Home Security System for Seniors

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Abstract-- **Today's society is battling issues of ageing and low birth rate. As many seniors spend the day alone at home or live alone altogether and since many suffer from chronic disease, a home security system is essential in monitoring a senior's condition at home to further analyze their behavior at home. This study applies beacon technology to conduct analysis on the amount of time a senior spends in a certain home area in order to assess whether they are in dangerous condition. In case of danger, the system can immediately notify family members to come to aid. This project utilizes beacons' low power consumption feature to reduce frequency in battery changes to avoid seniors' adaptation issues with information technology. Moreover, beacons and beacon receivers are affordable to family of all ranges.**

I. INTRODUCTION

Taiwan has now entered an ageing society era [1]. Aside from elevated healthcare costs, an ageing society also faces increased demand for care workers. While many seniors are mobile enough to live alone, many still suffer from chronic disease such as high blood pressure and heart disease, and might even experience problems with taking medication or subsequent repercussions. Hence, nowadays, there are many home security systems available on the market, such as smart watches and monitoring equipment. Smart watches bear the problems of battery charging and complex system operation, which can cause seniors to struggle with IT adaptation. Besides, monitoring equipment require long-term surveillance of the senior's conditions, which demand more human and material resources. Therefore, the design of a home security system must take affordability and automated monitoring into consideration in order to achieve popularization.

Reference [2] uses beacon technology and RSS to propose an indoor positioning algorithm. Relying positioning on beacons can reduce the number of sensors needed as well as the overall software and hardware costs. Reference [3] suggests monitoring physical activities to understand a senior's behavior at home by using wearable devices to detect a senior's health indices and physical location. However, wearable devices are power-consuming, so seniors need to frequently charge their devices, which could lead to IT adaptation difficulties. Meanwhile, Reference [4] employs wearable devices to perform health detection on seniors. Although wearable devices can detect physiological indices, physical activities, and sleep status, the more complex their functions are, the more power-consuming they will be and thus less advantageous for senior uses. Reference [5] examines the effectiveness of wearable devices for patients, and experiments show that wearable devices can indeed provide effective monitoring for chronic diseases and smoking cessation, in turn reducing the disease's impact.

This study uses beacon technology to establish a senior home security system. We arrange beacon sensors in multiple corners indoors and set a certain time of stay for each area. When the senior has lingered for too long in a certain area, it indicates irregularities for the senior, so notifications are sent out to family members. For instance, if a senior spends more than two hours in the bathroom, the system determines presence of irregularity and issues notifications to the family. The study takes advantage of beacons' low power consumption feature; additionally, the proposed system does not require that the senior manually input settings but only that they wear the beacon transmitter, which can reduce issues with IT adaptation while also relieving labor costs.

II. THE PROPOSED SCHEME

Our proposed system architecture is as shown in Figure 1. We arrange beacon receivers indoors and utilize the signal strength from beacon transmitters and receivers to determine the senior's physical location; when irregularity is detected, notifications are sent to the family. First, we register the beacon transmitter's serial number with the server; when the receiver receives a message from the transmitter, it forwards the message to the server, and the server determines the transmitter's signal strength to conduct positioning using the following formula:

$$\min\left(B_{User} - R_i\right) \in R_i \tag{1}$$

Formula 1 calculates the transmitter's location. BUser stands for the senior's transmitter. Given that the transmitter might be located between two receivers, we can first identify which receiver is closer to the transmitter and infer which receiver is within range of the transmitter. Next, we can determine whether the senior is within that area and how long they have been there. The formula is as follows:

$$Al = \begin{cases} 1, W_{User} > S_{i,t} \\ other, W_{User} <= S_{i,t} \end{cases} \tag{2}$$

In Formula 2, W_{User} stands for the length of time that the senior's transmitter has been within range of the receiver; $S_{i,t}$ stands for the receiver's setting of time lingered. When Al equals 1, it indicates that the senior has been in a certain area for longer than the time set; if this is the case, the system issues warning to the family. The receiver forwards the beacon's message to the server, and the server analyzes the message, reducing

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the receiver's computational complexity. Our proposed system can assist in understanding a senior's condition at home; its simple features also alleviate seniors from IT adaptation difficulties.

III. PERFORMANCE

The software and hardware equipment applied in this study are shown in Table 1. The server's operating system is Windows Server, the database is Microsoft SQL Server, and the programming language used for development is C. The beacon transmitters employ software and hardware developed by the company April Brother [6]. As shown in Figure 2, we use the Arduino development board to connect to Wi-Fi and Bluetooth in order to receives messages and forward them to the server.

Table 1: Software and Hardware Equipment

Software	Hardware
Windows Server	Beacon
C Programming language	Arduino
Microsoft SQL Server	wifi sensor
	Bluetooth sensor

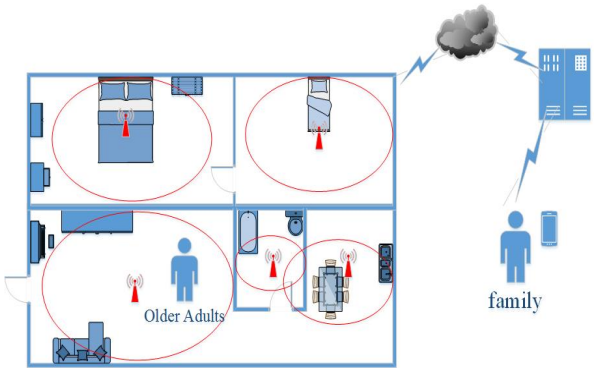

Figure 1: Illustration of the System

Figure 2: The Beacon Receiver

IV. CONCLUSIONS

This study's proposed scheme utilizes beacon technology to monitor the daily life and activities of elderly who live alone. Given the beacon's advantage of long battery stamina, this will reduce information technology adaptation challenges for the elderly while providing analysis of their at-home behavior based on the time they leave and stay home. Additionally, beacons can be used to analyze the elderly's condition when staying alone at a certain area to prevent dangerous incidents. Our proposed scheme is simple and thus advantageous towards practical application development; the software and hardware employed are low in cost, which facilitates product popularization and reduces financial burden for the elderly.

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REFERENCE

[1] Ministry of Foreign Affairs, Department of NGO, "Ageing Society's Huge Challenge Towards Social Benefits." http://www.taiwanngo.tw/files/13-1000-9962-1.php?Lang=zh-tw.

[2] Jen-Feng Huang, Guey-Yun Chang, and Gen-Huey Chen, "A Historical-Beacon-Aided Localization Algorithm for Mobile Sensor Networks", IEEE Transactions on Mobile Computing, Vol: 14, Iss: 6, June 2015.

[3] Leslie Mertz, "We carry our smart devices with us everywhere—even to bed—but have we been sleeping with the enemy, or are cautionary tales overinflated?", IEEE Pulse. 2016.

[4] Ao Buke, Fang Gaoli, Wang Yongcai, Song Lei, and Yang Zhiqi, "Healthcare Algorithms by Wearable Inertial Sensors: A Survey", China Communications, Vol: 12, Iss: 4, April 2015.

[5] Vijayalakshmi Ahanathapillai, James D. Amor, Zoe Goodwin, Christopher J. James, "Preliminary study on activity monitoring using an android smart-watch", Healthc Technol Lett. 2015.

[6] April Brother, https://www.aprbrother.com.