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Design, Assembly and Testing of Infusion Monitoring System Based on Internet of Things

Sari Narulita[1], Mohamad Syafaat[2],Wulan Fitriani Safari[3]

[1] *Faculty Nursing and Midwifery, Binawan University, Indonesia*
[2] *Faculty Health Science and Technology, Binawan University, Indonesia*
[3] *Faculty Health Science and Technology, Binawan University, Indonesia*

Abstract.
Intravenous therapy (infusion) or IV therapy is widely used in the medical field. IV therapy is the giving of fluids into the body, through a needle, into a vein to replace lost fluids or nutrients from the body. Monitoring of intravenous fluids is still done manually. Many cases of patient deaths are caused by negligence in monitoring intravenous fluids, to overcome this, an infusion fluid monitoring system is needed that facilitates nurse's work. The monitoring system designed must be adapted to the latest technology that may ease nurses work load. Objective. The purpose of this study is to design and test it according to Internet of Thing-based infusion monitoring system. Methods. The research was carried out in several stages, system design, instrument assembly, subsystems testing Settings. The parameters observed in this system are the volume of infusion fluid (percentage) and the number of infusion fluid's drop in real time according setpoint. The system will provide a warning on the smartphone and also through a buzzer sound if something very crucial happens such as the infusion runs out. Designs. This monitoring system is equipped with sensors consisting of an infrared Light Emitting Diode (LED) and a Photodiode to observe the condition of the drops, a load cell sensor to determine the volume of infusion fluid (percentage), a servo motor to control the number of drops of infusion fluid. The sensor reading data was processed by Node MCU and then displayed on the smartphone via the Blynk application. There is a color indication in the application. If the LED is green, it means the condition is good. If the LED is yellow, it means the IV fluid is less than 20%, and if the LED is red, the IV fluid is less than 5% and the buzzer will be active. Results. IoT-based monitoring system can count infusion fluid drops with an average error of 0.73%, detecting the remaining volume of infusion fluid with an average error of 0.95% and the fastest information delivery time is 30 seconds. Conclusions. Internet of Things-based infusion monitoring system has been successfully made and works according to design.

Keywords: Infusion, Internet of Things, Monitoring System

1 INTRODUCTION

Intravenous therapy devic (infusion) is equipment that is widely used in the medical field. Intravenous therapy is the administration of a certain amount of fluid into the body, through a needle, into a vein (vein) to lose fluids or nutrients from the body**[1]** protein, fat, and calories, which cannot be adequately maintained orally, improve acid-base balance, improve the volume of blood components, provide a route for administration of drugs into the body, monitor central venous pressure (CVP), provide nutrition at the time of the digestive system is disturbed**[2]**

Factors that influence the success of intravenous therapy include close monitoring. Close monitoring makes it possible to replace intravenous fluids that have reached the minimum replacement limit or o come disturbances in intravenous therapy so that complications can be avoided. Monitoring of intravenous fluids in hospitals is currently still being done manually. Medical personnel checks the volume of infusion fluids and the drip rate of infusions and infusions regularly. This is highly ineffective and has great potential for harm. Many cases of death are caused by medical personnel who are negligent in monitoring the patient's IV fluids. To overcome this, an infusion fluid monitoring system is needed that facilitates the work of medical personnel.

Efforts to develop technology to support infusion fluid monitoring are ongoing. In 2012 a system for detecting the condition of intravenous fluids was created in real-time. Infusion fluid condition detector infusion fluid volume, disturbance, and flow rate, but the system created is not connected to the internet [3] Infusion fluid monitoring systems with internet networks have been designed, but only observe the volume and rate of infusion fluids [[4] [5]

The Internet of Things is a structure in which objects are provided with an exclusive identity and the ability to transfer data over a network without requiring two-way human-to-human interaction but rather human-to-computer interaction.Internet of Things is a future science that humans use to optimize their work involving intelligent sensors and smart devices that work together via the internetIoT emerged as a big issue in the era of the industrial revolution 4.0, where it is expected that billions of physical things or objects will be equipped with various types of sensors connected to the internet. IoT is used to collect raw data in Realtime in an efficient way. Where the raw data can be analyzed and processed into information needed by humans [8]. Internet of Things in its application can be used to identify, find, track, and monitor objects automatically and in real-time. The application of the Internet of Things has a great impact on human life in various fields, such as management, production operations, social management, and even personal needs[9]. Monitoring system designed to be developed according to the needs of the latest technology medical personnel. Therefore, this research will design, manufacture and test an Internet-based infusion fluid monitoring system, where the equipment to be made can monitor the volume of infusion fluid, the

flow rate of the infusion fluid, and the number of drops and disturbances in real-time. The data generated from the system can be accessed via the internet. If there is a condition where the infusion fluid volume is almost depleted, the flow rate and the number of infusion fluid drop that are not appropriate and their presence will be given a notification on the smartphone. The implementation of this monitoring system is expected to reduce problems that arise due to the negligence of officers.

2. METHOD

This research is experimental and descriptive. experimental research is at the design stage of the infusion monitoring system while descriptive research is at the stage of testing the effectiveness of the infusion monitoring system. The stages of the research and the expected achievements are shown in Figure. 1

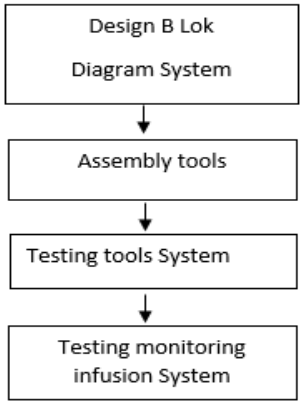


Fig 1. Research Steps

3. RESULTS AND DISCUSSION

The research results that have been successes: designing, manufacturing, and testing an internet of thing based infusion fluid monitoring system, while testing the effectiveness of the internet of thing based infusion fluid monitoring system to patients in hospitals is still in process.

3.1 Design of Infusion Fluid Monitoring System Based on The Internet of Thing

The design of the system begins with making a system design which can be seen in Fig. 2.

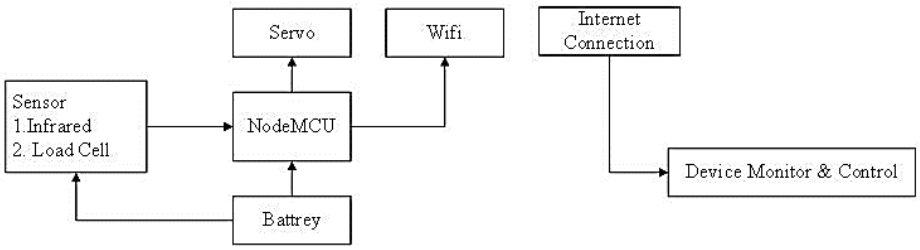


Fig.2 System Design

An infrared sensor is used to determine the time of drip of infusion fluid (drops per minute and time per drop) and the number of drops of infusion fluid. A Loadcell sensor is used to determine the volume of intravenous fluids. Servo is used to adjust the infusion scroll so that the infusion flow rate is always under the set points (drops per minute) that have been given. Nodemcu is the main microcontroller that connects the monitor and control devices with the equipment. As long as the internet of thing-based infusion monitoring system equipment is connected to wifi, the process of monitoring and controlling the equipment can be carried out. the device used for control and monitoring can be an Android cellphone or computer. It could be both. The data displayed on the screen of the device that is used as control and monitoring is the volume of infusion fluid, input set points (TPM), on/off indicator of equipment, battery level, and the number of drops of infusion fluid. In addition, the data will be recorded in real-time and can be sent to email in CSV format. The data recorded are the date, time, volume of infusion fluid, set points used, and number of infusion drops. The main source of internet-based infusion monitoring system equipment is batteries. It is used to make it easier for the patient to perform activities, such as urinating..

3.2 Development of Internet of Thing-Based Infusion Fluid Monitoring System

Making tools consists of assembling hardware (hardware) and software (software). Hardware assembly is done by assembling each component into a microcontroller (Nodemcu) as shown in Figure 3.

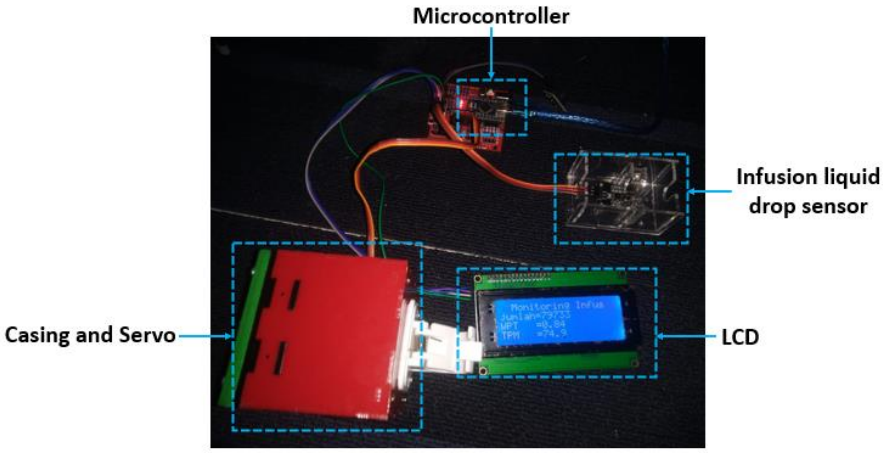


Figure 3. Hard Ware Assembly

Software assembly is done by programming on the Arduino IDE. After the program is following the design, the program is downloaded to the microcontroller. The program snippet is like Figure. 4

```
int targetTetes = 60;
int pos = 90;
void kontrolTetes() {
  if (TPM > targetTetes) {
    if (pos > 0) pos -= 5;
    servo.write(pos);
  }
if (TPM < targetTetes) {
    if (pos < 180) pos += 5;
    servo.write(pos);
  }
}
```

Figure 4. Sample of Program

3.3 Testing of Infusion Monitoring System Based on Internet of Things

The tests carried out were testing the infusion fluid drop sensor, load cell sensor, and monitoring. The test results of the infusion fluid drop sensor are shown in Figure. 5

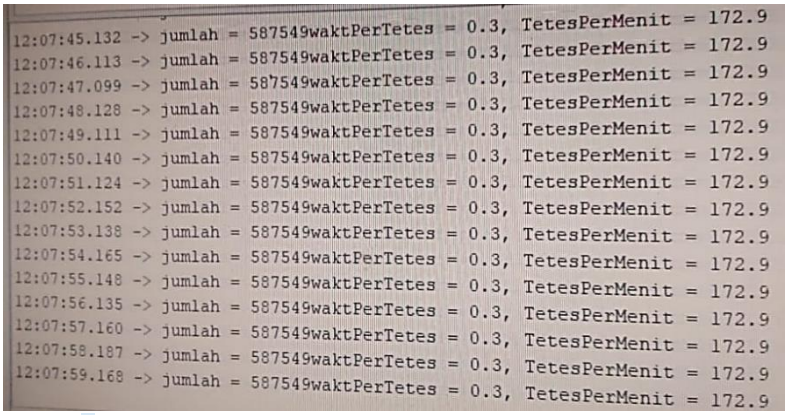
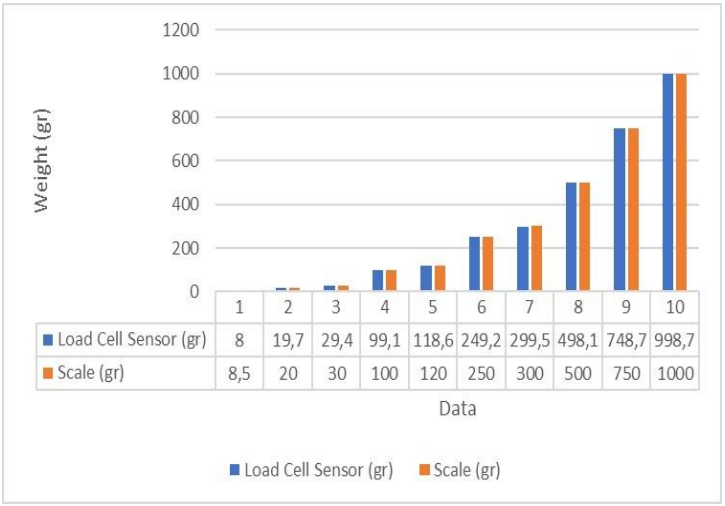


Fig. 5 Test Result from infusion drops Monitoring Based on IoT

Figure 5 is the result of sensor readings when infusion drops to pass through the sensor. The program shows the readings of the number of drops, the time per drop and drops per minute, and the time the infusion fluid drips. When this system was tested, the number of drops per minute was 58754, the time per drop was 0.3 and the number of drops per minute was 172.9. The trial was carried out when the servo motor was open (the infusion hose was not clamped).

The loadcell sensor test results are shown in diagram 1

Diagram 1. Test Results of the Load Cell Sensor



	1	2	3	4	5	6	7	8	9	10
Load Cell Sensor (gr)	8	19,7	29,4	99,1	118,6	249,2	299,5	498,1	748,7	998,7
Scale (gr)	8,5	20	30	100	120	250	300	500	750	1000

Before the sensor is installed in the system, the sensor is tested first by comparing the value reading by the sensor and its comparison device (scales). The system test result is 8 while the scale is 8.5. This means that there is an error in the test results. The error value in the first test was 5.88%. The error value is obtained from the calculation results, namely {(8.5 - 8)/8.5} x 100 %. After all the errors are calculated in each experiment, the average error is 1.26%.

The monitoring system that has been installed on the infusion pole is shown in Figure 6

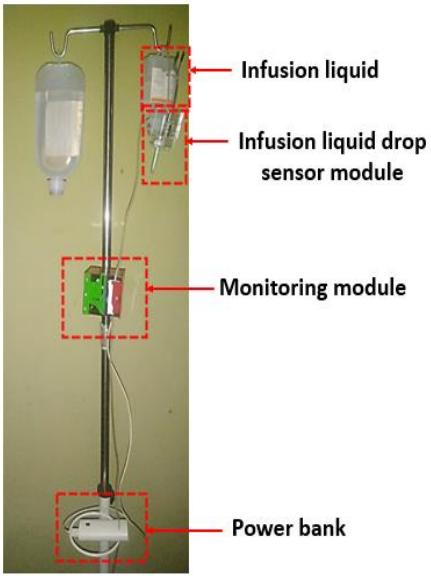


Figure 6. Infusion Fluid Monitoring System

4. CONCLUSION

The Internet of Things-based infusion monitoring system has been successfully made and works according to design. Future efforts should be performed to implement this finding to bring more merit to the population by collaborating with related stake-holders' industries.

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