Design of automatic infusion monitoring system based on Arduino

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Abstract. Intravenous Fluids Drops are very important for the process of healing or treatment for patients. The function of infusion is to replace the loss of fluids or nutrients in the body. In Indonesia, monitoring system of condition about infusion is still done manually, but for the cases such a large hospitals which is the number of patients is not balanced by medical personnel, it is becomes ineffective so that it can cause mistakes in monitoring. A very serious mistake can occur are too late in replacing the infusion. The solution to solve this problem is to make an automatic infusion monitoring system with an alarm warning. This research is experimental research. The measurement technique taken is direct and indirect measurement. Direct measurement data is mass of infusion and indirect measuremnet data is the number of infusion drops and the percentage of remaining intravenous fluid. The purpose of this research is to determine the design specifications and performance specifications of the instrument. The sensor used to measure infusion drops per minute is photogate and to measure the infusion volume is load cell. The display is use TFT LCD and using buzzer for alarm warning. The accuracy of infusion drops per minute system is 0.97 with error 2.15% and accuracy of infusion fluid percentage system is 0.98 with error 1.47%.

1. Introduction
Intravenous fluids is so reliable in the patient's healing process. This is because the infusion provides fluid directly to the blood vessels, so that the incoming fluid can be directly transported by blood to the parts of the body that need it. The purpose using infusion is to replace the loss of liquids or nutrients in the body. The infusion used must be in accordance with procedures that must be obeyed by doctors and nurses. In the process of giving infusions to patients requires very accurate calculations and careful monitoring based on existing rules to prevent fatal mistakes in patients. A very serious mistake can occur are too late in replacing the infusion, so it can cause the patient's blood to be sucked out the tube. To solve this problems, the monitoring of intravenous fluids in patients must be improved by utilizing the development of science and technological advances in the field of electronics and instrumentation by making tools that can monitor infusion automatically and can provide information and warnings about the percentage of infusion fluid remaining. One of the solutions to this problem is to make a measurement of automatic infusion monitoring system based on arduino.

In this research, a photogate sensor is used to measure the number of infusion drops per minute. Photogate sensor is a time measuring device that serves to detect an object so that it can be seen how long the object when blocking the sensor. This sensor consists of a light source and a light detector. The photogate sensor used can be seen in Figure 1.
Besides being able to measure the number of drops per minute the automatic infusion fluid monitoring system can also measure the percentage of the remaining infusion fluid. To measure it, a load cell sensor is used. Load cell sensor output voltage will change if there is a change in the load mass. Load cell sensor output is resistance, then with a microcontroller circuit, the sensor output changes to voltage, so that if the sensor detects changes in mass, there will be a change in voltage on the sensor. The load cell sensor used can be seen in Figure 2.

2. Research Methods
This research was conducted at the Physics Laboratory, FMIPA UNP. This type of research is experimental research. The instruments and materials used in this research are PC to make programs in Arduino IDE software, Arduino Mega as a microcontroller, Photogate sensor to measure the number of infusion drops per minute, Load Cell sensor to measure the percentage of infusion fluid remaining, buzzer as a warning alarm that will sound if the remaining volume of the infusion is measured 15%, and TFT LCD as a display of the system.

There are two types of instrument design, hardware design and software design. In hardware design which includes the design of electronic design, whereas in software design that is programming the system designed to be able to carry out its functions as desired.

2.1. Hardware Design
In the design of the research, block diagrams are very important in order to know the process of the planned system. The block diagram can be seen in Figure 3.
2.1.1. **Electronic System Design.** The electronic circuit in monitoring system is designed to connect the sensors, buzzers, and TFT LCD to arduino mega. The electronic circuit system can be seen in Figure 4.

![Figure 4. Electronic Circuit in Infusion Monitoring System](image)

2.1.2. **Mechanical System Design.** The mechanical design of the infusion fluid monitoring system used a tripod as a place to attach the sensor frame. On the sensor frame there is an arduino mega circuit connected to the load cell, photogate, buzzer and TFT LCD. The infusion bottle will be placed hanging on the load cell sensor as the load on the sensor and the photogate sensor is located attached to the drip tube to detect the drip and then count the number of drip infusion per minute. The monitoring system is designed to monitor two infusions in patients. The LCD will display the monitoring results of the number of drops per minute and the percentage of residual infusion fluid in Patient 1 and Patient 2. The mechanical design of the infusion fluid monitoring system shown in Figure 5.

![Figure 5. Mechanical System Design](image)

2.2. **Software Design**

Software design is a design created using software Arduino IDE. Flowchart explains how the monitoring system works. When the system is turned on, the LCD will display the percentage of the remaining infusion fluid based on the weighted mass in the load cell and the number of infusion drops per minute from the infusion of Patient 1 and infusion of Patient 2. at first, the remaining percentage of infusion fluid will show 100%, which means the infusion fluid is in full condition. When the LCD displays the remaining 15% infusion fluid, the buzzer alarm will sound as a warning sign that the infusion is running low and must be prepared to replace it with a new one. After the software design is made, then the programming is done on the software and the program is embedded in Arduino. The
display of the program that has been made is displayed on the TFT LCD. The program flowchart can be seen in Figure 6.

![Program Flowchart](image)

**Figure 6.** Arduino Program Flowchart

3. Result and Discussion

The result of the design that has been done is an automatic infusion monitoring system based on Arduino Mega. This instrument is able to measure the number of infusion droplets per minute and the percentage of remaining infusion from the infusion set in two patients. The results of these measurements will be displayed using a TFT LCD. The mechanical form of the infusion fluid monitoring system can be seen in Figure 7.

![Mechanical of Infusion Monitoring System](image)

**Figure 7.** Mechanical of Infusion Monitoring System

Arduino mega board is connected to load cell sensor, photogate, buzzer and TFT LCD. When the monitoring system is turned on, the system will work by reading the measurement results on the sensor and displayed on the TFT LCD. The display on the TFT LCD is shown in Figure 8.

![Display on TFT LCD](image)

**Figure 8.** Display on TFT LCD
Instrument testing is done by measuring the sensor output and measurement accuracy of the system. Testing is done to find out whether the measuring instrument managed to achieve the objectives of the research or not. Testing on the photogate sensor as a measure of the number of drops per minute is done by looking at the effect of various types of intravenous fluids on the sensor output voltage. This is done to determine whether different types of intravenous fluids will affect the performance of the instrument. The test results are shown in the graph in Figure 9.

![Figure 9. Influence of the Type of Liquid on the Photogate Output Voltage](image)

Based on the graph in Figure 9 it can be seen that the type of infusion fluids does not affect the performance of the photogate sensor. The sensor can still work even with different types of liquids. Testing the load cell sensor as a instrument to measure the percentage of the remaining infusion fluid is done by looking at the sensor output voltage with a different mass. The test results are shown in the graph in Figure 10.

![Figure 10. Relations of Load Cell Output Voltage with Mass](image)

In measuring the number of drops per minute, the speed of the drops is affected by the width of the infusion hose gap. The width of the hose gap is controlled by a klemp that presses the hose, so that it makes changes to the hose gap width to then affect the speed of infusion drops. The results of testing are shown in the graph on Figure 11.
Based on the graph it can be seen that if the gap width of the hose gets bigger then the speed of drops faster and the number of drops per minute gets more. The test results obtained the average accuracy of number of drops per minute is 97.85% with a average percentage relative error of 2.15% and average precision of 96.70% with a percentage relative error of 2.50%.

Measurement of the accuracy of the measuring instrument the remaining percentage of infusion fluid is done by comparing the mass read on the device with the total mass of fluids. Measured mass is the variation in mass read on the instrument and the total mass is the amount of mass of the infused fluid in its full state. The measurement results can be seen in the graph in Figure 12.

Based on the graph above, the measurement results obtained are the average accuracy value of percentage of remaining infusion is 98.53% with average percentage relative error is 1.47% and average precision of 98.80% with percentage relative error of 1%.

4. Conclusion
Based on the results of research and data analysis on the infusion fluid monitoring system that has been done, it is concluded that the average accuracy in measuring the number of drops per minute is 97.85% with average percentage relative error is 2.15% and the average accuracy in measuring percentage of remaining infusion is 98.53% with percentage relative errors is 1%.

References
[1] Wadiano, & Zhafirah Fihayah. 2016. *Simulasi Sensor Tetesan cairan Pada Infus Konvensional*. Politeknik Kemenkes Jakarta. Vol. 3, No. 3, November 2016.
[2] Nataliana, Decy, dkk. 2016. *Alat Monitoring Infus Set pada Pasien Rawat Inap Berbasis Mikrokontroler ATmega 8535*. Vol. 4, No. 1, Januari-Juni 2016.

[3] Weinstein, Sharon. M. 2012. *Buku Saku Terapi Intravena Edisi 2*. Jakarta: EGC.

[4] Windarto, Yusmana. 2017. *Kontrol Pasien dengan Infus Nirkabel karya Mahasiswa*. http://pojokitu.com/baca.php?idurut=42003&&top=1&&ktg=Jatim&&keyrbk=.Metropolis&&keyjdl=kontrol, diakses 29 Maret 2019.

[5] Handaya, Yuda. 2010. *Infus Cairan Intravena: Macam-Macam Cairan Infus*. http://dokteryudabedah.com/infus-cairan-intravena-macam-macam-cairan-infus, diakses 29 Maret 2019.

[6] Candra, Riski. 2019. *Serba-Serbi Infus: Mulai dari Prosedur Pemasangan hingga Resiko Efek Sampingnya*. https://hellosehat.com/hidup-sehat/fakta-unik/penyebab-tangan-di-infus/, diakses 29 Maret 2019.

[7] Mahardika, Gilang Prihadi & Mutiara Herawan. 2015. *Rangan Bangun Perangkat Pengendali Debit Infus Otomatis untuk Proses Terapi Infus*. VI, p. 22, 2015.

[8] Yulkifili. 2013. *Sistem Sensor dan Aplikasinya*. Padang : Universitas Negeri Padang.

[9] Wibowo, Agus. 2019. *Analisis Penyakit Gen Sensor Load Cell dalam Perhitungan Berat Benda Padat dan Benda Cair Berbasis Mikrokontroler*. Vol. 12, No. 1, Maret 2019.

[10] Suhendra, Imam & Wahyu Setyo Pambudi. 2015. *Aplikasi Load Cell untuk Otomasi pada Depot Air Minum Isi Ulang*. Vol. 1, No. 1, Juni 2015.

[11] Yohandri. 2013. *Mikrokontroler dan Antar Muka*. Padang : Universitas Negeri Padang.

[12] Arifin, Jauhari, dkk. 2016. *Perancangan Murottal Otomatis Menggunakan Mikrokontroler Arduino Mega 2560*. 12, No.1.

[13] Anandya, Vanesa Bagus & Dwi Basuki. 2014. *Rancang Bangun Sistem Kontrol Sequence pada Mekanisme Pengganti CD Player Secara Otomatis Berbasis Mikrokontroler ATmega 328P*. Vol. 2, No. 2. 109-119.