

Jogging Support System with Portable Monitoring Device and Health Manage Software

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Abstract

As an application of an ambulatory biosignal memory device, we have developed a portable jogging monitoring device and studied its application for health management here. This device is a micro processor based system with some sensors necessary to monitor condition of the user during jogging, that is, a heart rate sensor, a GPS sensor and a physical activity sensor. We also have developed PC based health management software that receives jogging data after jogging and stores it as a long term jogging trend data. From these long term data it feeds back the distance completion of jogging on the virtual course. Moreover it can show the trend of jogging time, distance, average heart rate and the user can know his / her own health condition.

Keywords

Jogging, Heart rate, Energy expenditure, GPS sensor, Health management.

Introduction

Japan will soon meet highly advanced aged society and now it becomes an urgent agenda how to keep old people healthy and make them to participate in social activities. In this study "jogging" was picked up, because the jogging is most popular to maintain and promote the health condition of the aged and the middle age [1]. Here a portable jogging support system has been developed and its application for health management has been studied [2, 3].

The conceptual idea of our system is as follows; 1) this system may make jogging joyful by feedback of running distance and heart activity during jogging. 2) It may make jogging safety by the alarm of abnormal heart activity comparing with running velocity to prevent the heart attack like cardiac infarction popular disease during jogging. 3) It may be applicable for health management. Jogging is thought to be the most desirable physical load test in daily life and the abnormal symptom of disease is expected to be found within the long term monitoring data recorded during jogging.

Portable Jogging System

Figure 1 shows the configuration of our jogging support system. As shown in this figure our system consists of a portable device

that a user carries during jogging, and a home PC software that manage health condition of the user. The portable device is micro computer based intelligent system with a heart rate sensor, a GPS sensor and a physical activity sensor and is designed to assist the jogging and monitor the health condition during jogging.

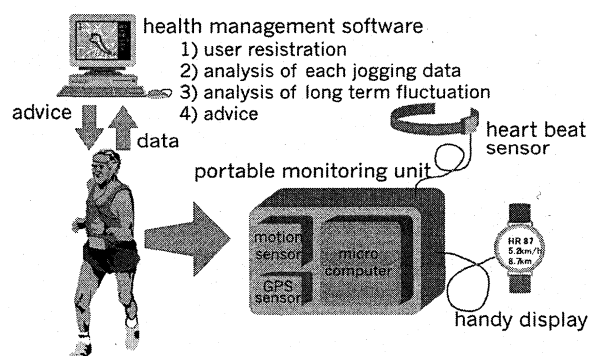


Figure 1 - Configuration of jogging support system

Data got from these sensors are processed in real time and are momentarily fed back to the user as the jogging assist information, that is, distance, total running time, velocity and energy expenditure, and the health condition information, that is, heart rate, abnormal heart activity and abnormal physical activity.

Figure 2 shows pictures of the portable jogging monitor device. Figure 2 a) shows the portable unit with GPS sensor (black square), b) the handy display unit, c) the portable unit set on the interface / battery charge unit and d) a user wearing portable unit around his waist. The portable device was designed to be set on a waist belt. Its size is 90 * 60 * 15mm and weight is 262g.

To get the jogging position a GPS sensor (Jemini, System Producer associates Co.) was installed. This GPS sensor is connected with the portable unit through RS232C serial interface. Communication speed is 4,800 bps.

Figure 3 shows the block diagram of jogging support system. As shown in this figure, an 8 bit micro chip (PD780078Y, NEC Co. Ltd.) was selected as CPU and 512 KB SRAM were installed to store data of 2 hours jogging. The user can see various informa-

tion, that is, total time, distance, velocity, pitch, heart rate and energy expenditure through the handy display.

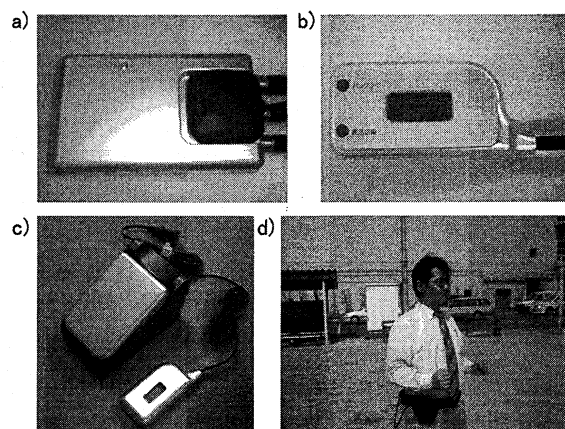


Figure 2 - Pictures of jogging support system a) portable unit with GPS sensor b) handy display unit c) portable unit on interface unit d) a user wearing portable unit and sensors.

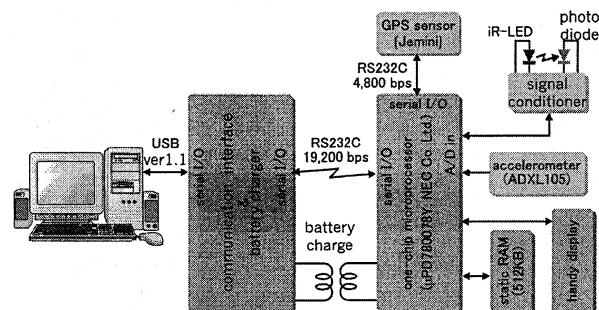


Figure 3 - Block diagram of jogging support system

To know heart activity an infrared LED and an infrared photo diode are set on the superficial temporal artery of the user's head. Head shows less motion than the other body parts during jogging and this point was thought to be the best part to get the pulse wave. Pulse wave can be detected as the change of light reflex according to the blood flow change in the artery. Figure 4 a) shows the principle of heart rate monitoring; Right half of this figure indicates subject's head and an infrared LED is set just upon the superficial temporal artery. A photo detector is set near to get the reflected infrared light and to know the pulse wave from the fluctuation of intensity. Infrared light is well known to be easily absorbed by blood and the intensity change of reflected light is expected to change according to the heart beat. Output current of the photo detector was converted into voltage signal, 0.1Hz-high-pass filtered, amplified and was put into the A/D converter of portable unit. Figure 4 b) shows a picture of heart rate sensor.

In the previous study we made it clear that we can monitor the energy consumption according to subject's physical activities and his rough behavior, like standing, sitting, walking and getting on a vehicle using an accelerometer set on the waist.

Here we also used the same method to get the user's energy consumption and jogging pitch.

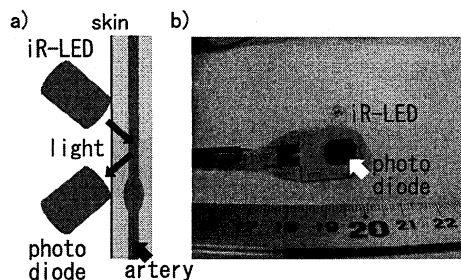


Figure 4 - Heart rate monitoring; a) principle of monitoring, b) picture of heart rate sensor b) principle of hearth.

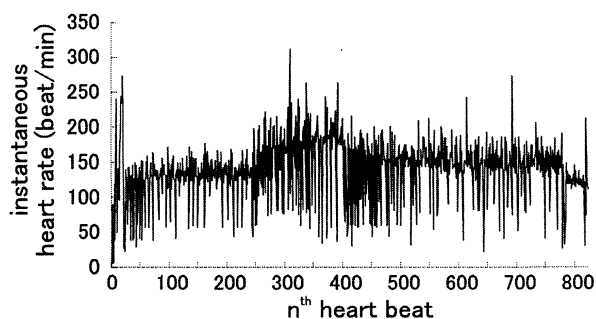


Figure 5 - Example of instantaneous heart rate monitoring.

To monitor physical activity an accelerometer (ADXL105, Analog Devices Co.) was selected. This acceleration sensor has 1 sensitive axis, 5G maximum sensitivity, is very small (14 pin DIP type package) and needs no additional signal conditioning circuit. Figure 6 shows an example of physical activity monitoring. In this case the subject was asked to stand up still and ascend his moving speed that is, walking, jogging and running. As shown in this figure the amplitude of acceleration increased according to his moving speed.

To get the energy consumption, the acceleration data was processed in real time into energy expenditure and pitch. Here the energy expenditure is calculated by the following equation [3].

$$EP = 0,1642 \times \sum_{\text{every } 1 \text{ min}} Acc_i + BW \times 0,0232 \quad (1)$$

Here, EP is Energy expenditure (cal/min), Acc_i is sampled acceleration data at time t and BW is body weight.

Health Management Software on PC

As shown in the previous introduction. our jogging support system has three main purposes; 1) to make the jogging more fun, 2) to make the jogging more safety, and 3) to manage user's health based on depending on the long term jogging data.

Health management software assembled on home PC has four main functions. The 1st function is registration; many users can

be distinguished by their nickname, and this system can manage them respectively.

2nd function is feedback of each jogging result; jogging trajectory or time course of each parameter can be shown on the PC screen. Figure 7 shows an example of jogging trajectory displayed on the map with the magnitude of jogging velocity colored. Figure 8 shows an example of fluctuations of some parameters during jogging.

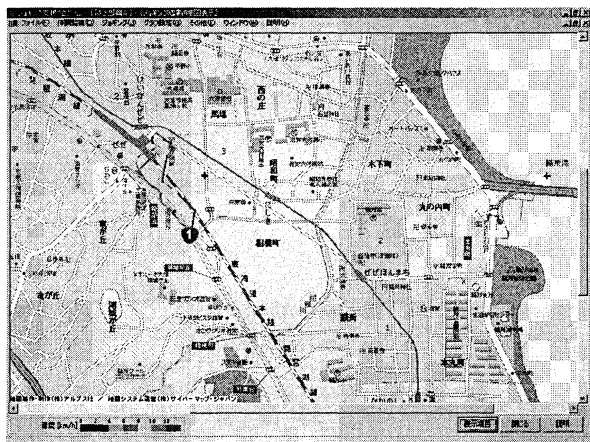


Figure 6 - Jogging results displayed on the map.

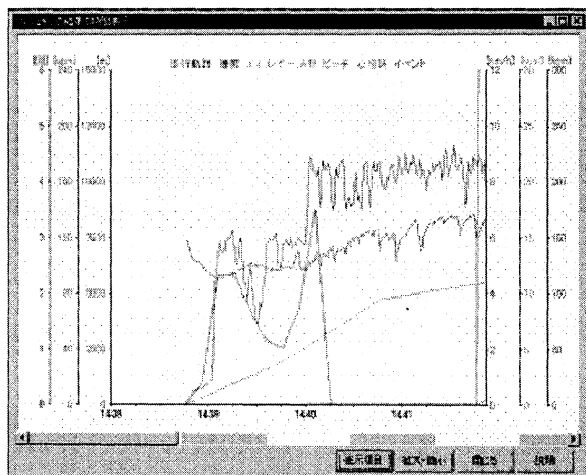


Figure 7 - Display of fluctuations of some parameters during jogging.

The 3rd function is health management and the user can know his health condition through long term jogging data. He can check the change in jogging distance, time, average velocity, average heart rate, average pitch and average energy consumption. Figure 9 shows an example of display of long term change in some parameters.

The 4th function is advice. Advices of expert trainers are implemented into this software and the user can get adequate advice according his jogging result. Anyway the user can select one of

three jogging purpose, that is, "health maintenance," "health improvement" and "diet," and of course advice changes his jogging purpose.

Besides these four basic functions this system is equipped following options to make the jogging joyful; 1) each jogging distance is summed up and the total jogging distance is converted into the equivalent point on the virtual long course, like a travel round the earth. This gadget may make the user more cheerful. This virtual course is set to be link with the relational web site and this gadget is expected to make the jogging more cheerful.

Health management software supports the linkage of weighing / somatic lipids scale through RS232C serial interface. This is because it is important for the diet user to check these parameters correctly.

Jogging experiment

Figure 10 shows a picture of jogging experiment. The subject checks his jogging parameter through handy display unit. In this case a normal subject (m, 22y.o., 174cm, 58kg) was asked to enjoy jogging around the ground of our university. He stood for a while, walked, run and walked again for about 10 minutes. Figure 11 shows the jogging trajectory got by the GPS sensor, figure 12 the pitch fluctuation got by the accelerometer, figure 13 the energy expenditure at every minute calculated by the equation 1) and figure 14 the heart rate fluctuation got by the heart rate sensor. As shown in these figures our system is proved to be effective to monitor many parameters during jogging..

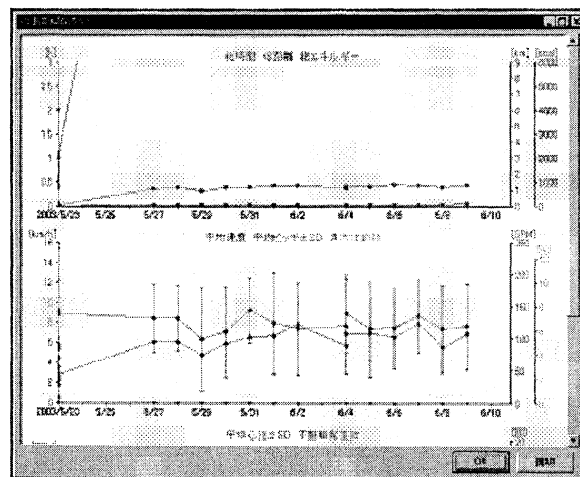


Figure 8 - Display of long term change in some parameters.

Conclusion

A portable jogging support system developed here is an attempt to make jogging more joyful and more safety, and simultaneously a trial to find out the symptom of disease from the long term jogging data. Jogging may be compared to load test done in the physiological laboratory in hospital and the user may easily find out the abnormality from the response to this physical load.

Expected user of our system is not only old people but also middle aged. This generation usually feels uncertainty in their health but they are too busy to visit hospital. There expected to be a big market of health maintenance apparatus..

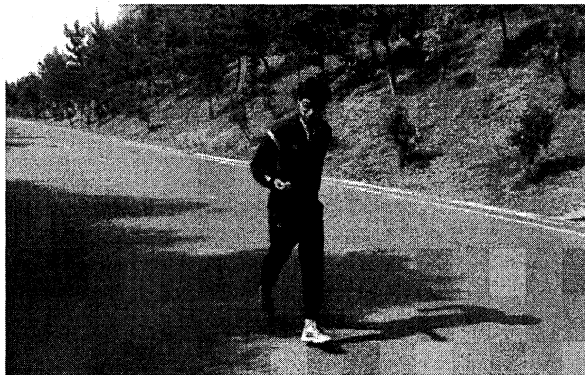


Figure 9 - The user can know jogging condition through handy display.

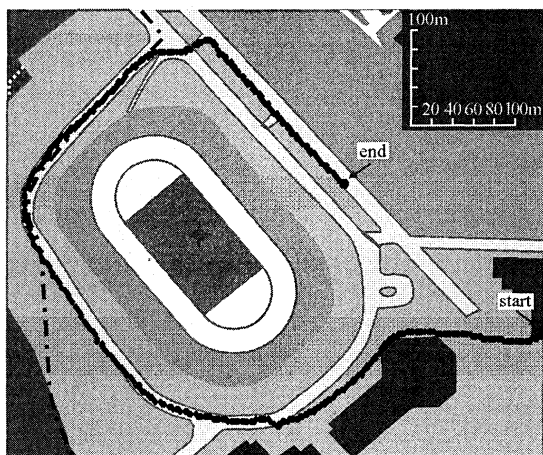


Figure 10 - Example of jogging trajectory.

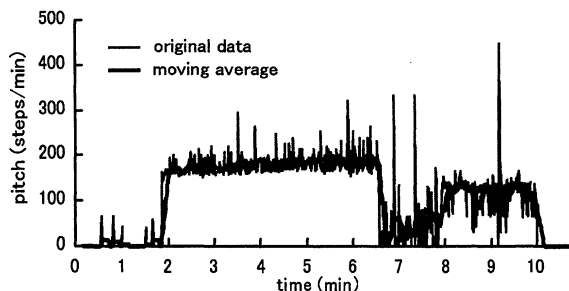


Figure 11 - Example of jogging trajectory.

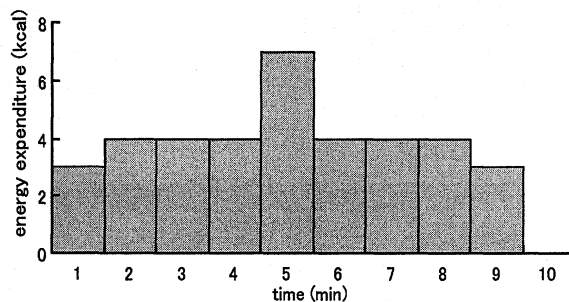


Figure 12 - Example of energy expenditure during jogging.

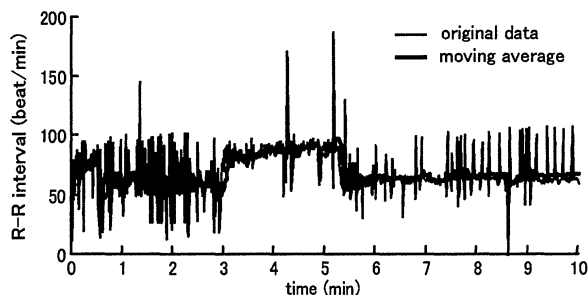


Figure 13 - Example of heart rate fluctuation during jogging.

Acknowledgments

This study was supported by the 2002 Shiga new technology development project collaborating with industry, university and local government.

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