Development Trend of Operating System Technology for Smart Car

Jang, Seung-Ju

1Department of Computer Engineering, Dongeui University

Abstract: Smart automobiles are "vehicles that can be automatically operated using advanced computer, communication, measurement technology, etc." In other words, it refers to a vehicle that is equipped with a Global Positioning System (GPS) receiver mounted on a car, notifying the accurate latitude and longitude, and presenting precise maps to the instrument panel and making the most efficient travel from the current location to the destination. Smart automobiles need to develop complex technologies through fusion technology such as mechanical devices, electronic devices, and SW technologies. This smart car operating system technology is really a technology for interfacing with a user to act as an autonomous vehicle. The technology is now in its infancy. This competition of smart operating system (OS) is spreading from smartphone to automobile market. Apple and Google, which dominated the smartphone market, plan to enter the new auto market by developing technology related to the smart auto. In particular, it anticipates that various functions of smart phones will implement in automobiles and the smart car era connected with the network will advance

Keywords: Smart Automobiles, Smart Car P.S, Smart Car, Apple Smart Car, Google Smart Car

I. INTRODUCTION

Smart automobiles are "vehicles that can be automatically operated using advanced computer, communication, measurement technology, etc." In other words, it refers to a vehicle that is equipped with a Global Positioning System (GPS) receiver mounted on a car, notifying the accurate latitude and longitude, and presenting precise maps to the instrument panel and making the most efficient travel from the current location to the destination. (As defined by the Ministry of Strategy and Finance, November 2010).

In modern civilization, automobiles are a convenient means of transport and have an important status as a leader in the industry that drives the economy. In Korea, the automobile industry is a comprehensive industry covering machinery and electronics, forming the central axis of the national industrial structure, and now firmly established as the fifth largest automobile producer in the world. In the automotive industry as a comprehensive industry, electronic parts (electronic control units (ECUs) have been integrated into automotive technologies and electronic parts of automobiles have become electronic.

The introduction of smart vehicle technology can improve the safety of vehicle operation and can serve as a convenient means of transportation according to the driver's choice. In particular, it is possible to reduce traffic accidents by eliminating a mistake of a driver that occurs during a vehicle operation. This function can expect to reduce social costs by reducing traffic accidents in an increasingly aging society. The installation of these electric devices is leading to the development of more convenient automobile technology.

Smart automobiles need to develop complex technologies through fusion technology such as mechanical devices, electronic devices, and SW technologies. This smart car operating system technology is really a technology for interfacing with a user to act as an autonomous vehicle.
The technology is now in its infancy. This competition of smart operating system (OS) is spreading from smartphone to automobile market. Apple and Google, which dominated the smartphone market, plan to enter the new auto market by developing technology related to the smart auto. Apple is preparing to launch its smart car operating system based on ‘Car Play’ and Google based on ‘Android Auto’. Microsoft, which has not been able to respond quickly to the smartphone market, is developing a Windows in-car operating system for the smart car market.

In response, automakers are also pursuing OS development strategies independently. Car companies are developing their own OSs or developing their own automotive OSs in cooperation with various companies to avoid dependence on Apple, Google, or Microsoft's automotive OS. In terms of smart cars, Apple's Car Play for car infotainment system and Google's Android Auto expect to gain momentum thanks to the proliferation of smart cars as a key OS for operating in-vehicle infotainment systems. It also expects that the technological development and staggering of the initiative between the automobile and ICT industries will become more intense. In particular, it anticipates that various functions of smart phones will implement in automobiles and the smart car era connected with the network will advance [14]. This paper researches the development trends of smart automobile operating system among rapidly changing automotive technology fields.

II. DEVELOPMENT TREND OF AUTONOMOUS DRIVING CAR TECHNOLOGY

This section examines the development trends of autonomous vehicle technology. We will look at the development of technology linked with smart car operating system by examining the development trend of autonomous driving car technology. The technology related to autonomous vehicle is as follows (Fig. 1) [1, 2, 3].

![Figure 1. Autonomous vehicle technology](image_url)

Figure 1 shows the technology related to autonomous vehicles. Autonomous vehicle-related technology above can classify into H / W technology and S / W technology. Sensors and systems are H / W technologies. The decision algorithms required for intelligent control and operation are S / W technologies.

The automobile industry is aiming for 2020 by the commercialization of autonomous vehicles. By 2020, commercial vehicles related to autonomous vehicles will emerge in various forms [4]. Consumer responses to autonomous vehicles are also positive. According to the JD Power survey in April 2012,
37% of users are willing to purchase autonomous vehicles. A study by the IEEE also predicts that autonomous vehicles will account for 75 percent of the world's cars around 2040. Figure 2 is the data related to the commercialization market of autonomous vehicles [5].

Figure 2. Prediction of autonomous vehicle commercialization

According to strengthening safety regulations of the Euro NCAP (New Car Assessment Program), and high performance and low price of ADAS (Advanced Driver Assistance Systems), smart car supply is expected to increase [6].

Table 1 below is the definition of step-by-step operation related to autonomous vehicles.

Table 1. Definition of step-by-step operation related to autonomous vehicles

<table>
<thead>
<tr>
<th>Operational level</th>
<th>Cognitive subject</th>
<th>Control subject</th>
<th>Responsibility subject</th>
<th>Driver driving Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>level 0: No-Automation</td>
<td>Driver</td>
<td>Driver</td>
<td>Driver</td>
<td>O</td>
</tr>
<tr>
<td>level 1: Function-Specific Automation</td>
<td>Driver</td>
<td>Driver</td>
<td>Driver</td>
<td>O</td>
</tr>
<tr>
<td>level 2: Combined Function Automation (watching nearby traffic conditions) Hands-Off, Feet-Off, Eye-on</td>
<td>Driver</td>
<td>vehicles</td>
<td>Driver</td>
<td>O</td>
</tr>
<tr>
<td>level 3: Limited Self-Driving Automation (Driver’s decision for Automatic operation) Hands-Off, Feet-Off, conditionally Eye-Off</td>
<td>Driver</td>
<td>vehicles</td>
<td>Driver/ vehicles</td>
<td>O</td>
</tr>
<tr>
<td>level 4: Full Self-Driving Automation (Enter destination only) Hands-Off, Feet-Off, Eye-off</td>
<td>vehicles</td>
<td>vehicles</td>
<td>Driver/ vehicles</td>
<td>X</td>
</tr>
</tbody>
</table>

<Data>: NHTSA

Autonomous driving automotive system technology is progressing step by step according to driver's intervention range and control technology level. In the autonomous vehicle system, the automobile
will gradually lead to the driving, and will develop into a system capable of autonomous driving by itself with minimal driver intervention. Finally, it will evolve into a fully autonomous vehicle system (Level 4) that can reach its destination without driver intervention [13, 16]. They are also spurring the development of operating system technology to realize such perfect autonomous driving.

III. DEVELOPMENT TREND OF OPERATING SYSTEM TECHNOLOGY RELATED TO SMART CAR

The competition of smart operating systems (OS) is spreading from smartphone to automobile market. Apple and Google, which dominated the smartphone market, plan to enter the new auto market by developing technology related to the auto market. Apple is preparing to launch its smart car operating system based on 'Car Play' and Google 'Android Auto'.

Apple based on 'Car Play' and Google based on 'Android Auto' are preparing to take control the smart car operating system market. Microsoft, which has not been able to respond quickly to the smartphone market, is developing a Windows in-car operating system for the smart car market.

In response, automakers are also pursuing OS development strategies independently. Car companies are developing their own OSs or developing their own automotive OSs in cooperation with various companies to avoid dependence on Apple, Google, or Microsoft's automotive OS.

A. Google's Android Auto

Google has entered into the development of the smart car operating system as an ICT company. Google recruited Sebastian Thrun team from Stanford University who is the winner of the 2005 driverless car competition of the DARPA Grand Challenge. Google has proceeded to develop autonomous driving vehicles with this team. Especially, it will pay attention to the development of smart car operating system connected with autonomous driving car. The research result, "Android Auto," is Google's new Android app for cars. Android Auto OS is designed to interface with Android mobile devices in smartphone [17].

In January 2014, Google unveiled a smart car made with Audi at the Consumer Electronics Show (CES) in Las Vegas. Google has formed the Open Automotive Alliance (OAA) with four leading automotive manufacturers, including Audi, GM, Honda and Hyundai, and chipmaker Nvidia. Google unveiled Android Auto, the automotive operating system, at the developer conference "Google I / O" held in San Francisco in June 2014. OAA aimed at seamlessly porting Android to the automotive operating system and securing its position as in the mobile OS market. Therefore, the carmaker cooperation camp of Google's Android Auto is evaluated as more robust compared to Apple's Car Play. A total of 28 automakers will be commercialized in the second half of 2015, and Android Otto is expected to have a superior advantage over Apple in terms of scalability in connection with map services and autonomous vehicle technology [13, 14]. Recently, Google has launched a new version of Google Auto Link (GAL) and is planning to push its own version of technology apart from Android Auto.
Above (Figure 3) shows Google Android’s auto operation screen.

B. Apple’s Smart Car Operating System

Apple will also develop CarPlay as an operating system for smart cars. At the Geneva Motor Show in March 2014, Apple announced a smart car operating system called "carplay". Apple's Car Play operating system is a car operating system that allows drivers to drive safely in a smarter, more pleasant environment. In the car installed “carplay”, the driver can drive the app with the car running. There are a variety of ways to get the app running.

It provides the motorist to take advantage of the voice recognition function when the user wants to operate the function during operation. It is possible to use 'Siri', a speech recognition program provided by Apple. Car play is expanding its coverage through partnerships with various automotive companies [3]. Car play is a car version of iOS and works almost seamlessly with the iPhone. But it is still in the state of simple interlocking so far. It is possible to control the mobile phone without touching the mobile phone while driving, so that it can guarantee a certain safety improvement. Above all, the development of a technology that operates in cooperation with an autonomous vehicle has not yet been achieved. Various car models with car play will be released in 2016. In addition, the company is developing services that are linked to user smartphones through In-Vehicle Infotainment (IVI).
C. Microsoft's (Windows) “Windows in the Car” operating system

In April 2014, Microsoft announced its Windows OS 'Windows in the Car'. Although it is released later than other smart car operating systems, it can be a strong driver of the smart car operating system using Microsoft's operating system technology.

Recently, Microsoft is struggling in the PC market and has not been able to make any clear results in the smartphone market. They are preparing to develop various technologies for smart car era. The functionality of the 'Windows in the Car' operating system, proposed by Microsoft, is designed so that all operations are centered on smartphones. 'Windows in the Car' operating system is based on basic functions. It provides 'mirror link' function for connection between smartphone and vehicle. This technology was developed by Nokia. When Microsoft acquired Nokia, it merged with the smart car operating system.

(Figure 5) Microsoft's automotive OS is the least known of the three. It adopts the same tile-like user interface as Windows 8 and is similar to Apple's carplay which sends a car screen based on a Windows phone. Since Microsoft has been offering Windows CE, the embedded system for automobiles for 20 years, it has been adopted long by many automakers such as Audi, BMW, Nissan, Ford and Kia as platforms.

Microsoft's Windows in the Car operating system is functionally similar to other companies' smart-car operating systems [4]. The ability to reach more users for these similar functions will be the dominant factor in the market. The following (Figure 6) summarizes the automotive operating systems being promoted by Google, Apple and Microsoft.

<table>
<thead>
<tr>
<th>Comparison of smart car related operating system</th>
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<tr>
<td><strong>Google</strong></td>
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<tr>
<td>Commercialization</td>
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<tr>
<td>OS Partners</td>
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<tr>
<td>Advantages</td>
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<td>Disadvantages</td>
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<tr>
<td>Commercialization OS</td>
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<tr>
<td>Partners</td>
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<tr>
<td>Advantages</td>
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<tr>
<td>Disadvantages</td>
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<tr>
<td>Commercialization</td>
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D. Development of operating systems for carmakers

Carmakers are making their own efforts not to become a technological subordination to computer software companies such as Apple, Google and Microsoft. The automakers are looking for various ways because they lack the SW research and development capability.

Toyota Motor Company is showing the technology to link mobile apps and automobiles through the concept of Smart Device Link linked with automobile companies such as Ford. The technology is based on Ford's open source technology. Automotive suppliers QNX Software Systems and UI Evolution will also adopt the technology.

Hyundai / Kia Motors is introducing its own connected car operating system named 'CCOS (Connected Car Operating System)'. This operating system provides a vehicle interworking framework
(providing functions such as vehicle network and vehicle control). It also provides an infotainment framework (providing functions such as navigation and multimedia).

Ford, a leading automotive company in the United States, is developing a way to match millions of SYNC® equipped vehicles with home automation or smart home products worldwide. Ford is developing a technology to integrate SYNC Connect and Amazon Echo to provide voice-controlled access between cars and homes. Technology is under development to enable drivers to access Internet-enabled devices such as lighting, home security systems, TVs and garage doors.

Google hopes that Android will become an operating system for smart cars and is joining several auto manufacturers in the Open Auto Alliance (OAA). Audi, GM, Honda and Hyundai have partnered with Nvidia and Google to build Google’s platform on their vehicles and are developing apps.

The goal of this system development is to bring satnav and other driving apps to the car system as well as entertainment such as music streaming. Google says it's safer than people using a smartphone or tablet while driving. Google is aiming to make it easier for drivers and passengers to use their cars by using Android as a car operating system [13].

European automakers are adopting a smart automotive OS with Android Auto OS. Taizen, a mobile operating system led by Samsung and Intel and participating in NTT DoCoMo, KT and SK Telecom operators, is also developing an OS for smart cars [13].

Recently, Alibaba and SAIC Motor Corp. (SAIC), China's largest automaker, demonstrated a co-developed vehicle equipped with a YunOS operating system that can be connected to a smart phone. YunOS provides innovative features such as intelligent maps to OS’ Car RX5 drivers through cloud-based data. This vehicle can issue commands directly via smart voice control, providing a more natural and safe driving environment [19]. In this way, automobile companies and IT companies are struggling to develop technologies for operating systems for smart cars.

IV. CONCLUSION

So far, we have reviewed the trends of operating system technology related to smart cars. Research on smart cars is actively conducted in many fields. Many experts predict the time of full commercialization of autonomous vehicles from 2020 to 2025. When the autonomous vehicle is commercialized, it will bring about another change in human daily life, and will revolutionize the related industries.

In addition to autonomous vehicles, recently, technology development for connected cars has been actively conducted. Google is developing Android Auto for smart car operating system technology development. Apple is developing a car entertainment operating system. Microsoft is developing Windows in-car. In addition, automakers are spurring their own development of technologies that use their own operating systems or existing operating systems.

Looking at the smart car operating system technology, it is not developed at present in connection with the autonomous driving function. In the case of Google, technology development is performed in conjunction with autonomous navigation, and the rest is centered on the user interface. As technological development progresses in the future, it will try to seamlessly integrate with autonomous navigation function.

In addition, the development of connected car technology is accelerating in connection with smart car operating system technology. These technologies are expected to eventually be implemented in an
integrated environment. Recently, Alibaba has been involved in the development of operating system technology for smart cars. As such, smart automobiles are evolving into the core technology of the future industry, which is full of machinery industry and IT technology.

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