A Study on In-Vehicle Diagnosis System using OBD-Ⅱ with Navigation

Mi-JinKim, Jong-Wook Jang, Yun-Sik Yu

Department of Computer Engineering Dong-Eui University, Busan, Republic of Korea
Department of Radiological Science Dong-Eui University, Busan, Korea

Summary
The vehicle navigation system is a representative driver support system that is available for the present path search and guiding functions. Its usability has been increasing. Under the present competitive situation because of the expanding navigation market to meet the customers' needs with regard to new services, differentiated services are dramatically increasing. In addition, the dashboard indicates the statuses of many of the vehicle's functions, all of which the driver must be aware of. It is not easy, however, to detect the abnormal parts of a vehicle, and there may be no device that will issue a warning of such to the driver. Therefore, it is difficult to prevent vehicular accidents because vehicles cannot immediately deal with their various abnormal functions while on the road.
In this paper, a vehicle diagnosis program within the navigation system that can manage and diagnose different kinds of vehicle malfunction is proposed. This program conforms to the OBD-II standard and can thus transmit diagnosis data from the ECU to the navigation system using the Bluetooth wireless communication protocol. Thus, this program provides enhanced services to the customers as well as multimedia and geometry information services.
Key words:
Vehicle Diagnosis, Bluetooth, Navigation, OBD-Ⅱ, CAN

1. Introduction

According to the changes in the automobile industry paradigm, automobiles are bound to develop focusing particularly on eco-friendliness, safety, and comfort. Automobiles used to be considered merely means of transportation with independent hardware. As diverse additional services and safe and convenient automatic internal control systems have been introduced to satisfy the customers' needs, however, IT technology must be added as a software for providing electronic systems in the powertrain, body, chassis, and infotainment systems, via the vehicle network (CAN, LIN, FlexRay, MOST, etc.), to ensure eco-friendly and high-quality customized services.
Many mobile terminals in South Korea have a Bluetooth device for short-range wireless communication as well as a CDMA module, and diverse products are being developed using this feature. Most automobile multimedia devices are being integrated in the navigation system, and diverse services for satisfying the customer expectation of new service functions are increasingly needed in the greatly competitive navigation market situation.
While complying with the OBD-II automobile diagnosis standard, a new business opportunity that provides more customer-oriented diagnosis services can be offered. The communication of fault detection and sensor output signals can be conducted in real time using the wireless Bluetooth module. Therefore, more improved functions for automobile maintenance and diagnosis, and more convenient device control, must be added to the limited features of the existing navigation system based on the multimedia service and geographic information system.
In this study, a vehicle diagnosis program was developed, in which vehicle information is retrieved from the ECU according to the OBD-II standard, to maintain and diagnose the vehicle using the navigation system via the Bluetooth wireless network technology. With this program, the diagnostic data can be precisely checked in real time to maintain the optimal vehicle conditions. This technology can be applied to the reduction of CO_2 emission and can improve vehicles' eco-friendliness.
The OBD-II and Bluetooth technology is introduced in Chapter 2. In Chapter 3, the composition and design of the system are described. Finally, Chapter 4 presents the conclusion and future relevant challenges.

2. Relevant Studies

2.1 OBD-Ⅱ

Studies on electronic devices in vehicles have been conducted since the 1970s. With the rapid development of the electronics industry since the 1990s, there have been many improvements in the areas of engine control, body parts monitoring, body and additional-devices inspection, and network diagnosis control. Studies are currently being conducted to establish the standard for parts and communication devices that would ensure more precise vehicle diagnosis.[1],[2],[3]

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When environmental pollution became a serious social issue in the 1970s, the U.S. established the Environmental Protection Agency (EPA). EPA established a new standard to limit the environmental pollutants emitted from vehicles. The car manufacturers devised an electronic control system for the fuel supply and ignition devices, based on the standard.[2],[3],[4] In addition, the Society of Automotive Engineers (SAE) established OBD in 1988 as a standard for the plug connector and on-board diagnosis

번호	용도
2	버스의 양극(+) 라인 (SAE-J1850)
4	배터리 접지
5	신호 접지
6	CAN_H
7	K시그널 라인 (ISO 9141-2, ISO 14230-4)
10	버스의 음극 라인
14	CAN_L
15	L 시그널 라인
16	배터리 양극

No.	Function
2	Positive (+) bus line (SAE-J1850)
4	Battery ground
5	Signal ground
6	CAN_H
7	K signal line (ISO 9141-2, ISO 14230-4)
10	Negative bus line
14	CAN_L
15	L signal line
16	Battery positive

Figure. 1 OBD-II communication standard

program. The OBD standard developed into OBD-1.5 and OBD-II.[3],[4],[5],[6],[7],[8]

According to the OBD-II standard, the standardized diagnostic trouble code and connection interface (ISO J1962) are applied to all vehicles, but there are five kinds of electronic signals according to the historical background. To solve the non-compatibility problem in the signal system, all vehicles in the U.S. market, which is the greatest in the world, have had to conform to ISO 15765-4 since 2008.[1],[2],[3],[5] Since 1996, all the vehicles manufactured in the U.S. have had to support OBD-II. The standard became mandatory in 2001 in Europe and in 2006 in South Korea.[9]

Before the establishment of the OBD-II standard, the connector, which connects the ECU with the external devices, was located in diverse places, such as on the dashboard and under the hood. In vehicles manufactured according to the OBD-II standard, however, the connector is located only under the instrument panel or near the ashtray, and anyone can easily find it.

If the standard ISO J1962 connector is connected to an external scanner, communication with the ECU is possible using the scan software in the PC or PDA, and the OBD-II standard. The vehicle exhaust gas level, misfire in specific cylinders, or abnormality in the three-way catalytic converter can be inspected or diagnosed using the OBD-II scan system.

OBD-II describes the fault information using the five-digit fault diagnosis code when a fault occurs in the vehicle.3,4,7,8 The fault types and codes are also standardized. General car maintenance agencies use the fault codes based on the OBD-II standard to detect the abnormalities in vehicles and to repair them.[3],[6],[8]

All vehicles that conform to OBD-II use three standard signal methods: VPW-PWM (SAE-J1850), ISO (ISO 1941-2, ISO 14230-4), and CAN (ISO 15765, SAE-J2234).

2.2 Bluetooth

The Bluetooth wireless system refers to the standard that enables real-time two-way communication by connecting computers, mobile terminals, and appliances wirelessly, or to products that are compatible with the standard. It works within the 2.4GHz industrial, scientific, and medical (ISM) frequency range and uses the frequency hopping transmission and reception mechanism to prevent interference and fading. Ericsson in Sweden started studying the Bluetooth system in 1994. It led the research on such matter, and IBM, Intel, Nokia, and Toshiba participated in the study (Bluetooth SIG) in February 1998. In December 2001, Microsoft, 3Com, Lucent Technology, and Motorola participated in the research group, and the Bluetooth system became the global standard. It was first applied to mobile phones and laptops and is now being used in diverse systems, including PDAs, MP3 players, printers, vehicle navigation systems, and digital cameras.10

Bluetooth boasts low cost, low power, and a small size. The standard has continuously developed for the last ten years, and version 3.0 has been launched. It is divided into classes 1, 2, and 3 depending on the transfer distance, and the power consumption increases with the increase in the transfer distance.

Bluetooth, unlike wireless LAN, defines all the seven OSI layers and addresses many of the protocol issues with the relevant software. The usable protocols include RFCOMM, which establishes the serial port; PPP, which works on it; and IP or TCP/UDP over them. The TCS BIN protocol is used for the application to the phone; OBEX, which is being used by IrDA, is used to transfer large-volume files; and WAP and WAE are being used as the wireless Internet protocols for mobile phones. The logical link control and adaptation protocol (L2CAP) is always active and covers the use of these protocols.

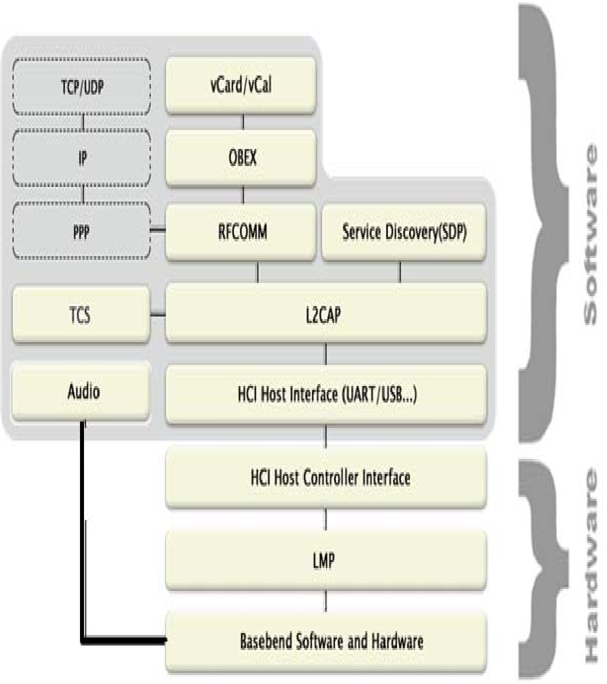

Figure. 2 IPTV service architecture.

3. System Configuration and Design

The system in this study was configured as follows:

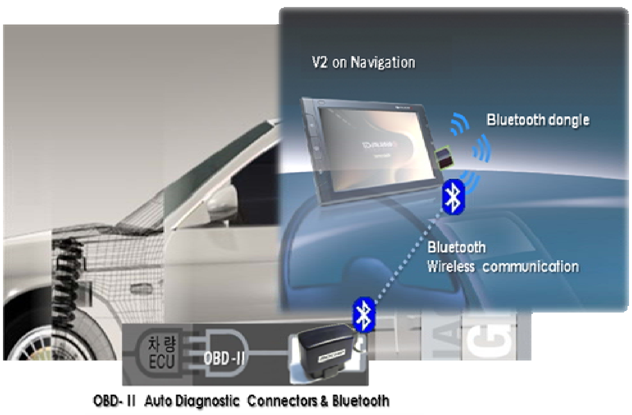

Figure. 3 Diagram of the entire system.

In this study, vehicle data were collected by analyzing the protocol that was suitable for the vehicle type using the OBD-II automatic diagnosis connector. The collected data were wirelessly received via the Bluetooth dongle and were used to provide improved services to the driver in the vehicle information menu of the navigation system.

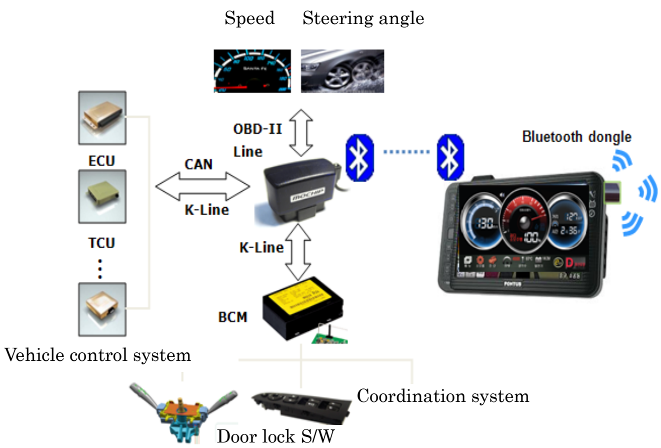

Figure. 4 Automatic diagnosis connector and Bluetooth communication.

The protocol converter converts the data outputted from the ECU through the 16-pin hardware interface of the SAE standard J1962 connector into the data that are suitable for the applications.

As all vehicles that conform to OBD-II use multiple standards, such as VPW-PWM (SAE-J1850), ISO (ISO 1941-2, ISO 14230-4), and CAN (ISO 15765, SAE-J2234), the standard data in the vehicles in South Korea were converted into one format, and the protocol was converted to transmit or receive the data via the Bluetooth system.

The following block diagram represents the OBD-II diagnosis connector. The OBD-II connector is connected to the J1920 connector part. The vehicle data are converted into the CAN and ISO communication protocols and are used to provide detailed diagnosis data, supplies diagnosis and management, and trip and driving habit information via the Bluetooth system.

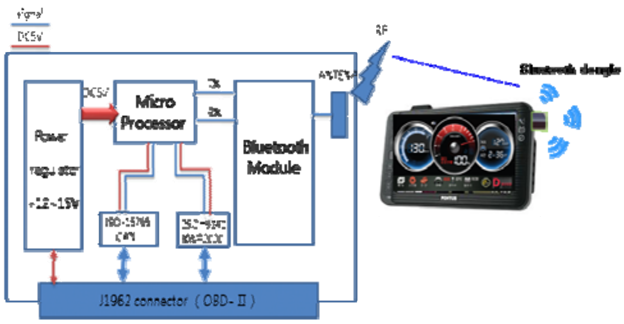

Figure. 5 Block diagram of the OBD-II automatic diagnosis connector.

The vehicle diagnosis program that is linked with the navigation system shows the real-time vehicle conditions and the useful sensor data on the navigation screen, processed in such a way that the driver can easily understand. This can help the driver detect the abnormality in the vehicle and prevent its progress into another unit, which can reduce the vehicle maintenance cost. In addition, this can help the driver become aware of the real-time conditions of the vehicle and can prevent accidents while driving. With real-time diagnosis data for vehicles, a vehicle's optimal conditions can be maintained, which can contribute to the improvement of the green technology and to the reduction of CO_2 emission.

The main services of the navigation diagnosis applications include detailed vehicle diagnosis data, supplies diagnosis and management, trip data, driving habit data, and eco-information service. The following table shows a summary of the main services.

Table 1. Main services of the navigation application

Cost	Driver-customized service	· Decrease in maintenance cost via the reasonable vehicle management · Prevention of malfunction via real-time vehicle diagnosis and inspection
Maintenance	Vehicle diagnosis and maintenance service	· Notice of optimal supply replacement cycle depending on the driver's driving habits
Safety	Safe driving service	· Driving habit analysis · Safe driving information, including rapid acc/dec values
Cost saving	Economical-driving service	· Real-time notice of travel distance, driving propensity, and fuel consumption index · Optimal economical-driving guide service
Information	Driver-based trip com.	· Real-time fuel consumption index · Average driving speed
Eco-friendliness	Eco-information service	· Eco-information service based on the real-time fuel consumption data

4. Conclusion and Future Challenges

With the development of the electronic control features in vehicles, data, including the driving status, are recently being collected via electronic-control devices and sensors, to ensure more efficient driving conditions.

In this study, a wireless protocol converter as a system of reading and processing the data in the ECU, which transmits and receives the data from the ECU, and a vehicle diagnosis program, which is linked with the navigation system, were presented so that the driver can easily check the relevant data, including the vehicle conditions, and can diagnose different kinds of malfunction and supplies. Thus, the abnormalities in a vehicle are detected via personal diagnosis and the real-time vehicle diagnosis features, and the resulting precision vehicle diagnosis and management service can prevent vehicular accidents and can enable systematic vehicle management. As the OBD-II standard is becoming mandatory not only in the U.S. and EU countries but in many other countries as well, especially in Asia, the vehicle self-diagnosis system is expected to have much greater marketability in the future.

The applicability of the vehicle self-diagnosis system will have to be improved in the future, however, to satisfy more diverse environments, by developing App Store applications for all smart phones and by promoting the mobile-contents market.

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Jong-wook Jang. Feb, 1995: Obtained Doctor's Degree in Computer Engineering at Pusan National University
1987 – 1995: Worked for ETRI
Feb, 2000: Postdoctoral in UMKC
1995 – Present: Professor of Computer Engineering, Dongeui University
※ Interest subjects: Wire and Wireless Communication System, Automobile Network, Vehicle Network

Mi-Jin Kim Feb, 2004: Obtained Bachelor's Degree in Computer Engineering at Dongeui University
Aug, 2008: Obtained Master's Degree in Computer Education at Education School of Pukyong National University
Mar, 2009 – Present: Doctorial Course of Computer Applications Engineering at Dongeui University
※ Interest subjects: IPTV, Routing Protocol, Next-generation Internet Protocol, IP Network, Vehicle Network

Yun-Sik Yu. Feb, 1978: Obtained Master's Degree in Physics at Pusan National University
Feb, 1990: Obtained Doctor's Degree in Physics at Pusan National University
1983-Present: Professor ofRadiological Science, Dongeui University
2008- Present: Direct of Convergence of IT Devices Institute Busan(CIDI)
※ Interest subjects: IT convergence, Optical communication.