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Automatic dressing change and monitoring infusion speed control system

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Abstract. Intravenous drip is a common form of treatment, but the wrong rate of injection or dose of medication can have serious consequences for patients. Monitoring devices can detect the speed of drug infusion and drug response in real time, helping medical care personnels adjust treatment regimens in a timely manner and reduce the risk of human error. At present, some rooms in the Intensive Care Unit (ICU) require a sterile environment. In view of the above situation, this paper proposes a new device, which adds the function of automatic dressing change to the intravenous injection monitoring device, and synchronizes the obtained data to the user interface in real time by using the Internet of Things (IoT), so as to reduce the frequency of medical staff entering and leaving the ICU, realize remote monitoring of the intravenous injection process and data related to automatic dressing change, and improve the treatment effect of patients and the work efficiency of medical staff.

Keywords: Intravenous monitoring equipment, 3D modeling, automatic dressing change.

1. Introduction

As an important technology in the medical field, intravenous monitoring equipment provides accurate drug infusion monitoring and patient safety guarantee for medical personnel. Nowadays, many ICU wards require comprehensive and detailed monitoring of patients, severe patients usually need to be given a variety of drugs through intravenous injection, and the need to monitor patients' vital signs and drug response in real time, in addition, for some sterile ICU wards, patients need to change their dressing multiple times, and medical staff will waste a lot of time after disinfection into the ward. Intravenous monitoring equipment can monitor the injection speed and dosage in real time to ensure the safe and effective delivery of drugs to the patient by monitoring the patient's intravenous response and drug infusion in real time [1]. The automatic dressing change system can fully automate the switching of drugs, effectively improve the medical effect, and provide more convenience for medical personnel. Such devices can effectively prevent and timely identify problems during medication, thereby reducing the risk of complications and improving treatment outcomes.

Based on the social investigation and analysis of relevant people in different regions, this study designed a new type of equipment to try to solve the above problems. This paper will discuss the research status, social research and new equipment of automatic dressing changing and monitoring infusion speed control system, in order to explore the development trend and potential of this field.

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2. Systematic Literature Survey

2.1. Related Works

At present, there are many kinds of equipment for monitoring the flow rate of intravenous injection, which can be divided into the following categories according to its technical principle: mechanical and intelligent.

Mechanical devices: In the medical field, the ball titrimeter is a more common device. This device controls the drip speed by using ball rolling, which creates less liquid disturbance as the droplets drop, effectively reducing the formation of bubbles and the possibility of other disturbances. Smart devices: These devices use electronic components such as pressure and flow sensors to monitor the pressure and flow during intravenous injection in real time, and combine mechanical, electronic and information technology to monitor and automatically adjust the intravenous flow rate in real time. Here's how smart devices have monitored intravenous devices in the past.

S. sekitoleko et al. used a gravity infusion device to ensure that droplets were dropping into the droplet chamber at a constant rate, and then used photoelectric sensor technology to monitor the flow rate. The sensor unit in the monitoring module contains a reference light source and a photocell with a fixed optical sensing gap between them. When droplets fall into the droplet chamber, they interrupt the beam provided by the light source and modulate the signal provided by the photocell. This modulated frequency is processed by a microprocessor/controller and compared to a preset titration rate for precise flow rate control [2]. Sourabh Suresh Alagundagi et al proposed to use photoelectric system to monitor the intravenous injection process, and added alarm system to conduct a large number of experiments to reduce the risk of other problems in the intravenous injection process [3]. Rehan Tariq Abbasi et al. proposed a new drop count system, which counts drops using light transmitters and light detectors placed on both sides of the drop chamber. By monitoring the number of drops in the drop chamber in real time, the liquid infusion rate can be more easily monitored [4]. Saad ABDULLAH et al. proposed a low-cost BLE based intravenous monitoring and control infusion system, which uses a Bluetooth low power microcontroller, an infrared based drop counting system and a digital servo motor to control the drip rate. The system was connected to an existing intravenous infusion rack, and a LabView graphical user interface was developed. Finally, remote control and monitoring of intravenous infusion were realized [5]. Nicola Giaquinto's team proposed a method of real-time drip monitoring using a computer vision system. They found through comparison that this method of monitoring using cameras is non-invasive and safe, and the cost and size of cameras are constantly decreasing, which can be easily used in smart low-power devices. The use of cameras can also achieve remote monitoring, when the monitoring system sends alarm events, you can quickly check the status of the drip device from a remote location [6, 7]. Andrea Cataldo et al. proposed a monitoring method based on TDR, which monitors the drip rate by directly sensing the change of liquid volume in the bottle. Their team studied the application of different bottles and different TDR probes to the bottle and concluded that this method has good repeatability [8]. Malthar U.Sapatnekar team and Sincy Joseph team have respectively proposed the application of iot to IV drip monitoring systems and designed different applications, among which Sincy Joseph team has proposed the free flow monitoring function for better monitoring of unexpected flow infusion processes. In addition, the Sincy Joseph team has used temperature sensors to monitor liquid temperature during infusion to prevent discomfort due to low temperature during infusion during the winter [9, 10]. Using Auduino and Android, S.Valmurugan enables multiple levels of saline transmission and control in a single-channel iot gateway, where the nurse can receive data from the infusion monitoring device via a central monitor and display it in chart form at the nurse's station. This remote infusion monitoring system can improve the work efficiency of nursing staff, reduce the workload of manual monitoring, and ensure the safety of infusion process [11]. J Ranjani et al. proposed the application of iot to a saline infusion monitoring and control system, in which infrared sensors use infrared radiation to determine the presence or absence of objects, detect the amount of reflected radiation through infrared leds and phototransistors or photodiodes to determine liquid levels, and, The infrared sensor can be connected to the Arduino microcontroller to trigger an alarm or send a notification

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when the liquid level gets too low [12]. Shizhen Huang and Fusheng Pan designed a robust intravenous infusion monitoring device. Compared with the infusion device using infrared and flowmeter, the intravenous infusion monitoring device designed by Shizhen Huang et al has wider applicability, and can reduce the influence of temperature changes on measured values through correction according to the correction formula. Improve equipment accuracy [13].

2.2. Summary and analysis

Based on the above investigation and research, the results show that the current intravenous monitoring equipment mainly has the following functions: (1) The use of photoelectric system or pressure, flow, temperature sensors to monitor intravenous injection; (2) Use computer vision system to monitor the intravenous injection process; (3) Use the Internet of Things in combination with the above methods for remote monitoring.

3. Social research

Based on the above investigation and research, the results show that the current intravenous monitoring equipment mainly has the following functions: (1) The use of photoelectric system or pressure, flow, temperature sensors to monitor intravenous injection; (2) Use computer vision system to monitor the intravenous injection process; (3) Use the Internet of Things in combination with the above methods for remote monitoring.

Social research is carried out through systematic and detailed surveys of medical staff, patients and their families in hospitals in different regions. According to the survey data, the following results are obtained: 1. Medical staff agree that remote monitoring is necessary. 2. for the need to inject multiple bottles of medicine to use automatic dressing system, most people agree. 3. Most people believe that the medical basis required for the dressing change process does not need to be high. The social research statistics is shown in figure 1.

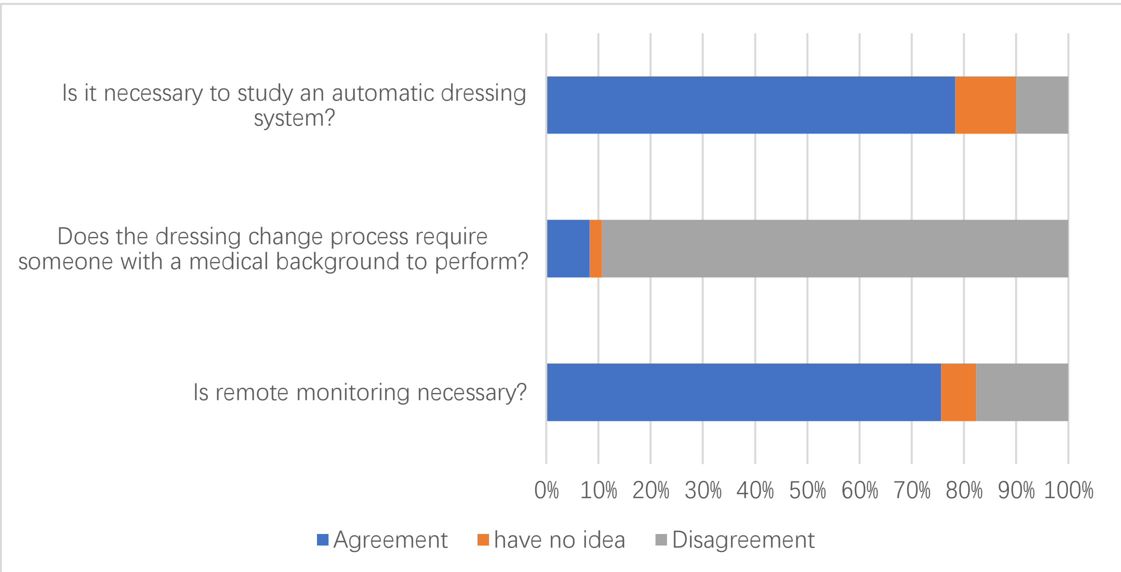

Figure 1. Social research statistics (Photo/Picture credit: Original)

4. Solution

Based on the results of social research and the relevant functions of existing intravenous monitoring equipment, the demand for new equipment is put forward. The proposed new device is designed to address the problem identified today by providing healthcare professionals with automated monitoring of intravenous and automatic dressing systems, which add automatic dressing to the function of

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monitoring the intravenous process and can be monitored remotely from a mobile phone. The main features of the new equipment are as follows:

Fig.2 (a) is a simulation of the device used when a patient needs to input multiple drugs using SOLIDWORKS software. Fig.2 (b) shows the planning of this device. The device consists of three parts: a top cover, a channel, and a funnel.

Top cover: It can be adjusted according to the number of drugs entered by the patient. The hole in the middle is the channel corresponding to normal saline, and the hole around it is the channel corresponding to the drug required by the patient. Channel: Hose used to simulate the flow of fluid. The funnel part : collects the needed drugs, which plays a role in reducing bubbles. Method of application: First, all drugs are inserted into the holes around the device according to the sequence of infusion using the channels shown in Fig.2 (c) (simulating a hose flowing through the drugs), and each channel is closed with a one-way valve; The saline solution is then inserted into the middle channel and closed again with a check valve, as shown in Fig.2 (d).

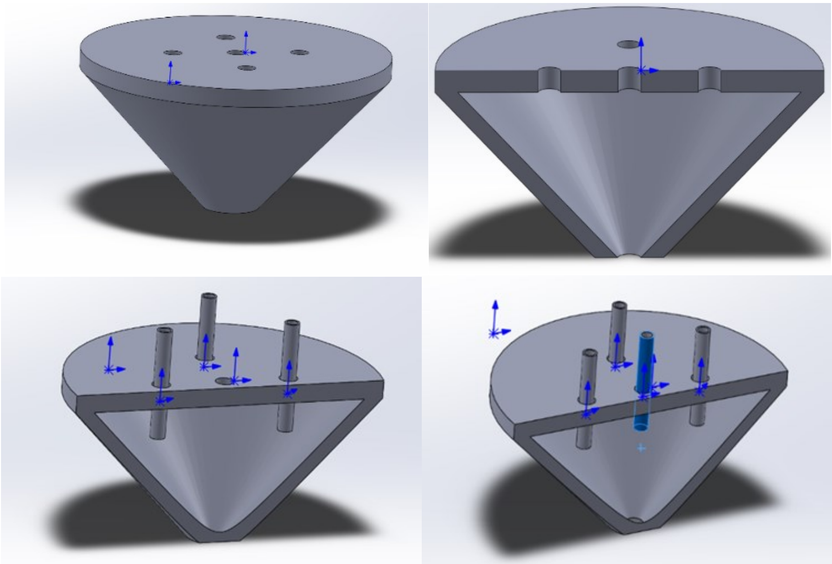

Figure 2. Simulation of the device (Photo/Picture credit: Original)

The new equipment is mainly composed of three parts: the sensor part, the controller part and the main equipment part which is shown in figure 3.

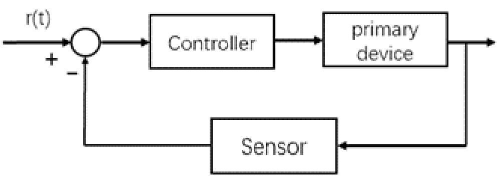

Figure 3. Equipment working flow (Photo/Picture credit: Original)

Sensor part: The infrared drop count technology system is used to monitor the flow rate of intravenous drops, and the infrared sensor is fixed in the location where the infusion drug is stored.

Controller part: Control whether to change the medicine through the sensor feedback data, that is, when the liquid level is detected to be very low (about 5% at the bottom of the bottle), the controller will use the check valve to close the channel where the current medicine is located, and then open the corresponding channel of normal saline in the middle.

Main device part: User interface for taking advantage of iot. Medical staff can monitor the operating status of the system in real time through the user interface. When there is an emergency, the user interface will receive an alarm reminder, so as to achieve the purpose of receiving feedback in time.

The new equipment should have the following functions:

Real-time monitoring and regulation: Combined with the Internet of Things technology, the device can monitor the flow rate and drug dosage of intravenous injection in real time to ensure the accuracy and safety of drug delivery. Through remote connection, medical staff can remotely monitor and adjust equipment parameters to avoid problems such as too fast or too slow infusion.

Remote alarm and notification: The application of Internet of Things technology can achieve automatic early warning of equipment failures and abnormal situations. After the device is connected to the Internet of Things, real-time alarms and notifications can be sent to the medical staff, prompting the time of drug dressing change, the exhaustion of medicine liquid, etc., to help timely treatment and avoid interrupting the infusion process.

Data analysis and optimization: iot technologies provide vast amounts of real-time data that can be analyzed and mined to optimize treatment flows and improve patient safety. Through continuous monitoring and analysis of the data, possible problem patterns and treatment abnormalities can be identified and appropriate measures can be taken to improve them. In addition, the collection and analysis of data can also be used for research purposes to drive the development and improvement of medical treatment models.

Remote maintenance and upgrade: After the device is connected to the Internet of Things, the manufacturer can remotely maintain and upgrade the device to repair problems and improve functions in a timely manner to ensure continuous and stable device performance.

The current new equipment has the following problems: 1. The new equipment may have the problem of drug waste: In order to avoid the situation of blood reflux, when the liquid level is detected at about 5% of the bottom of the bottle, the controller will switch the switch to change the drug, resulting in drug waste. 2. The size requirements of the new device have not been accurately designed: the device used in picture 1 when the patient needs to input multiple drugs can replace the top part according to the amount of drugs input by the patient, but the size has not been tested experimentally and needs further study.

5. Conclusion

This paper proposes an intravenous injection monitoring device with automatic dressing change function. The proposed device can be combined with the Internet of Things to realize intelligent monitoring, remote management and data recording of the device, improve the efficiency and safety of medical services, and bring better treatment experience and medical quality. At the same time, this combination can also provide more convenience and support for healthcare staff, reduce human error and improve treatment effectiveness, so that they can focus more on patient care and reduce the workload. However, at present, this device still has some shortcomings, such as the problem of drug waste caused by dressing changes has not yet found a solution.

In the future, the above issues will be simulated and tested in a large amount of data in the clinical environment, and with the continuous development and application of Internet of Things technology, the combination of automatic dressing system and monitoring intravenous injection equipment may be further improved and innovative. For example, artificial intelligence algorithms can be added to optimize the speed and dosage of drug delivery, personalizing the treatment of patients; It is also possible to establish connections between devices to enable collaborative work and data sharing, improving efficiency and coordination across the healthcare system.

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