Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 63 (2015) 229 – 235

Procedia Computer Science

5th International Conference on Current and Future Trends of Information and Communication Technologies in Healthcare (ICTH-2015)

In-home Health Monitoring System for Solitary Elderly

Toshifumi Tsukiyama*

Tokyo Denki University, 2-1200 Muzai-Gakuendai, Inzai 270-1382 Japan

Abstract

In this paper we propose a sensor-based monitoring system that evaluates the health status of solitary elderly based on daily living activities, and provides forecasts of emergency situations to a local nursing center without explicit user interaction. We focus on three daily living activities: urination, kitchen work, and activities related to maintaining physical cleanliness because these activities are closely involved in maintaining a healthy lifestyle and are usually accompanied by the usage of tap water. There is a certain regularity in the usage of tap water in these quotidian activities,and health status is correlated with the regularity. Therefore, the system monitors health status by using water flow sensors which are attached to faucets in the kitchen and washroom and to the toilet. An advantage of this method is that the system can be readily installed in any type of housing at low cost. In addition, this system does not require personal data to be saved or transmitted. We will present the initial results from an experiment.

Peer-review under responsibility of the Program Chairs

Keywords: In-home health monitoring system; Solitary elderly; Water flow sensor; Active RFID tag; Vibration sensor; Quotidian activity

1. Introduction

We are confronted with an increasing population of solitary elderly, many of whom live in their own homes and for whom dangerous situations that may require medical attention are ubiquitous. However, the number of caregivers available for frequent home visits is limited. Thus, new care services, such as those that use monitoring systems, are needed to cut costs in health care while still providing security and adequate medical treatment for people who live alone and are restricted physically.

There are a number of compact wearable sensors used for the detection of emergencies such as sensors for the observations of vital signs[1]. This kind of emergency sensor has one disadvantage: it has to be worn constantly and operated actively, making it highly limited in regards to functionality and comfort. Recently, research into this aspect of health care has focused on capturing the activities of daily living by using ambient monitoring systems. Such monitoring systems can be divided into two categories: to identify short-term emergencies and long-term variations in health status. In this paper we focus on long-term variations in health status, in other words, a sensor-based

* Corresponding author. Tel.: +81-476-46-8614 ; fax: +81-476-46-8449.
E-mail address: t-tsuki@mail.dendai.ac.jp

Peer-review under responsibility of the Program Chairs
doi:10.1016/j.procs.2015.08.338

monitoring system that evaluates the health status of an elderly person based on his/her daily living activities and provides forecasts of emergency situations to a local nursing center without explicit user interaction.

One method for the early detection of emergency situations is monitoring systems that use position sensors. The best-known representatives of position sensors are infrared-ray sensors, which are installed in the living room, bedroom, corridors, and so on[2,3,4]. Positional information for the person is acquired from the detection of body heat as he/she moves through the house. A model of the normal day-to-day behavior patterns is created based on the individual's at-home habits, such as their movements, living room use frequency and living room use time, which are derived from positional data[5,6]. Problems with the individual's physical condition can be detected when there is a major variation between the model behavior and actual behavior patterns. The development with this kind of day-to-day behavior models using machine learning methods is that they require a solid database with a substantial number of cases in order to achieve reasonable results. In addition, a unique model must be made for each and every person. Therefore, the installation of such technologies takes a great deal of time.

Moreover, these position sensors provide only indirect information on health status. In other words, positional information does not always correspond to vital activities related to health status. From the viewpoint of reliability, it is desirable to directly specify normal daily activities and then to detect variations which may be signs of a dangerous situation. TV cameras can observe daily activities and detect dangerous situations, but privacy concerns make their introduction into private homes limited. A smart meter, which is used for the billing of electricity, can also be used for activity recognition[7]. Daily variations in power consumption are recorded in the smart meter, and use of household appliances such as a vacuum cleaner and a toaster oven, can be ascertained from the variations, allowing the inference of daily living activities. However, it is very difficult to analyze the variations in power consumption.

In our system we focus on three quotidian activities: urination, kitchen work, and activities related to maintaining physical cleanliness, because these activities are closely involved in maintaining a healthy lifestyle. These quotidian activities are usually accompanied by the regular usage of tap water, and an individual's health status can be correlated with this regularity. Therefore, we propose a monitoring system for health status that uses water flow sensors that are attached to faucets. An advantage of this method is that rule-based methods[8,9] can be used for analysis and interpretation of the sensor data. The rules can be derived from experiential knowledge of water usage during urination, kitchen work, and activities related to maintaining physical cleanliness. In addition, these sensors are available at a reasonable cost. The system can be installed easily in any type of housing, and no interaction by the user is required. No personal data such as photographs or video recording are saved in the system or transmitted.

This paper is organized as follows. In Section 2 we give a brief outline of the proposed method and monitoring system. Section 3 describes the technical aspect of the monitoring system. Section 4 describes the implementation of the monitoring system and experimental results. Concluding remarks and future goals are given in Section 5.

2. Overview of the Proposed Monitoring System

In our system we focus on three quotidian activities, that is, urination, kitchen work, and activities related to maintaining physical cleanliness. As mentioned below, there is a certain regularity in the usage of water during these activities and health status is correlated with the regularity. We know that humans urinate an average of six to eight times a day[10]; thus, if an individual makes much less or much more frequent use of the toilet, then some illness or problem can be suspected. If one wakes two or more times before dawn to urinate it can also be a sign of a poor state of health. Therefore, the number of times and the time of day that an individual urinates are important signs of health status. It is possible to infer the health status by checking the flow of water at the toilet's flush tank in the bathroom. If a person is healthy, they usually wash their face and rinse their mouth when they get up in the morning and before going to bed at night. They also perform activities such as hand washing during the day to keep themselves clean. Such activities are also important signs of health status, including mental health. The volume of water used at the washroom sink is not large, but the frequency of use of tap water is generally high. Activities such as hand and face washing can be inferred based on the water flow at the washroom sink. Cooking is also a fundamental human activity. It is not only connected with the joy of eating but also deeply affects various aspects of human life such as health. Needless to say, healthy eating habits improve quality of life and help the elderly maintain good health. Therefore, daily kitchen work, including cooking, is also an important sign of health status. At mealtimes people use a large volume of water in the kitchen for cooking and washing dishes. Time periods when the use frequency of kitchen tap