Mongolia Autonomous Region by China Telecom Tianyi Cloud Company. The Resourse pool consisted of 340 physical machines and was divided into 3250 VMs. Results show that about 528 Yuan was saved for each physical machine, indicating an average power saving rate of about 34%. AI-based energy saving products in data centers could not only lower production cost greatly, but also reduce energy consumption effectively.

3.2. AI-based public security management platform

Government customers are one of the major customer groups for telecom operators. The world's mainstream operators are all trying their best to help government make city management easier and more efficient. At present, the city administrators in China are confronting the increasingly complicated public security management problem. One of the facts is that the rapid development of urbanization has been constantly impacting the urban "steady structure" shaped in the planned economy period, and the urban management is facing increasing challenges with the growing population, especially in metropolises. In this context, the contradiction between the lower-level police deployment and the persistently ascending new cases has posed great challenges for the investigation and interrogation of cases; the conventional way cannot meet the needs of public security. Therefore, it is urgent to apply the intelligent means in investigating and comparing from multiple dimensions, such as suspect's funds, action track and associated figures, which helps to improve the efficiency of interrogating information, find out the crime clues and the total pieces of crime evidence and greatly reduce the investment of investigator resources. In this way, the prosecutors can focus more on determining the nature of the case, the directions and the means of investigation, so as to strengthen the detection efficiency.

The "intelligent police" as the AI relation insight system is researched and developed to work for public security, urban comprehensive management and other industries. The industry customer can apply "intelligent police" to establish a public safety management solution for intelligent cities.

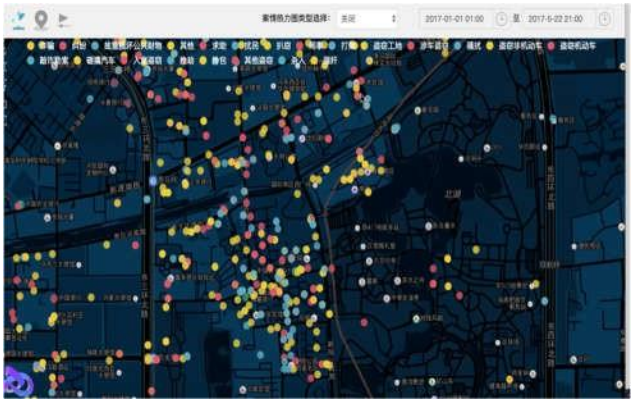

Fig.4. The interface of the "intelligent police"

Based on AI, cloud services, big data and the Internet of things technologies, this program accesses public security data and telecom data to help the urban administrators quickly transform various complicated unstructured data into knowledge mapping. After demonstrating, in the form of data visualization, the intelligence association based on the location information is completed and the comprehensive reports for processing tasks are presented, so as to supervise the multidimensional public opinion of the target object and events. An "intelligent police" AI relation insight system works to provide the varied customized features which center on three modules of case, map and association, including case analysis, clue extraction, case relation display, crime early warning, case thermodynamic diagram, suspect tracking, external population detection and urban road flow analysis. It has vastly enhanced the intelligence of public security management.

During the process of adopting AIT in the realized function of crime prediction, we have conducted a variety of effective algorithm exploration and research. (1) After the preliminary data analysis and technical investigation, random forest algorithm is selected to predict the type of crime, and months, days, periods, latitude and longitude are perceived as the features to

train the classifier. The classification accuracy rate is approximately 44%. There are four stages during our development iteration. Subsequently, the Xgboost algorithm which is the multiple decision tree algorithms as the random forest but possesses better effects and performance is chosen [7]. And the accuracy is increased to 48% via appropriately adjusted parameters. However, there are only about 3300 valid data obtained from the collected public security data for half a year in the preliminary stage, while the data is divided into more than 10 categories, which may trigger over-fitting. (2) In order to obtain better prediction accuracy, we reconsidered the real implication of the crime prediction and found that the model based on the case classification can merely provide the type of case when it happens rather than the probability of actual occurrence or the expected quantity. After the investigation, it is found that Self-Excitation Point Process Model (SEPP) put into use by PredPol, the famous crime forecast company in the United States, can serve to predict the crime quantity spatial density and makes some effective achievements. With the research on the related papers, the team adjusts the algorithm model in line with the features of public security data, including a selected appropriate time, space bandwidth and intercept, interceptive iterative process and the proper sampling method, the SEPP achieved the expected performance. The prediction accuracy goes up to 92%. The specific modeling process is as follows:

1) Parameter estimation: present a crime model composed of a variable bandwidth kernel smoothing estimate for the background intensity and a simple exponential-in-time, Gaussian-in-space kernel for the excited intensity.
2) Model fitting: determine the appropriateness of a model by using the data collected from a police station.
3) Simulation: test the goodness of the fit of the model.

At present, the team is trying to use the deep learning algorithm to improve the accuracy of crime prediction.

The intelligent public security management system has been implemented in one Public Security Bureau of Beijing and Sichuan Politics and Law Committee. The system has access to the local urban public security management data and is integrated with the mobile station data of operators. It is now assisting the urban administrators in making decisions with the aid from AIT, which has actually enhanced the intelligent level of city management.

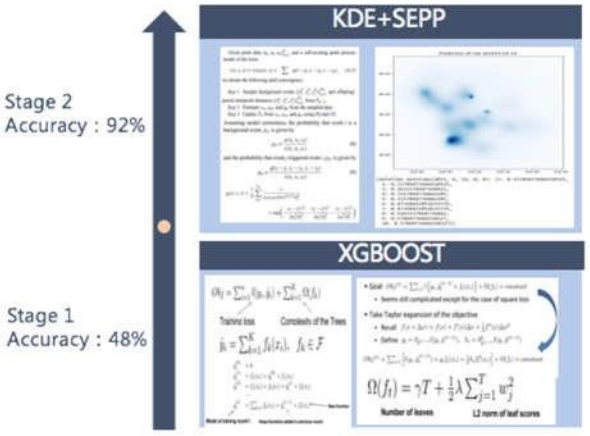

Fig.5. The evolution process of a prediction algorithm for crime prediction

3.3. AI-based health management and control

In recent years the medical AI market has shown a vast growth. Published by Chinese digital medical network, the report "The analysis report of 2016-2017 AI in medical market", analyzed that in the first quarter of 2017 more than 30 AI enterprises have obtained financing, most of which are in medical fields. Indeed, AI enterprises in the medical field have great development potential. Also, residents' health is a major concern of the government. Hence, telecom operators are doing a series research in health management and control field to fulfill government customers' requirements.

Operators have a great number of fixed networks and mobile network subscribers, thus a huge amount of data could be obtained. By analyzing these data, operators can extract the user's network behavior information. And by accessing other related data information, user's health database can also be established. Gradually, the medical image cloud could be built, which means a lot for developing AI in the medical field.

In the technical aspect, through the effective use of our abundant infrastructure resources, such as the basic light width, 4G network, Wi-Fi equipment, cloud storage, etc. operators could actively develop the AI technology in the medical field. Medical image features and a clinical problems classification model have been built based on the SVM and CNN model [8][9]. By quantitative analysis, depth comparison, deep learning, efficient and accurate picture reading could be achieved, which could help doctors diagnose intelligently. For instance, China Telecom's experimental results show that the medical image recognition accuracy based on deep learning can reach

90% and above. At the same time, the medical image cloud diagnostic center, image data center and image computing center have been constructed to realize remote image diagnoses, remote ECG diagnoses and remote test diagnoses effectively. Also, disease information database have been established. When the patient inputs his own disease information, the steps of extracting, normalizing, judging, and modeling the characteristic words could be immediately completed in turn, which could realize the AI guide. Additionally, by using the intelligent Q & A system (AIJust), common questions, such as how to register, how to pay, how the department is distributed and so on, could be answered intelligently.

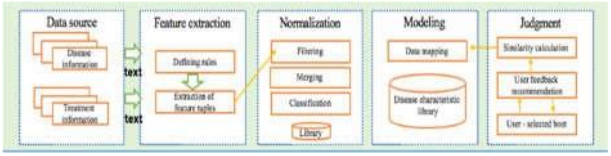

Fig.6. The technical framework of the AI guide

Take chronic disease management for example. AI could be used to predict the trend of the morbidity for one particular disease, by going through the following two stages:

1) Construct a comprehensive disease control index model. By accessing the data provided by a residents' health database, this index model was built upon comprehensive consideration of various factors such as disease morbidity, climax, humidity and so on.
2) Construct an artificial neural network model. The existing residents' health data can be used to get the artificial neural network model, while the patients' data could be utilized as a test set to determine the model accuracy.

For AI research in medical fields we believe that the technology of intelligent identification and diagnosis has been relatively mature, while data "quantity" and "quality" is the key to success.

At the application level, a "cloud + big data + AI" big data solution has been framed by China Telecom, which also effectively promotes the development of optical fiber broadband, cloud computing and cloud network integration. The operators' practice in the medical field mainly focuses on six application scenarios, that is chronic disease management, AI diagnosis, big data on meteorological medicine, prevention and control of infectious diseases, decision-making of drug use, and big data prediction. Among them, AI diagnosis works based on logical inference, of which the subjectivity is stronger, and neural network framework based on intelligent inference. Refer to the data from China Telecom, Logical inference could affirm the type of disease by correlating the 5000 diseases and 6000 symptoms in the structural database, while the F1 (assessment values of comprehensive accuracy and recall rate) of intelligent inference could be up to 0.5876. In the field of chronic disease management, operators have also achieved fruitful results. By classifying slow disease users according to their geographical distribution and presenting the distribution condition on the map, we can provide a city health department's visual disease distribution information and help them control chronic disease in some way. The product of preventing and controlling chronic disease has been recognized by the National CDC and put into use. This product will not only transform the existing medical image cloud and other resource-based business to the application-oriented business, but also increase the business input-output ratio.

4. SUMMARY AND PROSPECT

As the advancements of deep learning and other technologies, AI is now in the stage of being used in specific industries to increase efficiency and reduce costs. AI has been successfully applied to automatic pilots, medical treatments and health, finance, retail, entertainment, AR, VR and many other fields with unprecedented importance. Some experts say that AI may become the new productivity and even one of the key drivers of the fourth industrial revolution. For telecom operators, the opportunities and challenges coexist behind AI development. On the one hand, the largest big data infrastructure and the massive data resources greatly facilitate telecom operator's AI development. Rich data resources can greatly help to study AI algorithms and train models. On the other hand, there are still many obstacles to overcome, such as the gap between operators and Internet enterprises in the aspect of algorithm design and market promotion. In the future, telecom operators will make greater use of the traditional advantages, seek more distinctive areas for AI development and cooperate with other enterprises to create a development ecosystem and promote industrial change more efficiently.

REFERENCES

[1] Buchanan, Bruce G. "A (Very) Brief History of Artificial Intelligence." Ai Magazine 26.4(2005):53-60.

[2] Kim, Keun Heui, et al. "A Study on Message Queue Safe Proper Time for AI Open API Fintech Architecture." Computer and Applications 2016:33-36.

[3] "NTT and MIT to collaborate in next-generation Internet and AI." Computing Japan (1998).

[4] Gao, Jim, and Ratnesh Jamidar."Machine learning applications for data center optimization." Google White Paper (2014).

[5] YinShi An. The exploration and practice of operators' AI [J]. Communication enterprise management, 2017(5):73-75.

[6] Lecun, Yann, Y. Bengio, and G. Hinton. "Deep learning." Nature 521.7553(2015):436-444.

[7] Chen, Tianqi, and C. Guestrin. "XGBoost: A Scalable Tree Boosting System." (2016):785-794.

[8] Joachims, Thorsten. "Making Large-Scale SVM Learning Practical." Technische Universität Dortmund, Sonderforschungsbereich 475: Komplexitätsreduktion in multivariaten Datenstrukturen, 1998:499-526.

[9] Ozturk, Gurkan, Z. K. Ozturk, and A. A. Islier. A Comparison of Competitive Neural Network with Other AI Techniques in Manufacturing Cell Formation. Advances in Natural Computation. Springer Berlin Heidelberg, 2006:575-583.

[10] Setiawan, Noor Akhmad, et al. "Diagnosis of coronary artery disease using Artificial Intelligence based decision support system." University Malaysia Perlis 9.5(2009):93–118.

