Abstract—An increasing number of people are suffering from lifestyle disease in recent years. However, the radical treatment for the disease has not been found, so that the people have to manage their daily meal and exercise for the remedy. We developed the health management support system on the Web. This system manages the collection of user’s daily exercise data and provides appropriate health advices for each user using these data. We used a sensor device and mobile devices to collect the data and the ontology and inference rules to derive the advices. This paper introduces the design and implementation of the system.

Keywords—Health management, sensor device, mobile device, ontology, inference rule

I. INTRODUCTION

Recently, the lifestyle disease is becoming a big problem in many countries. Especially in Japan, the lifestyle disease occupies about 60% in all the cause of death. However, the radical treatment for the disease has not been found. The basic treatment of the disease is to inhibit its symptom by self-management. We can use sensor devices such as a pedometer and a manometer for self-management. But keeping health management by using these items and compiling the measured data are burdensome work for the people. Therefore, not a few people abandon the treatment by the decline in their motivation.

In this paper, we present a health support system that helps people who aim to prevent lifestyle disease or to improve their constitution. This system can reduce the works that are the burden for health management by collecting and compiling user’s exercise data and supporting the filling out exercise diary. Moreover, the system can provide health advices for each user based on his/her data. It can help maintaining the user’s motivation for health.

To collect the exercise data, the user uses sensor devices and a mobile device. The measured data are sent to and stored on the database on the Web. Using these data, the system supports the user’s health management through the Web pages. The users of the system can record the daily exercise data easily and receive the health advices depending on their conditions. For the derivation of health advices, we defined and have used ontology and inference rules.

This paper is structured as follows. Section 2 shows the overview of the health management support system that we developed. System implementation and examples are shown in Section 3. Finally, Section 4 concludes this paper.

II. CONCEPT OF THE HEALTH MANAGEMENT SUPPORT SYSTEM

First of all, we have to understand what the problems in general health management are. This section extracts the issues of health management of nowadays and shows the concept of the system we developed based on the issues.

To continue health management for the prevention of lifestyle disease and/or the improvement of our constitution, we need to have strong will and endeavor to overcome some difficulties for ourselves. For example, we use wearable sensor devices to measure and compile the effect of exercise. However, as most devices that we can purchase at stores can measure particular data, we have to use several sensor devices to collect enough data for our health management. In this case, we have to understand how to use these sensor devices first. This is a barrier to middle-aged or elderly people who do not get used to operating smart and small devices. In addition, we have to preserve the record of the exercise and the meals for health management. But it is a daunting task and is a factor of abandonment of the treatment of lifestyle disease to record these data every day. These are major obstructions to do health management privately. Therefore, it is expected that they can keep up their health management longer and accomplish their goal by reducing these tasks and maintaining their motivation.
Considering the issues previously mentioned, we developed a support system to help the user’s health management. An overview of the system is shown in Figure 1. When a user does certain exercise, the user wears sensor devices to measure diary exercise data. The measured data are sent from the sensor devices to the mobile device by Bluetooth communication, stored and showed on the mobile device in real time. After the measurement, the measured data stored on the mobile device are sent to and stored on the database on the Web. This structure realizes the process from collecting data using sensor devices to uploading the data on the database on the Web by an application program on the mobile device. As a result, it can reduce the user’s work. Moreover, we can use any sensor devices with the wireless communication system that compatible with our application program. Using these uploaded data, users can do their health management on the Web pages. These pages enable the users to record the diary health data, browse the recorded data, learn about health, ask some questions about health, request health advices and so on. The questions and requests are transferred to the inference system. Then the system infers the answer using the user information and provides the answer for the user through the Web pages. Consequently, the user can easily get the information and/or advices depending on the user’s health condition. And the inference system can also presents a concrete plan for losing weight. The user does an exercise and controls meals referring to the plan, records the health data and then checks the achievement on the day on the Web page. When we record the health data, this system inserts the data that can calculate from the measured data into the input form automatically. Therefore, the user can create the daily health record only by filling out the data on blank spaces. By these functions, the users can keep doing health management without the decline of motivation for health.

III. IMPLEMENTATION

This section realizes the support system explained in previous section. The system is divided into two main parts: the part that collects the daily exercise data and the part that supports the user’s health management on the Web using their data.

A. Collection of daily vital data

We developed the application program that operates on the mobile device. It realizes the communication among the relay server on the Web, a mobile device and sensor devices. The application program also enables us to collect exercise data easily and show the data in real time. This application program is developed according to MIDP (Mobile Information Device Profile) that is the specification for Java runtime environment defined for mobile devices. And the required amount of memory to install this application program is just 40kbytes. Thus, this application program operates any mobile devices that are compatible with MIDP and Bluetooth communication.

We used M1000 [1] sold by DoCoMo Inc. in Japan as a mobile device to implement the application program. M1000 is a smart phone with Bluetooth communication function and we can install application program developed by C++ or Java languages. As the device has a touch panel screen, we can operate the device using a stylus pen. The application program we developed is compatible with 2 mobile devices: Bluetooth i-monii (hereinafter referred to as “i-monii”) [2] made by IT Research Co., Ltd. in Japan and Model 4100 Wrist-Worn Patient Module (hereinafter referred to as “Model 4100”) [3] made by Nonin Medical, Inc. in USA. Both devices have Bluetooth communication function.

The basic communication flow among sensor devices, the mobile device and the relay-server is show in Figure 2. When we start the application program, the authentication screen (Figure 3) is displayed first. The application program sends the entered user name and password to sever and receives the user ID and information as a result of authentication. The user ID is needed to send measured data to the relay-server. The user information is needed when the sensor device measures the exercise data or the mobile device shows the measured data. For instance, i-monii uses the age, sex, height and weight of the user to measure the exercise data accurately. On the other hand, in the case of Model 4100, the mobile device uses resting heart rate and maximum heat rate to display the user’s exercise intensity in real time. The mobile device receives user information used in all sensor devices in block at the authentication process. After the authentication, we can check the received data on the screen. As the received data are stored in the record-store installed in the mobile device.
device, we can skip the authentication process afterwards. After that, the application program finds sensor devices and establishes the Bluetooth connection between the mobile device and a sensor device. If the application program finds more than two sensor devices, the user selects one of the devices that the user uses.

The processes that come after the establishment of Bluetooth connection are different in each sensor device. In case of i-mon, the application program configures initial setting for the device and sends a command to i-mon to start measurement. Then every once a second, the application program starts sending a command and receiving the measured data. The received data are displayed on the screen in real time (Figure 4). After the exercise, the user sends a command to i-mon to stop measurement on the application program. Then the application program receives whole measured data from the sensor device and sends them to the database on the Web through the relay-server automatically. The relay-server is constructed from a Web server, Apache, and an application server, Tomcat. The data storing processes to the database are operated by a Servlet stored in the application server. Servlet is a java program module operated on server on the Web and has been applied to the generation of dynamic Web pages with JSP (Java Server Pages) and Java Beans technologies. When the sending process has been succeeded, the stored data at the record-store are deleted. On the other hand, when the sending process has been failed during communication or by server troubles, the data are left on the record-store and are sent to the database together with the data measured next time.

**B. Health management on the Web**

Using the collected data, the users can do their health management through the Web pages. These pages are generated dynamically using Servlet, JSP and Java Beans. The most impressive point in our system is that the system can provide health advices for each user on the Web pages. By preserving exercise diary on the Web pages as a part of health management, the user can receive the advices about his/her lifestyle based on the data. Moreover, the system can also derive the recommended and/or non-recommended exercise for each user based on the ontology, inference rules that we defined and user’s information.

Figure 5 shows the weekly advices and the result of weekly exercise based on the user’s diary. The upper part of this page shows the result of weekly exercise and the lower part shows the advices based on the result. The users can receive the advices about the changes in weight and the amount of energy consumption during the week.

The inference system [4][5], a part of our system, derives some health advices. The internal structure of the inference system is shown in Figure 6. When the user requests health advices, the inference agent gets the data of the user from the database and hands it to the inference engine. Then, the inference engine derives the health advices based on the data of the user, the ontology and the inference rules. Ontology is computer-usable definitions of basic concepts in the domain and the relationship among them. The derived advices are returned to the user through the Web pages.

To describe the ontology, we used RDF (Resource Description Framework) [6], RDF Schema (RDF Vocabulary Description Language) [7] and OWL (Web Ontology Language) [8]. These are the standard languages proposed by W3C (World Wide Web Consortium).

Figure 7 shows an example of the inference. The upper part of the figure shows a part of the ontology that we defined. An oval represents a concept (called a class in OWL) and an arrow represents a relationship (called a property in OWL) between classes. In this ontology, a user is associated with an exercise to accomplish a goal which the user has. We assumed that the goal conformed to the effect of the exercise. We defined the goal and the effect of the exercise are equivalent. The user is also associated with an exercise which the user must not do due to the health condition of the user.

This example assumes that Ms. A wants to lose weigh, and she requests the system to derive what kind of exercise she should do. It means “Ms. A” is an individual of a class, “Person” and “to lose weight” is an individual of a class, “Goal” on the system. We also assume that “aerobics” which has an effect, “losing weight” is an individual of a class, “Exercise”, “losing weight” is an individual of a class, “EffectOfExercise” and “losing weight” is the same as “to lose weight”. These assumptions are rep...
The inference rule follows. the inference system uses the inference rule presented as SWRL [9]. The left side of right side is a consequence. A word with a question mark (e.g. ?p,?g) is a variable. A negation cannot be represented in SWRL. But here we use “¬” as a negation. This rule means the following. If a user has a goal (1), an exercise has its effect (3), the goal and the effect are the same (2), and the user does not have the exercise as a non-recommended exercise (4), then the exercise is recommended for the user (5) and the user gets a health advice (6). In case of this example, the atom hasNon-recommendedExercise(“Ms. A”, “aerobics”) is not satisfied. Therefore, the atom (4) is satisfied (negation as failure). As all the atoms are satisfied, the system derives the consequences that “Ms. A” gets the advice “Aerobics is recommended for Ms. A.”

For the implementation of the inference engine, we utilized some existing tools. We used Protégé [10], an ontology editor which developed at Stanford University, for the description of the ontology. We utilized Jess [11], developed at Sandia National Laboratories in America, as the inference engine of our system. To use the inference rules on Jess, they are written in Jess format.

IV. CONCLUSION

We developed the health management support system for people who aim to prevent lifestyle disease or to improve their constitution. As a part of this system, we developed the application program that operated on the mobile device. The application program enables the users to send the exercise data easily and we can use these data to daily health management on the Web. We also developed the Web pages that enable the users to preserve the exercise data easily and to receive the health advices based on the ontology and inference rules. By utilizing these pages, the users can keep the motivation for health management. As a result, we can expect that the users continue the health management for a long term and improve their constitution.

As a future work, we are going to improve the application program to be compatible with other devices. The application program that is compatible with many more devices can collect various kinds of vital data, so that the inference system can provide wide variety of advices. Another issue in the future is to evaluate the system. We have already improved the system based on the questionnaire results that was conducted by the people who tested the system. The trend of the questionnaire was that almost all the people were interested in the system and wanted to use it. However, we could not get enough replies in questionnaires every time. In order to make the system better, we have to collect much information when the users use.

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