Monitoring system of body movements for a bedridden patient

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Abstract In this article a system to detect the physical behavior of bedridden elderly people is proposed. This system is used to prevent elderly people from falling down and injuring themselves. The basic idea of our approach is to measure the body movements of the person using an acceleration sensor. Based on the data measured, dangerous actions are recorded and warning signals to the care workers are generated via wireless signals. A feature of the system is that the sensor is compactly assembled as a wearable unit. Another feature of the system is that it adopts a simplified wireless network system. Owing to its network capability, the system can monitor the physical movements of many patients. The applicability of the system is now being examined at hospitals.

Key words Dementia patient · Monitoring system · Acceleration sensor · Elderly · Vital sign

1 Introduction

The increase in the number of elderly people is becoming a serious social problem. In a care home for the elderly, a few care workers look after many aged people. Typically, in the nighttime the care workers are too busy to deal with every task. Most of the care workers are doing their best, but are too busy. One serious problem in a care home is injuries caused by slipping and falling down. Once they break their leg or foot, it is often difficult for them to recover. Typically in the case of a dementia patient, they are often not obedient to the request not to leave bed alone. One simple measure to protect such cases is to fasten the patient onto the bed, but such treatment means neglecting the human rights of the patient. Touch sensors and pressure sensors are proposed to detect an escape or wake-up motions of patient from the bed. However, what required by the care workers is a technique to detect the body movements of the patient and forecast the occurrence of a risky action. Of course, forecasting risky actions reliably is not easy, but skillful care workers say every elderly person shows individual physical signs before a risky action. They say an alert signal can be generated before the risky event occurs by preparing an individual criterion for each elderly patient. Already some related research has resulted in techniques to measure vital signs like sleep stages, heartbeat, respiration, and snoring. Image processing is one technique to measure such signs, but this technique is not preferred because of the violation of privacy.

Here, a monitoring system is proposed which measures the body movements of a bedridden patient. The data measured are used to evaluate the current physical status of the patient and the possibility of risky actions. For practical applications, a compact wearable sensor unit employs a two-dimensional acceleration sensor, a one-chip computer, and a wireless communication module. Owing to the introduction of simplified wireless network systems, the system is applicable for many users.

The proposed system can recognize some kinds of physical condition like deep sleeping, light sleeping, walking, standing up, slipping, falling down, and jumping up. Furthermore, based on the criteria of the time sequences of these physical movements, the sensor sends an alert signal to care workers. The proposed system is now under examination at hospitals.

2 System configuration

The system configuration is shown in Fig. 1, where patients wear sensor units on their chest. On the sensor unit, an acceleration sensor (ADXL202: Analog Device), a one-
chip CPU (PIC16F84A), and a wireless communication module (iTRX315: itec Co.) are implemented in a compact body, as shown in Fig. 2. The acceleration sensor detects two-dimensional acceleration. Of course, since the sensor detects the acceleration caused by gravity, it gives information about the posture of the sensor. Therefore, if a patient wears the sensor on their chest, the physical behavior or posture of the patient can readily be detected from the data measured. A compact wireless communication module on every sensor unit allows communication with the master computer. Furthermore, by introducing an original communication protocol, every unit can communicate with every other unit. In each sensor unit, an individual criterion is implemented according to each patient’s situation. Based on each criterion, the one-chip computer recognizes the risky condition of the patient. Once the one-chip computer recognizes that the situation of the patient is dangerous, it sends the risky signal to the master computer. It should be noted that the sensor unit can also detect extraordinary body movements like gastric spasm or spasmodic asthma.

3 Network system

In the proposed system an original network protocol is introduced. The basic idea of the protocol is that every communication module communicates with every other module, and synchronizes with the base synchronous signal emitted by the master computer. A feature of our protocol is that even if a sensor unit cannot detect the base synchronous signal emitted by the master computer, another sensor unit that can detect the base synchronous signal acts as an auxiliary master computer. This feature provides the great benefit that only a low-power communication system is available.

Suppose the base synchronous signal can be detected in the range of sensor units 1–5, as shown in Fig. 3, and sensor unit 6 is out of range. Everyone knows that the master computer can recognize that sensor units 1–5 are in the accessible range and sensor unit 6 is out of range. In this situation, the master computer asks every sensor unit if it can access sensor unit 6. After that, each sensor unit tries to communicate with sensor unit 6 sequentially. If one of the sensor units is able to communicate with sensor unit 6, that sensor acts as an auxiliary master computer for sensor unit 6. Thereafter, the sensor unit can communicate with the master computer via the auxiliary master computer. This means that even if the maximum accessible range of the communication module is less than 10m, by introducing relaying sensor units, the accessible range can be expanded as far as we require. Therefore, our proposed system can be applicable to hospital or nursing facilities.