Approaches to Creating Human-Centric Solutions

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Fujitsu Laboratories is developing several new solutions to social problems that help enhance information and communications technology (ICT) capability using mobile terminals, to establish a Human-Centric Society. Each solution consists of the following three steps: 1) sensing to acquire real-world information, 2) analyzing that information, 3) actuating people or circumstances at a proper timing and according to the situation. These three solution steps seem to be applicable for other solutions. Also each solution is targeting new areas where ICT has yet to reach for several reasons. In this paper, we describe the research and development status of the above three steps for solutions in three areas: energy management in office buildings, agriculture, and healthcare. The solutions are still being developed.

1. Introduction

Fujitsu Laboratories is working to realize a Human-Centric Society, in which information goes back and forth between the real world and virtual world built on a cloud. Also in a Human-Centric Society, services appropriate for the circumstances or environment of users are offered at a proper timing. At present, we are developing several solutions as a preliminary step to identifying technology development requirements and using the developed technology as test fields.

The realization of human-centric solutions requires three technology elements: sensors to acquire real-world information, engines to process and analyze the acquired data, and actuation (prompting services or people) to provide services to the real world. Of these, we must select and develop sensors and methods of actuation according to the solution. Meanwhile, the data processing and analysis engines mentioned above, which are provided on a cloud, apparently allow users to share solutions to some extent. Hence, they can be seen as an element that constitutes a so-called information platform. For details of this information platform, see another paper in this magazine.[1]

In developing the solutions, we have taken the following points into consideration.

1) They must provide solutions to social problems.
2) They may not necessarily make use of information and communications technology (ICT) at present, but are expected to bring about effects when ICT is introduced with mobile terminals and other devices.

As a result, we have selected business solutions in areas in which people engage with other people, materials or the environment.

Of these, this paper presents the state of development of solutions in the areas of energy management in office buildings, agriculture and healthcare.

2. Energy management in office buildings

The Great East Japan Earthquake that occurred on March 11, 2011 has greatly changed the state of supply and demand of energy (especially electricity) in Japan. There are strong demands to reduce power usage mainly in eastern Japan. Corporate activities are not exempt and companies need to reduce their power usage by at least 15% compared with the previous year.

Under such circumstances, we need to have an understanding of and control over power usage. However, offices are characterized by the large number of points at which electricity is used. This not only makes it difficult to measure the electricity used but also makes the energy-saving efforts of individuals less effective in reducing the total usage.

In view of these problems, Fujitsu Laboratories has developed a smart power strip (**Figure 1**) capable of easily measuring the amount of power used by individuals. We have started offering it as a product available from Fujitsu Component.[2] This smart power strip makes it easy to visualize the amount of power used by an individual. In addition, information obtained from this smart power strip can be compared with a person's schedule, for example. This then enables actuation such as reminding someone that they have forgotten to switch off their PC monitor when they leave their desk to attend a meeting.

As a method of actuation in the initial phase, it is effective to show a person a comparison of their power usage and that of others. In an in-house trial experiment that lasted for a year, a power saving of 15% was achieved in one month after the start of the experiment, and we confirmed that this level was continuously maintained. **Figure 2** shows a sample screen that the users saw in the experiment. They could see multiple indicators (total power usage, amount of reduction, rate of reduction, etc.) as options for comparing their power usage with others. This was done by using indicators that were not tied to the absolute values of power consumption of the office devices. This seems to have been effective in helping individuals maintain their motivation to save power. That is, if the total power usage alone is used as an indicator for comparison, desktop PC users are positioned relatively lower than notebook PC users. However, switching to notebook PCs requires time and investment, and this possibly reduces their motivation to save power. However, using indicators such as the rate of power reduction allows the power-saving efforts of individuals to lead to an improvement in the relative position of their ranking. This has apparently helped them maintain their motivation.

In the future, we intend to take into account the state of power usage in relation to air conditioning and lighting to help people visualize the energy consumed in the entire office environment and correlate the behavior of office workers with the energy they consume. In addition, we plan to work on measures to change people's behavior in the office so as to save on the energy used there and make people more comfortable at the same time.

Figure 1
Smart power strip.

3. Agriculture

Japan's food self-sufficiency rate is said to be 40% in terms of calories[3] and it is very important to improve this rate from the perspective of ensuring food security. At the same time, the people who are supporting Japanese agriculture are getting older. This is regarded as an issue from the viewpoint of having people

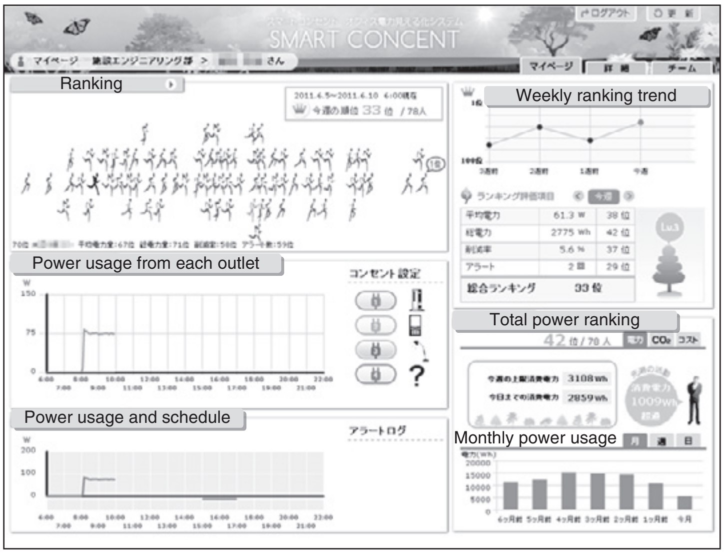

Figure 2
System for monitoring power usage in office.

learn and practice traditional agricultural techniques as well as the deterioration of production capacity. Fujitsu is moving ahead with an approach that improves the efficiency of agriculture by allowing farmers to visualize agricultural management and turn agricultural techniques into explicit knowledge by making use of ICT in agricultural sites.[4] This section describes the development of technologies to support this approach.

1) Visualization of agricultural management

The first step to visualizing agricultural management is to clarify the costs incurred when growing food with reference to the crops harvested. The costs dealt with here can be roughly classified into costs of raw materials including seeds, seedlings, and fertilizers; and the person-hours used on agricultural work. The costs of raw materials are relatively easy to grasp, but records of the person-hours used depend on people's memory and are prone to be roughly calculated. To address this problem, we have devised a system in which the Global Positioning System (GPS) is used to locate agricultural workers and machines and they are then shown on a map (**Figure 3**). In this way, the time spent on the relevant farms (rice and vegetable fields) can be added up and calculated. We have confirmed that the data collected on agricultural sites are usable for calculating the person-hours used. Making agricultural workers carry new GPS devices increases their non-work burden and so the GPS function of their cell phones was used. Meanwhile, we needed to take some measures when we processed the data because locational errors of cell phone GPS output tend to be larger than those of dedicated GPS devices. To deal with groups of vinyl greenhouses with work areas closely spaced, we had to combine greenhouse ingress/egress information to enable us to more accurately detect the locations of workers and machines.[5]

In visualizing agricultural management, as described so far, the present state of research is still limited to sensors to understand the real world and data analysis. In the future, however, we believe that combining such research with other information, such as long-term weather forecasts and market forecasts, will make it possible to give farmers advice to help them improve their management efficiency.

2) Turning agricultural techniques into explicit knowledge

Turning agricultural techniques into explicit

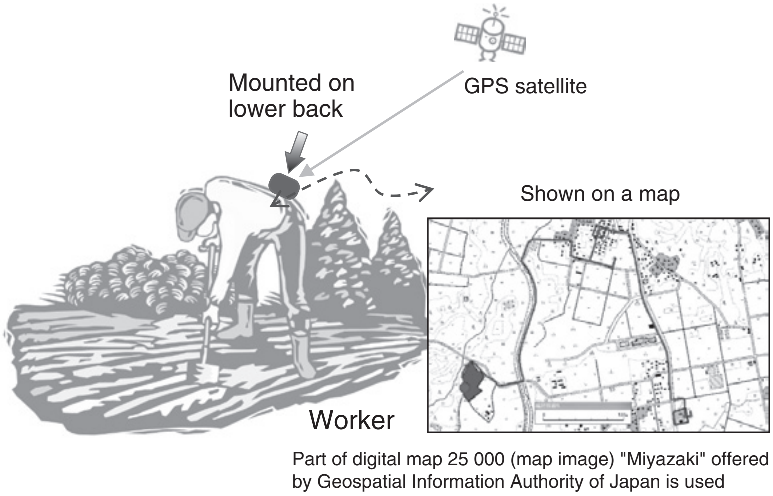

Figure 3
Agricultural fieldwork sensing.

knowledge is done by adding expert knowledge to various data collected during the growth period of crops. Agricultural experimental stations and agricultural cooperatives of prefectures have offered us standard agricultural workflows and we have made good use of them. This research requires environmental data including the weather and temperature during the growth period to be reliably acquired. Hence, we have developed a sensor unit mainly intended for collecting data outdoors (**Figure 4**). By studying the correlation between the groups of data collected and states of growth, we have found that temperature estimates provide a rough estimation of the time of harvest. In addition, farmers can use a specific event during crop growth, such as the earing of rice, as a way to prompt them to check on the state of growth (actuation) a few days later. Furthermore, we are also working on a method to automatically extract knowledge from environmental and work data.[6)]

In the future, we intend to verify the validity and versatility of the extracted knowledge and improve the method of knowledge extraction.

Figure 4
Sensor unit for use in agricultural field.

4. Healthcare

The populations of advanced nations including Japan are aging at an unprecedented rate. In combination with the falling birthrate, this has given rise to a pressing need to revise Japan's social security system. Above all, we recognize that the trend of higher medical expenses is a factor that could jeopardize Japan's universal health insurance system. We urgently need to curb this trend. Meanwhile, the numbers of medical care workers and beds in medical institutions are falling[7)] and medical care and nursing for the elderly in particular requires reconsideration.

In view of the circumstances described above, Fujitsu Laboratories has been united with overseas laboratories in embarking on the development of healthcare solutions. Such solutions are based on the core technologies of remote sensing and aggregation and analysis of data distributed among medical institutions. This paper mentions the state of research and development in Japan, while activities in overseas laboratories are described in detail in another paper in this magazine.[8]

The word healthcare refers to both medical care and wellness and, to see it in terms of solutions, totally different customer segments must be addressed. For the latter, Fujitsu has already started the Karada Life service in Japan and we have decided to discuss this theme as a new research area, moving one step closer to the field of medical care.

The field of medical care has introduced ICT in the form of electronic medical records, and hospitals and clinics have started to distribute data. On the other hand, it has been hard to manage the clinical conditions at home for outpatients who visit hospitals or discharged patients. For that reason, we believe that demand for at-home monitoring systems capable of seamlessly connecting with electronic medical record systems will grow in the near future. For example, if the conditions of a person with a chronic kidney disease (CKD) can be prevented from worsening into those requiring artificial dialysis for one year, the medical care expense can be reduced by 5 million yen according to a trial calculation made in a medical institute. Consequently, at-home monitoring technology is raising high expectations.

An at-home monitoring system functions as follows. The patients carry a sensor to upload the state of their activities and vital data to the cloud. The uploaded data are analyzed on the cloud, and then the system generates advice appropriate for the patients' conditions and sends it to them, prompting them to change their behavior (actuation). This flow is depicted in **Figure 5**. In the future, it will be possible to link the uploaded data or generated advice with electronic medical records for use in medical examinations and treatment. However, this system involves handling personal information and many hurdles have to be cleared including regulations and security. Furthermore, to ensure medical accuracy for data analysis we believe it will be necessary to obtain cooperation from medical specialists so as to make the results more reliable.

At present, we are developing the fundamental portion of the system above and have completed prototyping a sensor that is

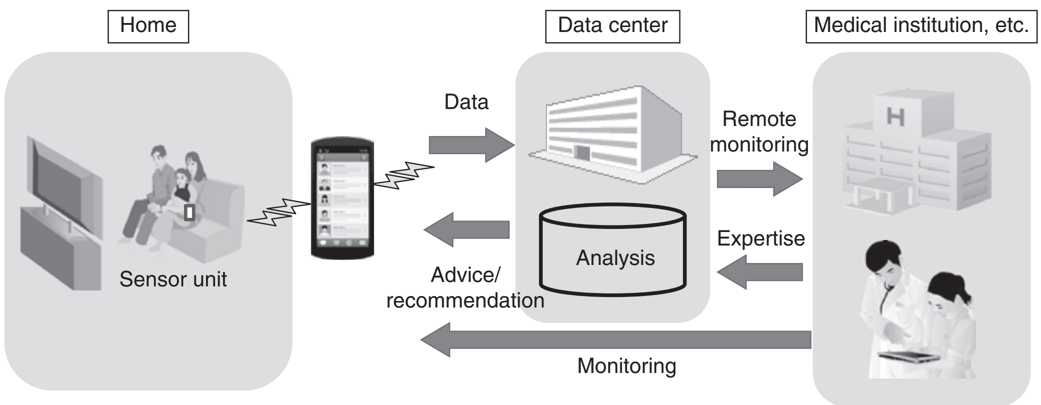

Figure 5
System configuration.

Figure 6
Healthcare sensor.

Table 1
Measurement functions of healthcare sensor.

Measurement object	Measuring frequency, resolution, etc.
Heartbeat	200 Hz to 1 kHz
Body surface temperature and humidity	0.2 Hz, 0.1°C, 0.1%
Electrical skin resistance	0.2 Hz, 1 Ω
Myoelectric potential	200 Hz to 1 kHz
Pulse wave	100 Hz min. (1 ch)
Blood oxygen saturation	100 Hz min. (1 ch)
3-axis accleration	200 Hz min.
3-axis gyro	200 Hz min.
Atmospheric pressure	1 Hz min., 0.03 hPa

carried about by sticking it to the surface of the body (**Figure 6**) and the network portion for uploading the data to the cloud. The functions of this sensor are listed in **Table 1**. We think that the sensor needs to be further reduced in size by limiting the functions according to the specific disease.

5. Conclusion

This paper has taken three fields of energy management in office buildings, agriculture, and healthcare as examples to present the approach to the construction of a Human-Centric Solution. This Human-Centric Solution consists of three technologies: sensors to extract real-world information, engines to analyze and process data on a cloud, and actuation to feed back the analysis results to the real world. We think of these as ambitious activities to solve social problems and cultivate a new market for Fujitsu. We intend to cooperate with the relevant divisions and make the system more complete so that it can be commercialized.

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