

Unusual Situation Detector Facilitating Old People to Live Their Own Life

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1. Introduction

The expensiveness of formal caregiving and the shortage of caregivers have become parallel problems by the increase of the elderly population. Elderly people prefer to live independently in their own environments, i.e. their homes, where ubiquitous computing technologies are necessary to provide healthcare for them. In this paper, we propose a system to help the continuous situation observation of old people living alone in their homes for timely detection of unusual situations, such as falling down, sedentary manner, frequent evacuations, and so on. We define the situation as a consequence of posture, location, and behavior in a particular time series. By analyzing these three items timely, caregivers can be informed of unusual situations. Caregivers can obtain clear and detailed report of the unusual situations of old people on a daily basis.

2. Related Works

The risk of elderly people being found helpless or dead in their homes is expressed in [1]. For providing help to them in time, falling down detection [2], ambulatory monitoring system [3], and activity monitoring for health condition [4] have already been studied. However, these are specialized to a specific situation and not usable for various unusual situations. [5] introduces an intelligent house where the behaviors of the elderly are recognized and the unusual situations are detected. Nevertheless, this house needs to be equipped with 167 sensors and some of these sensors can cause discomfort to them.

3. Detection of unusual situations

3.1 Time tube

The situations can be detected according to the posture, location, and behavior during a particular time period. Restriction on posture, location, and behavior of a person can specify his state in a specific duration. We refer to a situation as a sequence of time tubes [6]. A time tube represents conditions on

posture, location, and behavior in the specified time length. When a particular situation is to be detected using a time tube, this time tube shows that a subject possesses a specific posture, location, and behavior for a determined duration. Available data of posture, location, and behavior from respective sensors in a specific time tube should be analyzed for detecting the situation occurrence.

By detecting these three items according to the starting point to the ending point of a duration defined with the combination of posture and location, we can detect a situation at that time. For example, from the beginning point to the ending point of duration where the subject is standing (posture) in his bedroom (location), suppose he/she is touching a blanket, a pillow and a bed sheet (behavior), which means he/she is making bed.

As shown in figure 1, unusual situations are detected through comparison of continuous posture, location, and behavior data with time tubes. By analyzing time series data of these three items in a specific time, we can detect an unusual situation. For example, lying on the bed with no behavior at night time is a usual situation. Lying in the bathroom with no behavior at night time is an unusual situation.

3.2 Factors related with time and sequence

When an unusual situation occurs, the set of posture, location, and behavior at a particular time becomes different from those of usual cases. Not only a set of these three items in a specific time, but the following temporal or sequential factors are also important for detecting the unusual situations.

• Time length

Some unusual situations can be defined as long-time stability of the posture, location, and behavior. For example, if the posture of an elderly is stable in one state for a long time, we should be skeptical about long-term sedentary manners. In such cases, the system asks him whether he is ok or not. The system automatically notifies the caregivers if it receives no reply for a determined time period.

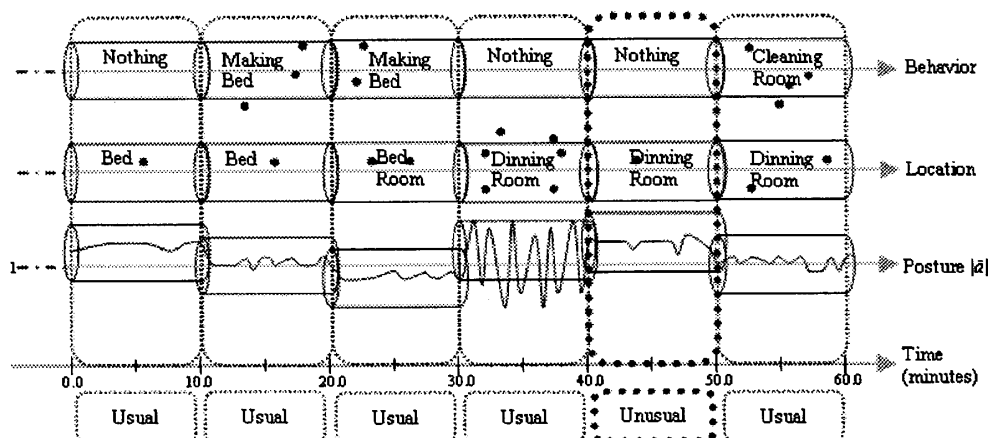


Figure 1. Situation analysis with time tube

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- Frequency

Even though one case is a usual situation originally, if it occurs too frequently, it should be treated as an unusual situation. For example, if the subject is in sitting posture, locating in the lavatory, and in the behavior of evacuation, it can be observed as a usual situation. However, if this situation occurs very often, it turns into an unusual situation and that information should be sent to the caregivers in time to provide appropriate care for him.

- Change of postures

Falling down is a major problem that frequently happens in the people of over 65 years old. Posture changing is a significant factor for detecting an unusual situation. For a clear point of view, if the postures change from walking or standing to lying, it seems falling down. Normally, a sitting down case should occur between walking or standing and lying.

- Trend of posture patterns

Occurrence of the same pattern of posture changing for several times in one location can state an unusual situation. In reality, except from exercise cases, it is very rare case to occur the same pattern of posture changing in one place. For instance, let us consider the case of a subject is sitting down on a chair, and trying to stand up many times. We can estimate that case as an unusual situation where he cannot stand up and falling down in sitting position again and again.

4. System configuration

For keeping attention on posture, location, and behavior periodically, we utilize G-sensors and RFID technologies in our system. The subject is wearing a G-sensor on the waist for obtaining the posture data, an RFID reader on the ankle for identifying the location data, and an RFID reader on the wrist for specifying the behavior data. The G-sensor sends respective values to a server when the subject changes his postures such as sitting, standing, walking, and lying. The RFID reader having on the ankle reads the location of subjects. The RFID reader putting on the wrist scans the touched objects ID.

4.1 Postures by G-sensor

The G-sensor is a kind of embedded sensor in a storage device that provides 3-axis (x, y, z) acceleration information. Let $|\vec{a}|$ be the magnitude of the current total acceleration. This is the vector sum of the acceleration along x , y , and z axes [7], i.e.,

$$|\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2}$$

Sitting, standing, walking, and lying status have different $|\vec{a}|$ values. The timely posture can be observed according to $|\vec{a}|$ values in a specific time tube.

4.2 Behaviors and locations by RFID technologies

Activity of Daily Living (ADLs) can be detected by using RFID technologies. In our proposed intelligent environment, small and cheap passive RFID tags are installed in every object that can cause the activities. RFID reader wearing on the wrist of the subject can sense the objects ID he touches. By checking what kinds of objects are touched and sequences of touched objects, behavior of him can be detected. The floors of the house where a subject is living are assumed to be embedded with RFID tags. When a subject putting RFID readers on his ankle moves around on the floors, the tag ID and timestamp are sent to the server. By mapping the tag ID with predefined data of locations, the located area of the subject can be realized timely.

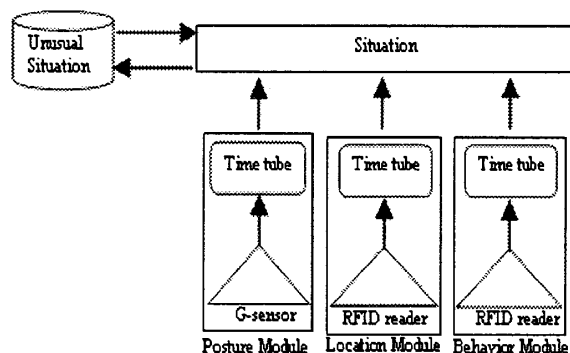


Figure 2. System Configuration

4.3 Assemblage of G-sensor and RFID technologies

The system configuration of our system is shown in figure 2. As shown in this figure, the aggregation of the G-sensor values, location RFID data, and behavior RFID data in a specific time represents the situation at that time. If this situation matches with predefined time tubes that are corresponding to unusual situations, the unusual situations at a particular time can be detected.

5. Conclusion

In this paper, we have proposed a system that observes the unusual situations of elderly by detecting posture, location, and behavior of them all the time. Our proposed system can facilitate them to live their own life in their prefer environments. It can be used to state the unusual situations as well as the emergency situations of them. This system enables caregivers to provide immediate health care to them.

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