LIFE^{2}GUARD: MONITORING SUDDEN PHYSICAL DISORDERS IN PRIVATE ROOMS

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Abstract

We present a research result of our project named Life^{2}Guard. The project aims at detecting a person facing a sudden physical disorder in private rooms such as restrooms. Our first goal in this paper is to specify the required functions for the system to detect physical disorders in private rooms. These functions are Privacy-Aware Sensing, High Availability, Quick Responsiveness and False-Call Avoidance. Secondly, we propose how we have implemented the system to fulfill the requirements using following key approaches: IR Sensor, Bayesian Network, Approximate Inference, Naive Bayes and User Interaction. Lastly, we compare Life^{2}Guard to the former works of this field and show our achievement.

1. Introduction

It is commonly reported that many people are attacked by a sudden physical disorder in restrooms. Since people are alone in such rooms and isolated from others, these situations tend to be left undiscovered and the time loss often leads to the person developing severe health problem. Monitoring systems for such rooms are extremely desired.

The monitoring system that we aim to design must protect users privacy, monitor the user at all times, detect the urgent situation immediately and call for rescue. These requirements reveal four goals for the system, they are Privacy-Aware Sensing, High Availability, Quick Responsiveness and False-Call Avoidance. To realize the goals ,we have designed Life^{2}Guard System using IR Sensor for sensing device, Bayesian Network's Approximate Inference, Naive Bayes Model for Sensor Data Analysis, and Touch Panel Interface for User Interaction.

2. Life^{2}Guard

Pictures in Figure 1 show the 1)Life^{2}Guard System's installation in a restroom, 2)sensor implementation and 3)interaction panel installation. As for the sensor, we use Crossbow Mica2Dot as a base and Panasonic NaPiOn IR Sensor for sensing unit. As for the user interaction panel, we use Sony Vaio Type U.

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Figure 1. System Overview

2.1. Privacy-Aware Sensing

The system must protect user's privacy. This requirement eliminates the use of cameras. Also, people might take off on-body sensors in baths or restrooms. Therefore, the use of biometric sensors is eliminated as well since the sensors have to be attached to the user's skin directly. For those reasons, the user's behavior that can be detected from environmental sensors is the only clue to find out if a sudden physical disorder has occured. There are many environmental sensors that can somehow detect users' behavior. We have set three barometers to choose appropriate sensor for Life^{2}Guard System. They are Real-time Reaction, Anti Environmental Noise and Cost Performance. Real-time Reaction means a user's behavior affects on sensor data in no time. Anti Environmental Noise means that the sensor only detects the effect caused by the user behavior, not environmental change. Lastly, the Cost Performance means how reasonable we can afford the sensor. Table1 shows the satisfaction level of these barometers for each sensor.

Table 1. Sensors and properness

Sensor Type	Real-Time	Anti Noise	Cost
illuminance	great	poor	great
temperature	poor	poor	great
sound	great	poor	great
IR(infra-red)	great	good	great
pressure	great	good	poor
lazer-beam	great	great	poor
ultra-sonic	great	great	poor

Looking at Table1, IR sensor is the only a sensor without failure. IR sensors sometime affected by light but most of the time, it reacts only IR from human body. Therefore, the noise is considered to be ignored. Also it has a great cost performance and real-time reactive ability. For those reasons, we have chosen to use IR sensor. The type of IR sensor we chose is the pinpoint focus. A wide range IR sensor can only detect that the user has stopped moving. By attaching several pinpoint type of sensor, more sensor data patterns can be created and so the system can potentially detect more and richer context. This includes detecting such things as fainting and convulsions.

2.2. High Availability

A sudden physical disorder can happen any time, and therefore the system must monitor the user at all time. However, sensors are usually very fragile for many reasons such as packet losses caused by radio wave collision, battery exhaustion or sensor node breakdown. Therefore the data are not promised to be reached. If the system requires complete dataset of sensor data that it should have, the system stops functioning when there is a lack of sensor data. It is not allowed to stop functioning for Life^{2}Guard System, because this system should protect user's lives.

To make the system durable to handle the instability of wireless sensors, we use Bayesian Network for context analysis. Bayesian Network is known as the algorithm to handle three types of uncertainties. These uncertainties are namely ignorance, physical randomness and vagueness. Data loss is considered to be ignorance and therefore Bayesian Network uses latency value to complement unknown data. In addition, the definition of physical disorders is considered to be vague. Bayesian Network handles this problem as well. For these reasons, an algorithm using Bayesian Network is appropriate for Life^{2}Guard System.

2.3. Quick Responsiveness

The person who is attacked by a sudden physical disorder needs help right away. The system has to detect the urgent situation immediately. To realize this, quick sensor data inference is needed. For quick responsiveness, Life^{2}Guard System adopts Approximate Inference and Naive Bayes. Approximate inference performs a computer simulation approach, and gets a reasonable answer in a reasonable amount of time. We use an algorithm named Likelihood Weighting. The merits of using the other approach, Naive Bayes, are Simple Calculation, Easy Training and Powerful Reasoning. The powerfulness of Naive Bayes in context extraction can be referred from the research of Emmanuel Manguia Tapia [4].

2.4. False-Call Avoidance

The function of the Life^{2}Guard System is to protect the user's lives and therefore the system must call for rescue to others when it detects a problem. It is bothersome and inefficient if the system calls for help by inference mistakes. The system needs False-Call Avoidance function. Also, we can not allow the system to miss detecting physical disorders. So we must set the threshold probability value for judging the user is in a physical disorder lower enough for the system not to miss the situation. However, consequently, the number of false-positive mistakes increases. We have used inquire interaction to avoid false-positive mistake. The system asks for interaction to the user and waits a certain time after it detects a physical disorder. If the user answers within timeout, the system continues monitoring. However, if the user does not answer, the system calls for help.

3. Related Work

This field has been researched by several organizations especially in Japan, the country in which society is aging. Takuo Suganuma et al. have developed uEyes[3]. The system regulates the quality of the streaming video of the room depending on the observer and the situation. This system is available for semi-private room such as a living-room. However, it obviously can not apply to restrooms as we did. Toshio Hori et al. is working on Sensorized Elderly Care Home [1], which is another example of

privacy-considerate monitoring. Because they think cameras are not appropriate for home monitoring, their approach is to monitor the elderly by attaching ultra-sonic badges to wheel chairs. This allows the location of the person to be monitored without the istrusion of a camera. However, people who do not use a wheel chair need to bring a sensor with them everywhere. It is difficult for people to bring a sensor 24 hours a day and therefore the system can not monitor the user all the time.

Yoshimitsu Shinagawa et al. [2] have researched an algorithm for automatic emergency calls using non-response intervals of IR sensors. We have the same purpose and use the same kind of sensors. However, since they use non-response intervals of IR sensors, they can only detect one kind of physical disorder that is faint. On the other hand, our system can detect more physical disorders such as fainting and convulsion because we use patterns of sensor data. Also, Life^{2}Guard System can detect if the user has fainted 100% in 30 seconds, while their system takes 120 to 240 minutes.

4. Conclusion

We have given approaches to four system requirements to monitor physical disorders in privacy rooms, namely Privacy-Aware Sensing, High Availability, Quick Responsiveness and False-Call Avoidance. In the experimental run, Life^{2}Guard System failed to detect some physical disorders such as convulsion with the user sitting. However, it can detect convulsion with the user lying down 100% of the time. We could see that the four approaches have great possibilities in detecting physical disorders in privacy rooms. At the same time, we have found future tasks to accomplish. Improvement of detection accuracy is a primary task. We must find a method taht is able to detect more types of physical disorders more accurately. Then, improvement of interface is the next task. This is to hide the presence of the service. Lastly, adaptation of Life^{2}Guard system to other privacy rooms is important. After all these improvements, Life^{2}Guard system will be a killer application of sensor networks for the home consumer market.

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