Car Navigation System with Enhanced Connecting Function

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In November 2013, FUJITSU TEN released three models of Z Series as new products of ECLIPSE car navigation systems, and they were the first commercially available models with Wi-Fi communication. They offer the following services: a voice interactive destination search service, push-type agent application software through which information on the surrounding facilities is given to the driver in speech form, and a new service that allows the driver to remotely operate a car navigation system from an electronic user manual application on a smartphone. In conjunction with the My Cloud service provided by Fujitsu, these products also come with application software that lets users retrieve and enjoy pictures and music saved on their home PC via the Internet. In November 2014, three further models were released as the SZ Series, and they came with a feature to automatically update the map data and facility information installed on the system. This paper gives an overview of these services and their features, and describes the future challenges in their development.

1. Introduction

Since the successful commercialization of a connected car audio system in June 2003, FUJITSU TEN has been launching network connected on-board equipment mainly in its ECLIPSE series of car navigation systems (hereafter CNS).

The recent smartphone market has been led by two major players: iPhone (running iOS) and Android-compatible devices (running Android OS), and FUJITSU TEN took the first move by adapting to the iPhone system. However, an adaptation to the Android system also became urgent. Given this situation, we chose Wi-Fi as a connecting medium between on-board systems and smartphones, aiming to realize connectivity compatible both with iPhone and Android devices, and also aiming to minimize the dependency on mobile device models so that more users can enjoy the benefit of our services. The ECLIPSE Z Series, which was launched in Japan in November 2013, offered connectivity to smartphones equipped with a conversational speech recognition agent CarafL, electronic user manuals that can also control on-board systems (Dokodemo[note)] Support), and other dedicated applications, via a Wi-Fi connection. This series has also adopted the MirrorLink, which makes the CNS display panel show the smartphone content, providing users with an alternative interface. Through this media, users can access My Cloud, Fujitsu's cloud service, using the dedicated application Drive Studio, and play music files or view pictures directly from their computers at home via the Internet. The SZ Series launched in November 2014 is equipped with a wireless communication unit that keeps CNS and service center connected at all times, offering out-of-the-box, easy-to-use navigation functionality based on the latest maps and facility information.

This paper describes the development and outlines of each of these four services (CarafL, Dokodemo Support, Drive Studio, and automatic map update), together with the future challenges in their development.

2. Conversational speech recognition agent

On-board user interfaces (UIs) must conform to a safety design to limit driver's operation of the system while travelling. For this reason, many functions are available only when the vehicle is stationary. At the beginning of the 1990s, some CNSs incorporated

note) Dokodemo means everywhere in Japanese.

speech recognition functionality for controlling the on-board system to increase the availability of such functions. However, the forerunners of speech recognition features could only respond to certain, specific commands or sound sets, and the recognition accuracy was poor, leaving much room for improvement in practical applications.

Apple Inc. started a voice recognition service called Siri in October 2011, which heralded a global trend for voice-recognition-enabled in-vehicle functions owing to its highly accurate speech recognition, coupled with a rich vocabulary base to capture even conversational speech forms correctly. Soon, Google Inc. and others followed suit, starting to offer their own voice recognition services for mobile devices. Concurrently, manufacturers of in-vehicle devices worked to enhance smartphone compatibility, fast adapting the voice recognition technology thus developed for mobile devices to their on-board UIs. FUJITSU TEN was no exception, and as part of mobile connectivity—one of the company's fortes—we started development in preparation for the launch of a Japanese model with a device application for conversational voice recognition agent in early 2013.

2.1 Outline of the services

For this service, we focused on the destination search function, which is one of the features of CNS that are the most suitable cases for adopting voice recognition. Users only need to speak their desired destination in a way as they would in a normal conversation. Then, the system will pick up the voice, understand the user's intention, search for the destination location, generate response sentences, and speech-synthesize the query results. Taking into account the already existing mobile services and trends in our rivals' developments, at FUJITSU TEN we pursued the following to differentiate our services:

- The entire process from destination search to setting the destination into the navigation system can be operated by speech.
- Speech-based query filtering.
- Push-style comments in speech.
- Enhancement of dedicated on-board content.
- Entertainment elements by employing an animated character on the UI.

2.2 System configuration

Figure 1 depicts the system configuration. The service is delivered by dividing processes among the smartphone, on-board system and the service center. The UI designs, including the character and menu rendering, are executed in the smartphone. The on-board system transmits the voice data from a microphone to the smartphone, plays the talk-back voice data returned from the smartphone, and executes the navigation to the destination. The rest of the speech recognition function is undertaken by the installed

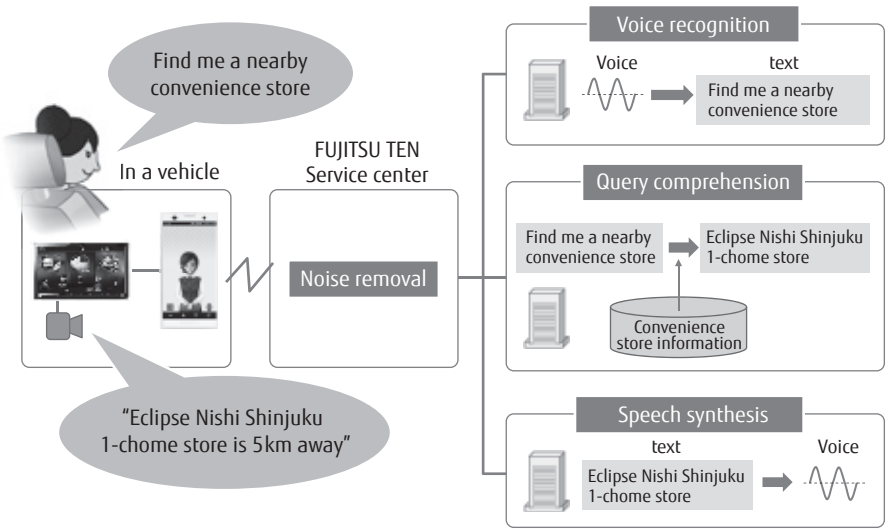

Figure 1
System configuration of the conversational speech agent.

application (app) for the processing on the center side.

1) The app on smartphone

The app on the smartphone analyzes the speech data streamed from the on-board system via the Wi-Fi connection, and automatically determines the end of the speech. Subsequently, the extracted speech data are sent to the service center, whereby the data are divided into small packets to improve the overall processing performance.

The UI design (**Figure 2**) employs a human-like character, which reproduces realistic motion according to the talk-back content, by means of a 3D motion engine. We opted to have a human-like character so that users would feel more relaxed about speaking to the system. Other ideas to appeal to a more diverse range of users include having different wardrobe items for the character, which are made available to users according to the season or the frequency of their use, and some entertainment factors such as special UI designs for destination locations, obtainable only when the user visits the location (prefecture).

2) Noise reduction

The speech data captured via the app on the smartphone is transmitted to the dedicated server for FUJITSU TEN and undergoes a process to reduce typical in-vehicle noises. There are noises emanating from the engine, road surface, air conditioner blowers and other factors, constituting a major hindrance to voice recognition. We have therefore developed a unique noise reduction algorithm that works in an environment where there is low signal-to-noise ratio or one with non-stationary noises. We applied the algorithm to an app installed at FUJITSU TEN's dedicated center, and repeated tests in an actual in-travel environment to improve the performance. As a result, we have achieved an average improvement of 20 dB in the signal-to-noise ratio, and demonstrated the effects of reducing non-stationary noises such as wind noise.

3) Voice recognition

Voice recognition is the key technology for realizing a conversational speech recognition agent. The voice recognition engines mounted on existing CNSs had all components built in, including a recognition dictionary. Therefore, they were not able to adapt to the latest terms such as names of new shops and brand names, or to specific new phrases. Since the cloud-based voice recognition was successfully put to practical use, voice recognition has been relieved of the constraints of library capacity and version maintenance, opening up a possibility to develop apps without the conventional restrictions. We have adopted the cloud service provided by Nuance Communications, Inc. (Dragon Drive) for this speech recognition feature.

Human-like character Search results on display Wardrobe options

Note) There is no English version of this app. As a reference, the Japanese version is shown here.

Figure 2
Smartphone screen display of the conversational speech agent.

4) Query comprehension, inference and search

The speech recognition process yields the user's speech in letters and passes it on to the query comprehension process that follows. The query comprehension analyzes the users' speech to infer their request, and proceeds to appropriate responses. For example, a speech segment "I'm hungry" will be construed as "I want to go somewhere to eat, so find a restaurant nearby and take me there." Then the system proceeds to locate the current absolute position from the geographical coordinates which the on-board system provided at the same time it sent out the request, and executes a category search for "restaurant" through the facility database.

In a conventional way, a user would open the destination search from the system menu, select the category "restaurants" and execute a nearby facility search to find the nearest spot to the current location. All these procedures can be completed automatically, simply by the user's utterance of the phrase "I'm hungry," as the query comprehension engine understands the meaning and executes the rest of the process on the user's behalf. Furthermore, a context-based comprehension is also possible. For example, suppose a user

says "find me an Italian restaurant in the Shibuya area," and sees the search results. Then he says, "on second thought, give me a French." The system takes the initial speech into account and understands the second spoken section as meaning "I want to go to a French restaurant in the Shibuya area." If the user continues and says "Ebisu not Shibuya," the engine interprets it as meaning "I want to go to a French restaurant in the Ebisu area." In this way, the query comprehension engine seeks to understand the user's query in an overall context of the "conversation" rather than each, distinctive utterance, and provides the information relevant to the user's request as closely as possible even from an ambiguous piece of speech.

The query comprehension engine cannot respond to a user request without having appropriate category databases corresponding to the query category. Knowing that speech recognition is most frequently used for a destination search in this case of CNS, we can specify the query category database to be the Point of Interest (POI) DB. Therefore, FUJITSU TEN focuses on the POI deployment (e.g., real-time parking information, convenience stores with a toilet), as it is most likely to be needed during a car journey, and differentiates its products on this point. We adopted the cloud service provided by iNAGO Inc. for the query comprehension feature.

5) Speech synthesis

The results from the query comprehension, inference and search must be fed back to the user, and to do this the information is converted into letters and passed on to the speech synthesis. This engine converts the string data into voice sound data. This is also a crucial element in that, however accurate the voice recognition processes are in the initial, comprehension phase, a flat robotic voice or speech with an awkward accent would seriously spoil the ultimate user satisfaction.

In voice recognition for the Japanese language, performance of a speech synthesis engine is evaluated in terms of accurate vocal reproduction of sentences that have a combination of kanji and kana phrases (accuracy level). However, the accuracy level deteriorates unless the "latest terms" that keep being generated on a daily basis are added to the database. In particular, it is often difficult to decipher the sounds of brand names included in facility information. Therefore, there is a need to develop an operational maintenance system to regularly update the database with the latest content. We adopted the cloud service by Animo Limited for the speech synthesis feature.

As of May 2015, many on-board system manufacturers around the world are launching their voice-engine agent services. At FUJITSU TEN, we have been exceeding our competitors in that our services are based on conversational speech recognition, and offer unique entertainment value through a human-like UI character. We will enhance these differentiating aspects further in the future, and keep developing the services to always be a step ahead of the rivals.

3. Electronic user manual app with on-board system control function

FUJITSU TEN has been working to convert manuals packaged with its CNS products into an electronic form. The AVN Z Series launched in November 2013 was equipped with a new electronic user manual with a function to directly control the interface of on-board system.

The most frequently asked customer inquiries made to FUJITSU TEN's call center are about how to use the purchased products and about their functions. The functions that are embedded deeply in the function tree cannot be easily located, and therefore customers are more likely to inquire about them. To address this problem, we provide a user manual app to be installed on smartphones, and it helps customers to find what they want to know not only by the function names, but also by query keywords. We added to this app a function to automatically switch the screen on the navigation device via the Wi-Fi connection. This enables even a novice user with little understanding of the device operation to easily find the content they are looking for (**Figure 3**).

Installing this function on an on-board system requires a special interface that makes it possible to externally control state transition. Fortunately, FUJITSU TEN's on-board systems are equipped with a dedicated interface for automated external control of state transition, provided for the purpose of in-line testing. We managed to economize on the software development cost by adapting this mechanism to the developed function, instead of freezing it up before shipping. The software simulates the events taking place on the on-board system as if the device is operated through

its touch panel. The screen displays the content as it would appear if the user followed given procedures, thereby creating a secondary effect of operational instructions for users who are not familiar with the on-board system operation.

As on-board systems become equipped with more and more connectivity features, the utility will be enhanced, but at a cost of making the device operation more complicated. In order to make the connected functions user-friendly to all, including those who are new to the system, we will continue our diligent efforts to develop user-friendly UIs and functions for operational assistance.

4. Fujitsu My Cloud connectivity service

The MirrorLink is the standards for connectivity between smartphones and on-board systems, allowing users to transfer the smartphone display onto the on-vehicle display panel and operate the smartphone contents through the vehicle's touch-panel. The standards are endorsed by the Car Connectivity Consortium (CCC) and FUJITSU TEN is part of the initiative.

We thus installed MirrorLink on Fujitsu's ARROWS smartphones and FUJITSU TEN's ECLIPSE CNS, and developed a system that allowed drivers to access Fujitsu's cloud service, My Cloud, and other apps even while driving (**Figure 4**).

The on-board system and smartphone are connected via a USB interface, and communicate using the MirrorLink 1.0 standards. While a server function is installed on the smartphone, on-board systems are equipped with the MirrorLink client function, and we have also developed a dedicated application launcher for MirrorLink, Drive Port (**Figure 5**), to automatically start up the apps when the devices are connected. Since the Drive Port presupposes the utilization in a car, FUJITSU TEN undertook the development, and Fujitsu

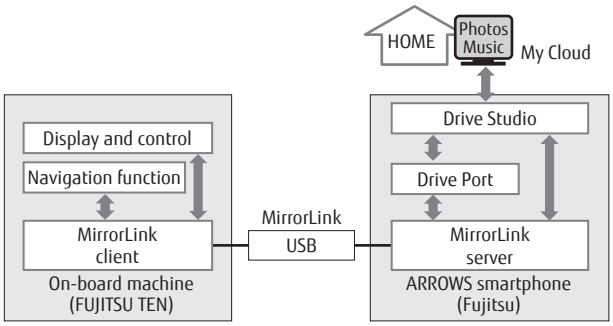

Figure 4
System configuration of My Cloud connectivity service.

Electronic user manual display Function to control on-board machine

Note) There is no English version of this app. As a reference, the Japanese version is shown here.

Figure 3
Smartphone screen display of the electronic user manual.

worked to have it introduced in ARROWS.

1) Drive Port

Drive Port is a program dedicated for MirrorLink-enabled devices—respective models of ARROWS and ECLIPSE—to automatically launch the program when these devices are connected in MirrorLink mode. The initial menu has three options: Photo, Music, and New Apps. The Photo and Music options will initiate the client application Drive Studio, a dedicated program for My Cloud service by Fujitsu, to access files on the server. The New Apps option provides news updates on new applications for MirrorLink offered by Fujitsu or FUJITSU TEN, and guides users to download sites. FUJITSU TEN manages the app release information on its exclusive website. When a connection is established, the system references the information about apps already installed in the smartphone, and sends out notification if there is an app that is not yet installed.

2) Drive Studio

Drive Studio allows users to access photo viewer and music player functions provided on the initial menu of Drive Port. The app prioritizes the data stored in the smartphone for reference, both photos and music files; the data is then relayed to the on-board system via the MirrorLink for displaying onto the device's display panel and playing the sound through the car's stereo speakers (**Figure 6**). Drive Studio also serves as a My Cloud client program, allowing the user with My Cloud user ID to access data (photos and music) saved on their PCs at home, and play them on the on-board system.

For this development, members of Fujitsu and FUJITSU TEN were involved in the process from the app planning phase, which enabled them to realize the service that differentiated itself through leveraging the best of both companies. We will continue making our contributions to the planning and development of new products and services that build on what we have achieved this time.

5. Automatic map update

Customers often give us feedback on pre-installed maps and facility information, saying that maps and facility information that they are not up to date, so they "had to take a longer route," and "map update is complicated," or expensive. The SZ Series launched in November 2014 is equipped with a connectivity unit, and it has been made possible to always get the latest map every month for navigation without having to undergo complex updating procedures. The connectivity unit on the CNS compares the built-in map and the latest map stored on the service center once a month, and it automatically downloads the information on new roads (difference update). The downloaded data will be written into the map SD card of the on-board system automatically when the vehicle's accessory power is turned off, completing the update procedures. The scope of the map to be updated includes information on all roads in Japan (expressways, national roads, prefectural roads and others).

6. Conclusion

We envisage that future on-board systems will be further differentiated by connectivity as navigation functions are more commodified. In particular, there

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Figure 5
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Figure 6
Drive Studio.

will be fierce competition in the areas of connectivity to ever-evolving smartphones, and inclusion of cloud-based services, where all companies are trying their hardest to differentiate their products and services. In this climate, Fujitsu Group is the only player that is able to mobilize its concerted strength to pursue global promotion of a cloud-enabled on-board system, with its expertise and own products in all three areas of home appliances, mobile devices and vehicle equipment. We will continue our proactive pursuit for products and services that seamlessly enhance our customers' in-vehicle experiences, in concerted efforts of our group companies.

Teru Sawada
FUJITSU TEN LIMITED
Mr. Sawada currently engages in the planning of on-board products and services.