A Study of the Current State of Development of Internet Technology for Smart Connected Cars

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Abstract. If we say that the most important terminal of the Internet now is the smartphone. In the future, the most important terminal of the Internet of Things will be the car. The car, will become one of the most important dimensions in the Internet of Everything. And the ultimate goal, is zero emissions, zero casualties, zero obstacles - no pollution, no car accidents. Our environment will be cleaner and our travel will be safer. An era of automobiles ruled by traditional fuel cars for more than 100 years is coming to an end, and an era of smart and connected cars is coming. Based on this, this paper explores the current study of Internet technology on the development of smart connected cars.

Keywords: Internet Technology, Intelligent Networked Automobile, Development Status

1. Introduction
This is really a time of change. The automotive industry, on the other hand, is one of the most change-intensive industries. Smart connected cars will give birth to a huge industry. It is predicted that the global market size of smart connected cars will reach trillions in 2035. In fact, it doesn't have to be 2035. Right now, a wave of smart connected car development is coming in like a tidal wave. The wave is being set off by none other than our own China. Just in terms of driverless, from cars, trucks, buses, and then buses, aircraft ...... almost all in the direction of driverless in the effort, and the automotive industry, just a small microcosm of this industrial Internet era of great change.

2. Intelligent Networked Automobile (ICV) architecture
Intelligent Connected Vehicle (ICV) is a high-tech complex integrating environment perception, planning and decision making, control and execution, and information interaction, and has interdependent value chain, technology chain and industry chain system.
2.1. **Value chain of Intelligent Connected Vehicle (ICV)**

Intelligent networked vehicles (ICVs) play an important role in improving driving safety and reducing the burden of drivers, as well as contributing to energy saving and environmental protection and improving traffic efficiency. Studies have shown [1], that in the primary stage of ICVs, advanced intelligent driver assistance technologies can help reduce traffic accidents by about 30%, improve traffic efficiency by 10%, and reduce fuel consumption and emissions by 5%, respectively. At the ultimate stage of I-NETV, i.e., fully autonomous driving, it can even avoid traffic accidents completely, improve traffic efficiency by more than 30%, and finally free people from boring driving tasks, which is the most attractive value of I-NETVs.

2.2. **Technology chain of Intelligent Connected Vehicles (ICV)**

In terms of technology development path, there are three directions of intelligent vehicles: connected vehicle (CV), autonomous vehicle (AV), and the fusion of the first two, i.e., connected and automated vehicle (CAV) or intelligent and connected vehicle (ICV), as shown in Figure 1.

Figure 1. Three technological paths for smart cars

The technical architecture of I-NETV is complex and can be divided into "three horizontal and two vertical" technical architectures. The "three horizontals" refer to the technologies in three fields, namely, vehicles, information interaction and basic support, and the "two verticals" refer to the in-vehicle platform and infrastructure conditions that support the development of intelligent networked vehicles; as shown in Table 1.

**Table 1. Technical framework of intelligent networked automobile**

| Key technologies for vehicles/facilities       | Environmental Awareness Technology |
|-----------------------------------------------|-----------------------------------|
|                                               | Intelligent Decision Making Technology |
|                                               | Control Implementation Technology |
|                                               | V2X communications technology     |
| Key technologies for information exchange     | Cloud Platform and Big Data Technology |
|                                               | Information security technology    |
| Basic Support Technology                      | High-precision maps and high-precision positioning |
|                                               | Standards and regulations         |
|                                               | Test evaluation                   |

The key technologies in the three areas of ICV's "three-horizon" architecture can be subdivided into the following nine categories [2].
1) Environment awareness technologies, including image recognition using machine vision, perimeter obstacle detection using radar (laser, millimeter wave, ultrasonic), multi-source information fusion, sensor redundancy design, etc.

2) Intelligent decision-making techniques, including hazard state modeling techniques, hazard warning and control prioritization, group decision-making and collaborative techniques, local trajectory planning, driver diversity impact analysis, etc.

3) Control execution technologies, including drive/brake oriented longitudinal motion control, steering oriented lateral motion control, drive/brake/steering/suspension based chassis integrated control, multi-vehicle queue cooperation and vehicle-road cooperative control by integrating V2X communication and on-board sensors, etc.

4) V2X communication technology, including vehicle-specific communication system, communication guarantee mechanism to realize workshop information sharing and cooperative control, mobile self-organizing network technology, multi-mode communication fusion technology, etc.

5) Cloud platform and big data technology, including intelligent networked vehicle cloud platform architecture and data interaction standards, cloud operating system, efficient data storage and retrieval technology, correlation analysis and deep mining technology of big data, etc.

6) Information security technology, including automotive information security modeling technology, three-dimensional security system for data storage, transmission and application, automotive information security testing methods, emergency response mechanism for information security vulnerabilities, etc.

7) High-precision map and high-precision positioning technology, including high-precision map data model and standardization technology of collection style, exchange format and physical storage, high-precision positioning technology based on BeiDou ground-based augmentation, multi-source auxiliary positioning technology, etc.

8) Standards and regulations, including the overall standard system of ICV and the key technical standards for designing automobiles, transportation, communication and other fields.

9) Test and evaluation, including ICV test and evaluation methods and test environment construction.

2.3. Intelligent Networked Automobile (ICV) industry chain

ICV product system can be divided into three levels: sensing system, decision system and executive system, which can be compared to human perceptual organs, brain and hands and feet, as shown in figure 2.

Figure 2. Three product levels of smart netcom
The ICV industry chain involves automotive, electronics, communication, Internet, transportation and other fields, and mainly includes the following according to the upstream and downstream relationship of the industry chain [3].

1) Chip manufacturers, which develop and supply automotive-grade chip systems, including environmental sensing system chips, vehicle control system chips, communication chips, etc.

2) Sensor manufacturers, which develop and supply advanced sensor systems, including machine vision systems, radar systems (laser, millimeter wave, ultrasonic), etc.

3) Automotive electronics/communication system suppliers, companies that can provide R&D and integrated supply of intelligent driving technologies, such as automatic emergency braking, adaptive cruise control, V2X communication systems, high-precision positioning systems, etc.

4) Vehicle enterprises, which propose product requirements, provide intelligent vehicle platforms, open vehicle information interfaces, and conduct integration tests.

5) Platform development and operator, developing Telematics service platform, providing platform operation and data mining analysis services.

6) Content providers, suppliers of high-precision maps, information services, etc.

3. Current status of the development of key technologies for intelligent networked vehicles

3.1. Environmental perception technology

The task of environment perception system is to use the main vehicle sensors such as camera, millimeter wave radar, LIDAR, ultrasonic and V2X communication system to perceive the surrounding environment, extract the road condition information, detect obstacles and provide decision basis for intelligent networked vehicles. Due to the complexity of the vehicle driving environment, the current perception technology cannot meet the development needs of autonomous driving in terms of detection and recognition accuracy, and deep learning has been proved to have great advantages in the perception of complex environments [4,5]. Many scholars have used "deep learning" methods to identify objects that are difficult to recognize by traditional algorithms, such as pedestrians and bicycles. In the sensor field, LIDAR has become a standard sensor for more and more autonomous vehicles due to its high resolution, and low-cost and miniaturized solid-state LIDAR has become a hot spot for research and development. In addition, in response to the limited sensing capability of a single sensor, solutions for fusion of different on-board sensors have emerged to obtain rich surrounding environment information with excellent environmental adaptability. High-precision maps and positioning are also important sources of environmental information for vehicles. The joint pedestrian and cyclist recognition architecture mainly includes image input, target candidate area selection, target detection, multi-target tracking and result output. The target candidate region selection module selects regions from the input image that may contain the target to be detected, ensuring a high target recall rate while minimizing the selection of background regions. The main role of the target detection module is to correctly classify these candidate regions into the target to be detected and the background while ensuring as few false detections and missed detections as possible, and to further optimize target localization. At present, several large manufacturers in mainland China are actively promoting the construction of high-precision maps for autonomous driving. A high-precision positioning system based on the BeiDou ground-based augmentation system has also been applied in mainland China, which will provide a low-cost and wide-coverage high-precision positioning solution for self-driving vehicles. For the effective recognition of pedestrians and cyclists in complex driving environments, a research team from Tsinghua University has established a joint pedestrian and cyclist recognition method based on in-vehicle images, the architecture of which is shown in Figure 3.
3.2. Autonomous decision technology

The task of the decision system is to decide the driving behavior and the timing of the action based on the global driving objectives, the state of the vehicle and the environmental information. The decision mechanism should be able to adapt to as many operating conditions as possible while ensuring safety, and to make the right decisions for comfort, energy efficiency and efficiency. Commonly used decision-making methods include state machines, decision trees, deep learning, augmented learning, etc. The state machine is a simple decision making method, which represents the decision mechanism as a directed graph. The advantages of state machines are that they are highly readable, can clearly represent the logical relationships between states, and are simple to design when the states are clear and few; the disadvantages are that they require manual design, performance is not easily guaranteed when the states are complex, and machine learning is not possible. The current automated driving systems are mostly designed for some typical operating conditions, and state migration is not particularly complex, so there are more cases of decision making using state machine methods. A decision tree is a simple but widely used classifier that classifies from the root to the leaf nodes, with each non-leaf node being a test on an attribute and the edge being the result of the test. Decision trees have a readable structure and can be built by training on sample data, but have a tendency to overfit and require extensive data training. The results are similar to those of state machines when applied to automated driving in some operating conditions. Deep learning and augmentation learning are popular machine learning methods. It can be used to make decisions on complex working conditions through extensive learning and online learning optimization; however, its comprehensive performance is not easy to evaluate, and its performance for unknown working conditions is not easy to specify. Deep learning is generally a popular technique for autonomous driving research in the computer and Internet fields because of the large amount of computational resources required [6].

3.3. Control execution technologies

The task of the control system is to control the speed and direction of travel of the vehicle so that it follows the planned speed profile and path. Most of the existing self-driving vehicles are designed for conventional operating conditions, so they mostly use traditional control methods, such as proportion-integral-derivative (PID) control, sliding mode control, fuzzy control, model predictive control, adaptive control, and robust control. Adaptive control, robust control, etc. These control methods are reliable and computationally efficient, and have been applied in active safety systems. For the existing controllers, the adaptability of working conditions is a difficult problem, and a feasible method is to adapt the controller parameters according to the working condition parameters, such as adjusting the controller parameters according to the vehicle speed planning and reference path.
curvature, which can flexibly adjust the performance under different working conditions. The linear actuator is the key to achieve automatic vehicle control. Domestic key technologies for braking and steering systems have been developed on a certain basis, but compared with Bosch, Delphi and other large foreign enterprises, there is still a large gap in control stability, product consistency and market scale [7].

1) Multi-objective coordination type adaptive cruise control

In the adaptive cruise control system, it is important to have three types of functions: automatic following driving, low fuel consumption and conforming to the driver's characteristics, in order to comprehensively enhance driving safety, improve vehicle fuel economy and reduce driving fatigue. The current research mostly focuses on the implementation of a single function, without considering the constraints between the three functions, as well as the uncertainty of vehicle modeling and the nonlinearity of driver behavior, which makes it difficult for the existing linear optimal control methods to solve the contradiction between the three types of functions.

2) Cooperative multi-vehicle queuing control

Vehicle queuing is the formation of neighboring vehicles in a single lane, and the longitudinal motion of the vehicle is automatically adjusted based on the information of neighboring vehicles to achieve a consistent travel speed and desired configuration. A proven method is the multi-agent system (MAS) approach. In the field of control, a multi-agent system is a dynamic system formed by multiple autonomous intelligences that interact with each other through a certain information topology.

3.4. Human-machine co-driving technology

The complementary control of the control layer is the core concern in the field of human-machine co-driving. The human-machine co-driving is controlled in parallel, with redundant and game-like control inputs from both sides. On the other hand, traditional dynamics safety control systems cannot be extended to a wider area due to insufficient research on driver behavior characteristics (e.g., decision intentions and maneuvering forces) and the lack of information on the surrounding vehicle environment [8]. Therefore, the integration of driver decision recognition and perimeter trajectory prediction information into traditional active safety systems, and the construction of a dual safety envelope control system that includes kinetic stability risk and kinematic crash risk, are the core of improving human-machine driving stability and active safety. Therefore, the human-machine co-driving technology in the control layer can be divided into shared control and envelope control according to the system function. Shared control means that the human-machine is online at the same time, and the control of the driver and the intelligent system is transferred with the scenario, and the human-machine control exists in parallel. It mainly solves the problems of human-machine conflicts caused by control redundancy and load increase caused by unreasonable distribution of control rights. Envelope control refers to the formation of a control envelope by acquiring safety zones and boundary conditions in the state space, and then supervising the safety of the vehicle and intervening when it determines that risks may occur, thus ensuring dynamic stability and avoiding collisions.

3.5. Communication and platform technologies

The modes of in-vehicle communication can be divided into intra-vehicle communication, inter-vehicle communication, and wide-area communication according to the coverage of the communication. Intra-vehicle communication has evolved from Bluetooth technology to Wi-Fi and Ethernet communication technologies; inter-vehicle communication includes dedicated short-range communication (DSRC) technology and long term evolution-vehicle (LTE-V), which is also an evolution of 4G communication technology in the field of automotive communication, and is being established as a standard. LTE-V is also an evolved version of 4G communication technology in the automotive communication sector. Wide area communication refers to the 3G and 4G communication methods that are widely used in the mobile Internet. Through the networked wireless communication technology, the in-vehicle communication system will integrate and analyze the driver information, the posture information of the vehicle and the environmental data around the vehicle more effectively
[9]. The typical platform architecture is the framework of Telematics platform and the open technical standard protocol (NGTP) jointly developed by BMW, Connexis and WirelessCar, which is the "Next Generation Telematics Architecture". "It provides greater flexibility and scalability for the development and application of Telematics platform. China's enterprises are basically self-built service platforms, and the data between the platforms cannot be interconnected, and there are problems with the information security management model [10]. The Ministry of Transportation's networked control platform for operating vehicles has achieved large-scale access to key operating vehicles nationwide, but not to the largest passenger car sector. The application of communication and platform technology has greatly improved the range of vehicle perception of traffic and the environment, and has provided support for the development of energy-saving technologies based on the cloud control platform [11,12].

4. Conclusion
With the help of Internet technology and the smart connected car as a model, an innovative China, led by technology, will win a bright future! For the first time in history, information change, material change, and biotechnology have organically merged together and burst forth with great power. With the smart connected car as a model, innovative China, led by technology, will surely win a bright future.

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