AI and Its Application in Intelligent Connected Vehicle

Hui CHEN
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What’s Artificial Intelligence (AI)[1]

Intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans and other animals.

“Narrow AI”
- Works in different individual domains;
- Not capable of experiencing consciousness

“General AI”
- Perform any intellectual task that a human being can;
- Capable of experiencing consciousness

Why AI brings so much attention?

1 : Introduction of AI and ICV

What’s Artificial Intelligence (AI)[1]

Why AI brings so much attention?

Artificial Intelligence

- Expert Systems
- Fuzzy Logic and Rough Set
- Heuristic Search
- ...

Machine Learning

- Supervised Learning[2]
- Unsupervised Learning[3]
- Reinforcement Learning[4]

Deep learning

- CNN
- RNN
- ...

Study and construction of algorithms that can learn from and make predictions on data

Use a cascade of multiple layers of nonlinear processing units for feature extraction & transformation

Concerned with how to take actions in an environment to maximize the cumulative reward

Learning a function that maps an input to an output based on example input-output pairs

Inferring a function to describe hidden structure from "unlabeled" data

What’s intelligent connected vehicle (ICV) [1]? Why ICV is an inevitable trend?

- **Autonomous vehicle (AV)**
  - Using vehicle sensors
  - Infrastructure-independent automatic driving

- **Connected vehicle (CV)**
  - Communicating with nearby vehicles and roadside facilities
  - Infrastructure/traffic-dependent automatic driving

- **Intelligent connected vehicle (ICV)**
  - Using vehicle sensors
  - Communicating with surroundings
  - Infrastructure/traffic-aided automatic driving
  - Safe, efficient, comfortable, energy-saving, ultimately autonomous

The relationship of AV, CV and ICV

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Features of AI/ICV Policies of Different Areas

• **America**
  ✓ Led by enterprise. Google, Facebook, Microsoft have increased investment in the research of AI;
  ✓ Valued by government, to ensure the leading position in the field of AI;
  ✓ Good at standards making, leading the development of global AV.

• **Europe**
  ✓ Academic institutions in Britain have made outstanding achievement on AI;
  ✓ The motor producer over Europe will help to the realization of the internationalization of future traffic.

• **Japan**
  ✓ The Japanese government and automobile companies are cautious about automated-driving vehicles, and slow to develop technical standards;
  ✓ Japan is focusing on making automated driving vehicles popular as soon as possible.

• **China**
  ✓ China still has a relatively short board in the basic theoretical research of AI, key common technologies, basic platforms, and talent teams;
  ✓ the government has repeatedly stressed on the establishment of a new generation of AI basic theoretical system and key common technology system.
### Algorithm

**Machine Learning Algorithm**
- Regression, Decision tree, SVM

**Deep Neural Network**
- Image Recognition: CNN
- Machine Translation: RNN, LSTM

**Reinforcement Learning**
- Model is known: Dynamic programming
- Model is unknown: Value function, Policy search

**Development Community**

- **GitHub**

- **Apollo by Baidu**

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### Recent R&D Activities

**Up & Down stream**

**Application in ICV**

**Progress of CEC**

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[Image of algorithm and development community]
**AI Chips**

- **Development of chip design technology**
  - Brings the cost and power consumption characteristics of machine learning-related parallel processing to an acceptable level;
  - Making it possible to use large amounts of data to train deep neural networks.

- **Examples of hardware solutions for automated driving**
  - NVIDIA Drive PX Xavier

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**Drive PX Xavier**

**NVIDIA DRIVE — AI CAR PLATFORM**

- Localization
- Path Planning
- Perception
- Computer Vision Interfaces
- Code, models, TensorFlow

Big data

- **Features of big data:**
  - Volume
  - Velocity
  - Variety

- **Big Data Industry:**
  - America has advantages in information and software/hardware technology;
  - Europe, Japan and Australia focus on the fundamental research;
  - China is still in a primary stage, but market grows rapidly.

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**Big Data Industry Chain**

- Data Collection
- Data Storage
- Data Analysis
- Data Application

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**Big Data Technology**

- Web Spider
- Distributed File System
- Machine Learning
- Data Visualization

- Internet of Things (IoT)
- Quantum Computer
- Deep Learning
- Text Visualization
Network Information Security

- **Network virus attacks spreading from IT to Internet of Things (IoT)**
  - Wide variety of IoT devices with no unified operating system makes it impossible to develop specialized security software for each type of device
  - Limited computing capacity of IoT device terminals makes it impossible to apply general-purpose systems with powerful functions
  - Internet of Things devices are connected in a variety of ways
  
  Traditional security solutions may not be competent in IoT security

- **AI-based information security solution example**
  - The MIT Computer Science and Artificial Intelligence Laboratory (CSAIL) and the company PatternEx have jointly developed an artificial intelligence-based cybersecurity platform AI² that can accurately predict, detect, and block 85% of network attacks.
3: Recent R&D Activities

Up & Down stream  Application in ICV  Progress of CEC

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Intelligent connected vehicle (ICV)

- The general architecture of ICV
  - Environment perception
  - Decision making
  - Motion planning
  - Motion control

Environment Perception

- The function of environment perception
  - processing data from multiple sensors
  - Perceiving & understanding the surroundings
  - obtaining key information related to automatic driving tasks from the surroundings
Environment Perception

- **DNN-based solution example in target perception**\(^1\)
  - Using video information captured by a camera as input to a trained Convolutional Neural Network
  - Multi-target detection and classification results can be obtained

- **Comparison of these two types of algorithms**

<table>
<thead>
<tr>
<th></th>
<th>Traditional vision algorithms</th>
<th>DNN-based vision algorithms</th>
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<tbody>
<tr>
<td>Feature extraction</td>
<td>Manually</td>
<td>Self-learning</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Usually with an upper limit</td>
<td>Inclined to get more accurate results with more data</td>
</tr>
<tr>
<td>Robustness</td>
<td>Robust under simpler scenarios</td>
<td>Inclined to get more robust results under complex scenarios</td>
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\(^1\) 袁贵珍, 深度学习在自动驾驶环境感知中的应用, 2016.
**Decision & Planning**

- **The function of decision and planning**
  - Assess the environmental information
  - Determine the goal of safety decision
  - Local path planning for vehicle movement

- **AI-based solution example in decision & planning**[1]
  - Posing autonomous driving as a supervised learning problem is difficult due to strong interactions with the environment
  - Valeo proposed a framework for autonomous driving using deep reinforcement learning
  - The vehicle learned autonomous maneuvering in a scenario of complex road curvatures and interaction of other vehicles

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Motion Control

- The function of motion control
  - Calculate the steering and speed control commands for vehicle, based on the results of local path planning

- AI-based solution example in motion control[1]
  - Nvidia trained a CNN to map raw pixels from a single front-facing camera directly to steering commands

Human-Machine Interaction

• **Definition**
  The kind of language used to accomplish information exchange tasks between human and machine.

• **Function**
  - Higher reliability and ensured safety of ICV;
  - Improved maneuverability and flexibility;
  - More excellent practicability and user experience;
  - Assistance to help perform driving tasks better.

• **Traditional HMI: Interface Design**
  Media: Screen and buttons
  Function: Vehicle state information, communication, entertainment, navigation, safety function.

• **HMI of ICV: Perception Intelligence + Cognition Intelligence**
  Voice: front-end processing, voice recognition, speech synthesis, speaker distinguishing.
  Vision: face recognition, gesture recognition, driver state perception, object detection.
  Tactility: force/torque, movement, temperature.
  Bioinformation: physiological index like blood pressure, heart rate and galvanic skin response.

- BMW I Drive
- Baidu DeepSpeech
- Google Tacotron
- Megvii MegBrain
- Ford ECG

- Deep neural network & end-to-end system
- 152 layers, ResNet
- Driver mental work load index definition
Experiment and Testing

- Base Vehicle Test
- Hardware Test
- Software Test

- Functional Safety
- Reliability and Durability
- Simulation
- Closed-Course
- Real-World Driving
Service for Travel

- Intelligent order assignment
  - Only consider the distance from driver to passenger
  - Consider the arrival time based on route planning and evaluation of driver’s service
  - Consider the supply and demand over the area and optimize the matching

- Traffic light interval is fixed
  - Interval is dynamically adjusted according to nearby traffic

- Autonomous Parking System
  - Difficult for parking
  - Automatically complete parking
  - The product has been push out in Marvel X
Local path planning

Local Path Planning

- Behavior Decision
- Vehicle State
- Environment Perception

PF Model
- Obstacle PF Model
- Road PF Model

Lateral Planning
- Desired Steering Wheel Angle Generation

Longitudinal Planning
- Desired Acceleration Generation

Local Path Planning Algorithm Diagram

- Heuristic Search
- Low-level Control

A stereogram of an obstacle's potential field
A stereogram of the potential field representing a road with two lanes
The contour map of the corresponding potential field
Local path planning
Validation scenarios:

Papers:

Patents:
1. "一种统一的自动驾驶横向规划方法与系统（申请号：20161082955.4）".
2. "一种自动驾驶纵向统一规划方法及系统（申请号：201710811002.4）".
3 : Recent R&D Activities

Up & Down stream Application in ICV Progress of CEC

Automatic Parking: Traditional Method

Environment Perception

Planning & Tracking

HIL Test

Automatic Parking: AI-based Method

Method

Perception

AI-based Algorithm

relative posture

historical information

Feature

▷ Learn from parking experience to improve algorithm efficiency
▷ Uniform framework for different scenarios

Co-Simulation

Learn from parking experience to improve algorithm efficiency
Uniform framework for different scenarios

Paper

- Kunpeng Cheng, Ye Zhang, Hui Chen. (2013), Planning and Control for a Fully-automatic Parallel Parking Assist System in Narrow Parking Spaces

Patent

- 2012104293726.8, 201310545995.5, 201410557306.7

AI and It's Application in Intelligent Connected Vehicle

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In the era of big data, with the development of computing chips, algorithms, and the increased market demands, AI ushered in a golden period of rapid development.

As a key enabling technology, AI is gaining more and more government investment and policy supports, and will profoundly influence the international competitions in industries and nations.

As the strategic commanding point for the development of the global automotive industry, intelligent connected vehicles have huge market prospects and will become an important area for application of AI.
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Thank you for your attention!

Hui CHEN
School of Automotive Studies
Tongji University, Shanghai, China
hui-chen@tongji.edu.cn