IMMS: An Intelligent Medical Monitoring System

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Abstract. In this day and age, with the improvement of medical level, we continue to try more difficult operations to save more patients. However, the consequent problem is that postoperative recovery requires a large number of medical staff, which seriously consumes the energy of the doctors and nurses. This paper aims to propose a feasible scheme of an intelligent cloud platform medical monitoring system (IMMS). Through the deployment of the system, we can realize the real-time monitoring of patient signs as well as intelligent diagnosis of illness, and the system can send the acquired information to the doctor in time. Through this system, the hospital can not only ensure doctors' rest, but also facilitate timely treatment.

1. Introduction

In today's society, with the development of economy, medical conditions are gradually improved, and people's living standards are also improved inch by inch. With the improvement of medical level, we continue to try more difficult operations to treat more patients. However, the consequent problem is that postoperative recovery requires a large number of medical staff, which seriously consumes the energy of the doctors and nurses. As a result, for the care of critically ill patients, the existing hospitals are generally faced with a shortage of human resources, insufficient equipment, financial pressure and so forth. Even simply inspecting and recording every patient requires enormous resources. Obviously, the treatment and care of critically ill patients need to invest a lot of human resources and costs. How to take care of each critically ill patient, pay attention to the patient's health status in time and reduce the cost is one of the urgent problems to be solved by major hospitals[6][8]. The traditional manual inspection mode has been unable to meet the medical needs. Therefore, we need to analyze the needs of critical patients and the level of hospital resources and transform the needs into services in order to propose a new operating system[3].

The system can automatically monitor the patient's condition through the machine, integrate the data to make intelligent judgments, and show the monitoring results to the medical staff[4]. A mature medical system itself is a cyclic linkage operation mode. The back end of the system emphasizes real-time performance and accuracy. It needs to comprehensively collect the physiological characteristics of patients in real time, make intelligent discrimination on the patient's condition, and accurately transmit the results to the cloud. This process is fully automated and doesn't require human intervention. The front end of the system emphasizes multi-channels and simplicity. It needs to acquire cloud data in real time so that medical staff can obtain the latest condition of the patient. If the patient's condition deteriorates, alarm information should be sent to the doctor at the first time. The front end of the system is supposed to ensure that doctors can obtain patients' information on time through a variety of ways. At the same time, the display of the front end needs to be concise and clear, so that doctors can understand easily and make decisions quickly. The medical monitoring system is oriented to multiple groups, which can provide basic services to meet common needs, and can also provide customized services to meet special demands[5].

Based on the above requirements, we propose the intelligent medical monitoring system(IMMS), which relies on the Internet of Things technology, cloud platform technology, SMS passthrough technology and deep learning technology. By deploying the system, we can utilize the machines to monitor several physiological indicators of the patient in real time, and the doctor can rest adequately. In the meantime, the system can combine the patient's performance to analyze the patient's condition intelligently, explore potential risks and display the patient's status roundly. Through the APP which is set up in advance, the hospital can understand the health status of each critical patient in time. For the critical patient with high risk, the system will send the relevant early warning information to the medical staff on duty timely, so that the hospital can carry out a rescue in time[10].

The second chapter of this article analyzes which problems the hospital care for critically ill patients are faced with, puts forward the intelligent health monitoring system and defines the overall architecture of the system as well. This paper discusses the operation process of the system and comes up with a concrete implementing scheme which uses artificial intelligence technology, the Internet of things technology and SMS passthrough to raise the level of critically ill patients nursing. The third chapter refers to the existing nursing system for critically ill patients, expounds on the characteristics and innovations, and introduces the impact of the system in monitoring the vital signs of critically ill patients from the perspective of function. At the same time, we estimate the input cost to one system and look forward to the future which is about system applying in the hospital. In Chapter 4, we summarize our existing work and propose further development directions.

2. Materials and Methods

Nowadays, the simple manual inspection mode has been unable to meet the increasingly heavy nursing work, and the postoperative recovery system needs to change. Therefore, the intelligent medical monitoring system came into being. The overall architecture of the intelligent medical monitoring system is shown in the figure below:

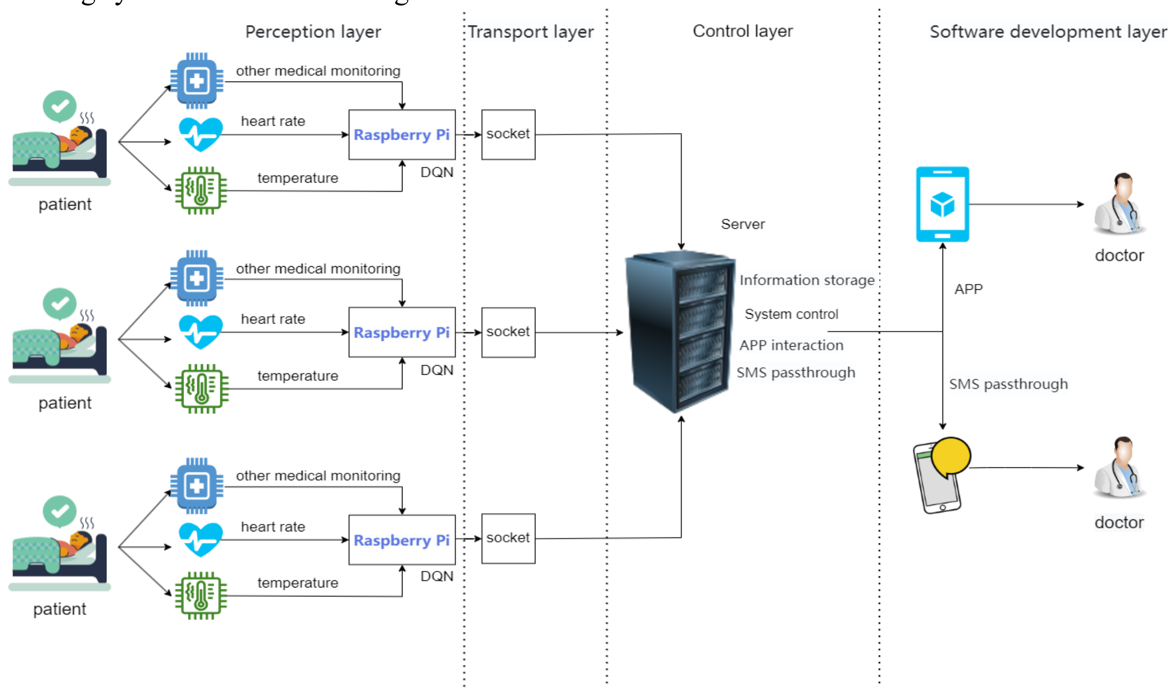

Figure 1 System Architecture diagram

From the above figure, we can clarify the operation process of the intelligent medical monitoring system. First, we need to use medical equipment to monitor patients' vital signs, such as heart rate, blood pressure, temperature and so on. Second, we transmit the patient's information to Raspberry PI, where a deep reinforcement learning network (DQN) is designed in advance, which could intelligently determine the patient's condition based on the collected information, such as whether the patient is allergic to drugs or has postoperative complications and so forth[1]. Third, Raspberry PI will transmit the patient information and discrimination results to the server through a socket. The server stores the data in the database and further processes the data to extract useful information. If the server finds that Raspberry PI has sent an alarm message, it will immediately send the corresponding patient's warning message to the doctor on duty in the form of a short message. At the same time, the server provides the APP with readable data according to the negotiated interface protocol. Finally, the APP reads the data from the server in real time and refreshes the page, so that doctors can obtain the latest situation of patients through the APP in order to facilitate the treatment of the next step.

The system has four layers, namely: Perception layer, Transport layer, Control layer and Software development layer. Among them, the Control layer is deployed on the cloud server, so it involves the cloud application at the same time. In the following, we will discuss the four layers respectively.

2.1. Perception layer

The function of the Perception layer is to obtain the vital signs of the patient through various ways, use the raspberry party to conduct intelligent analysis of the patient's condition, and send the patient's condition to the server after preliminary processing for subsequent storage, processing and query. The Perception layer includes various devices to monitor patient vital signs as well as the Raspberry PI which has been equipped with DQN in advance. And the structure of the DQN network is shown in the following figure[7]:

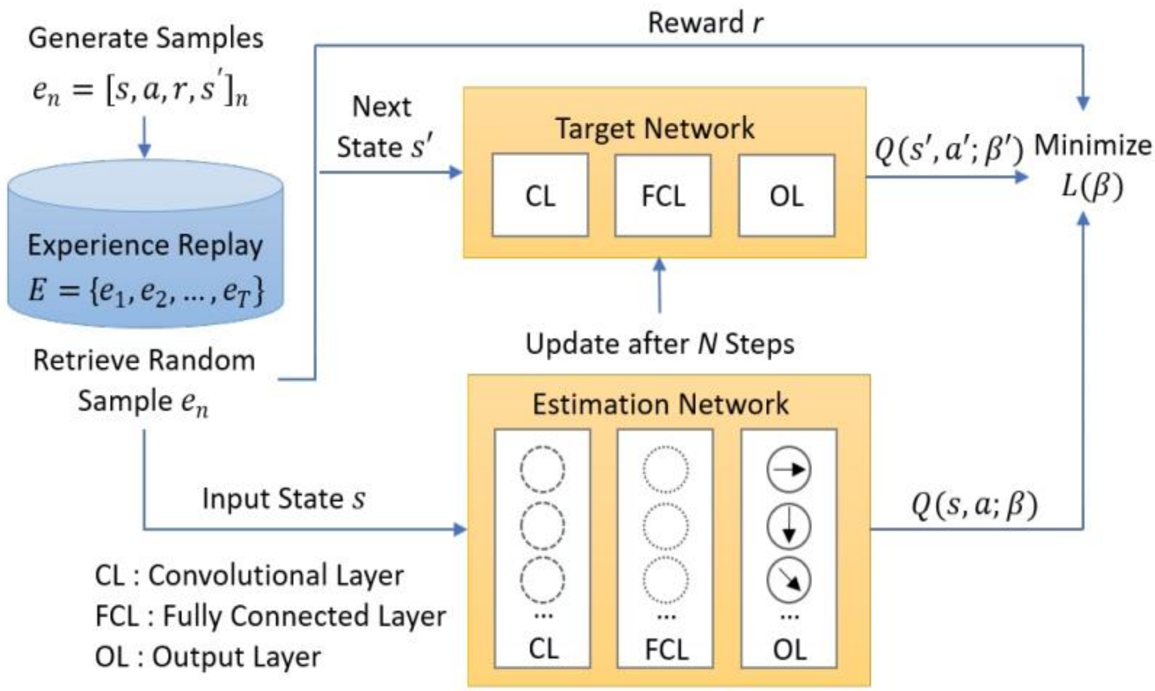

Figure 2 The Architecture of DQN

The Perception layer monitors and records the patient's vital signs through various devices. The monitoring device can be one that is currently in use in hospitals, such as monitoring blood pressure, heart rate and temperature. The results are sent into a raspberry PI for temporary storage and the pre-trained DQN network is configured in Raspberry PI. The input of the model is the data about the patient's physiological signs, then the DQN network will analyze the patient's condition according to the information and the learned knowledge, and the output of the model is the intelligent diagnosis result. The model is essentially a classification model, which classifies patients according to the information obtained, such as drug allergy or postoperative complications. Among them, the knowledge which is learned by machines is a large number of real patient signs data and diagnostic results[9]. The Perception layer processes the collected information initially and sends it to the server for subsequent processing through the Transport layer.

The Perception layer is the part that directly contacts the patient and utilizes instruments to monitor the patient's physical signs, so its technology involves a wide range and has high technical requirements. In this era, it has produced a lot of equipment with excellent performance, wide application and high integration. Therefore, we do not need to spend time on the underlying implementation of the Perception layer technology, but only need to give full play to the function of the already configured devices to realize the monitoring of the patient's condition.

2.2. Transport layer

The function of the Transport layer is to send the information processed by the Perception layer to the server for subsequent processing by the Control layer. The Transport layer needs to ensure the stability and accuracy of the information transmission process. The Transport layer is essentially a socket program, which is the bridge of information interaction between Raspberry PI and the server. We need to close the firewall in Raspberry PI, so that information interaction between different operating systems can be carried out by using sockets.

The Raspberry PI holds the patient's vital signs and reads the information collected by the medical monitoring devices every 10 seconds to update the temporary information in the Raspberry PI after processing it. When data is updated, raspberry pie as the client requests the server communication and establishes a socket connection. After completing the Transport layer, information can be interacted. For instance, after raspberry pie sends the data to the server, the server will respond and then close the connection. When the raspberry pie updates the data again, it will reconnect to the server by socket and send the data until the transport process is over.

The Transport layer is essentially a socket program. Due to the reason that we need to ensure the accuracy and integrity during the information transmission, we choose to establish a TCP connection. Through the Transport layer, we can transmit the information in the Perception layer to the Control layer for subsequent processing.

2.3. Control layer

The Control layer is the core of the intelligent medical monitoring system. It is responsible for integrating the other modules into an organic entirety. It gives instructions to other modules so that the system can operate in an orderly manner according to the established requirements. The Control layer includes the database to store patient information, the control program to allocate each module, the APP interface program and the program to interact with the SMS passthrough device.

The Control layer is a very important part of the system. It receives the data sent by the Perception layer through the TCP socket, processes the data according to the agreed protocol, and stores the patient information in the database. The APP will regularly access the server of the Control layer. After receiving the data request from the APP, the server will process the data according to the interface protocol and send it to the interface for display by the front end of the APP. If the Control layer finds that the patient's condition is aggravated or abnormal, it will actively trigger the SMS passthrough device and control the device to send a warning message to the doctors.

The Control layer is the brain of the intelligent medical monitoring system. It is responsible for all the logic behind the system and connects the other modules into an entirety. The Control layer is the core of our programming, which determines the stability, efficiency and exception handling of our entire system. Usually, an efficient and stable Control layer can make the system run more smoothly, so the preparation of this part is the difficult and key point of our system construction.

2.4. *Software development layer*

Software development and visualization applications are the hubs of human-computer interaction in this system. Doctors obtain real-time information about patients through visualization application software, and SMS passthrough software will send warning messages to users when abnormalities occur. Software development layer includes a mobile APP combined with cloud servers and SMS passthrough software based on SMS passthrough devices.

The Software development layer is located between the Control layer and users at the application layer. This layer contains two independent modules, which are the mobile APP and SMS passthrough software. The APP sends GET requests to the server at fixed intervals, updates and displays the acquired data in the front end, so that users can obtain the real-time situation of patients. It should be noted that the design of the APP is based on the hospital beds. Each module in the APP corresponds to a sickbed to be monitored in the hospital. Click each room module to see the corresponding bed information in the room. The APP needs to pass the token authentication first, and then the rest access needs to carry the token. This way can ensure that user information is not leaked, improve the security of the system, and help to achieve the separation of permissions, which can provide different views for different users. The SMS passthrough software is based on the SMS passthrough device. When the patient is abnormal, the server will automatically trigger the software and send a warning message to the doctor. The software design requires the use of AT instructions, and the Control layer can immediately send a short message to the doctor when detecting abnormalities to ensure the real-time performance of the system. The software only needs to send short messages to the doctors who need to be on duty tonight. When there is an abnormality, the doctor on duty will inform other doctors, so as to ensure the doctors' rest to the maximum extent. And the hospital only needs to update the phone numbers of the doctors who are on duty every day, which is simple and efficient.

The Software development layer and visual applications are the interfaces of human-computer interaction. The information display needs to be concise and clear, and the short message transmission software needs to ensure real-time performance. The technology it needs to apply mainly focuses on the front-end design and the software development based on specific equipment, and this layer determines the usability of the system[11].

3. Discussion and Future

In this era with rapid development, we need to continuously improve efficiency. The way to improve efficiency is not only to focus on the task, but also to divide the complex and repetitive tasks into machines, while we only need to deal with the most important tasks, so that the tasks can be executed in parallel to achieve high efficiency[2].

In traditional patient condition monitoring, the hospital needs to arrange a large number of doctors and nurses to take turns on duty to monitor the patient's condition, which is not only inefficient but also consumes much energy of the medical staff. While if we introduce an intelligent medical monitoring system, the hospital can reduce the number of doctors on duty, and use machines automatically to monitor the patient information. The system can realize real-time information display on the front end, real-time feedback to the doctor on duty and real-time warning, and it can with fewer doctors get more work done, which can promote efficiency and at the same time allow the doctors to get better rest in order to focus on the key parts like surgery. Moreover, the system has good function expansion, wide application scenarios and great effect, which is convenient for future upgrades.

The intelligent medical monitoring system may play a very significant role in the future medical field. First of all, the system can monitor the physical signs of patient in real time. It uses machines to replace manual monitoring, freeing doctors from the complicated and boring postoperative monitoring work. Moreover, the system has better accuracy and real-time performance than the manual. Secondly, the system can intelligently analyze the patient's condition. It receives the data sent by the real-time monitoring part, extracts useful information, integrates blood pressure, heart rate, body temperature as well as other factors, and uses the DQN network to conduct an intelligent assessment of the patient's condition. Third, the system supports real-time queries. Authorized users could acquire the patient's real-time situation, and doctors can obtain the patient's information anytime and anywhere to assist in the design of treatment plans. Finally, the system has a real-time warning function. If the system finds that a patient's condition is deteriorating, it will send an alert sign in the form of a text message to a designated doctor, who can quickly make salvage. In this way, the hospital can not only reduce the input of the number of doctors on duty, but also ensure real-time performance.

The intelligent medical monitoring system has many highlights, such as real-time performance, accuracy, end-cloud integration, multi-channel, scalability and so forth. When deploying the system, the hospital has no need to invest a large amount of money, while just needs to modify the existing equipment, which can easily complete the construction work. We are only supposed to introduce Raspberry PI installing at sickbed and SMS passthrough equipment which is connected to the server, and the software development cost is also small. According to reliable estimates, the input cost of each system is under ten thousand RMB. Moreover, the operating structure of the system is small, so it does not need to occupy a large amount of space. It can naturally solve the difficulties which the hospital is encountering. hence it has a great application space in the future with great development potential.

4. Conclusions

In this paper, we describe the existing medical monitoring system, analyze its disadvantages, and propose a pioneering intelligent medical monitoring system(IMMS) to solve the dilemma which today's hospitals are facing. We design the overall architecture of the intelligent medical monitoring system, describe the operation process of the system, and explain the components of the system in detail. Combining theory with reality, we discuss the role of the system, estimate the construction cost of the system, explain how to use the system for clinical monitoring, identify the advantages of the system and looked into its future. Of course, this system is only a preliminary architecture, we still need to update it continually. Next, we will introduce a more powerful AI algorithm to improve the accuracy of the system. Meanwhile, we will continuously evaluate the system and continue to develop the system according to the feedback to ensure its stability and usability when facing mass data.

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