Technology Reports

Coming Era of Changing Mobile Terminal Functions — Interchangeable Sensor Jackets —

As smartphones become even more popular, diversifying usages are bringing more and more demands for customization. To meet these demands, we have developed an "interchangeable sensor jacket" as a system that enables quick customization of sensor hardware including smartphone sensor functions. This article describes basic concept and structure, and three types of prototyped interchangeable sensor jacket functions, and discusses the outlook for this technology.

Communication Device Development Department
Masanori Ishida
Koki Hayashi
Kunio Yoshikawa

1. Introduction

As the popularity of smartphones has increased in recent years, it has become much easier for users to add functions to and customize their smartphones once they have purchased a device, by downloading and installing applications. However, these modifications are nearly always achieved via software. If users would like to add functions, such as sensors that are dependent on peripherally connected hardware devices, they need to use USB, Bluetooth®*1, Wi-Fi®*2 and so forth.

There is a wide range of hardwired and wireless peripheral devices available on the market including headsets, keyboards, scales and barcode readers, however, all of these devices require connection via cable or initial wireless settings to be made before they can be used, but at the same time, custom jackets (protective covers) that are mounted on the rear of mobile terminals*3, mainly smartphones, are commonly used to protect the device and customize the way it looks. Taking advantage of this, we have developed a system whereby users can quickly and easily customize hardware functions by interchanging custom jackets, into which we have included a range of hardware sensors that communicate with the device via FeliCa®*4.

This article describes the interchangeable sensor jacket we have developed and its future prospects.

2. Linking Mobile Terminals with Variety of Sensors

2.1 Advantages of Linking Sensors with Mobile Terminals

There are mainly two classes of data that can be obtained by miniaturized sensors designed for consumer uses:

- Physiological data

  E.g., Heart rate, pulse, electrocardiograms, body temperature, body fat ratios, weight and blood pressure etc.
- Environmental data

  E.g., UV levels, air temperature,

*1 **Bluetooth®**: A registered trademark of Bluetooth SIG, Inc. in the United States.
*2 **Wi-Fi®**: A registered trademark of the Wi-Fi Alliance.

humidity, air pressure and radiation levels etc.

By conveniently linking sensors designed to collect these different types of data with a mobile terminal, new usages are enabled that were previously difficult to achieve. For example, large mobile terminal screens can be used to graph the results of physiological measurements, thus putting them in a format that is easy to understand, or by making use of position data such as GPS, environmental measurement results can be displayed on a map. Furthermore, these results can be shared among multiple users across the network, or sent to a server to be used by medical institutions for diagnosis and so forth.

2.2 Mobile Terminal Connection System

Figure 1 shows the connections required for using hardware functions such as sensors with a mobile terminal.

Conventionally, the following two main systems have been used for connecting hardware to mobile terminal:

(1) USB/Bluetooth/Wi-Fi connections

Advantages: Can be used with devices that are relatively large.

Disadvantages: USB devices require plugging in and unplugging of cables, and Bluetooth and Wi-Fi devices often require authentication or initial encryption settings etc, and there are many peripheral devices which require batteries.

(2) Functions built into the mobile terminal

Advantages: Built-in functions are convenient because they require no connections.

Disadvantages: Built-in functions can result in increased mobile terminal size and higher device cost.

Positioned between the two above considerations, the interchangeable sensor jacket offers a compact solution that addresses the issues of adding sensor functions that are difficult to build into the mobile terminal itself as standard items.

In particular, since there has been great diversification of user needs in recent years, it isn't possible to include a range of built-in sensors large enough to meet these various demands, however, the interchangeable sensor jacket offers flexibility by enabling users to select the functions that they require, and thus can respond to this widening range of needs.

Some types of sensors may be embedded in some mobile terminals as standard, but as different phone models are marketed and spread throughout society, there would exist a mixture of phones with certain built-in sensors and ones without. Therefore, in the course of these advancing technical innovations, this system can offer options to users who own mobile terminals that are not equipped with certain sensor functions.

3. System Structure

The basic structure of the system is shown in **Figure 2**.

3.1 Connection Method

The sensor jacket exchanges data with the mobile terminal via FeliCa.

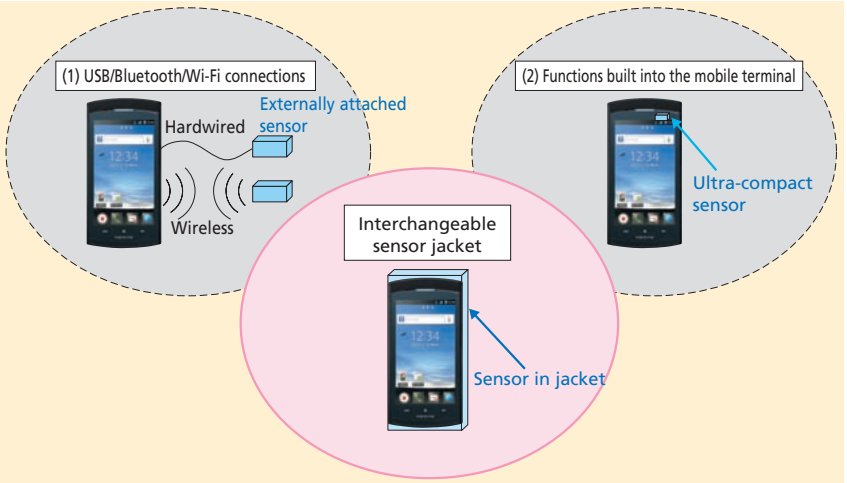


Figure 1 Sensor and mobile terminal connection system

*3 **Mobile terminal**: As the prototype, we used an Android™ smartphone, however in principle, since this system should be achievable with devices other than smartphones, we have used the general term "mobile terminal" in this article. Android™ is a trademark and registered trademark of Google, Inc. in the United States.

*4 **FeliCa®**: A contactless IC card technology developed by Sony Corp. A registered trademark of Sony Corp.

As with other hard-wired connection methods (USB etc.), supplying power from the mobile terminal to the sensor jacket would involve plugging in and unplugging a cable. Furthermore as mentioned, wireless candidates like Bluetooth or Wi-Fi require initial settings to be made in order to open the connection, which is a hurdle for inexperienced users to overcome.

Because the FeliCa chip we have adopted for this development requires no prior initial settings, the system can be used by simply fitting the sensor jacket onto the mobile terminal. Apart from FeliCa, it is also possible to use other types of contactless communications standards (NFC Type A/B[*5] etc.).

3.2 Sensor Jacket Structure

The sensor jacket includes a FeliCa antenna to receive electricity and communicate data, a FeliCa control module, the sensor element and a control microcomputer.

Because FeliCa can supply power to a peripheral device by electromagnetic induction, depending on power requirements, the sensor jacket may or may not need a battery (e.g. lithium ion, button type).

3.3 Mobile Terminal Structure

As mentioned, the mobile terminal which uses FeliCa or NFC Type A/B that conform to contactless communication standards is needed.

Apart from those, there are no other mobile terminal hardware modifications required, and control commands and data exchange with the sensor jacket can be achieved by simply installing an application.

3.4 Communications Sequence

Figure 3 shows an example of the communications sequence used.

The supporting application is started on the mobile terminal with the sensor jacket in place (Fig. 3 (1)). When the user presses the "Measure" button on the application (Fig. 3 (2)), a start measurement command is sent to the microcomputer in the jacket via the FeliCa (Fig. 3 (3)). The microcomputer drives the sensor as it takes measurements, the results of which are sent back to the application on the mobile terminal via the FeliCa (Fig. 3 (4)). Results data is then displayed and saved by the application on the mobile terminal (Fig. 3 (5)).

4. Prototype Sensor Jacket Overview

To achieve working examples of this system, we created three prototype sensor jackets fitted with MEDIAS®[*6]

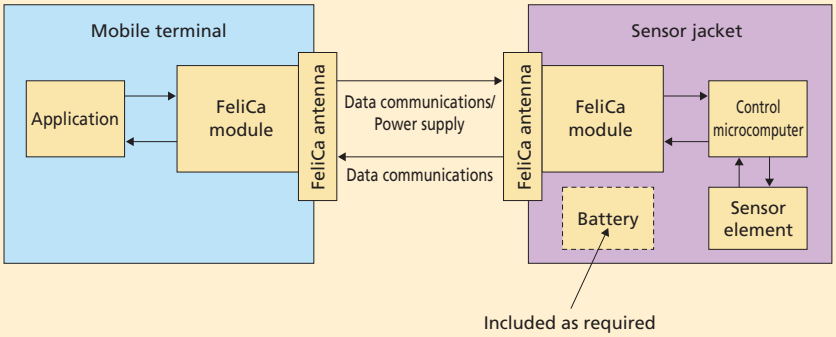


Figure 2 Interchangeable sensor jacket-basic structure

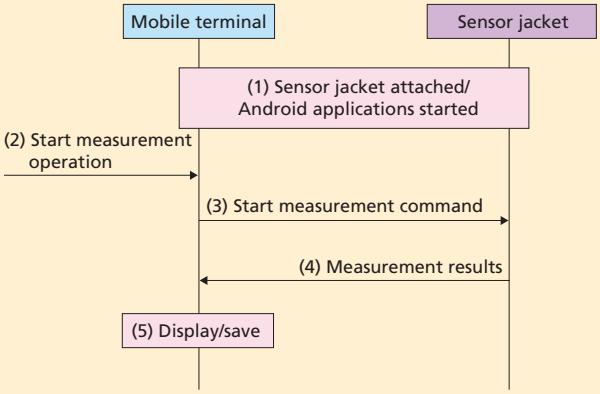


Figure 3 Communications sequence example

*5 **NFC Type A/B**: Contactless communications technologies similar to FeliCa. ISO14443 Type A and Type B are well known internationally.

*6 **MEDIAS®**: A registered trademark of NEC CASIO Mobile Communications Ltd.

WP (N-06C).

Different specialist sensor vendors provided us with technical help regarding the sensor elements and related measurement algorithms.

4.1 Sensor Jacket for Females

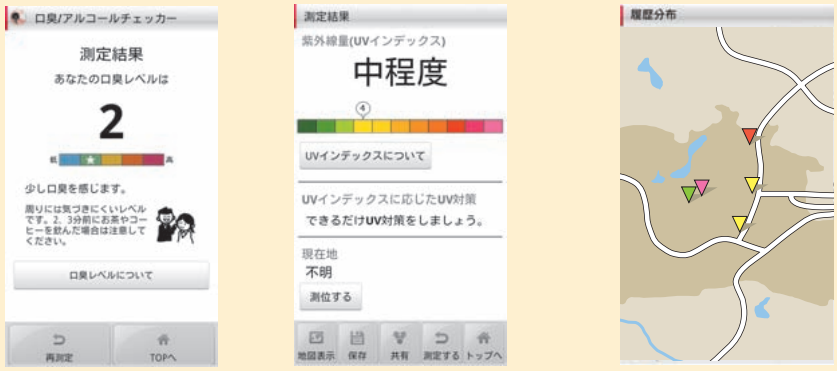
Figure 4 shows the external appearance of the sensor jacket for females, while **Figure 5** shows an example of measurement results display.

As well as sensors that detect odors in expired breath or alcohol level, we also included a UV sensor that measures ultraviolet levels, as this is a particular concern among females when they are outside.

For the breath odor and alcohol level data, we included a five-step scale that displays the level of breath odor or alcohol from data collected by a semiconductor gas sensor in the jacket.

For the ultraviolet light levels, we included an 11-step display to indicate the UV level detected by the sensor, based on the UV index defined by World Health Organization (WHO)[*7]. The sensor jacket also can display measurement results history on a map for areas for which position data has been acquired.

Figure 4 External appearance of the sensor jacket for females



Example of breath odor measurement results

Example of UV measurement results

Example of UV measurement history displayed on a map

*This is provided only in Japanese at present.

Figure 5 Examples of measurement results from the sensor jacket for females

Figure 6 Health management sensor jacket-external appearance

4.2 Health Management Sensor Jacket

Figure 6 shows the external appearance of the health management sensor jacket, while **Figure 7** shows an

*7 **WHO**: The World Health Organization.

example of measurement results display.

After entering the user's gender, age, height, weight and waist size, the user grips the four electrodes on the side of the sensor jacket with the thumb and forefinger of both hands to enable body fat and muscle ratio measurement.

Also, measurement results can be managed for individual users, and past measurements displayed as a table or graph for easy understanding.

4.3 Disaster Response Sensor Jacket

Figure 8 shows the external appearance of the disaster response sensor jacket, while **Figure 9** shows an example of measurement results display.

This sensor jacket is fitted with a semiconductor gamma radiation sensor to measure the dose equivalent rate[*8] (μSv/h) in real time.

As well as displaying measurement results history on a map for areas for which position data has been acquired, the device sounds an alarm if a threshold value preset by the user is exceeded, and has a function that displays a warning etc. prompting the user to contact the relevant authorities and so forth.

4.4 Usage Examples

Because this system enables individual users to select the sensor jacket that they require, one user can own a number of sensor jackets, and attach

Example of body fat/ muscle ratio measurement results

Example of fat/muscle ratio measurement history (graph)

*This is provided only in Japanese at present.

Figure 7 Measurement results from the health management sensor jacket

Figure 8 External appearance of the disaster response sensor jacket

Example of radiation measurement results

Example of radiation measurement history display

*This is provided only in Japanese at present.

Figure 9 Example of Measurement results from the disaster response sensor jacket

*8 **Dose equivalent rate**: A value that indicates the amount of bodily exposure to radiation over a certain period of time. This is also called the radiation level.

them to suit different circumstances. For example, the sensor jacket for females can be attached to measure the ultraviolet level at a destination, the disaster response sensor jacket can be attached when going to play in the park with children to measure the radiation level, and the health management sensor jacket can be attached after exercising to measure body fat and muscle ratio, and since they can be quickly interchanged, they enable mobile terminals to be easily equipped with sensors that are not already built-in.

5. Conclusion

This article has described an interchangeable sensor jacket system that enables users to utilize a variety of hardware such as sensors.

By adopting FeliCa for data exchange between the mobile terminal and the sensor jacket, we have eliminated the need for initial settings to enable communications, and depending on the type of sensor installed, battery installation in the sensor jacket can also be omitted.

Furthermore, by simplifying the linkage between sensors and the mobile terminal, we believe that the range of usages of sensors can be expanded, and new markets established not only for mobile communications businesses, but for terminal manufacturers and sensor vendors as well.