MONITORING SYSTEM OF PATIENT INFUSION IN RSIA MUTIARA HATI BASED ON INTERNET OF THINGS

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ABSTRACT

The purpose of the study can assist nurses in monitoring the condition of patients in real time. This monitoring tool is composed of a series of sensors, to detect remaining fluid infusion using a load cell sensor, body temperature using a DS18B20 sensor, and a heartbeat using a pulse sensor. The method used is the prototype with the communication process, quick plan, quick design modeling, construction of the prototype and the development of DeliveryPand feedback. Based on the results of testing the system that has been implemented, the system can monitor the health of inpatients through an Android Smartphone application that is connected to the internet network, the system can also provide information in the form of notifications if an abnormal condition occur in one of its parameters.

Keywords: Monitoring, Inpatient, Body Temperature, Heartbeat, Infusion, Internet of Things.

1. PRELIMINARY

Hospitalization is a form of treatment, where patients are treated and stay in the hospital for a certain period of time. One of them is Mutiara Hati Hospital which is located on Jalan Raya Subang-Pagaden Km. 13 Sukamulya, Pagaden, Subang. Mutiara Hati Hospital this is often used as a referral from other hospitals, then many patients inpatients which in the Hospital Mutiara Hati. During the patient being treated, the hospital must provide the best service to patients. Currently in the Hospital Mutiara Hati has 37 rooms and only has 40 nurses. With the limitation of nurses in Mutiara Hati hospital, the nurses often have difficulty in checking the patient's condition. Checking the patient's condition is very important in every hospital, because it can help us obtain information about the physical condition of the patient.

Inpatients generally get health monitoring covering 3 parameters namely body temperature, heart rate and infusion. These three parameters are used as an indication of significant patient health development. Heart rate and body temperature very influential on the patient's health. If the heart rate and body temperature are not normal, then further action needs to be taken so as not to make the illness suffered worse. For normal body temperature the average ranges from 36.1 ° C to 37.2 ° C. While the normal heart rate is 60-100 bpm (beats per minute), if the heart rate is below 60 bpm or above 100 bpm the heart rate is abnormal , which causes the heart to stop pumping blood throughout the body.

In addition to body temperature and heart rate, monitoring of infusions fluids is also needed. Every patient will have an IV to help the healing process. The thickness of the infusion fluid varies and the entry of the body also differs in capacity. Usually for patients who have critically been used fluid that has a high concentration of drug content, while for patients not too critical, only used metabolic fluids.

With the description above, the researchers intend to create a three-parameter monitoring system, namely heart rate, body temperature and infusion droplets for patients. Based on the background above, this study is entitled "Patient Monitoring System at the Hospital Mutiara Hati Based on Internet of Things ”

And with this tool nurses can easily monitor patients because the required inpatient data will be displayed in an Android application. In addition nurses will get a notification if there are patients who get obstacles for example such as blockage of infusion droplets that do not flow properly or heart rate and body temperature that is not normal.

1.1 *Internet Of Things*

Internet of Things (IoT) consists of 2 main pillars namely "internet" and "Things", so every object that is able to connect to the internet will fall into the "Things" category as it includes a set of more common entities such as smartphones, sensors, humans and other object. The context is able to communicate with other entities, making it accessible anytime, anywhere. Broadly speaking with the Internet of Things (IoT) objects must be accessible without limitation of time or place [1].

1.2 Hospital

The hospital is an integral part of a social and health organization with the function of providing plenary

services (comprehensive), healing disease (curative) and prevention of disease (preventive) to the community. The hospital is also a training center for health workers and a medical research center.

Based on Law No. 44 of 2009 concerning hospitals, which is meant by hospitals, is a health care institution that conducts complete individual health services that provide inpatient, outpatient and emergency services.

1.3 Nurse

Nurse is a person who has graduated from nurses education both at home and abroad in accordance with statutory regulations (RI Minister of Health Regulation No. HK.02.02 / MENKES / 148 / I / 2010). Nurses consist of Associate Nurses, Nurses and Special Nurses. Whereas the AD / ART PPNI / INNA Results of VII National Conference in 2005 [6] explained that the nurse was a person who had taken and passed formal education in the field of nursing whose educational program had been approved by the Government of the Republic of Indonesia.

1.4 Inpatients

Patients are biological, psychological, social, economic and cultural beings who need to meet the needs and expectations of the aspects of bio (health), psycho aspects (satisfaction), socio-economic aspects (clothing, food, housing and social affiliation), and cultural aspects [10]

Inpatients are sufferers in a health care facility who must stay in the health care facility for more than 24 hours because of their illness [11].

1.5 Infusions

The infusion is also called Intravenous Fluid Drops (IVFD), which is interpreted as a pathway for entering fluid through veins. Despite the fact that intravenous fluids have various types so they do not necessarily say that the infusion is a substitute food for the sick.

Figure 1. ***Infusion set***

Infusion of fluids is administration of fluids given to patients who experience heavy fluid or nutrient discharge. This action requires sterility because it is directly related to blood vessels. The administration of fluids by infusion by inserting into a vein (a patient's vein) including the arm vein (basal cephalic vein and mediannakubiti), in the limb (safer vein) or the vein in the head, such as the frontal temporalis vein (especially for children)

Infusion is a technique used for transcutaneous venous displacement using rigid sharp stylets performed with sterile techniques such as angeocateters or with needles connected to syringes [9]. Installation of infusion is one way or part of treatment to enter drugs or vitamins into the patient's body. While the infusion is entering a certain amount of fluid through the patient's vein continuously in a certain period of time. Meanwhile according to Lukman [7], intravenous infusion is inserting a needle or cannula into a vein (vein) for intravenous fluids / treatment, with the aim that a certain amount of liquid or drug can enter the body through a vein within a certain period of time. This action is often an olife saving action such as in heavy fluid loss, dehydration and shock, therefore successful therapy and safe administration methods require basic knowledge of fluid and electrolyte balance and acid base. So it can be found that infusion is a technique to insert a needle or cannula into a vein to put intravenous fluids into the body.

1.6 Body temperature

Most humans perform activities in a "normal" environment, that is, at moderate temperatures on a plain not too far above sea level.1 Compared to other primates, humans have a far greater ability to tolerate heat, due to the large number of sweat glands and the body which has only fine hair.4 In the body heat energy is produced by active tissue, especially in muscles, then also in sweat, fat, bone, connective tissue, and nerves. The heat energy generated is distributed throughout the body through blood circulation, but the temperature of the body parts is uneven. There is a quite big difference (around 4 ° C) between core temperature and body surface temperature.6,7 The body thermoregulator system must be able to achieve two suitable temperature gradients, namely: a) between core temperature and surface temperature, b) between surface temperature and ambient temperature. Of the two, the core temperature gradient with surface temperature is the most important for optimal bodily function continuity. Furthermore, the heat exchange with the surrounding environment takes place through the respirator and skin, because every effort to maintain core temperature will affect the peripheral parts of the body, especially the hands and feet.

In the process of exchanging body heat follows the laws of physics. In this case the human body is a black body, and the body surface is a good radiant heat absorber as well as a good transmitter of heat. Biologically the body has several mechanisms to maintain body temperature:

1. Core body temperature is maintained within a narrow limit, the body can tolerate variations in temperature to as deep as 2 cm from the body surface. Body temperature can vary around 1.5 ° C above or below core temperature without having a harmful effect. 2. The automatic control mechanism of the nervous and endocrine systems that work when the core temperature or skin temperature changes, this mechanism makes it difficult to measure dry heat. 3. Mechanisms of behavior and postural changes that can modify exposure to radiation and heat convection, but workers are usually not free to use this method. 4. Use suitable clothing and create a protective environment from heating to air conditioning.

1.7 Pulse Sensor

Figure 2. Pulse Sensor

Pulse sensor is a sensor that can calculate the human heart rate produced by Fungky Corporation. This sensor uses infrared and photodiode. Infrared will emit a signal that penetrates the skin on the hands which will then be captured by the photodiode. The concept is infrared and photodiode will capture changes in blood volume in the fingers when the heart pumps blood throughout the body. this is where heart rate data will be obtained for later processing.

1.8 Microcontroller

A microcontroller is a processor (stripped-down) that is equipped with memory, timers, I / O pins (parallel) and others on the peripheral chip. The driving force behind all this is cost: Integrating all elements on one chip saves space, lower production costs and shorter development time. This saves time and money, which is a key factor in embedded systems. The added benefit of easy upgradability integration, lower power consumption, and higher reliability, which is also a very important aspect in embedded systems. On the downside, using a microcontroller to complete tasks in software that can also be completed with a hardware solution will not provide the same speed that a hardware solution can achieve. Therefore, applications that require very short reaction times may still call for hardware solutions. Most applications, however, and especially those that require some kind of human interaction (microwave, cellular telephone), do not need such a fast reaction time, so for this application a microcontroller is a good choice [8].

1.9 *Raspberry Pi*

Raspberry Pi is a single board computer (Single Board Circuit / SBC) or a mini computer that has the size of a credit card. Raspberry Pi is very useful for various purposes, such as spreadsheets, games, playing high definition video. Raspberry Pi was developed by the Nirbala Foundation, the Raspberry Pi Foundation, which is managed by developers and computer experts from the University of Cambridge, England [3].

Figure 3. Raspberry Pi 3

Raspberry Pi is controlled through a website for monitoring and automation.

1.10 Prototype

The software development method uses a prototyping model, because in making this system the user involvement is very high so the system meets the user needs better [4,5].

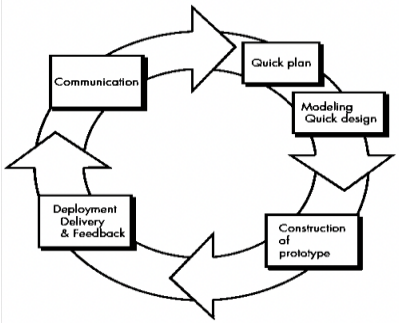

Figure 4. Metode Prototype

Explanation of the prototype model point is as follows:

1. *Communication*
   At this stage communication is done with nurses in Mutiara Hati Hospital to define the overall objectives of the system and identify problems.
2. *Quick Plan*
   In this stage plan by analyzing the needs needed to create a patient monitoring system.
3. *Modeling Quick Design*
   Immediately make models and quick designs quickly to make an overview of the tools to be built.
4. *Consturciton Of Prototype*

At this stage the system development is based on the results of the analysis, both in the form of software and hardware.

5. Developtment Delivery & Feedback
   Prototype acts as a mechanism for identifying software requirements specifications. Development took place so that the prototype was improved to satisfy the needs of the hospital, while at the same time allowing doctors and SR parties to understand what was needed to complete a system.

2. RESEARCH CONTENTS

2.1 Analysis of the Current System

The current system is the stage that gives a picture of the current system and aims to provide a more detailed picture of the workings of the current system. The focus of this research is the procedure for monitoring the health of inpatients in RS. Mutiara Hati.

2.2 Systems Architecture Analysis

System architecture analysis is a process to describe the physical system to be built and also its supporting components. The following is an illustration of the system architecture to be built as shown below.

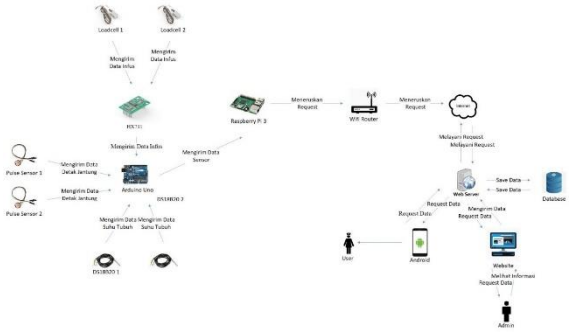

Figure 5. System Architecture to be Built

The following is an explanation of the architecture of the patient's health monitoring system as shown in the figure, there are three channels, namely, monitoring body temperature, heart rate and the remaining fluid infusion of the patient.

The process of monitoring the patient's body temperature, heart rate and remaining intravenous fluids is as follows:

1. The DS18B20 sensor reads body temperature data and sends the data to Arduino Uno.
2. The heart rate sensor reads the patient's heartbeat and sends the data to Arduino Uno.
3. Loadcell reads the infusion fluid waste data and sends the data to Arduino Uno.
4. Arduino Uno as a microcontroller that takes data from all sensors and modules as well as sending data to the Raspberry Pi.
5. Raspberry Pi 3 as a media receiver of data from Arduino Uno and as a sender of data to web services via an internet connection.
6. The web service will store data on body temperature, heart rate and patient's IV fluids in a database.
7. The database provides data to web services.
8. Web service sends data to an Android-based system.
9. Android based system displays data sent by web service.

2.3 Data Communications Analysis

Data communication is a very important thing, because without data communication, an application that is built will not be able to run properly or optimally. Data communication itself is related to sending electronic transmission system data from one terminal to another. The data referred to are electronic signals generated by data sources that can be captured and sent to the receiving terminal.

Following is an explanation of the 3 main elements in data communication systems. As follows.

1. Data source
   Data sources are part of the system that functions as a data provider and also as a data sender. Data sources available on this system can be described as follows :
   a. Load Cell Sensor
      the weight of a load, this sensor is used as a data source to indicate the separation of the patient's IV fluids.
   b. HX711 Amplifier Module
      The HX711 is an integrated component of "AVIA SEMICONDUCTOR", the 24-bit precision analog to digital converter (ADC) HX711 made for supporting load cell sensors for conversion.
   c. DS18B20 Sensor
      DS18B20 is a temperature sensor which is intended as a source of data to detect body temperature in patients. The black cable is GND, the red cable is vdd, the yellow cable is data.
   d. Pulse Sensor
      Pulse sensor is a sensor that can detect heart rates, this sensor is used as a source of data for heart rate in patients. Pin 1 is GRD, pin 2 is VCC, pin 3 is A0.
   e. Arduino Uno 3
      Arduino UNO R3 is used as a control center for data sources. Arduino UNO R3 will request to the DS18B20 sensor, Pulse sensor, and Loadcell sensor which will then be sent to the Raspberry Pi.
2. Transmission Media

Media transmission is the path through which the process of sending data from source to receiver. The transmission media used in this system are wireless, the following are the tools used in the patient's health monitoring system.

a. Raspberry Pi 3
   Raspberry Pi 3 is used as a control center for data received from Arduino UNO and as a liaison between Arduino UNO R3 and WIFI routers.
b. WIFI router
   The wifi router used is the Vivo Y83 smartphone, this device is used as a hotspot so that connected devices can access the internet. The main purpose of using the internet is to access the webservice.

3. Data Recipients
   Data receiver is a device that receives data and information from a data sending device. The device that receives data as follows:
   a. Smartphone.(Android)
   Smartphones can include data receivers on this system because smartphones receive data in the form of body temperature, heart rate and residual fluid infusion of patients by accessing the monitoring application on a smartphone (android).

2.4 Use Case Diagrams

Use Case Diagram is a modeling for the behavior (behavior) of information systems that will be made. Use Case describes an interaction between one or more actors with the information system to be created. Roughly speaking, the Use Case is used to find out what functions are in an information system and who has the right to use those functions. From the identified actors involved above, the Use Case Diagram can be seen in Figure 6.

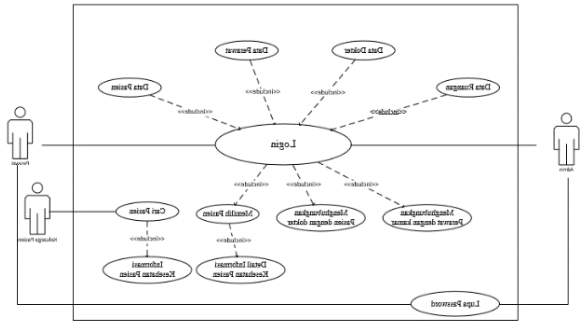

Figure 6. Use Case Diagram

2.5 Class Diagram

Class Diagram is a specification of functionality that produces objects and is the core of the development of this application. Class diagram of the control system and monitoring the health of inpatients, for more details can be seen in Figure 7.

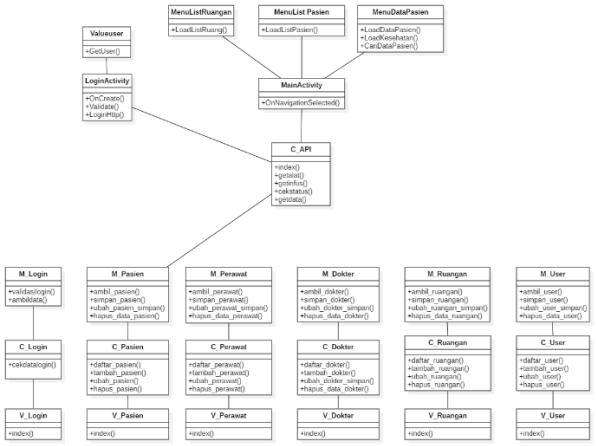

Figure 7. Class Diagram

2.6 Relation Scheme

Relation scheme is a series of relationships between several tables in a database system. Explanation of database series. In this system can be seen in Figure 8.

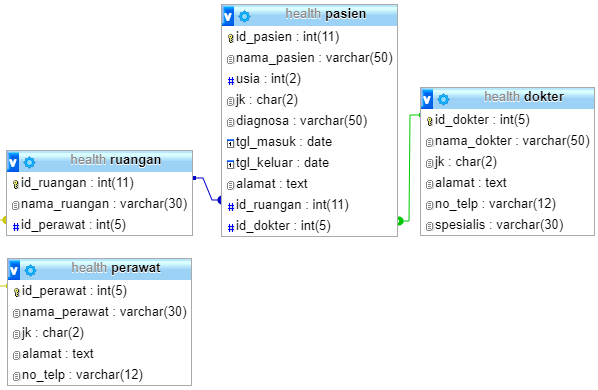

Figure 8. Relation Scheme

2.7 System Testing

System testing is the most important thing that aims to find errors or deficiencies in the information system being tested. System testing is intended to determine the performance of information systems that have been made in accordance with the objectives of information system design. Types of Testing conducted include testing Functionality and Usability.

The test plan that will be carried out is by testing the system that has been built on the Functionality side of the system maker by Black Box and from the Usability side by the user through interviews.

2.7.1 Black Box Testing

Black box testing focuses on whether the software built meets the requirements mentioned in the

specifications. Tests carried out by running or executing units, then observed whether the results of the units tested whether in accordance with the business process or not.

2.7.2 Black Box Admin Testing Scenarios

The software testing scenario for the admin on a patient health monitoring system can be seen in table 1.

Table 1. Nurse Black Box Testing Scenarios

Kasus Uji	Detail Pengujian	Jenis Pengujian
Login	Login User	Black Box
Data Dokter	Melihat Data List Dokter	Black Box
Data Perawat	Melihat Data List Perawat	Black Box
Data Pasien	Melihat Data List Pasien	Black Box
Data Ruang	Melihat Data List Ruang	Black Box
Data User	Melihat Data List Ruang	Black Box

2.7.3 Nurse Black Box Testing Scenarios

Software testing scenarios for nurses in the patient health monitoring system can be seen in Table 2.

Table 2. Black Box Testing Scenarios

Case Test	Detai Test	Testing Type
Login	User Login	Black Box
See Patient Details	See the name of the patient, the room, the doctor who examined it and the patient's health status	Black Box
Patient Data Details	See patient health data	Black Box
Detail Space List	See the name of the room, building, floor, and room capacity.	Black Box

2.7.4 Black Box Admin Test Results

Testing is done by testing each process for possible errors that occur.

Table 3. Black Box Testing Results

Cases and Test Results (Correct Data)			
Action / Data Input	Which are expected	Observation	Conclusion
Enter all input fields that correspond to the database	Displays the notification "you have successfully logged in" and displays the main page	A notification will appear "You have successfully logged in and entered the main page"	[√] Be accepted [ ] Rejected
Cases and Test Results (Incorrect Data)			
Action / Data Input	Which are expected	Observation	Conclusion
Leave Username and Password fields blank	Displays notification "login failed, username not found	A notification appears "fill in your username and password correctly"	[√] be accepted [ ] rejected

2.7.5 Nurse Black Box Testing Results

Testing is done by testing each process for possible errors that occur.

Cases and Test Results (Correct Data)			
Action / Data Input	Which are expected	Observation	Conclusion
Klick Button data perawat	Displays nurse data in the form of name, gender, address.	Nurse data in the form of name, gender and address	[√] be accepted [ ] rejected

2.7.6 Conclusion Black Box Testing

Based on the results of Black Box testing that has been done, it can be concluded that functionally all processes in the system have been partly running as expected.

2.8 Testing of Hardware Components

Installation of tools has been carried out on the IoT hardware implementation. To find out if the equipment is running according to the original design, a test is needed. The test is carried out with a LoadCell sensor, Pulsesensor, DS18B20 sensor, and the entire tool works.

2.8.1 Load Cell Sensor Testing

Loadcell sensor is a sensor that is used to detect the capacity of the patient's remaining IV fluid, the test results can be seen in the Figure 9.

Figure 9. 500ML infusion fluid

From Figure 9 it can be seen that the IVML capacity is 500ML.

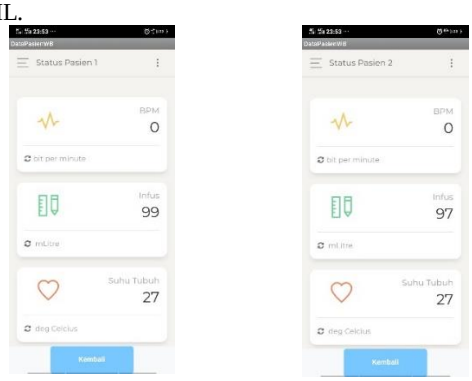

Figure 10. Infusion fluids of patients 1 and 2

From figure 10 it can be seen that the monitoring application displays a percentage of 99% and 97%.

2.8.2 Testing the DS18B20 Sensor

DS18B20 is a sensor that is used to determine body temperature in patients. The sensor is placed on the patient's armpits. This test aims to determine whether the DS18B20 sensor can function properly.

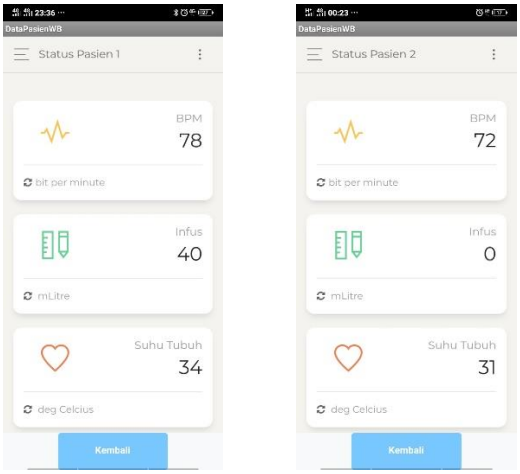

Figure 11. Body Temperature of Patients 1 and Patients 2

From these images can be seen measurements of body temperature in patients. From this test it can be concluded that the DS18B20 sensor can work well.

2.8.3 Pulse Sensor Testing

Pulse sensors are used to detect heart rates in patients. The sensor is mounted on the patient's index finger. This test aims to determine whetherPulsesensor works well.

Figure 12. Pulse Sensor Testing

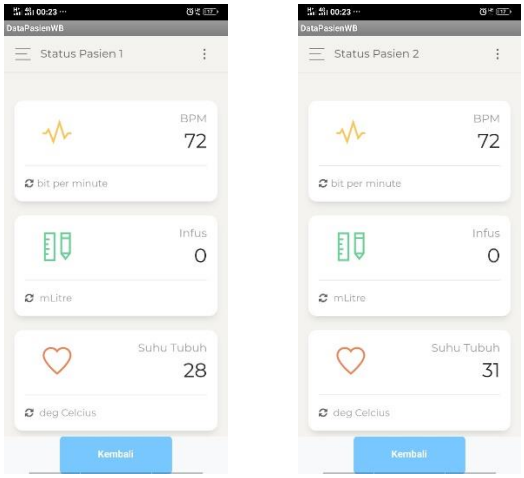

Figure 13. Results of Pulse Sensor Testing

In the picture it can be seen that the pulse sensor is working well as indicated by the change in BPM of the patient's heart rate in the application. The conclusion of this sensor test is that using a pulsesensor to detect a patient's heartbeat g) can run well and in line with expectations

Based on the results of Beta testing with the User Accepted Test method, interviews with hospital nurses, can be drawn. Conclusions that:

1. This IoT-based patient health monitoring system can monitor the patient's body temperature, heart

rate and fluid intake and is easy for users to understand.

3. COVER

3.1 Conclusions

Based on the results of software and hardware testing that has been made as a patient health monitoring system, the following conclusions are obtained:

1. The system that has been built can monitor the health of inpatients through an Android smartphone application that is connected to the internet network.
2. The system that has been built can control data through the website.
3. The system that has been built can provide information on body temperature, heart rate and separation of intravenous fluids in patients.

3.2 Suggestions

The system that has been made still needs to be developed again in the future, so that the system that has been built can work more real time. The suggestions for developing software that is built are as follows:

1. The system on an android smartphone can bring up notifications when something happens that is not normal for patients.
2. Develop a platform that can be supported by other software, considering that currently only supports the Android platform.

BIBLIOGRAPHY

[1] R. Buyya and A. V. Dastjerdi, Internet of Things: principles and paradigms. Amsterdam: Morgan Kaufmann, 2016

[2] Saipul Mugni, "Rancang Bangun Sistem Monitoring Kesehatan Pasien Rawat Inap Berbasis Internet of Things (IoT)" Bandung, 2019.

[3] Raspberry Pi Foundation, “Raspberry Pi 3 Model B Technical Specifications,” RaspberryPi 3 Model B, p. 8, 2016

[4] R.S. Pressman, “Prototype”, dalam Software Engineering A Practitioner’s Aproach, Thomas Chasson, 2001, pp. 31-32.

[5] D. Hirawan and P. Sidik, “Prototype Emission Testing Tools for L3 Category Vehicle,” IOP Conference Series: Materials Science and Engineering, vol. 407, p. 012099, 2018.

[6] Simamora, Roymond. 2009. Dokumentasi Proses Keperawatan. Jember: Jember University Press.

[7] Lukman. (2007). Intravena Terapi. http://www.sehatgrup.com. Di akses pada tanggal 12 Agustus 2017.

[8] Gunther Gridling and Bettina Weiss, "Introduction to Microcontrollers," California: Vienna University of Technology, 2007.

[9] Kusyanti, Eni. "Keterampilan dan prosedur laboratorium keperawatan " Jakarta:EGC, 2006

[10] Supriyanto S., dan M. Ernawati. 2010. Pemasaran Industri Jasa Kesehatan. Yogyakarta : ANDI.

[11] Departemen Kesehatan RI. 2009. Profil Kesehatan Indonesia 2008. Jakarta: Departemen Kesehatan RI.