CAICT 中国信通院

中国人工智能产业发展联盟
Artificial Intelligence Industry Alliance

Machine Learning Applications in Telecommunication Network

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Machine Learning shown great progress recent years

- Image classification
  - Success rate raise from 72% in 2010 up to 97% in 2017 in ImageNet competition
- Machine dominates almost all table games
  - Chess: Human cannot win from 2006
  - Go: Human cannot win from 2016
  - Poker(Holdem): AI defeat top players in 2017
- ML makes big progress in many other areas
  - robot, autopilot, Natural Language Processing, etc.

ML has already been used in our everyday life

- Mobile internet
- Finance
- Medicine
- Education
- ……

Recognize

- voice、face、handwriting、vehicle

E-shop and Apps

- product recommendations, precision advertising, news aggregation, label

Finance

- quant finance、invest recommendations

Bank、Insurance

- Credit Card Fraud Detection、Loan evaluation

Medicine

- Diagnosis in Medical Imaging、Disease Identification、Drug Discovery

Education

- Foreign language learning、translation

Why telecom needs ML

Network O&M is more complex along with network evolution

- Software plays a key role in SDN/NFV. Diagnostic crosses multi-layer and multi-domain.
- Lots of information that hide in logs/alarms are omitted
- Automation is needed to Improve efficiency and reduces cost

New service/applications require for new network capability

- The programmability, flexibility and high levels of automation of 5G operations create new service paradigms which might be even beyond our imagination. e.g. applications of the **Internet of Things, Tactile Internet, advanced Robotics, Immersive Communications** and, in general, the X-as-a-Service paradigm.
- These new applications create challenges of network scale and traffic volume
- Network needs to manage complicated resources and dynamic traffic in intelligent way

New services opportunities for ML based applications

- Many applications need ML computation platform as a service
- Transport: Autopilot/traffic monitor/vehicle identification
- Security: Video surveillance/face identification/vehicle tracking
- Business: sales data/stock data/income analysis

ML used for user interaction

ML based language/speech processing has been used for saving lots of labor cost and make the device UI work in a natural way.

Using ML for subscriber service

- Chatbot: reply customs question automatically. Used on various service channels e.g. website/im/sms
  - China mobile's chatbot named "Yiwa". Serve more than 50 million replies per month and save hundred million RMB costs per year.
- Service robot:
  - China telecom's service robot can listen/answer questions from customs by voice

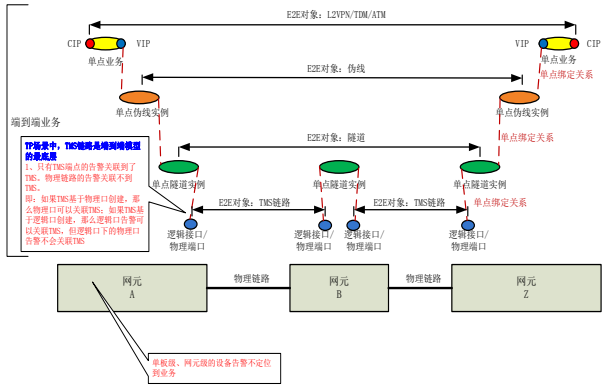
Speech interface for home devices

- IPTV set-top box / OTT box
  - Search programs by speech
  - Remote control by speech

ML aimed Operation/Maintenance/Optimization

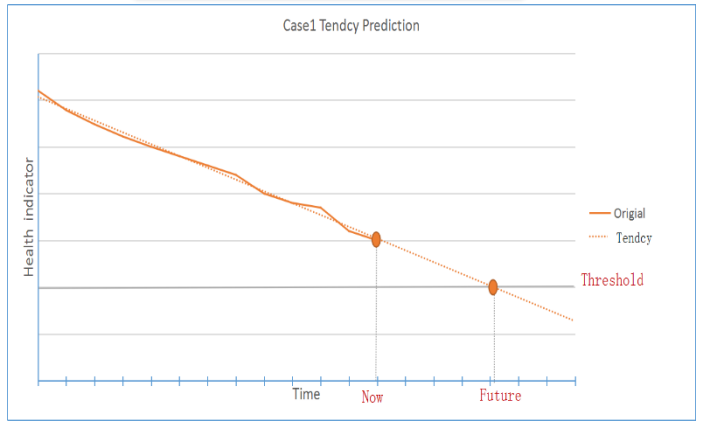
ML has the potential for a broad range of applications that can improve network design, operation, and optimization

Fault management



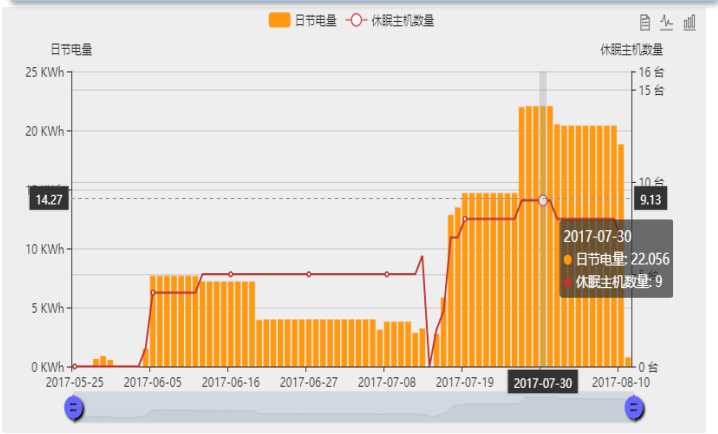
- Find connections between alarms
- Knowledge extraction from network logs
- locate the root alarm
- Troubleshooting by Alarm/log/statistic multi sources analysis

Fault prediction



- Analyze optical monitor parameters to predict failure of Laser
- Analyze server IO statistic values to predict failure of hard disk
- Analyze DSL line error and SNR to predict the DSL service quality

Data center PUE optimization



- Learn model from DC’ s load, power consumption, temperature etc.
- Predict server load , trigger migrate and server low power mode
- CTC has applied this method saving 80 USD per server per year

ML stack for open services

A large number of ML applications require different kinds of computing platforms to serve them at different levels

Common ML video/image/speech service

- License plate recognize
- Human/vehicle traffic monitor
- Face identification
- Natural language processing

ML computation framework service

- tensorflow
- Kaffe
- Mxnet
- Torch

- CUDA
- MKL
- NNVM
- ONNX

TensorFlow Caffe2 mxnet

CUDA MKL

Virtual/physical servers optimized for ML

- CPU/Memory/IO optimized cluster
- Heterogeneous Computing
  - CPU+GPU
  - CPU+FPGA
  - CPU+ASIC

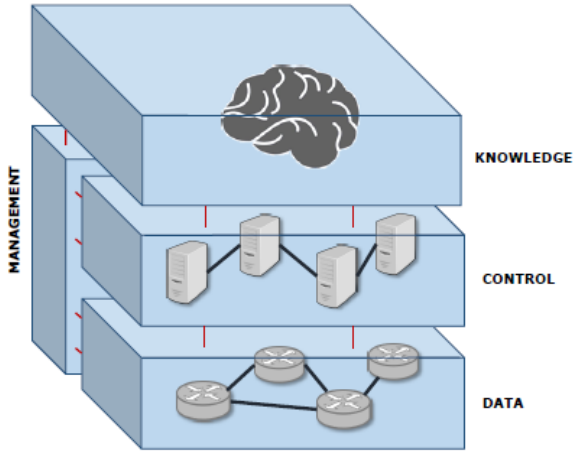
ML applies to networking

ML techniques so far are more or less related to prediction, classification and decision-making in networking area

Information cognition	Information cognition with high efficiency is critical to capture the network characteristics and monitor network performance.
	Machine learning can help evaluate network reliability or the probability of a certain network state.
Traffic prediction and classification	Prediction: the accurate estimation of traffic volume is beneficial to congestion control, resource allocation, network routing. Many studies focus on reducing the measurement cost by using indirect metrics
	Classification: machine learning approaches based on statistical features have been extensively studied in recent years, especially in the network security domain
Resource management and network adaption	e.g. address traffic scheduling, routing , and TCP congestion control.
	These issues can be formulated as a decision-making problem, deep reinforcement learning achieves great results in many problems
Network performance prediction and configuration extrapolation	Example applications are video QoE prediction, CDN location selection, best wireless channel selection, and performance extrapolation under different configurations.

Future network driven by ML

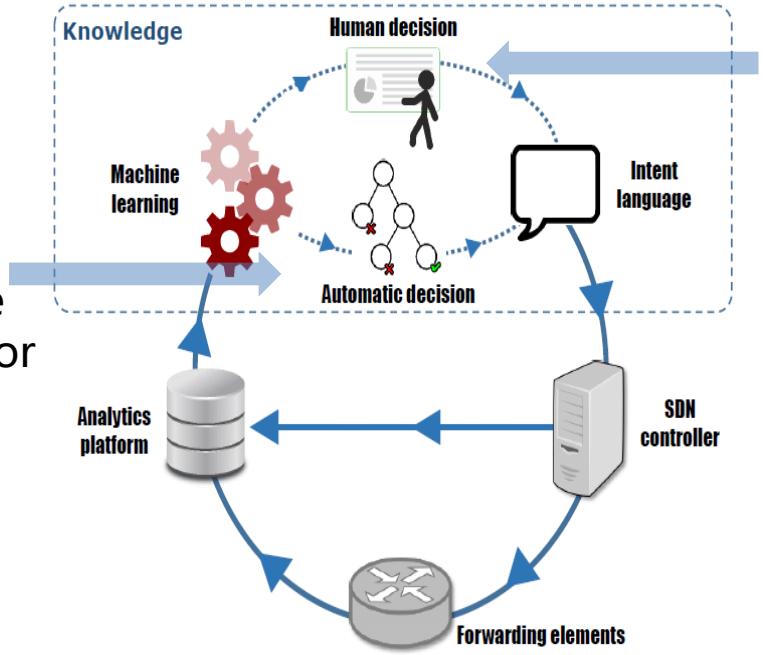
ML is expected to play an important role in future network model



- A. Mestres et al. published Knowledge-Defined Networking in 2016
- KDN describe a new paradigm that accommodates and exploits SDN, NA and AI
- Add a knowledge plane to the traditional three planes of the SDN paradigm

"the heart of the knowledge plane is its ability to integrate behavioral models and reasoning processes oriented to decision making into an SDN network"

Closed loop: make decisions automatically on behalf of the network operator



Open loop: the network operator is still in charge of making the decisions

Factors prevent the application of ML in network

Non-determinist

- Typically networks operate with deterministic protocols that are well understood. But output from ML usually lack of Interpretability to humans. So

Data issues

- all ML is data dependent, and the performance of ML algorithms is affected largely by the nature, volume, quality, and representation of data.
- High quality data is expensive in time and money

Validation

- ML algorithm need be selected carefully for different problem and the trained model should be validated to avoid overfitting
- Diagnostic and tuning model is not easy

Performance

- many networking applications are delay-sensitive, but it is non-trivial to design a real-time system with heavy computation loads

Errors sensitivity

- high cost brought by learning errors

Summary

- Dealing with complex problems is one of the most important advantages of machine learning
- Machine learning has shown big potential to many aspects of network
- Research, industry and SDOs have a lot of work to do making machine learning play a valuable role in telecom network

Thanks