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Integrated Blood Type Detector with IoT System to Improve Indonesian Red-Cross Public Health Services

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Abstract

In 2008, a survey held by the World Health Organization shows that the blood stock in Indonesia is 0.2% of the total population, which is lower than the minimum requirement for health services (2,5% of the total population) because of the low quality of donor equipment and incompetent workers. In addition, the current regulation on blood availability monitoring seems a rather complex and challenging process. This study aims to create an integrated device that can test the blood type and serves as a database of bloodstock in several IRCs to accelerate the distribution of blood between IRC and hospital. This research utilizes the Internet of Things (IoT) using a Wi-Fi module to create a device that could send data to computers using the internet. Through an experiment of 85 respondents, results showed that the accuracy of the device in detecting blood type is 96.5%. The time taken for the data to be received by the computer varies with the internet network used. The fastest data transfer was accepted using a 4G network, which requires only 1.9 seconds. Meanwhile, the 3G and 2G networks took around 3.17 and 18.17 seconds, respectively.

Keywords:
Blood type, Hospital, Indonesian Red Cross, IoT, Public Health Services,

1. Introduction

The World Health Organization has been persuading people to donate their blood regularly. Donated blood can supply patients in hospitals to meet the requirement for medical services. To encourage people even more, the 14th of June was selected to be Blood Donation Day, supported by many countries worldwide. Blood Donation Day was set by WHO in 2005 and has shown many donors [1]. The standard bloodstock must be met in each country is around 2.5% of the population. However, the bloodstock in Indonesia is found to be lower than the required amount that the WHO regulated. A survey held by the World Health Organization in 2008 shows that the blood stock in Indonesia was 0.2% of the total population. This number is much lower than the minimum requirement for the recommended health services. Several studies suggested that this is caused by the low quality of donor equipment and incompetent workers [2].

In addition, the current regulation on blood availability monitoring seems a rather complex and challenging process. The Blood Bank in the hospital should send a request first to the Indonesian Red Cross (IRC) to meet the needs of patients through intermediary supervision. The exact process goes for the blood monitoring between IRC and the hospital. The request is usually sent by making reports, which are then received and replied to by both parties. This process may take several days, hence considered ineffective [3]. A certain amount of bloodstock should be maintained at the hospital at any time to prevent any urgent

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situations. If there is no bloodstock of a specific blood group or a meager amount, the patient will be in a life-threatened condition since blood is a primary substance for medical services. Most of these cases are dominated by men with accidents and women giving birth at the hospital [4].

It was reported that implementing technology can further improve the IRC public health services. The coordination and integration of information systems may solve problems in managing Indonesian blood supply procedures. A blood traceability system method has been proposed to ease the monitoring and distribution of blood bags to hospitals [5]. This system was implemented in several ASEAN countries, such as Thailand, Malaysia, and Singapore. The benefit of this system was to reduce human error, improve monitoring of blood supply distribution, increase the safety of patients and medical staff, and promote blood supply efficiency [6,7].

The ABO blood type typing has also developed throughout the years. Synthetic receptors may detect a blood group on red blood cells, but it is expensive and requires experienced labor. Blood group may also be determined by using genotyping approach [8], implementing paper–based detection, and serological tests [9]. These methods were relatively expensive and less mobile, hence not suggested for emergencies. IRC has not yet implemented any blood type detection methods in these innovations. Recently, a device has been proposed to detect blood using a spectrophotometry approach with 96% accuracy, yet still relatively expensive [10].

We are figuring out a low-cost device to detect blood type using the agglutination principle, but it also implements the change of blood voltage that passes through agglutinated blood. This study aims to create an integrated device that can test the blood type and serves as a database of bloodstock in several IRCs to accelerate the distribution of blood between IRC and hospital. By doing so, hospitals would have easier access to blood availability in a particular area. This research utilizes the Internet of Things (IoT) using a Wi-Fi module to create a device that could send data to computers using the internet.

2. Methods

3.1 Blood Type Detector Model

The concept in this research follows the design in Figure 1. The device is designed to detect a person's blood type using light sensors and a microcontroller. Several different properties of each blood type, such as viscosity and color intensity, can distinguish the blood type. That information is sent to a cloud system using a Wi-Fi module. The device's length, width, and height are 15 cm, 9 cm, and 4 cm, respectively. The electrical circuit is designed using Fritzing software (Figure 1b). The main components of this device include an ATMEGA 8535 microcontroller, a Liquid Crystal Display (LCD), 2 Light Dependent Resistors (LDR), 2 Light Emitting Diodes (LED), a 5-volt power supply, as well as 6 AA type batteries. To add the feature of the Internet of Things (IoT), the microcontroller installed the ESP8266 Wi-Fi module, which serves as a tool that could send data from the device to the cloud. After the fundamental component is assembled, a plastic casing is carved around the device.

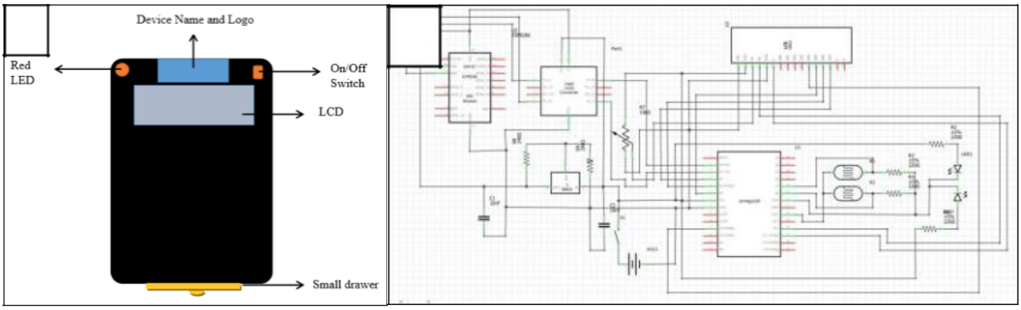

Fig 1. (a) The external view of the design shows an LCD, a switch, and a small drawer containing a slot for blood samples. (b) Electric components are designed using Fritzing software.

Determination of the blood type can be known through blood viscosity level after the provision of antibody reagents. A small rack inside the device serves as the slot for two blood samples. Blood samples will be reacted with anti-serum A and anti-serum B reagents. The light produced by the LED will penetrate the object glass, which contains the reacted blood samples. The light will affect the resistance of the LDR, which is located beneath the blood samples. Thus, changing the voltage value depending on the intensity of the light received. An agglutinated blood will have a different voltage value than one that does not.

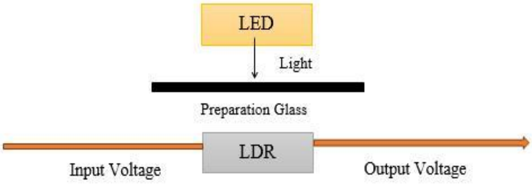

Fig 2. The light penetrating the blood samples in the object glass changes the output voltage value by affecting the resistance of LDR.

3.2 Voltage Determination

Information regarding the voltage value of both blood samples will be sent to the microcontroller, which will then be processed as binary numbers. The process of determining the voltage value of agglutinated and non-agglutinated blood was done using a multimeter and was repeated as much as 30 times. The microcontroller will then convert the voltage value to binary numbers (1 and 0). Each type of blood type has a different set of binary numbers. Thus, the microcontroller can give LCD commands to display the recipient's blood type results. The microcontroller installation uses the Codevision AVR program in C language.

3.3 Accuracy Test

The accuracy was determined by evaluating the blood type of 85 respondents taken randomly from Brawijaya University. Blood was taken to the Accuracy and was tested by comparing the result with each respondent's IRC blood type card. The accurate result is shown if the result matches the blood type card.

3.4 IoT Installation

Data transfer of the device can be done by applying a particular module in the system. The component used in this research is the Wi-Fi ESP8266 module installed on the ATMEGA 8535 microcontroller. The purpose of this IoT system implementation is to receive
the information on blood type contained in the device, which would then be sent to a database using an internet network [11]. To begin with, the frequency of the type of blood type read by the tool is transferred to the database. Afterward, the blood type frequency is converted into units of volume (cc) by multiplying it by 250cc. It is based on the IRC regulation that a blood donor of a healthy adult is 250cc[1]. IoT system is implemented to form a network between blood type detector users, the IRC, and a hospital in a particular area. By doing so, blood availability can be monitored in real-time. Microsoft Visual Studio uses an application to receive the information in the database to a personal computer.

Fig 3. a) A database provides access between IRC and the hospital so that both parties can share information. This database will ease the real-time blood monitoring of a certain area. b) The value of bloodstock is displayed using Microsoft Visual Studio software.

3. Result and Analysis

The small drawer has two object glasses provided for the blood samples. The left preparatory glass will be tested with anti-serum A, while the right glass will be tested with anti-serum B. Anti-serum contains plasma-containing antibodies, which will cause agglutination. The voltage value assessed shows that agglutinated blood clot has a voltage value of 0.79 V, while the blood that does not agglutinate has a 3.4 V. These values are the average of 30 repetitions of each blood sample. Inside the microcontroller, these data will be converted into the numbers 1 and 0. The number 1 shows agglutinated blood, whereas 0 is for non-agglutinated blood. The microcontroller converts these binary numbers as a simple set code for each blood type, as shown in Table 2.

Table 1. The voltage value of each blood type

Blood Type	Anti-Serum A (V)	Anti-Serum B (V)
A	0.79	3.4
B	3.4	0.79
AB	0.79	0.79
O	3.4	3.4

Table 2. Binary code for each blood type

Blood Type	Anti-Serum A	Anti-Serum B
A	1	0
B	0	1
AB	1	1
O	0	0

The accuracy was determined by evaluating the blood type of several respondents directly. Tests conducted on 85 respondents showed three mistakes (errors). Meanwhile, the remaining respondents have the same results with blood type cards released by IRC. Based on these data, it can be seen that the device has an accuracy of 96.5%.

Fig 4. The accuracy is evaluated by matching the result with a blood type card released by IRC.

In the IoT scheme, the device sends the data regarding the blood type frequency that it detects during blood type detection. Those frequency values will be converted into volume units (cc) in the database and sent to computers with specific applications. Microsoft Visual Studio-based applications were used to monitor the number of blood stocks in a particular area, specifically in the IRC. The data transmission time is measured from the transmission of data from the tool, and database, until the application on the computer. Based on Figure 5, all internet networks have fluctuating values. However, the 4G network has the fastest average time of 1.9 seconds. The 3G network has an average time of 3.17 seconds, while the 2G network is 18.17 seconds. Understanding the time taken for different internet networks might help measure how fast the data would be sent, especially if it were to be used in remote areas. Users in the hospital will be able to watch over and monitor the blood availability as long as both parties, in this case, the hospital and IRC, are connected to a delicate and smooth internet network. However, using a faster internet network is recommended to provide better real-time monitoring.

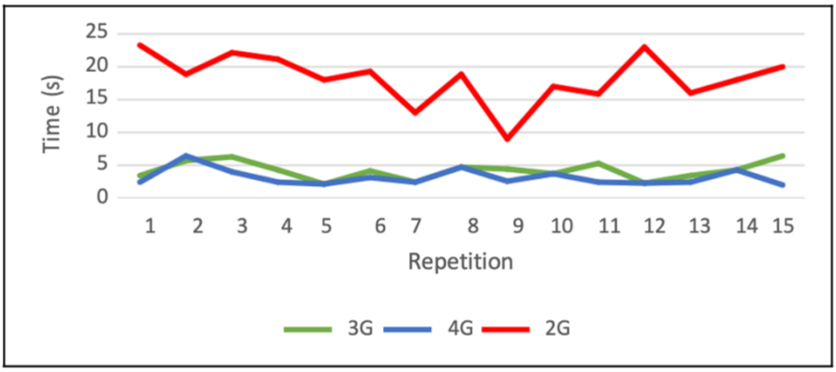

Fig 5. Time is taken for data transmission in 2G, 3G, and a 4G internet network from device to computer application.

4. Conclusion

An innovative microcontroller-based device that can detect a person's blood type and serves as a database of bloodstock in several IRCs to accelerate the distribution of blood between IRC and hospital is proposed. This research utilizes the Internet of Things (IoT) using a Wi-Fi module to create a device that could send data to computers using the internet. Through an experiment of 85 respondents, results showed that the accuracy of the device in detecting blood type is 96,5%. The time taken for the data to be received by the computer varies with the internet network used. The fastest data transfer was received using a 4G network, which requires only 1,9 seconds. Meanwhile, the 3G and 2G networks took around 3,17 and 18,17 seconds, respectively.

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