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A multipurpose smart activity monitoring system for personalized health services

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ABSTRACT

One of the most popular types of personal health device is the activity monitor, which is attached to the user's wrist or waist in order to measure physical activity data such as exercise time/duration and calorie consumption. However, for the purpose of checking the physical conditions, medical staffs may want to check remotely the movement of a patient's body parts. Given that it has an activity sensor to measure the speed of a user's movement, an activity monitor can also be used to track the movement of a user's body part.

In this paper, a multipurpose smart activity monitoring system for personalized health services is proposed. The purpose of the system is twofold. The first purpose is to perform easily smart monitoring of a user's physical activity. The system proposed in this paper is referred to as "smart" because the personal activity monitor can be managed remotely through the management commands issued by the monitoring server. The personal data, device data or programs installed in the personal activity monitor can be updated remotely by the monitoring server or medical staffs, and error reports can be delivered to the server or the medical staffs for personalized health services. To do this, the ISO/IEEE 11073 and OMA DM communication protocols are extended and the protocol transformation between two protocols is performed.

The second purpose is to perform convenient motion tracking of a user's body part in order to monitor the speed of the body part, as well as its tracking path. The system is also referred as "multipurpose" since the activity monitor can be used in motion tracking as well as in activity monitoring. The objects in motion to be tracked remotely by medical staffs can be a human body part. To do this, in addition to the acceleration sensor, a gyro sensor is installed in the personal activity monitor and the movement data captured by the activity monitor is analyzed to show 2-way views of the movement of the body part on which the activity monitor is attached. Then medical staffs can check remotely the physical conditions of the body part in various ways.

1. Introduction

In recent years, as the concept of healthcare has shifted from disease diagnosis and treatment to disease prevention, the importance of technical development for systematic and continuous exercise management has been emphasized. Moreover,

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the increasing public attention to healthcare and the development of medical technologies has led to the necessity of personal healthcare devices (PHDs). One of the most popular types of PHD is the activity monitor, which is attached to the user's wrist or waist in order to measure physical activity data such as exercise time/duration and calorie consumption. The sole purpose of an activity monitor is to measure physical activity, such as while a user is jogging or running.

However, for the purpose of checking the physical conditions, medical staffs may want to check remotely the movement of a patient's body parts. Given that it has activity sensors to measure the speed of a user's movement, an activity monitor can also be used to track the movement of the patient's body parts.

In this paper, a multipurpose smart activity monitoring system for personalized health services is proposed. The purpose of the system is twofold. The first purpose is to perform easily smart monitoring of a user's physical activity. Most of the activity monitors on the market today lack secondary functions for device management, which is considered to be important for personalized service in u-healthcare environments. Therefore, this study proposes a smart activity monitoring system that monitors a user's activity and manages activity monitor devices remotely and easily by medical staffs. The system also can remotely set and reset a user's personal data stored in the smart activity monitor he/she carries for personalized health services.

Another purpose of the system is to track easily and remotely the movement of a human body part. In addition to the acceleration sensor, a gyro sensor is installed in the activity monitor for this study in order to monitor easily the speed of a user's body part, as well as its tracking path. And the movement data of the activity monitor is analyzed to show 2-way views of the movement of the body part on which the activity monitor is attached. Then medical staffs can check remotely the physical conditions of the body part in various ways.

The extended OMA DM communication protocol is proposed between the gateway and the monitoring server for this study, as the original OMA DM communication protocol is proposed as an international standard for remote mobile device management, not for PHDs. In addition, since the original ISO/IEEE 11073 communication protocol does not deal with the management data of mobile devices, the protocol is extended for this study also.

The remainder of this paper is organized as follows. Section 2 describes some related studies, Section 3 explains the multipurpose smart activity monitor system proposed in this paper, and Section 4 shows the results of some experiments using the system constructed in this study. Finally, Section 5 draws conclusions and discusses some possible directions for future research.

2. Related studies

Activity monitors are one of the most popular types of PHDs (Personal Health Devices) [4,15–17]. The activity monitor is normally attached to the wrist or waist to measure physical activity. Equipped with an acceleration sensor and a step counter, the activity monitor measures exercise time/duration and step count to calculate the amount of calories consumed during exercise. As public attention to the importance of good health increases, activity monitors are becoming more popular than ever. Nowadays, activity monitors with short-range wireless communication functions can transmit the physical activity data they measure to a monitoring server to enable comprehensive health management. However, they still have much room for improvement: Most of the activity monitors we can get today do not have any remote device management functions. This means that it is not possible to perform error reporting/handling, parameter settings and software upgrade remotely, which are considered important for personalized health services in u-healthcare environments.

Motion tracking is the process of recording the movement of objects. Most studies on motion tracking systems involve the fields of gaming, animation, virtual reality, sports, entertainment and medical training, etc. [7,21,2,6,22,12,11,9,14,20,13]. Motion tracking technologies use one or more of several approaches. The most commonly used approach is optical motion capture. Specially designed markers are placed at specific points of objects, and video cameras in fixed positions track the motion of the markers. Motion data captured by the cameras is analyzed by image processing software. The optical approach, when a large number of cameras are used, can capture very accurate motion data inside a specially designed room. However, an expensive setup is required for this approach. On the other hand, markerless optical motion tracking technologies have been studied recently, as these require neither markers nor special setups. However, the approach requires the development of very accurate and stable motion tracking algorithms. Generally, the optical approach may capture accurate motion data indoors, but this approach has trouble tracking objects outdoors.

In [18], a ubiquitous motion tracking system that tracks sporting equipment using the sensors installed in an activity monitor is proposed and constructed. The activity monitor with the tracking sensors is attached to places on sports equipment to calculate the speed and acceleration of these objects. The ubiquitous motion tracking system consists of four modules: a tracking sensor module and communication module in an activity monitor, a communication module in a USB dongle and a motion analyzer module in a laptop PC. For experiments, an activity monitor with the tracking sensor module and the communication module is attached to a golf club, and a golf swing is taken. The results of the experiments show that the motion data of sporting equipment can be captured and analyzed easily, in both an indoor and an outdoor environment.

Some studies used sensors to track elderly persons [1,8,10,17–20,26]. Pressure sensors [17,18] or capacitance sensors [19,20] are attached to a floor to locate a person on the floor. Accurate localization and monitoring of a person can be obtained through these approaches. However, these tracking efforts cannot be successful in the absence of the room with special floor sensors described above.

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