

Monitoring System for Patients with Mental Disorders based on RFID Technology

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Abstract

Based on the low efficiency of the supervision of patients with mental disorders in China, and the frequent occurrence of harm caused by mental disorders to caregivers and medical staff, the idea of using RFID technology combined with database and artificial intelligence technology to solve the problem of supervision of patients with mental disorders is proposed. By allowing patients with mental disorders to wear RFID tags, real-time positioning and tracking of patients with mental disorders can be achieved. Combined with a data collection and processing platform, their behavioral data can be analyzed to provide decision support for medical staff. At the same time, RFID and related technologies can also be used for drug management to ensure that patients take their medication on time and in the appropriate amount, avoiding missed or excessive medication. This system not only improves the supervision efficiency of patients with mental disorders, but also enhances the personal safety protection level of guardians and medical staff for patients with mental disorders, providing more efficient and comprehensive support and services for patients with mental disorders.

Keywords

Supervision of Patients with Mental Disorders; RFID; Location Tracking; Data Acquisition and Processing.

1. Introduction

In recent years, the state has issued the Opinions on Strengthening and Improving Mental Specialized Medical Services and introduced the Implementation Plan for Promoting the Construction of Mental Health Welfare Facilities During the 14th Five-Year Plan Period to support the construction of mental welfare facilities. It has also established a national mental disease medical center and promoted the construction of national regional medical centers to drive the construction and development of the national mental specialty field. Guiding principles for the treatment of mental disorders and specifications for psychotherapy have been formulated to build a systematic and standardized management system for severe mental disorders[1]. Through strengthening monitoring, improving service quality, protecting patients' rights and interests, and promoting public health, we will jointly address the challenges posed by severe mental disorders. At present, the main regulatory measures for mental disorder patients in China include: regularly cleaning the ward environment to ensure no dangerous items are present and prevent self-harm or injury to others; deploying sufficient staff to implement 24-hour monitoring to prevent patients from escaping or attacking others; and implementing special management for patients with violent tendencies, including protective restraint when necessary.

However, for mental disorder patients whose onset status is difficult to determine, the uncertainty of their behavior poses severe challenges to the medical environment. On one hand,

patients may exhibit potential high-risk behaviors such as self-harm, suicide, fighting, and attacks, which not only endanger their own safety but also threaten the safety of medical staff and other patients. On the other hand, patients may escape during free activities or medication collection, potentially causing injuries during the escape and greatly increasing the difficulty of management for medical staff. Therefore, this paper proposes an innovative concept of using RFID and related technologies to address the regulatory challenges of mental disorder patients, aiming to significantly enhance the management efficiency of mental disorder patients and strengthen the protection of the personal safety of patients, their guardians, and medical staff.

2. Overview of RFID Technology

RFID (Radio Frequency Identification), a wireless radio frequency identification technology, is a non-contact automatic identification technology. It uses radio frequency signals to automatically identify target objects and obtain relevant data through inductive coupling or electromagnetic coupling [2].

2.1. Principles of RFID Technology

The RFID technology is mainly composed of three parts: Tag, Reader, and Antenna. Among them, tag can be divided into: Passive tag, which does not contain a power source and is activated by the energy provided by the reader. When the signal from the reader and writer is received, the tag will send the information back to the reader; Active tag, which contains a built-in power supply, can actively send signals to the reader. The Reader sends electromagnetic signals to tags through an antenna to induce a current in the tag's antenna; it also receives signals transmitted by tags after they receive radio-frequency signals. The Antenna sends and receives radio-frequency signals to enable communication between tags and readers.

2.2. Advantages of RFID Technology

Compared with traditional information coding and identification technologies such as Barcodes and QR codes, the application of RFID technology in the monitoring system for patients with mental disorders has significant advantages: first, non-contact: tag information can be read without physical contact, which can effectively prevent dangerous behaviors such as attacks by patients when contacting custodians and greatly enhance the protection of the personal safety of patients with mental disorders and their custodians. Second, fast identification: the system can quickly identify a large number of tags at the same time with fast reading and writing speed, solving the chaos and low efficiency caused by patients' non-cooperation or illness during the traditional roll-call process and significantly improving the management efficiency of psychiatric hospitals. Third, good anti-interference and anti-destruction performance: it can be used in various harsh environments, uses electromagnetic waves to transmit information with strong anti-interference ability; by reasonably selecting tag materials, it can be made resistant to certain environmental conditions and can withstand a certain degree of physical damage such as high temperature, water immersion, wear, etc., to ensure long-term readability of data. Fourth, data security: data encryption for tags and readers can protect the data stored in tags from being accessed by unauthorized devices; encryption protocols can protect data from being intercepted during transmission.

2.3. Application Status of RFID Technology

RFID technology was first applied in supermarkets and shopping malls, enabling remote supervision of goods, self-service checkout, and anti-theft functions. In the transportation industry, it is commonly used for vehicle identification and highway toll collection systems (ETC), making highway toll collection faster, more convenient, and efficient. It is also widely used in logistics and supply chain management, such as inventory monitoring, product

traceability, and transportation tracking, which improves the transparency of the supply chain and enhances consumer confidence. In the medical service field, it can be used to manage medical equipment, identify patient identities, track medications, etc., significantly reducing medical errors caused by human errors and improving the quality and efficiency of medical services.

3. Design of a Supervision System for Mental Disorder Patients Based on RFID Technology

The advantages of RFID technology enable it to play an increasingly important role in multi-tag management and contactless reading and writing [3]. Therefore, considering the complexity and risk of supervising patients with mental disorders, designing a monitoring system that combines RFID technology with a data collection and processing platform can improve the management level of such patients while strengthening the protection of their custodians and medical staff.

3.1. Overall System Architecture

The application of RFID technology in the monitoring system for patients with mental disorders should adopt a hierarchical design to ensure the system's scalability stability and security with its overall architecture mainly including three aspects: first the perception layer responsible for data collection and preliminary processing including devices such as RFID tags readers/writers and positioners; second the network layer responsible for data transmission sending data to the server via wireless networks; third the application layer responsible for data processing analysis and interaction with the monitoring management terminal enabling real-time monitoring of patients and timely alarms in case of abnormal situations [4], as shown in Figure 1.

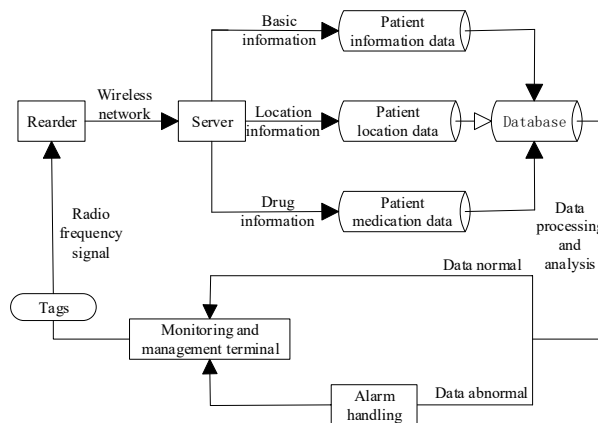


Figure 1. System architecture design diagram

3.2. System Hardware Architecture

The hardware devices of the RFID system are mainly composed of tags readers and antennas [5]. First tags are used to identify patients and contain personal information such as name gender age medical history and a unique identification code designed as non-removable wrist tags they must be worn and removed using special tools with an internal self-check circuit that will automatically alarm when subjected to strong damage [6]. Second positioners and readers should be installed in key locations such as wards corridors free activity areas and walls to enable real-time positioning of patients and receive signals transmitted by wrist tags. Third antennas are used to receive the radio frequency signals reflected back by the tags and convert these signals into processable electrical signals. Fourth monitoring and management terminals

include PC terminals and handheld devices which are used to receive transmitted signals and conduct real-time monitoring of patients wearing wrist tags.

3.3. System Software Architecture

The software modules of the RFID system mainly consist of a data collection module, a data processing module, a logic module, and a database. First, the data collection module is responsible for gathering data from RFID readers to ensure the accuracy and timeliness of the data. Second, the data processing module uses machine learning algorithms to remove noise, abnormal data, and duplicate data from the collected data, and then converts and compresses the data format to facilitate subsequent logical operations. Third, the logic module employs deep learning and neural networks to build an intelligent monitoring system, which can automatically identify and predict potential abnormal situations to realize core system functions such as monitoring and alarming. Fourth, the database module is used to store system data, including basic patient information, monitoring data, movement trajectories, alarm records, etc.

4. Design of a Supervision System for Mental Disorder Patients Based on RFID Technology

4.1. Information Registration and RFID Tag Issuance

An electronic file is established for each psychiatric patient, including personal information, blood type, allergy history, admission time, bed number, treatment plan, and a unique identification code. A non-removable wrist-type RFID tag is worn on the patient's wrist using special tools to ensure that each patient's identity is traceable, facilitating quick identification and management by supervisors and medical staff.

4.2. Patient Positioning and Real-Time Monitoring

RFID positioners and readers are installed in key locations such as rooms, corridors, and walls. The system monitors patients' positions in real time through these devices. Once a patient leaves the designated area, such as entering the wrong room or attempting to escape, the system immediately issues an alarm. In case of accidents or violent behavior by patients, the system automatically alarms, allowing medical staff to quickly determine the patient's location via the RFID tag and obtain critical patient information to take timely rescue measures.

4.3. Drug Management

RFID tags can be assigned to medications, and the issuance, usage, and remaining quantities of medications can be monitored through readers. When patients take medications, the RFID system records the administration time, dosage, and frequency to ensure that patients use medications correctly as prescribed. Thresholds and alarm mechanisms are set up so that when abnormal medication use or non-compliance with the medication plan is detected, the system automatically triggers an alarm to remind medical staff to take timely measures and ensure the safety of patients' medication use.

4.4. Data Analysis and Processing

After the positioners and readers capture information from the tags, the data is transmitted in real time to the server via wireless radio frequency signals. Following data cleaning and preprocessing, the information is categorized into basic details, location data, and medication records, which are then uploaded to the database. Visualization tools can display patients' geographical positions, movement trajectories, and medication intake status. Through statistical analysis and machine learning, the system can analyze patient data to proactively identify abnormal behavioral patterns and trigger timely responses. Additionally, it evaluates

the efficacy and safety of medications, providing personalized treatment recommendations for medical staff.

4.5. Monitoring and Management Terminal

The monitoring and management terminal can be divided into fixed monitoring computers and handheld pads, both of which can view the location information and medication status of psychiatric patients at any time to achieve real-time monitoring of patients. When an alarm occurs, the system will automatically remind the monitoring computer and handheld device, such as pop-up reminders, voice notifications, and automatic dialing, to ensure that someone responds and handles it within the specified time.

5. Conclusion

This paper designs an efficient, secure, and meticulous monitoring system for psychiatric patients based on RFID technology, integrating database and artificial intelligence analysis and data processing technologies. The system can realize remote monitoring and management of psychiatric patients' behavioral trajectories, medication conditions, abnormal behaviors, etc., so as to improve the supervision efficiency of psychiatric patients and enhance the safety protection level of psychiatric patients, their caregivers, and medical staff. It can be popularized to industries such as prison inmate management and underground mine operations. In the future, we will continue to improve the stability and reliability of system hardware, enhance the data analysis and processing capabilities of system software, and increase the accuracy of the system.

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