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

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Abstract

A survey held by the World Health Organization in 2008 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). This is caused by the low quality of donor equipments and incompetent workers. In addition, the current regulation on blood availability monitoring seems rather complex and difficult process. The purpose of this study is to create an integrated device which is able to test the blood type and serves a database of blood stock in several IRC to accelerate the distribution of blood between IRC and hospital. This research utilizes Internet of Things (IoT) using a Wi-Fi module to create a device which 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 network 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 be used to supply patients in hospitals to meet the requirement of medical services. To encourage people even more, 14th of June was selected to be the Blood Donation Day, which is supported by many countries all over the world. The Blood Donation Day was set by WHO since 2005, and has shown significant number of donors [1]. The standard blood stock that must be met in each country is around 2.5% of the population. However, the blood stock in Indonesia is found to be lower than the required amount that was regulated by the WHO. 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 equipments and incompetent workers [2]. In addition, the current regulation on blood availability monitoring seems rather complex and difficult process. The Blood Bank in hospital should send a request first to Indonesian Red-Cross (IRC) to meet the

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needs of patients through an intermediary supervision. The same process goes for the blood monitoring between IRC and hospital. The request are usually sent by making reports, which are then received and replied by both parties. This process may take several days, hence considered ineffective [3]. Certain amount of blood stock should be maintained at the hospital in any given time to prevent any urgent situations. If there happens to be no blood stock of certain blood group, or very low anount of it, the patient will be in a life-threatened situation since blood is a primary substance for medical services. Most of these cases are dominated by men who have accidents and also women giving birth at hospital [4].

It was reported that the implementation of technology can further improve the IRC public health services. The coordination and integration using information system may solve problems in managing Indonesian blood supply procedure. 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 promotes blood supply efficiency [6,7]. The ABO blood type typing has also developed throughout the years. A blood group may be detected by using synthetic receptors on red blood cells, but has expensive cost and requires experieced labour. Blood group may also be determined by using genotyping approach [8], implementing paper –based detection, and serological tests [9]. These method were relatively expensive and less-mobile, hence not suggested for emergency situations. IRC has not implemented any of blood type detection method these innovations yet. Recently, a device has been proposed to detect blood using spectrophotometry approach with 96% accuracy, but yet still relatively expensive [10]. We are figuring a low-cost device to detect blood type using agglutination principle, but also implements the change of blood voltage that passes through agglutinated blood. The purpose of this study is to create an integrated device which is able to test the blood type and serves a database of blood stock in several IRC to accelerate the distribution of blood between IRC and hospital. By doing so, hospitals would have easier access towards the blood availability in a certain area. This research utilizes Internet of Things (IoT) using a Wi-Fi module to create a device which could send data to computers using the internet.

2. Methods

3.1 Blood Type Detector Model

The concept in this reaserch follows the design in Figure 1. The device is designed to be able detect a person's blood type using light sensors and a microcontroller. The blood type can be distinguished by several different properties of each blood type, such as the viscosity and colour intensity. Those information are sent to a cloud system using a Wifi module. The length, width and height of the device is 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 Internet of Things (IoT), the microcontroller was installed ESP8266 Wifi module, which serves as a tool that could send data from the device to the cloud. A plastic casing is carved around the device after the whole component are assembled.

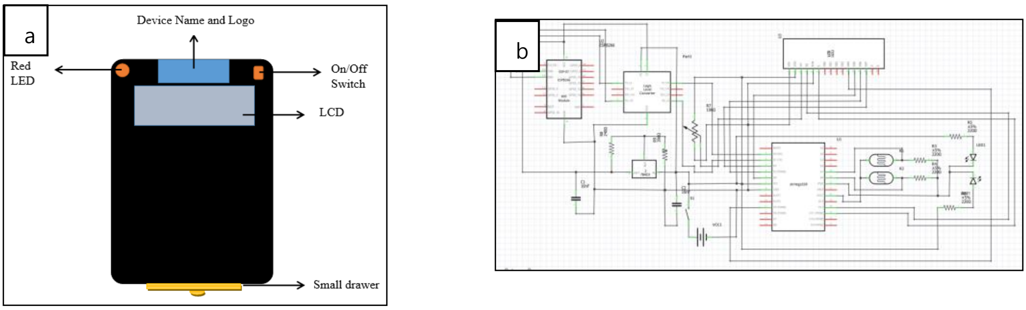

Fig 1. (a) The external view of the design, showing an LCD, a switch, and small drawer containing slot for blood samples. (b) Electric components are designed using Fritzing software**.**

Determination of the blood type can be known through the level of blood viscosity after the provision of antibody reagents. There is a small rack inside the device that 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 the one that does not.

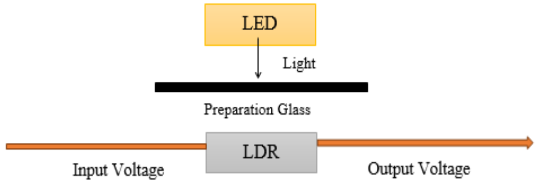

Fig 2. The light which penetrates the blood samples in the object glass changes the output voltage value by affecting the resistance of LDR.

3.2 Voltage Determination

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

3.3 Accuracy Test

The accuracy of was determined by evaluating the blood type of 85 respondents taken randomly from Brawijaya University. Blood was taken from the Accuracy were tested by comparing the result with the IRC blood type card from each respondents. Accurate result are shown if the result matches with the blood type card.

3.4 IoT Installation

Data transfer of the device can be done by applying a certain module in the system. The component used in this research is Wi-fi ESP8266 module which is installed on the ATMEGA 8535 microcontroller. The purpose of this IoT system implementation is to recieve the information of blood type contained in the device, which would then be sent a to database using internet network [11]. To begin with, the frequency of the type of blood type read by the tool is transferred to the database. Afterwards, the blood type frequency is converted into units of volume (cc) by multiplying it with 250cc. This 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, which is the IRC, with a hospital in a certain area. By doing so, the blood availability can be monitored in real time. An application is used to receive the information in the database to a personal computer using Microsoft Visual Studio. The application was set by using Visual Basic (VB) language, so that the application can display the blood type and its volume.

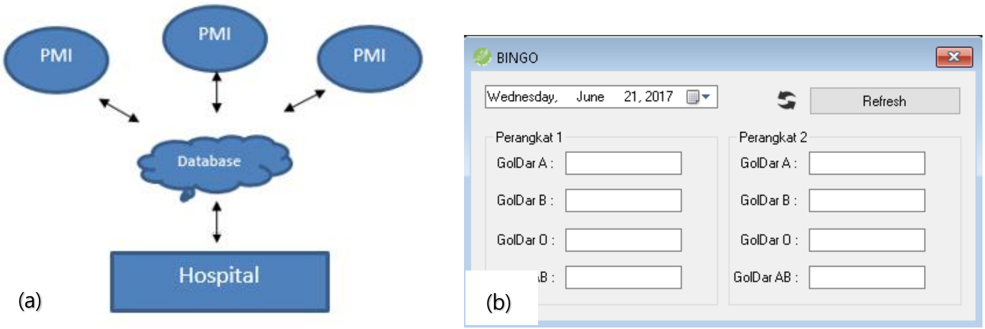

Fig 3. a) A database provides the access between IRC and hospital, so that both parties are able to share information. This database will ease the process of blood monitoring of a certain area in real time. b) The value of blood stock is displayed using Microsoft Visual Studio software.

3. Results

The small drawer has 2 object glass which were provided for the blood samples. The left preparatory glass will be tested with anti-serum A, while the right glass is 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 value are the average of 30 repetitions of each blood samples. Inside the microcontroller, these data will be converted into the numbers 1 and 0. The number 1 shows an agglutinated blood, whereas 0 is for the non-agglutinated blood. These binary numbers are converted by the microcontroller as a simple set codes for each blood type, as shown in table 2.

Table 1. 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 3 mistakes (error). Meanwhile, the remaining respondents has 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 send the data regarding the blood type frequency that it detects during a blood type detection. Those frequency value will be converted into volume units (cc) in the database, which will then be sent to computers that have specific applications. Microsoft Visual Studio-based applications were used to monitor the amount of blood stocks in a certain area, specifically to the IRC. The data transmission time is measured from the transmission of data from the tool, 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 be useful to measure how fast would the data be sent, especially if it were to be used in remote areas. Users in hospital will be able to watch over and monitor the blood availability as long as both parties, in this case is the hospital and IRC, are connected to a fine and smooth internet network. However, it is recommended to use a faster internet network to provide a better real-time monitoring.

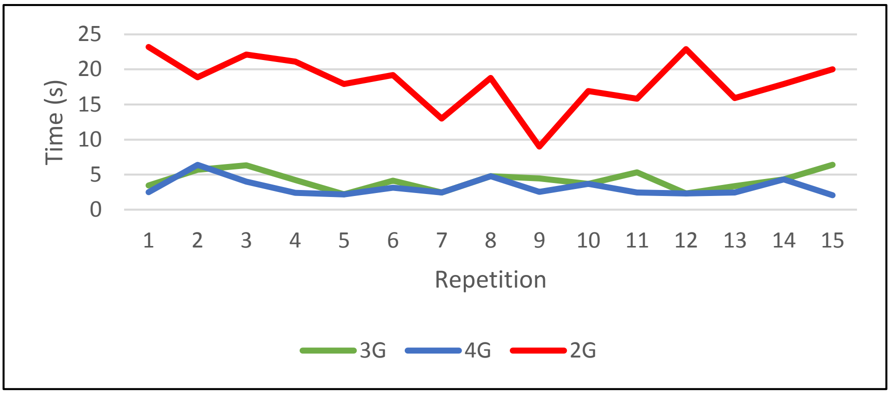

Fig 5. Time taken for data transmission in 2G, 3G and a 4G internet network from device to computer application.

4. Conclusion

An innovative microcontroller-based device that can detect a blood type of a person and serves a database of blood stock in several IRC to accelerate the distribution of blood between IRC and hospital is proposed. This research utilizes Internet of Things (IoT) using a Wi-Fi module to create a device which 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 network took around 3,17 and 18,17 seconds respectively.

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