

The Application of RFID to Healthcare Management of Nursing House

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Abstract The economic development and the changes of social demographic structure have resulted in the problems of population aging sharply and elders' chronic diseases getting serious. Population aging has become a critical problem in modern societies, and senior houses have become a primary option for the life care of elders. However, the regulations related to long-term care are not keeping up with the speed of population aging; also, the lack of caregivers cause the elders not receiving enough care on either outdoor or indoor activities from senior houses. Besides the lack of manpower, an effective healthcare management system is needed to solve the major problem. RFID used to apply on the identification in logistics industry and this technology has become more mature. RFID is now gradually applied to medical business and healthcare for elders. This study intends to replace traditional manual operation with the establishment of RFID positioning monitor and management system in order to reduce manpower as well as continuously transmitting data to the back-end server for real-time monitoring and post enquiry; the data in the database could also become the reference for risk evaluation and healthcare security. Moreover, the system provides not only personal tracker but alerts to secure healthcare so as to reduce chance of accidents happening in nursing homes. The integration of RFID with healthcare operation and information flow is proposed in this study, and the efficient management is also proposed to enhance the management benefits of nursing homes; therefore, this study is focusing on installing the equipment regarding to environment of senior house. The RFID auto positioning monitor system could real-time and continuously monitor and transmit seniors' physiological signals wirelessly through active RFID Reader and active RFID Tag to promote the quality of healthcare. Besides, the active RFID Tag could be embedded in a wristband with RFID electronic label, tied with elders to receive real-time elders' body temperature, location, and conditions for the information system.

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Caregivers in nursing homes therefore could understand the current situation of elders and monitor the seniors' situations to prevent accidents.

Keywords Radio frequency identification technology · Positioning monitoring · Elderly care · Monitoring management · Nursing institution

1 Introduction

1.1 Research Background

Recently, information technology (IT) has affected human civilization and societies. Progress of a country can also be determined by its information technology. Therefore, IT becomes an international indicator so that government has to invest a huge amount of funds in IT in order to compete with others. RFID technology used to be an emerging technology; on the other hand, it was not well-recognized to the market so that the cost was too high and this technology was difficult to be applied. However, RFID technology has become more popular since few years ago and it results in lower cost and being applied broadly. RFID was mainly used to identify packages on logistics, but now, it can be applied from medical services to patient diagnoses, such as body temperatures and conditions. Moreover, in enterprise, the access control system and routine inspection could be more efficient by using RFID technology. Thus, IT technology is one of the future developing directions for nations and enterprises to maintain their level in the global village.

Chen [1] mentioned the main use of RFID is in manufacture, commodity flow and logistics. Also, sticking an RFID tag on an object for transmission can have the target be traced with the reader whenever it was in or out. The purpose of tracing an object or semi-product is to monitor the transporting schedule or manufacturing schedule. Nowadays, smart phones are popular so that mobile technology must be the future focus, and the characteristics of RFID are the crucial point.

At present, RFID is more user-friendly, and, due to the high usage of smart phones, "mobile technology" becomes the major development in the future. RFID has infiltrated into our daily life, for example, photoelectric technology, micro-computer technology, image processing and recognition technology, that its application is growing wider and wider. This is one of the reasons why enterprises and social organizations implement RFID to improve the operation procedure and increase the efficiency. With the improvement of 3G mobile technology and IT technology, RFID readers becomes easier to be carried around and applied to the future daily life. However, some obstacles appear when RFID technology is widely used, such as the security problem in message processing and transforming. If there is any efficient solution, RFID technology will be extremely helpful to enterprises and social organizations for management.

1.2 Research Motivations

In view of modern social construction, the elderly population has been growing and the younger's are focusing on their career resulting in less care of the elders. A lot of families usually send the elders to the senior houses. The administrators of retirement homes have the responsibilities on the elders' life safety. There are some tragedies of elders dying to

falling on the ground and they were not sent to hospital in time resulting in irretrievable accident. Besides, when an elder gets lost on the street, the retirement center should take the huge responsibility as well. In this research, RFID intends to decrease the probability of such accidents taking place by replacing traditional manpower management with locating technology and physiological monitoring. Moreover, when there is not enough employee of senior house to inspect locations and body conditions of elders at night, the system, which can sense the body conditions, would be capable of sending alerts to the manager immediately if certain values are unstable.

Monitoring elders' conditions through RFID technology in a retirement center allows the manager managing the patients more effectively. Using a management system can not only record elders' physical conditions but also prevent old people from going to certain unsafe locations so as to avoid unpredictable accidents. In addition, RFID allows the manager knowing the service quality through the Internet to achieve the purpose of far end monitoring.

This research proposes efficient ways to decrease the risk and increase the management efficiency for nursing homes by evaluating all conditions and variables such as environment and location.

RFID is extremely tied to our life nowadays so that it can even be put in other use like pet management and babysitting. If the system is stable enough, it can be used for many different kinds of industries to reduce the cost of management. The followings are the research purposes.

1. Locating the elders in the retirement center to prevent them from getting lost and accident.
2. Recording the data of position and physical information of the elders as the reference for preventive medication.
3. Reducing the cost of time and manpower with digitalized technology of patrolling, it can also improve the efficiency, monitoring the elders in 24 h.
4. Organizing the system and making its process easier in order to have senior houses implement it faster.
5. Understanding and implementing specific position monitoring system for retirement centers.

2 Related Works

2.1 Wireless Sensor Networks

The idea of wireless sensor networks came from smart dust project from UC Berkeley and this project was invested by the Defense Advanced Research Projects Agency in USA. It was originally designed for the military purpose. However, researcher had developed a sensing node in the size of aspirin pill. The wireless sensor networks technology is a combination of sensor, arithmetic and network. The data that is collected by sensors will be calculated before sending to users through wireless network. Then, users can apply these data with own knowledge to offer advanced service.

A common wireless sensing network system first scatters about sensor nodes in a sensor field to collect the external data like temperature, humidity, and luminosity. The next is to link sensor nodes together in a communication network with its self-organization protocol. Then, the system will transmit data to the data collecting device by one-hop or multi-hop,

the last step is to send data from a collecting device to the user or the manager. The wireless sensing network has the following characteristics [2].

1. **Low cost:** For the purpose of collecting broad data, installing abundant sensor nodes is necessary. Also, it requires wireless communication to transmit data between these nodes. Thus, it is an important topic on balancing the price and efficiency of the wireless sensor network system. However, keeping the cost low is needed in order to make the system able to be applied broadly. Therefore, many researchers decide to use simulator to reduce the cost, and it makes the sensor nodes more efficient and the price lower.
2. **Low power consumption:** To keep the data complete and accurate, sensor nodes have to continuously collect data. It makes the wireless sensing network require high power consumption control to save electricity. Some experts mentioned [3–5] that it could be reached by agent nodes, through dynamic power supply. As the result, the power consumption of sensor nodes becomes lower.
3. **Small volume:** In the sensor node network, each node contains more than one sensor nodes and each sensor node must be able to hold a radio transceiver, micro-controller and battery. It is necessary to limit the size of a sensor node for better setup and maintenance.
4. **Short Radio transmission range:** Taking Zigbee as an example, it usually sets 50–100 m as the transmission range in order to achieve low power consumption, low cost and short distance with maximum 100 m. In addition, the short range of radio transmission can increase the lifetime of the sensor nodes by reducing its power consumption.
5. **Network topology:** There are three main kinds of network topology including star-shape, mesh and tree diagram due to the short range of radio transmission. A wireless sensing network, also called a special Ad Hoc Network, doesn't need any basic construction but can be a self-independent network environment with wireless communication equipments.
6. **Fault tolerance and self-configuration:** The sensor nodes might suffer from shifting, damaging, or out of battery that they require fault-tolerance and self-configuration. Especially in the high density network environment, fault tolerance plays an important role in preventing whole system from shutting down due to few broken nodes. Therefore, researchers will modify each node to be a terminator or router when needed. In comparison, it is a huge difference to traditional wiring network.

2.1.1 Wireless Sensor

Regarding to the development of embedding technology, small electric devices can be embedded with sensing, arithmetic and communication functions. This type of sensors not only detects external environment data, but also analyzes them. A normal sensor node can be discussed in four parts, including sensing unit, processing unit, transmitting unit and electric unit [2].

1. **Sensing unit:** including sensors and analog-to-digital converters. A sensor is to collect external environment data like temperature and sound, while an analog-to-digital converter is to convert the analog signal to the digital format.
2. **Processing unit:** including processor and storage. Processor is responsible for all signal arithmetic after it is completely converted, while storage memorizes the collected data.

3. Transceiver unit: transmitting data to a wireless collector by IR or fiber-optical communication medium.
4. Power unit: supplying the power for sensor nodes and usually being made up by batteries.

Besides the foregoing four units, the sensors can also depend on their particular applications to create new functions. For instance, it can recognize the sensor site's positioning system, enable the sensors to take actions, and afford battery energy to produce unit.

2.2 The Foundation of RFID

RFID (Radio Frequency Identification), also known as electronic label, is a technology using Radio Frequency signals for automatically identifying a target and obtaining information. Basic RFID system includes tag, RFID reader, supporting application software. A tag is composed of chip and antenna. Every tag has a unique electronic code and is attached to an object for the identification. An RFID reader controls the RF module sending reading signals to the tag, receiving the tag's responses, and decoding the label object identity information. After the identification, it transmits the identity information and its relevant information to the host for further process. Several researchers have indicated that Radio-Frequency Identification (RFID) technology is a wireless sensor technology based on the detection of electromagnetic signals and contactless technology [6]. The main task of RFID is to provide an easy way to use an unambiguous and wireless way for identifying an object (goods, living beings etc.). This is achieved by allowing an RFID scanner (scanner, reader) to read the ID code and other information of an object from a passive/active RFID tag (transponder, tag, label etc.) from distance. Also, this information usually has been written by a RFID writer (writer, printer). A multi-frequency radio signal is used as the carrier frequency. With a responding time less than 100 ms, an RFID reader can instantaneously read many (several hundred) tags virtually. Tags coupled with sensors can provide important information on the state of goods, for example, temperature of refrigerated goods, problem areas identified and alarms raised [7]. Since this technology has been providing the simultaneously non-contact identification of multiple objects, the information-processing performance is increased which in turns of reducing the number of staff required. Moreover, RFID tags are rewritable and can contain much more information than a barcode does. RFID has been compared with other electronic labels such as bar codes and magnet strip cards. Hu and Li [8] showed that RFID needed more costs to build on, but the efficiency was higher and relatively safer. An RFID tag does not require direct visual contact with the scanner, this means that the object RFID tag does not have to be in the same orientation in the space as the scanner.

Domdouzis et al. [9] reported that the reader could be configured either as a handheld or a fixed-mount device. There was an emission of radio waves from the reader in ranges up to 100 feet or more, depending on its power output and the radio frequency used [9]. RFID tags can be distinguished into two categories, depending on their data storage capabilities of Read-Only and Read/Write Tags [10]. Most read-only tags do not have data storage capacity. They only have a unique pre-written ID pointing to a database, thus providing information about the object to the tag which is attached. Recently, RFID is a similar concept to bar coding [11]. It is seen as a means of enhancing data processes and complementary to existing technologies. As RFID systems have become more widespread, advances in technology lead to smaller and cheaper elements. Radio frequency

identification technology has been applied to many business areas and retail management to simplify complex processes and gain important benefits.

2.3 RFID Technique Applications

As an integrated part of our life, RFID increases the productivity and convenience [12]. RFID is a revolutionary application of automatic identification and data capture technology. Ashokkumar [13] pointed out that RFID applications could automate the collection of information about the movement and location of assets, components, stock or other items. Moreover, it could make the process quicker, cheaper and with greater accuracy and reliability than the equipment with manual methods. Also, RFID could acquire more details from a machine which obtaining techniques, such as bar-coding. Data collection can be a by-product of other activities, eliminating the need for efforts in filling form. Identifying the RFID of product use is quicker than barcode scanning or manual entry for product details. At the same time, with the development of the application making decisions based on RFID reader data, RFID technology has been widely adopted in routes recognition [14]. Roberts [11] investigated that RFID was used for a wide variety of applications, from familiar building access control proximity cards to supply chain tracking, toll collection, vehicle parking access control, retail stock management, ski lift access, library books tracking, theft prevention, vehicle immobilizer systems and railway rolling stock identification and movement tracking. Numerous organizations plan to install RFID in their operations in order to take advantages of a more automated and efficient business processes [15]. Furthermore, the benefit and cost of using RFID for the supply chain management are analyzed and promoted. For example, it can increase the efficiency and decrease labor costs for whole supply chain. Chen et al. [16] used Return-On-Investment (ROI) analyses to show that RFID implementation was effective and feasible. During an emergency, it was important that evacuees could be directed efficiently. In addition, Wu et al. [17] explained that an emergency evacuation system was designed with a wireless sensor network, RFID location technology, and mobile application. It could effectively guide people along an evacuation path by using a well-marked arrow when in danger mode and provide the information of the environment in normal mode. Furthermore, the emergency evacuation system could be linked with fire-fighting equipment or a station house to make a building safer and smarter. Moreover, Hu et al. [18] combined the handhelds based on RFID in the BTS routing inspection system of Guangzhou Mobile Communication Co., Ltd. and not only designing but also developing the Base Routing Inspection Management System, which could analyze and visually display the situation. The application of the Radio Frequency Identification Device (RFID) technology of BTS equipments routing inspection may provide automatic and intelligent means for operating condition information and maintenance information of BTS communication equipments. It can be indicated by the application results that the system can not only effectively patrol processes, but can also improve the efficiency of equipment inspection greatly and reduce the patrol officer's workload of data input when returning back to the management center; and, when RFID is used for a new medical sensor technology, it is expected to increase the usage of smart phones being for medical purposes because of its light weight and portability [19, 20]. RFID tags can contain more data than identification numbers. For example, they can include information about the host object, if RFID tags are combined with sensors; and, they are able to save some information in the closed place. For instance, temperature and humidity can be sensed and stored in the tag [21]. Specially, the US

military and United Kingdom armed forces have used RFID systems for years to control their warehouses and supply chain [22].

According to above research, it can be informed that RFID technology has been widely used in many applications and domains in various industries in both internal and overseas markets, such as aeronautics and medicine. The paper applies RFID technique to creating a system for caring about the health of aged people and achieving the goal of service quality and preventive care.

2.4 RFID Technique Applied to the Elder Health Care

There are some articles about RFID on elder health care. Eungyeong et al. [23] mentioned that u-Healthcare system could perceive emergency situations in chronic hypertension patients and initiate emergency action. The proposed system considered about patient mobility and integrated system agents in an RFID with cell phone architecture based on medical recommendation knowledge and communication protocols. The developed system could supply information to assist patients in regular health management and emergency situations. According to home accidents occurring from world's aged population, especially with the stumble and falling of the elderly, mortality and morbidity from falls have become one of the major issues in the healthcare system. In developed countries, most falls occur at home or in communities [24]. Wang and Chen [25] proposed a design of RFID-based home emergency and notification system with GSM, 3G video services and two-way radio functionalities for elders to avoid falls and any other home accidents. The goal was to provide emergency services through the help of real-time SMS messages, video images, and voices so that it not only reduced the response time of caregivers for early treatment of the patients but also saved their lives as well as decreased the healthcare costs. Lu [26] constructed a long term information healthcare platform to help elders get better medical services and built the health documents to upgrade the caring quality. It was made up by four basic systems, including the system being able to filter out the one who might needs help and proper medical resources, the long term management system to integrate the caring service resources and arrange the resources, dementia system to estimate the conditions of user mind for better way to take good care, and indoor and outdoor RFID safe care system to prevent elders from going out alone or entering the dangerous area. Mateska et al. [27] explained that the growing number of elderly people was increasing the demands for living assistance like permitting the elderly to live safely and independently in their own homes. The thesis proposed an integrated In-home elderly care solution, which was enabled with wireless sensor network and RFID technology. The solution assisted in living and improved the care of elders through home surveillance, item and medication usage reminder and early warning of potential dangerous situation (e.g., fire, gas leakage). Chen [1] also constructed an open system containing client, backstage system and database. The family could not only submit the RSS to update the current information through the web server system, but could also leave questions on. It was an easy, low-cost and efficient platform. In view of above reference, there are some precedents about the RFID application to elders' healthcare that this research directs to locating and monitoring. The Receive Signal Strength Indication is used as the basic algorithm, meaning that the signal will decay as the distance gets far. According to the distance, the signal will decay as farther it goes, the weaker the signal becomes [28].

Above all, there are previous cases on elder healthcare; so, this research is based on the Received Signal Strength Indication calculation revealing the intensity being due to the

distance. Therefore, the RFID application is planned and the errors of RSSI, such as environment, reflection, diffraction or other problems, are reduced.

3 Conception of RFID Positioning Monitor and Management System

3.1 Purpose of RFID Positioning Monitor and Management System

With the changes of societies and industries, Taiwan has become an aged society. Furthermore, the family structure has also changed from big into small. Thus, the number of solitary elder is increasing on account of this phenomenon. Nowadays, many concerns including diet, weight, and blood pressure, are required for taking care of the elderly. More and more families are sending old people to nursing homes in order to benefit their living. This study attempts to use the information management to promote the service quality of a nursing home by providing the best healthcare to avoid unnecessary risks.

The advance of technology forces the extension of the use of 3C products especially mobile phones allowing people to use GPS throughout the Internet to reach the destination. Besides, Internet connection and wireless network have become a part of healthcare. These tools can speed up the service for nursing home. When a positioning system can be implemented on a nursing home's management level, the efficiency of taking care of the elderly will be improved. However, how to keep abreast elderly whereabouts and understand the environment and conditions of a nursing home is the main topic of this study.

Recently, RFID has been applied to more and more fields. Many references from many places, for example parking lots, have been achieved overseas. Putting RFID tags in a particular area allows the system monitoring where an object with RFID is [29]. This study thus tries to research and contribute a system with positioning function for a nursing home's objects, help it check where the elderly is at and understand the body conditions by keying in the serial number. With the portable device, the system can send out warnings to the manager and detect where the old people is when old people go out themselves without notification. With this function, nursing homes will reach the other level of services.

To sum up, this study tries to apply RFID to poisoned-supervising system and embed it in wristbands for the elderly. With this system, elders' conditions, temperatures and locations can be uploaded to the system immediately, and the staff can understand old people's situations and then improve the quality of looking after them. Besides, this study also wants to embed the wristbands with RFID to track the aged for recording the movement. It can ensure that caregivers are really dedicated themselves into job and the aged are doing routine activities, for example eating on time. Thence, the research objectives of this study contain the followings.

1. Locating and supervising where the old people are, preventing and shrinking the risks of getting lost and dangerous.
2. Grasping the whereabouts of the elderly and record their movement and physiology information; storing the aforementioned data as the reference of healthcare and reaching the target of preventive medicine science.
3. Improving the time-taken and monitoring the old people's conditions all day with information technology.
4. Scheduling system analysis and simplifying its information flow; increasing the possibility of importing system for developers.

3.2 Ideas of Contributing RFID Positioning Monitor and Management System

This study tries to design a system which allows locating and monitoring elders for nursing homes and helping them improve the service quality. The RFID positioning monitor and management system will support managers and medical staff when they are monitoring physiological conditions and locations of the elderly. Through electronic RFID tag wristbands, which would immediately return the message of body temperature, a manager can monitor the data diagram of the system to understand the physiological information about the elderly to prevent them from facing accidents and danger.

Some elements should be considered such as user interface, positioning, algorithms, environment, RFID Tag condition, and signal and cost. In the user interface, for the purpose of quick-start, it should be concise and explicit so as to benefit future education training; it should consider the best way to achieve positioning relating to RFID Reader's allocation; the algorithm needs to consider its optimization mode to make the system with the most efficient path; the environment of a nursing home's circumstance should be understood. Hence, inference from other signal and confusion will influence the accuracy of positioning; RFID Tag should fit the size of a nursing home. Also, contributing an appropriate wearing way is important in order to prevent misalignment; Moreover, the signal intensity of RFID Tag is waving within particular range thus close signal will be influenced. This situation should map out an implementation to revise the positioning error, while the cost, size and requirement of nursing homes should be well comprehended. Equipment is purchased based on these to prevent unnecessary cost waste. All the decisive factors above will influence the RFID positioning monitor and management system being successfully installed.

This system uses RSSI to detect old people's locations and combines with wireless networking technology to detect old people's body temperature or be aware them staying in safe areas. The system will return all information to the rear-end system and save it. When family members take the elderly to a nursing home, the staff will help them to register and complete the old people's personal profiles into the system, and then give the elderly electronic RFID tag wristbands with serial numbers for the system monitoring these old people's positions.

The system can automatically check if an old person stays in safe areas and its physiological conditions. Followed by Active RFID Reader, which will read signals from an RFID tag, the system (application software) starts the procedures of identification of Active RFID Reader. Active RFID Reader will send its signal via radio waves to detect the chip in an electronic RFID tag wristband and upload information to the database, and the rear-end application systems will then catch information and do data analyses. Next, when the system sorts out the useful information, the manager can understand the current position and physiological conditions of the elderly.

When an old man leaves the nursing home, the system administrator will cancel the recorded data of electronic RFID tag wristband in order to avoid wasting resources on utilization. The basic RFID technology process is shown in Fig. 1.

From all the information above, when RFID can be applied to a nursing home's positioning monitor system, it will improve the service quality in huge. Besides, nowadays, the demands for elderly care are growing. With comparatively speaking, nursing homes should also be improved. Nursing homes should provide strategies as insurance, making

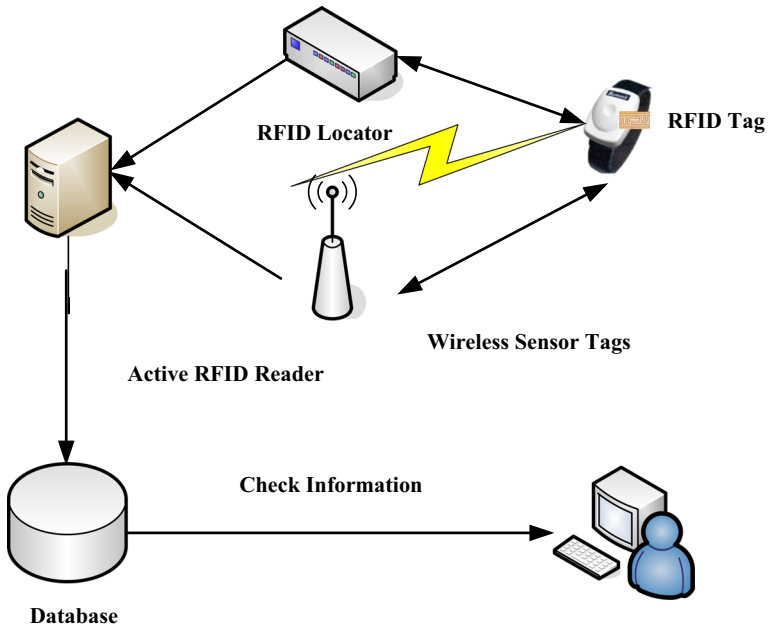


Fig. 1 The basic process of RFID positioning monitor and management system

family members feel relieved that a nursing home is capable of providing well-services and old people can live in group comfortably.

3.3 The Advantages of RFID Positioning Monitor and Management System

In past years, RFID was not popular in markets because the installation fee was high. Fortunately, with the advance of technology, RFID is getting mature; besides, the cost is lower. The technological advance leads to declining costs of hardwares so that more and more enterprises adopt RFID to add the company. Compared with other automatic identification systems, RFID has its own advantages but there are also some restrictions. The main traits are explained as follows:

1. **Non-touch automatic identification technology:** The system uses Wi-Fi to induce the signals from electronic RFID tag wristbands within the sensing range. Different RFID Tag antenna and devices will have different characteristics and sensing distances.
2. **Recognizing at a high speed:** The time for RFID Reader to read the RFID tag wristband is very short, and therefore, it can be used in real-time positioning function for grabbing the location of an elderly at any time.
3. **Good penetration:** When the antenna begins propagating the radio waves, the electronic RFID tag wristband will be started when receiving the signal for automatic coding. This system can penetrate paper, wood, plastic and other materials for communications.
4. **Recognizing in long distance:** The active RFID reader's specifications, antenna and the length of frequency will determine the distance identification distance. Active

- RFID Reader can detect multiple electronic RFID Tag wristbands in at 320 km per hour within 100 ms, which increases the information-processing efficiency.
5. **Accessibility:** A non-contact sensor can directly access the data in the system. It will shorten the operation time and reduce the risk of human errors.
 6. **Reusability:** Electronic RFID tag wristbands can be recycled and reused many times. It will also decrease costs for enterprises.
 7. **High data safety:** Data can be encrypted and decoded, which decreases the possibility of information exposure.
 8. **Big storage:** The storage can be up to 1 MB, providing the system with a very flexible space.
 9. **Accessing data with high accuracy:** When detecting one or more electronic RFID tag wristband signals, the system will synchronically process auto-recognition and management, which will make data more precise.
 10. **High-abrasion resistance:** The protective material on the wristband RFID tags is wear-resistant and waterproof. Thus, electronic RFID tag wristbands can be applied to dark or poor environments in order to achieve the effect of automatic identification.

According to the characteristics of RFID above, this study aims to use its technical traits to set up the RFID positioning monitor and management system. The fundamental purpose is to identify the safety of the elderly hosted by the family. The ability to understand the situation of an elderly through the system is the purpose of preventive care.

Traditionally, the staff in a nursing home can determine to patrol each room and then record the results on the inspection form. When encountering elderly physical discomfort, it would inform people in charge of precautions checking and eventually fill the form for records. After the inspection is completed, all information will be input to the computer to

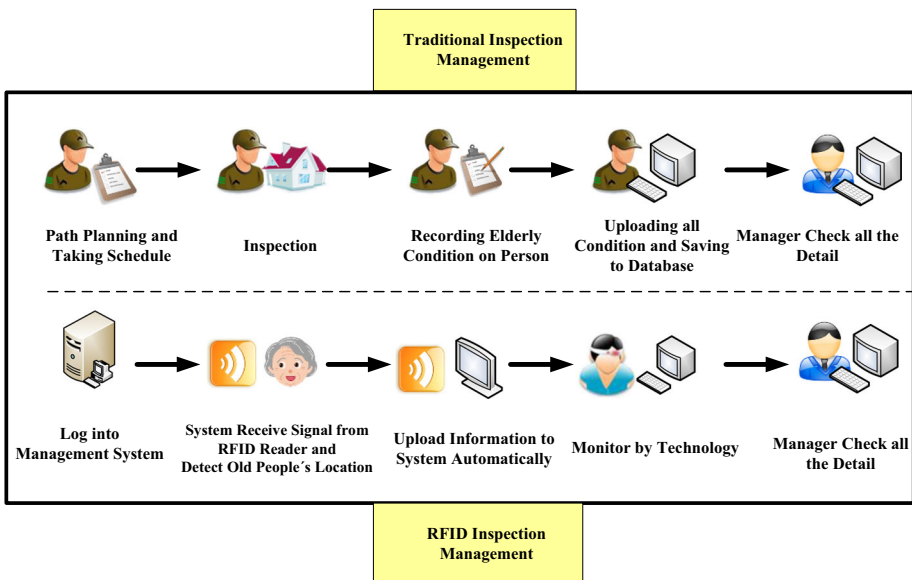


Fig. 2 The comparison of traditional inspection management and RFID inspection management

complete the inspection operations. It means that the traditional way of inspection is based on human recourses and there are many practical problems existing.

Most traditional inspections are regularly conducted by the staffs, who record all information by handwriting, and then key in the data for follow-ups. Obviously, this approach will slow down the inspection process and the transcription lacks efficiency. In addition, traditional inspection will increase workload on the staff and it is impossible for people to monitor the elderly 24 h. Hence, this study attempts to use RFID technology for monitoring, locating and improving the traditional inspection practices through information-oriented ways to achieve the goal of preventive care for the elderly.

Figure 2 shows the comparison of traditional inspection management and RFID inspection management. It can be concluded that the RFID system can detect and upload the information of old people's locations and body temperatures automatically. The manager or system administrators can notice old people who should be paid more attention to when checking the data. Besides, with the RFID system, labor costs will be cut, required information time will be reduced, and the efficiency of inspection will be increased, which means that nursing homes can promote its efficiency with this system.

As for the locator, there are many different kinds of equipment pieces applied as positioning tool, such as active RFID, passive RFID, infrared ray, ultrasound, camera, wireless network, and pressure sensors. Table 1 illustrates each tool's advantages and disadvantages.

From the information above, this study chooses active RFID because of a nursing home's environment. With active RFID detecting technology, the setting of electronic RFID tag wristbands will help attain the goals of nursing homes' safety management and efficient information technology management.

4 Setting up RFID Positioning Monitor and Management System

4.1 The Structure of RFID Positioning Monitor and Management System

Before setting up the system, all the equipment should be located based on the environment and hoisted the accuracy of positioning. It is required to set up the interface at the

Table 1 The comparative advantages and disadvantages of different devices

Devices	Advantages	Disadvantages
Active RFID	Can be used in long range of area	Batteries are needed
Passive RFID	Send signal without electricity	Sensor range is limited
Infrared ray	Low cost, High accuracy	Only point on point, small sensor range
Ultrasound	High accuracy in close range, Low cost	Easily influenced by environmental interference
Camera	High accuracy	Easily influenced by environmental interference
Wireless network	Can be used in wild range of area	Easily influenced by barriers and other electronic frequency
Pressure sensors	High accuracy	Sensing range is limited

beginning, including choosing active RFID Reader, settling down fiducially point, and setting up positioning point. After modifying all settings, it will receive the information from RFID Tag, and then the algorithms of signal strengths are selected to calculate signal strengths and storage data. In the end, a positioning method is selected to do error analyses. With all the processes, this system will sent all the information to rear-end efficiently.

This study intends to place active RFID Readers into different simulation environments. Active RFID Reader can read the corresponding locators' and electronic RFID tag wristbands' signals within 100 m; each information will be stored to the rear-end throughout the Internet and then process RSSI. The environment of this study is in an elongated and grid area. Also, the database can start grasping all elders' location information after setting names in this block. In this environment, every active RFID Reader should keep distance from each other in order to avoid signals interrupting each other. Besides, active RFID Readers should be able to cover whole area. This distribution of locator equipment is illustrated as Fig. 3.

A positioning monitor and management system is mainly used for rear-end management. It will help manage the elderly who wear electronic RFID tag wristbands. As the result, the administrator can easily manage and monitor. When an administrator logs into the account, the system will start to operate and transmit signals. With algorithms to calculate the coordinates, active RFID readers and locators will start to detect the elder and then transmit data to the system. In order to make this monitoring system become more accurate, there are four main operating parts in it, namely "personal profile management", "real-time location monitors", "emergency return", and "system management", as Fig. 4 shows.

From the process above, the system allocation will be set on administrator's perspective based on nursing home's demands. There are four main functions in the study, personal profile management, real-time location monitoring and emergency returning to system management. With these four functions contributing to the system program, it will make developers be capable to understand the RFID positioning monitor and management system clearly and increase the possibility of guiding this system into nursing homes.

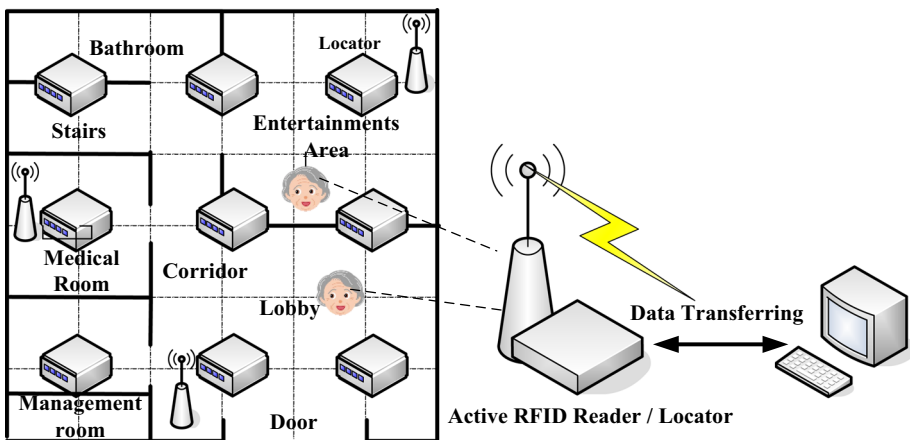


Fig. 3 Diagram of positioning equipment distribution

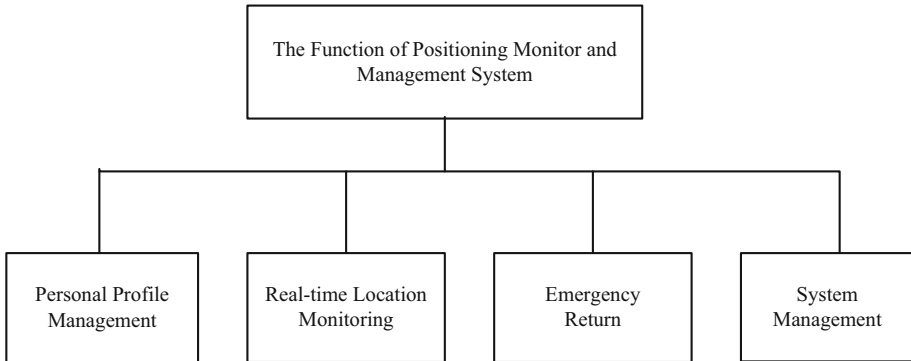


Fig. 4 Four main function of positioning monitor and management system

4.2 The Function of RFID Positioning Monitor and Management System

This study intends to simplify and reorganize the old system design to have administrator develop with those analyses, making this system able to enter nursing homes much more easily is one of the purposes in this study.

There are four main parts in the RFID positioning monitor and management system, including Personal Profile Management, Real-time Location Monitoring, Emergency Return, and System Management. In this section, the above functions will be discussed in details as follows.

4.2.1 Personal Profile Management

“Personal profile management” is a function for a manager to control basic information for the elderly, including “add”, “search”, “delete”, and “RFID tag condition”, and each function is described in details as following.

1. Add: When people are moving to nursing homes, the personal information is needed, where “name”, “gender”, “ID”, “birthday”, “age”, “address”, “contact number”, “marriage”, “children”, “financial situation”, “emergency interconnection”, “illness”, “illness of the past” are involved. These data will be unloaded into the system database, and then the system will issue a RFLD electronic tag wristband with a serial number to the particular old person. With the serial number, not only the system but also a manager can recognize a person’s status.
2. Search: This function allows managers browsing registered data and the information about who has already left the nursing home. The main idea is to support a manager filtering data without wasting time and improve the manual mode in order to raise the efficiency. Also, this function allows medical personnel understanding what disease an elderly has. Moreover, medical personnel can connect family’s emergency contact person quickly when some emergency things happen.
3. Delete: “delete data” and “dropout” are two sub-functions under “delete”. “Delete data” is a button to delete the information of old people who have been registered. This function is only for top managers in order to prevent inevitable mistakes. “Dropout” allows managers cancelling an electronic RFID tag wristband and releasing it for the next user to avoid wasting resources.

- RFID Tag: With this function, administrators or staff of a nursing home can check the registration condition of electronic RFID wristband tags; all “in-use”, “valuable”, and “under repairmen” can be confirmed in this feature.

However, with safety issue being concerned like deleting the data without the authority, permission to browse personal profile will be limited. Not only does “Personal Profile Management” under this function contribute to the system database, but wristbands with electronic RFID tag will be postulated as well so that the system can catch the location information of the aged.

4.2.2 Real-time Location Monitoring

“Real-Time location Monitoring” allows managers checking whether old people are staying in safe locations, recording and being acquainted with old people’s movement, like moving from a rest area to a scenic place, and then proving different medical help. These sections are “check people’s location” and “check location record”, respectively. When clicking “check people’s location” with active RFID, the system will automatically display where the old people are, and then a manager can notice if they stay in safe areas, buffer areas or dangerous sections. If the elderly stays in a dangerous field, caregivers can warn them and succeed in averting from accidents. The system illustration is shown as Fig. 5.

The real-time positioning and monitoring technology in this system proceeds positioning and monitoring through a wrist-band with active RFID tag, in which antenna, logic,

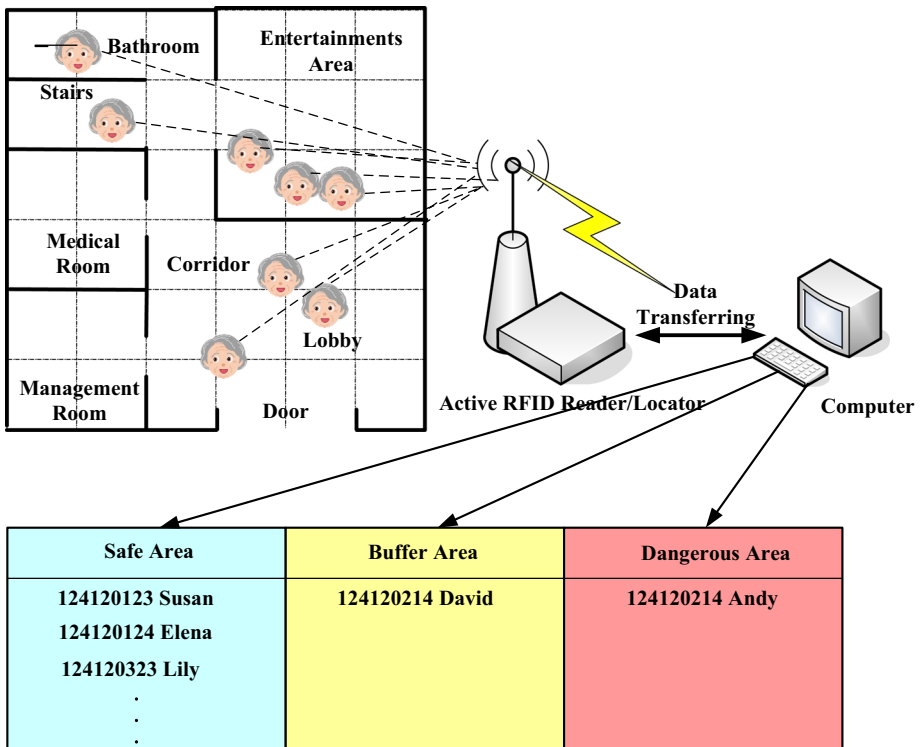


Fig. 5 Illustration of checking people’s location

and IC chip are contained. The chip stores the recognition data of the monitored, and the application of antenna and logic could completely emit and receive information for the positioning function. Regarding the positioning function, the signal attenuation RSS or Trilateration is applied to the calculation, aiming to calculate the location of the monitored in the house. PL stands for the signal attenuation RSS function related to distance, which is calculated based on the signal attenuation; the precise location of the active RFID tag wrist-band could be acquired through the following equation and the set-up of reader angle.

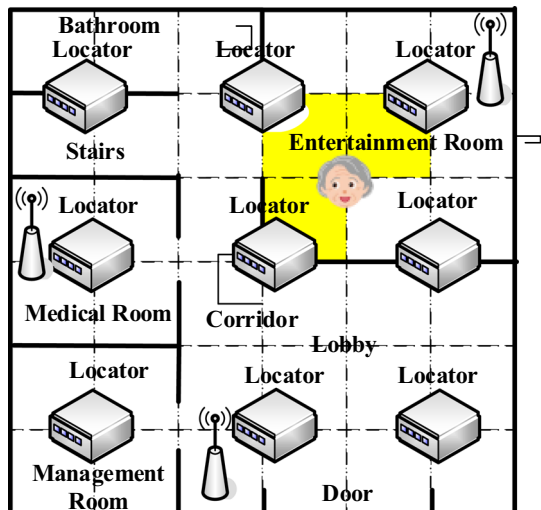
$$PL(d) = PL(d_0) + 10 \times n \times \log\left(\frac{d}{d_0}\right) + X_p$$

In addition to RSS, Trilateration could also be applied. Since a lot of RFID readers, as the locators on the diagram, are set up because of environmental factors, the target could be positioned simply by some reference points emitting signals. ToA or RSS could be applied to estimate the distance between points; the location of the monitored could be precisely positioned by more than three locators. Furthermore, the location could be easily calculated by the application of reference points and known locations on the map; the system could calculate the location through the following equation.

$$\hat{d}_{x,y} = \left| \sqrt{(x - x_A)^2 + (y - y_A)^2 - r_A} \right| + \left| \sqrt{(x - x_B)^2 + (y - y_B)^2 - r_B} \right| + \left| \sqrt{(x - x_C)^2 + (y - y_C)^2 - r_C} \right|$$

As the above Fig. 6 shown, assuming that a monitored with an active RFID tag wrist-band is at the lounge and the environmental locators are distributed as the above figure, the system could find out the location of the monitored by the signals emitted from the active RFID, according to three or more locators, the above positioning rule, and the back-end calculation; such a location is kept in the active record in the system for the information storage. When the monitored is found at the place with higher risks of accidents for too long, the accident process would be started.

Fig. 6 The environmental locators' distribution



This system will record old people's movement, thus, when managers click "check location record", they can look over the information of date and time to see if a person often goes to dangerous places or is sleepless during midnight and walks around somewhere else. This information can be the reference for managers and caregivers.

4.2.3 *Emergency Return*

In "emergency return", the system will monitor and upload physical information like temperatures and heart rates of old people to support nursing homes providing services. Human beings are limited by body vigor, which means that it is impossible for a person supervising old people in 24 h. With system management, caregivers' responsibilities will be decreased. In addition, if electronic RFID tag wristbands detect the user tripping and going down with bumps, the system will send warnings to system administrators automatically. Besides, if an emergency happens, a user can press personal distress button to remind the manager in order to lower unnecessary risk.

4.2.4 *System Management*

Top managers and system administrators are the main operators, and maintaining the system regularly and monitoring system safety are the most important obligation. Under system management, top managers or administrators can allocate rights for common people. If an error appears during active RFID reader and RFID tag locator in the detection process, the system administrators will fetch data and go to back-end doing maintenance to sustain the system stability. There are four primary functions as "rights management", "internet management", "date transport configuration", and "backup", and each part is defined as below.

1. Rights management

In this part, different people are provided different right management power based on their job responsibilities. For instance, caregivers can only use real-time location monitoring function because they need it.

This part is to give managers power to set up the user's "account", "password", and "permission", by setting the account password and giving nursing home personnel permissions to the positioning monitoring system.

2. Internet management

The positioning monitor and management system is established by wireless network, and administrators should be aware of the typical amount of data transmitted. In this feature, system administrators can check the Internet transmission quantity. Throughout this, it can guarantee whether its resources are appropriate for using and allow the positioning monitor and management system being in normal conditions. On the contrary, the system will inform system administrators of some problems being noticed so that system administrators can quickly respond.

3. Date transport configuration

This feature is capable of checking whether there is anything abnormal when RFID Reader and locator transfer data to RFID Tag, in order to ensure the accuracy of positioning. When an error is found, the system administrator can analyze this data and then try to figure it out. In addition, if the connection abort signal appears, the system will send out an alert message to inform the administrators, allowing them to do an emergency repair.

4. Backup

Backup includes system sources and lists of staff. System administrators can transfer these database servers to another desk top, in order to reduce the risk caused by disasters or the loss of data.

Backup is an important venture capital in information technology, and all the data are important, thus, system administrators should backup data to ensure the security. Faulty operation or disaster will cost unexpected loss for nursing homes, even the closure of business.

5 Conclusion

This study proposes to apply RFID technology to senior houses for more efficient management, setting RFID position monitoring systems regarding to the environment of each senior house. Also, using RFID technology to wirelessly update real-time conditions such as body temperature, location, health condition, and physical variables for the elders with RFID Reader and embedded wristband tag is to improve the quality of nursing homes. Moreover, the cared attendee could be located in anytime with the positioning monitoring system. With this platform, it will create the emergency report, if attendees press the emergency button on their RFID tag wristband. At the meantime, the system will beep as alert after it receives the red signal, then, administrator can react immediately. Besides, with the position monitoring system, it can not only reduce the insufficient time of inspecting but avoid the waste of manpower. In addition, this system allows nursing homes that have installed the platform to inspect the elders' condition in real time. It helps not only improve the quality of care but sharply increase the efficiency of administration management. With the analyses of working process and system from this study, it is easier for system developers to apply, helping position monitoring system become more popular on the elders' care and prevent them from accident.

Future research could not only apply intelligent systems to combine with health information analyses, design decision support judgment and risk evaluation, and hasten intelligent medical services but also apply with RFID to integrate medical care and information communication technology in order to develop mobile healthcare services and products. Besides locating locally with active RFID tag, future RFID healthcare systems can additionally apply to video system and instant communications with the elderly and relevant personnel through the data in the database for emergency. What is more, proper services could be provided according to seniors' demands to achieve the customized health management. The connection of information technology and healthcare services allow the elderly healthcare to be more perfect and smarter for the idea of intelligent healthcare.

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