Car Information Systems for ITS

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OVERVIEW: For ITS (intelligent transport systems) car information systems, of which car navigation is a typical example, are demanded to process advanced multimedia information and communication functions for implementing various information services, such as providing traffic information by means of the VICS (vehicle information and communication system) service, providing tips about points of interests by means of Internet communication, distributing music and video data by means of digital broadcasting, emergency call service, and ETC (electronic toll collection) service. In response to those demands for ITS car information systems, Hitachi, Ltd. has taken up the challenge of developing, in addition to car navigation technology, technology for cooperation between car navigation and multimedia communication systems via Internet, technology for highly-reliable car computers, technology for highly-reliable ETC on-board equipment (OBE) in a vehicle environment, and human interface technology for in-vehicle use, such as voice recognition technology with excellent noise tolerance characteristics that enables use in noisy vehicles, etc.

INTRODUCTION

AN ITS (intelligent transport systems) car information system is an information processing system that is installed in a vehicle for providing various types of information services to the driver through the exchange of information between systems inside and outside the vehicle via telecommunication and broadcasting. The car navigation system, which is representative of these systems, calculates the vehicles location using GPS (global positioning system) and displays that location onto electronic maps, and guides the driver to the destination. Also, the VICS (vehicle information and communication system) service for providing traffic information by means of telecommunication or broadcasting has been developed to a practical stage and is being introduced into car navigation systems.

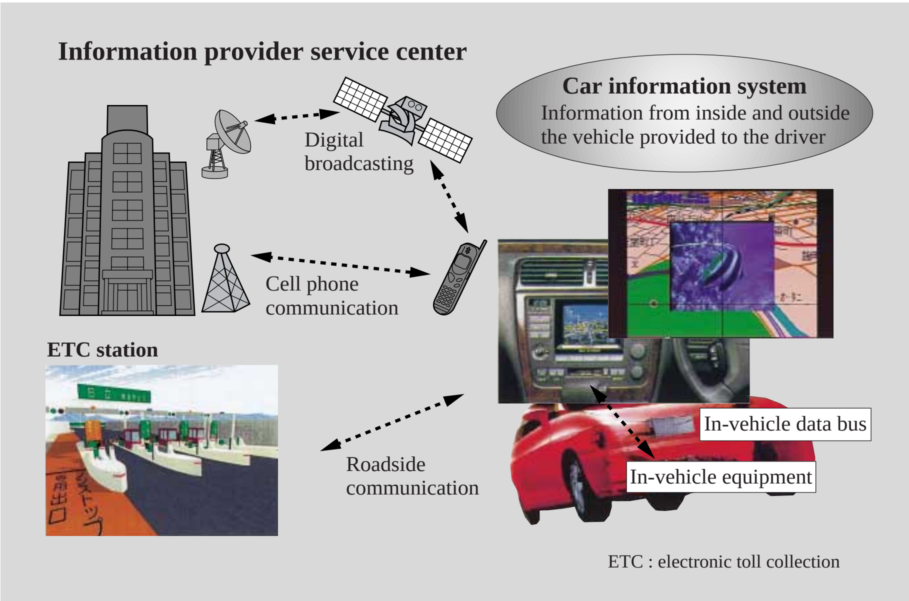

Fig. 1—The ITS Car Information System.
The ITS car information system uses telecommunications, broadcasting and an in-vehicle data bus to allow the exchange of information among various devices inside and outside the vehicle and to offer a variety of information services to the driver.

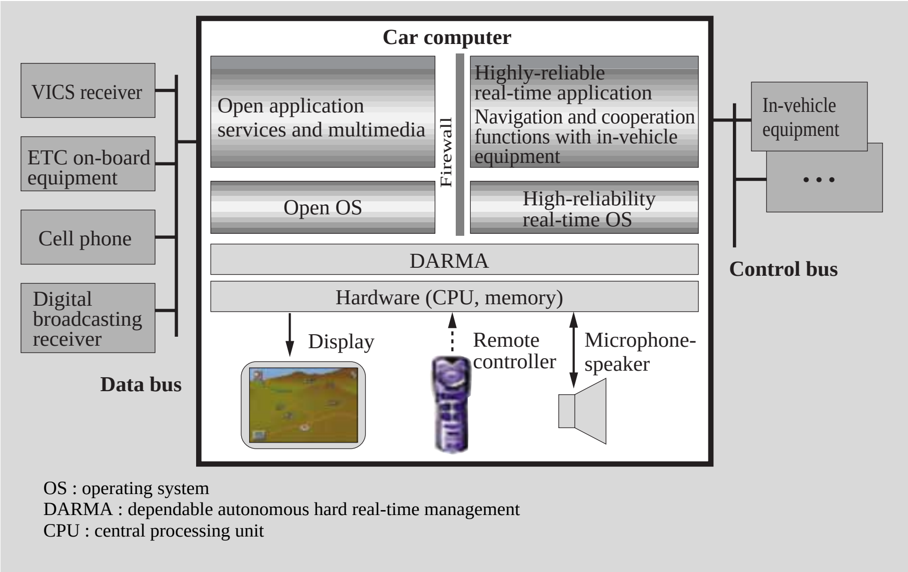

Fig. 2—Basic Configuration of the ITS Car Information System and the Car Computer Functions.
The car computer has an abstraction layer called DARMA, which allows an open OS and a high-reliability real-time OS to run simultaneously on a single processor. The information provision services from outside the vehicle that are required for open connectivity are executed on the open OS side and vehicle internal services that require highly reliable real-time processing run on the high-reliability real-time OS side.

The ETC OBE, which allows charging of highway tolls by communication between the toll collection facility and the vehicle, is also expected to come into wide use.

In future, we believe that this system will develop toward a car computer system for the advanced processing of information from inside and outside the vehicle, such as multimedia communication processing functions for receiving points of interest information through communication with the Internet and other such open systems outside the vehicle, downloading and doing the playback of music and video data through high-speed data communication and digital broadcasting and vehicle control cooperation processing functions for informing the driver of vehicle conditions and making the emergency call automatically in cooperation with vehicle control systems, and so on.

Here, we describe a basic configuration of the ITS car information system and its key component of a highly-reliable car computer system that achieves compatibility of multimedia communication processing, which requires open connectivity, and vehicle control cooperation processing, which requires high reliability. We also describe the ETC OBE terminal, which has been one of the hot topics, and voice recognition technology that features excellent tolerance of noise, which is expected to serve as a means of comfortable system operation in the vehicle.

BASIC CONFIGURATION AND THE CAR COMPUTER

The basic configuration of the ITS car information system and its car computer are shown in Fig. 2. The car computer is an information processing equipment that is installed in a vehicle and serves as a key component of the ITS car information system. It consists of a CPU, a display and other user interface devices, and has communication interfaces with other in-vehicle devices. This car computer is implemented at low cost as a single hardware processor that has both the open connectivity capability and the highly-reliable real-time processing capability.

Open Connectivity and Highly-Reliable Real-Time Processing Characteristics

The ITS car information system is expected to provide various information services to the driver via telecommunication and broadcasting channels. The system is also expected to inform the driver of the vehicle conditions, the proper guidance in case of an emergency and roadside conditions in cooperation with in-vehicle control units. A car computer that is equipped with many user interface functions, such as a display, is expected to play a central role in that processing. Thus, the car computer must have the open connectivity needed for open information provision services that allow rapid development of service content. To provide car navigation services and services that involve cooperation with other on-board devices such as electronic control units, on the other hand, highly reliable real-time processing characteristics are required. That is to say, the car computer must offer both open connectivity and highly reliable real-time processing characteristics at the same time.

In order to achieve open connectivity, a software download function for implementing new services that are offered by information service centers is required. However, the quality of downloaded software and the correct processing of it by the car computer cannot be verified at the time the car computer leaves the factory. Accordingly, open connectivity and highly reliable real-time processing characteristics can be said to be mutually opposing issues.

Dual OSs Computer

One solution to the problems outlined above that can be considered is to implement the car computer as two computers, one for implementing open connectivity and the other for implementing highly reliable real-time processing. That approach, however, increases system size and cost and involves many other problems, such as the sharing of the display and other user interface devices.

We therefore attempted to solve this problem by applying the DARMA software technology[1] of Hitachi, Ltd. to the car computer, allowing two different OSs to run on a single CPU at the same time.

This car computer employs the DARMA technology to allow an open OS and high-reliability real-time OS to run on the same hardware at the same time. In that way, the open services provided by information service center can run under the open OS and car navigation and cooperative services with electronic control units that require highly reliable real-time processing characteristics can run under the high-reliability real-time OS (Fig. 2). With the DARMA technology, the high-reliability OS continues to operate and provide its functions even if the open OS freezes up for any reason. In this way, it is possible to implement a compact and low-cost car computer that simultaneously satisfies the conditions of open connectivity and highly reliable real-time processing. The screen image of the ITS car information system presented on page 102 shows the display of a prototype car computer that was developed with DARMA technology in which MPEG (Moving Picture Experts Group) -4 video data is being presented via the open OS while car navigation functions are being run on the high-reliability real-time OS side [2].

ETC ON-BOARD EQUIPMENT[3]

The ETC on-board equipment (OBE) is expected to come into truly practical use in the year 2000. The ETC OBE consists of a main unit that is installed in the vehicle and an IC card [Fig. 3(a)]. The OBE accomplishes cashless toll collection by conducting wireless communication with roadside equipment (RSE). The IC card that is inserted into the OBE stores transaction settlement information. Considering use within a vehicle, a car mounted device that is small, easily installed, and easy to operate, as shown in Fig. 3 (a), has been realized. In addition, high reliability operation in the car-mounted environment has been maintained. The configuration of the ETC OBE is shown in Fig. 3 (b). Each component of the OBE is described below.

(1) Radio unit

This component conducts communication with RSE by receiving 5.8 GHz radio signals, demodulating them, and then sending the resulting digital signal to the communication controller and by modulating the digital signal sent from the communication controller to a 5.8 GHz radio signal and then transmitting that signal.

(2) Communication controller

This unit provides link connection control, such as establishing and releasing links with RSE, error control, and encoding and decoding abstract syntax code, etc.

(3) ETC processor

This unit performs ETC application communication with RSE and HMI control, such as charge notification

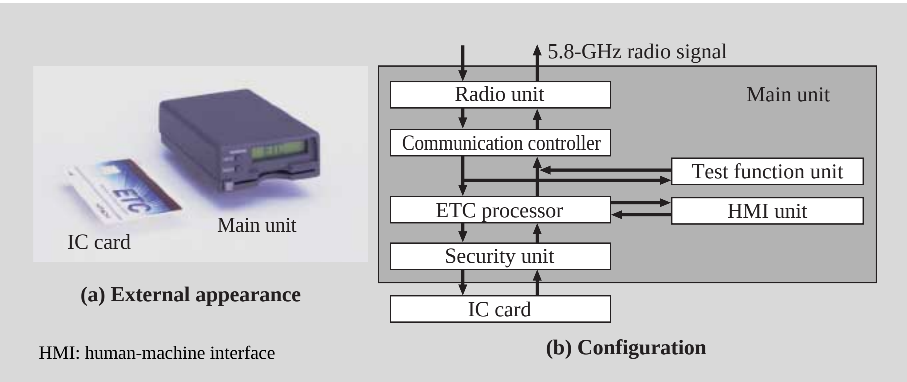

Fig. 3—External Appearance and Configuration of the ETC OBE. The ETC OBE consists of a car-mounted main unit and an IC card. Toll collection at the toll station without the vehicle having to stop is accomplished by means of wireless communication.

output to a liquid crystal display, etc.

(4) Security unit

This component performs OBE authentication by means of two-way communication with RSE using a specified authentication method.

(5) Test function unit

This component performs connection testing according to inter-connectivity technology standards for the purpose of guaranteeing the inter-connectivity of the wireless communication functions.

The functions described above are used by the ETC OBE to implement cashless toll collection by means of radio communication with RSE without stopping the vehicle.

VOICE RECOGNITION

Considering that more and more diverse automobile-oriented services will be offered, the question of how to implement a human-machine interface that is safe and easy to use in the limited space inside an automobile while driving is an important issue. Voice recognition technology holds promise as an in-vehicle HMI technology for that purpose. In the following sections, we describe the expectations for voice recognition technology, voice recognition principles, and the special features of speech recognition middleware products for microprocessors.

Expectations for Voice Recognition

Voice recognition is an essential support technology for the human interface, which serves as interfaces between human and machine. For the interior of a vehicle, in particular, there are high expectations for voice recognition from the viewpoints of operability and safety. The understanding of naturally spoken words is the ultimate goal of voice recognition research. The current practical state of the art, however, is recognition of a limited set of words.

Voice Recognition Principle

The block diagram of the basic processing for voice recognition is shown in Fig. 4.

(1) Voice input unit

The component performs the processing for converting the input analog speech signal to a digital signal.

(2) Speech analyzer

This component performs the processing for analyzing the speech waveform to convert the input to parameters that represent the speech features. The speech analysis is basically a matter of obtaining speech spectrum information. In short intervals of from 10 to 20 ms (frames), the speech waveform is analyzed and a series of speech parameters that represent the speech spectrum is obtained.

(3) Speech detector

This component detects speech segments in the input speech. Advanced technology is required for accurate speech segment detection in the presence of motor noise.

(4) Comparison unit (probability calculation)

This component compares the input speech with word models by calculating the degree of similarity of the two expressed as a probability. That comparison is based on a lexicon of word models that have been constructed as linked phonemes on the basis of an acoustic model (HMMs: Hidden Markov Models) in which the features of the basic sound units of speech, such as phonemes and syllables, are stored in advance.

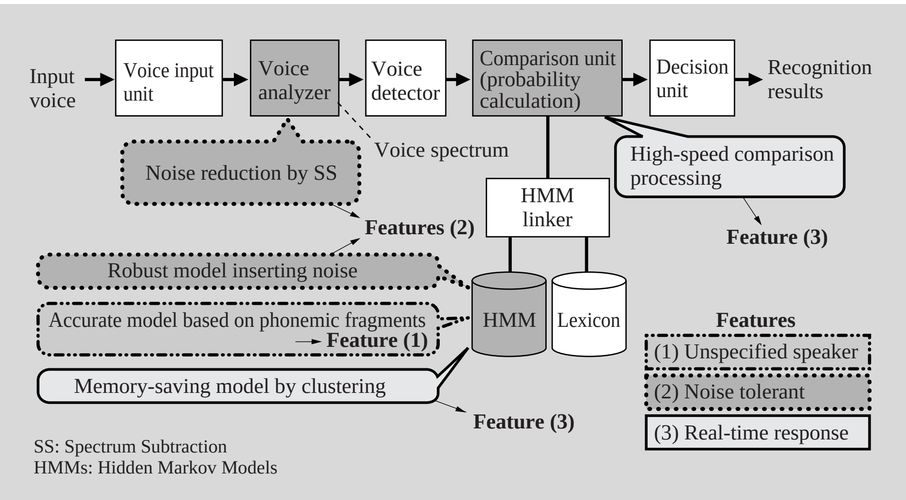

Fig. 4—Basic Configuration and Features of Speech Recognition Function.
Voice spectrum information is obtained from the input analog speech signal, the degree of similarity to words in the lexicon is determined by using a standard acoustic model (HMMs) and dictionary, and the content of the spoken words is decided.

(5) Decision unit

This component makes the final decision on the spoken content of the input speech and outputs the voice recognition.

Speech Recognition Middleware for Microprocessors[4)]

The special features of the Hitachi, Ltd. speech recognition middleware for microprocessors are shown in Fig. 4. Those features are (1) recognition of the speech of an unspecified speaker (speaker-independent recognition), (2) robustness even in the noisy environment of a moving automobile, and (3) comfortable real-time response. In particular, as a noise tolerance technology we have developed the SS (Spectrum Subtraction) method, in which estimated noise is eliminated from the spectrum. In this method, the ambient noise characteristics are estimated from spectral data immediately the speech command is input, and the estimated noise is then subtracted from the spectral data of the speech commands.

CONCLUSIONS

Among the technologies related to the ITS car information system, for which diverse information services for automobiles are expected to be developed in future, we have described the basic configuration and a car computer, the ETC OBE, which is expected to come into actual practical use in 2000, and voice recognition technology, which hold promise as a human-machine interface in the limited operating environment of a vehicle interior.

In future work, we intend to proceed with the development of devices that are even more useful and highly reliable for the field of information services for automobiles, which are expected to continue to advance.

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