

LifeMinder: A Wearable Healthcare Support System Using User's Context

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Abstract

This paper introduces a prototype of wearable healthcare support system 'LifeMinder', which consists of a wristwatch-shaped wearable sensor module and a personal digital assistant (PDA). The wearable sensor module, equipped with sensors of accelerometer, pulse meter, thermometer, galvanic skin reflex (GSR) electrodes and Bluetooth module to communicate with the PDA, monitors the user's context: health conditions, movements and behaviors. The system uses this information to guide the user in daily self-care in real time. Diet care and exercise care are especially significant to prevent the "lifestyle-related disease". The authors developed algorithms to recognize the user's movement from wrist motion and to detect the beginning of a meal from pulse rates and GSR values. The accuracy of both algorithms is about 90%.

1. Introduction

Medical technology innovation is taking on a new lease of life. On the other hand, the increase in "lifestyle-related disease" (e.g. diabetes, high blood pressure) has become a serious problem in economically advanced countries. "Lifestyle-related disease" is responsible for various illnesses (e.g. myocardial infarction, cerebral apoplexy), and daily healthcare in terms of exercise, meals, sleep, and stress has an important bearing on prevention against it. However, there is no radical care specifically for diabetics, only general care which involves diabetics treating themselves in terms of exercise and diet care. This requires determination and self-discipline on the part of the patient.

Although there are some works which support user's diet care by measuring the user's quantity of exercise through an exclusive apparatus, most of them force users to input meal menus at mealtimes on their own initiative. In these cases, users often forget to input or decide no to input because inputting is complicated. In the case of an installed system, it is difficult to support user's diet care when the user has a meal out (in particular, if the user has an unbalanced diet).

Some works focus on monitoring the user's heartbeat continuously by wearable sensors and giving an alarm when an irregular pulse occurs [1][2]. However, they

concern single-function systems for patients suffering from heart disease. Although some products, which measure the user's physiological data on the wrist, are already on the market [3][4], they only store the measured data, and later the stored data are used for analysis.

The authors have developed a wearable healthcare support system, called *LifeMinder* [5]. This paper introduces a new prototype of *LifeMinder*, which is a handy system composed of a wristwatch-shaped wearable sensor module and a PDA. The system recognizes the user's context: health conditions, movements and behaviors, and uses this information to guide the user in daily self-care. In the following sections, the authors describe how the system works and eases the user's burden regarding daily healthcare.

2. System overview

As shown in Figure 1, this system consists of a wristwatch-shaped wearable sensor module and a PDA. The wearable sensor module measures the user's physiological data and recognizes the user's movements, and communicates with the PDA via a Bluetooth module in order to dispense with complicated wiring between them. The PDA recognizes the user's health condition and behaviors, and provides the user with various services regarding daily healthcare according to the user's context in real

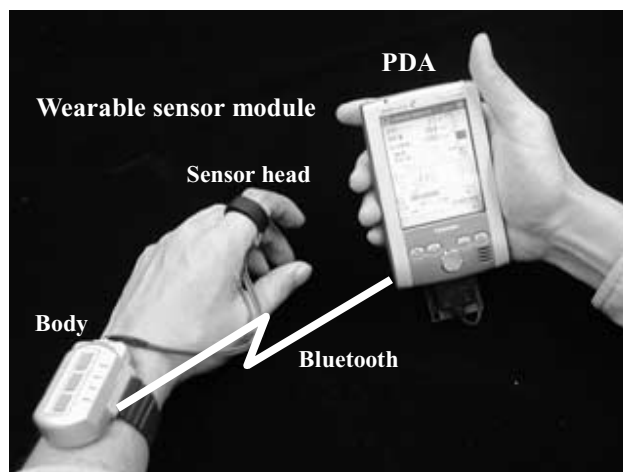


Figure 1. System overview

time.

3. Wearable sensor module

The wearable sensor module consists of a sensor head attached to a finger and a wristwatch-shaped body. The sensor head has three sensors: pulse meter, thermometer, and GSR electrodes. The wristwatch-shaped body consists of an 8-bit RISC microcontroller (PIC16LF877), a two-axis accelerometer, a lithium-ion battery, and a Bluetooth module to communicate with the PDA. The microcontroller acts as a signal processor for digitized sensor data and a system controller for Bluetooth communication. The A/D converter digitizes sensor data every 50msec, and the microcontroller recognizes pulse rate from pulse waves and movements ('Walking', 'Running', 'Working', and 'Quiet') from accelerations on the wrist in real time. When the status is 'Walking' or 'Running', the microcontroller also counts the user's steps. The wearable sensor module sends the recognized data and optional raw sensor data at appropriate intervals for applications. It weighs 70g and consumes 150mW in the worst case.

4. Application on the PDA

The wearable sensor module sends the data to a PDA (TOSHIBA GENIO e550) via a Bluetooth module. The PDA displays the received data graphically, which consists of pulse rate, movement status, number of steps, GSR value and skin temperature. It receives the data per one second in this prototype application and recognizes the user's health conditions and behaviors in real time. It also calculates the consumed calories from the number of steps and basal metabolism. The system uses this information to guide the user in daily self-care.

In some experiments, it was found that the relation between pulse rate and GSR value showed certain characteristic changes, when a user was eating. The authors developed an algorithm for eating recognition, and the system detected the beginning of a meal with about 90% accuracy within a couple of minutes after a user began to eat in an experiment involving 10 subjects.

Figure 2 shows the overview of this application. The PDA provides the user with some advice (e.g. "Input meal menu", "Take medicines" and "Measure a blood sugar level" especially for diabetics), according to the recognized eating event. Moreover, the PDA provides the user with some other advice, such as showing a recommended menu from the viewpoint of calorie balance and persuading the user to take exercise or take a rest from the record of movements and behaviors. In this way, the system eases the user's burden regarding daily healthcare by using the context.

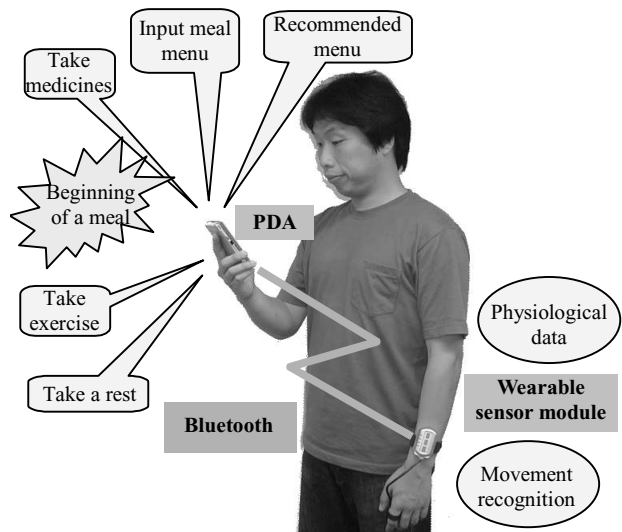


Figure 2. Application overview

5. Summary and future work

In this paper, the authors proposed a wearable healthcare support system, called *LifeMinder*, which is a handy system composed of a wristwatch-shaped wearable sensor module and a PDA. It eased the user's burden regarding daily healthcare by using the recognized user's context: health condition, movements and behaviors. The authors developed algorithms to recognize the user's movement from wrist motion and to detect the beginning of a meal from pulse rates and GSR values. The accuracy of both algorithms is about 90%.

The authors intend to miniaturize and lighten the wearable sensor module in order to improve the user's comfort, and also to analyze the user's contextual and physiological data in various situations of everyday life more minutely.

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