Bulletin of Electrical Engineering and Informatics
Vol. 13, No. 4, August 2024, pp. 2310~2319
ISSN: 2302-9285, DOI: 10.11591/eei.v13i4.7007

Human blood group type detection prototype focusing on agglutinin using microcontroller based photodiode

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Article Info

Article history:

Received Jun 16, 2023
Revised Oct 11, 2023
Accepted Nov 14, 2023

Keywords:

Agglutinin
Arduino Uno
Blood type
Light emitting diode
Microcontroller
Photodiode

ABSTRACT

Blood is a fluid in the body that mainly serves as a medium for transporting various substances in the body. Detection of human blood group types with this microcontroller utilizes dark and light properties. The dark character appears due to agglomeration, while the light nature arises because of no agglomeration, for this to happen, a liquid reagent is needed. Administration of this liquid uses the aviator's breathing oxygen (ABO) system, which consists of reagent a, reagent b, and reagent c and mixing it with blood on the test paper. The number of blood samples in each reagent is based on blood lancet. Furthermore, the sensors used to detect these properties are photodiode and light emitting diode (LED) each of 3 pieces. The Arduino Uno is used to process sensor input while at the same time producing displayed human blood group type on the display screen. The test is carried out involving 12 blood samples and a medical officer. Medical officer are tasked reading directly the results of mixing between reagents and blood samples, after that are compared with the system. The results show that the deviation of the system reading is 0.167 for the sensor reading distance with the sample as far as 0.5 cm.

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1. INTRODUCTION

All living organisms, including humans, have blood as a liquid [1], [2]. This is due to the fact that blood serves as a channel for the movement of many compounds required by the body [3], [4]. The aviator's breathing oxygen (ABO) system can be used to classify blood [5], [6]. This classification is based on changes in blood agglutinogen (antigen) and agglutinin (antibody) [7], [8]. Blood grouping is used to prevent the formation of clots during blood transfusions. This clumping might develop due to the many types of antigens. To prevent clotting, each blood type must be identified [9]-[11]. Serum is rarely used for blood group examination because antisera reagents are mainly used for ABO system blood group examination. In theory, the assessment of blood groups, namely antigens that respond with the same antibody, will result in agglutinin-based agglutination. Because blood group antibodies are globulin proteins, which are responsible for being a component of natural immunity, there are antibodies in the serum. To detect human blood type,

different methods can be utilized, one of which is the simple test method [12], [13]. On test paper, a blood sample is combined with chemicals. Mixing blood in the form of a clot or liquid reveals the user's blood type [14], [15]. Using current technological advances, it is possible to view the results of mixing blood samples with reagents more easily. A light emitting diode (LED) and photodiode combo can be used to determine blood type [16]-[18].

In the world of medicine, human blood groups are divided into four, namely A, B, AB, and O [19]. This division is made because of the different types of carbohydrates and proteins on the surface of the red blood cell membrane. To find out a person's blood type, a laboratory test is needed [20]. So far, the ABO method is often used to test blood type, which is done manually or by dripping three types of liquids or reagents on a blood sample. When undergoing a blood transfusion, it is critical that the recipient receive blood from the same blood type as the donor. When testing blood samples using the ABO method, the blood sample is dripped with a reagent, and then agglutination or blood clotting occurs in the blood sample. Blood clots are formed by antibodies interacting with antigens attached to erythrocytes. Blood contains antigens and antibodies, and each antigen and antibody is made up of A and B. Blood type tests and observations are typically carried out using a series of experiments on blood samples, notably performing reactions between fluids, blood samples, and antisera. This reaction results in either agglutination or non-agglutination [21], [22]. The examiner's eye is frequently used to directly observe this reaction, and the resulting reaction will determine the kind of blood group. The above test must be performed by an experienced individual, as the correctness of the data obtained is still dependent on the examiner's eyesight. Because fatigue affects the eyes, this method is less profitable for testing large amounts of blood samples. Errors in reading blood type can pose major complications for a person, such as during blood transfusion or offspring identification [23]-[25].

This study designed a gadget that can electronically read blood type in order to facilitate testing of vast numbers of blood samples [26]. This tool uses the ABO system to test human blood type. The developed tool consists of a light sensor made of LED, a photodiode sensor, an Arduino Uno data processor, and a display. The authors want to create an electronic blood group detection device utilizing a microcontroller based on the concerns mentioned above, which is a development of reading a blood group sample using sensors [27], [28] and the Arduino Uno circuit [29], [30]. This instrument reads and determines blood type using automatic blood group reading.

2. LITERATURE REVIEW

2.1. Arduino Uno

Arduino is an electrical kit or open source electronic circuit board in which the main component is an Atmel AVR microcontroller chip [29]. The Atmega328 IC is used in the Arduino Uno microcontroller [31]. The Arduino Uno contains 14 digital input/output pins, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. The Arduino Uno has everything needed to support a microcontroller, and it may be readily connected to a computer through a USB cable, powered by an AC to DC adapter, or powered by a battery [32], [33].

2.2. Photodiode

A light sensor is an electronic component that converts an optical quantity (light) to an electrical quantity. Light sensors are classified into two types based on the consequent electrical changes: photovoltaic and photoconductive. A photodiode sensor is one type of photoconductive light sensor. Photodiode sensors may detect visible or invisible light stimuli and transform the detected light intensity into a current [34].

2.3. Blood type

Because of the various types of carbohydrates and proteins on the surface of the red blood cell membrane, blood type is a unique property of an individual's blood [24]. Aside from ABO and Rh antigens, there are approximately 46 different types of antigens in the world. Karl Landsteiner's ABO system is the most important system in blood banking and transfusion therapy; the primary antigens are A and B, and the main antibodies are anti-A and anti-B. On the chromosomes, the genes that determine whether there is activity A or B are located. The kind of agglutinogen present in the cell and the agglutinin present in the serum are determined by blood group [35].

2.4. Previous research

There is research that has been done before as follows:

- Nakib [36] this study employed the OV2640 camera to acquire images for processing with the tensor flow object detection API. The limitation of this technology was that light easily passed through the medium, hence the majority of blood types read were AB.

- Another study conducted by Rajpurohit *et al*. [37] concluded that this study used multiple convolutional neural network (CNN), fuzzy neural network (FNN), support vector machines (SVM), and k-nearest neighbor (KNN) algorithms to identify cancer, with the best accuracy of 98.33%. The TensorFlow framework was used to create CNN and FNN. Other classifiers' accuracy: FNN, SVM, and KNN are 95.40%, 91.40%, and 93.30%, respectively.
- Another study conducted by Fleury *et al*. [38] indicated that machine learning (ML) approaches to image preprocessing, classification, and feature extraction in more complex dataset sets had expedited the developing usage of visualization tools in pathology and microbiology. This study had an 80% accuracy rate in classifying blood cancer.
- Another study conducted by Khouan *et al*. [39] concluded that Tensorflow and Keras were used in classifying white blood cells. The proposed approach gave quick forecasts (less than 1 second) and had a 95.73% accuracy rate.
- Another study conducted by Sayeed [40] concluded that in carrying out malaria detection, the researcher used a tensor flow library with a data set of 10,000 data for data sharing, which included training and testing data, resulting in 91% accuracy, but this needed to be tested with more data so that the model could be applied in the real world, making it easier to diagnose on the medical side.
- Another study conducted by Verawati and Hasibuan [41] concluded that in categorizing white blood cells, the faster R-CNN algorithm would be used with 364 images of human blood cells. The faster R-CNN has an accuracy of 94.92% in categorizing human red blood cells and white blood cells based on the data from the experiment above, which was separated into 328 training data and 36 testing data.

3. METHOD

This investigation was divided into sections in which the prototype is used to identify blood groups using a photodiode. Meanwhile, the processing part uses a microcontroller. The flow diagram below shows how to detect the kind of human blood group using a microcontroller-based photodiode, as shown in Figure 1.

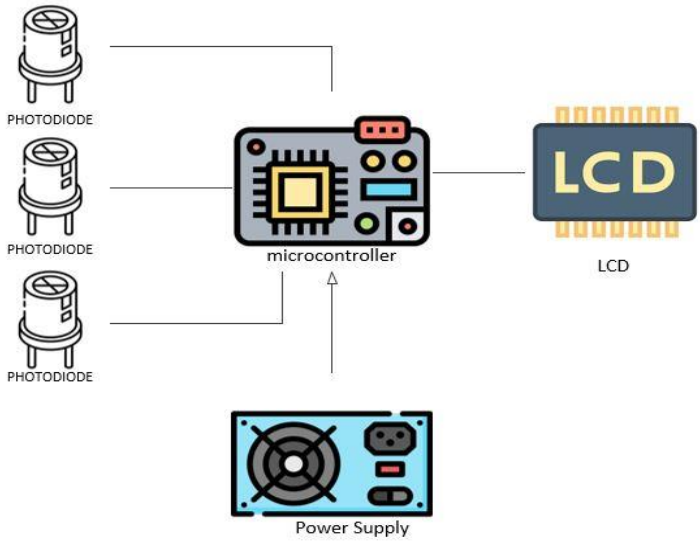

Figure 1. Block of research diagram

The followings are the explanations to Figure 1:

a. Input

Beginning with getting a sample from a blood lancet, then the sample is placed on a test paper with three sections. Which then drops reagent a, reagent b, and reagent c on top of the sample. The mixed results that occur on the test paper will produce 2 possible properties, namely agglomeration or not agglomeration. To express this property in the Arduino Uno system, a sensor is needed as shown in Figure 2. The basic principle of this sensor is in dark and light conditions, where if there is clumping then what happens is dark, whereas if it does not clot it is light. The sensor component consists of an LED component and a Photodiode

module. Next, the LED component produces a white light which is positioned on the test paper. Then the position of the photodiode module is under the test paper which contains a mixture of samples and reagents. To obtain optimum results, the gap distance between the LED components and the photodiode module is adjusted with 0.3, 0.5, 0.7 and 0.9 cm.

While the LED was positioned with the photodiode module as shown in Figure 2, the distance between the two would be determined later. A human blood sample would be deposited in the space between the two to be studied. Figure 3 showed the blood type test paper that was used to deposit the sample. The light from the LED would strike the sample and the test paper.

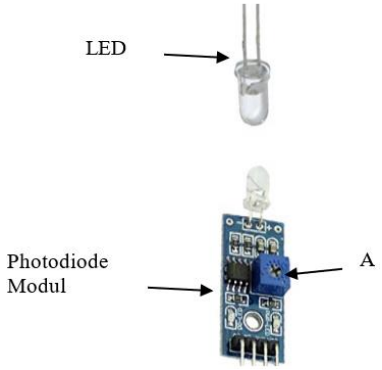

Figure 2. LED position and photodiode module

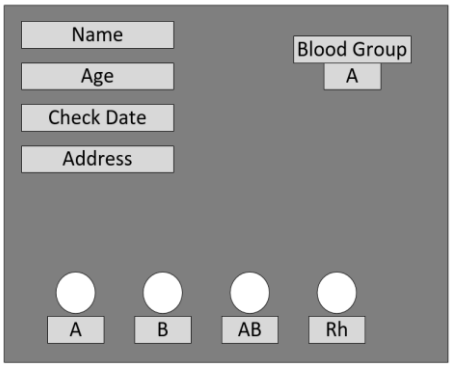

Figure 3. Blood group test paper

b. Block process

An Arduino Uno R3 microcontroller block was shown in Figure 1. The Arduino Uno operated to process and convert inputs from the four sensors into LED outputs. A 9 V battery powered the Arduino Uno.

c. Output

In Figure 1, an output block, the liquid-crystal display (LCD), would display the blood group as a result of the command from the combination of the three sensors in the form of a lump or liquid. This study explained the system flowchart in Figure 4 after discussing the series of flows in the research block diagram.

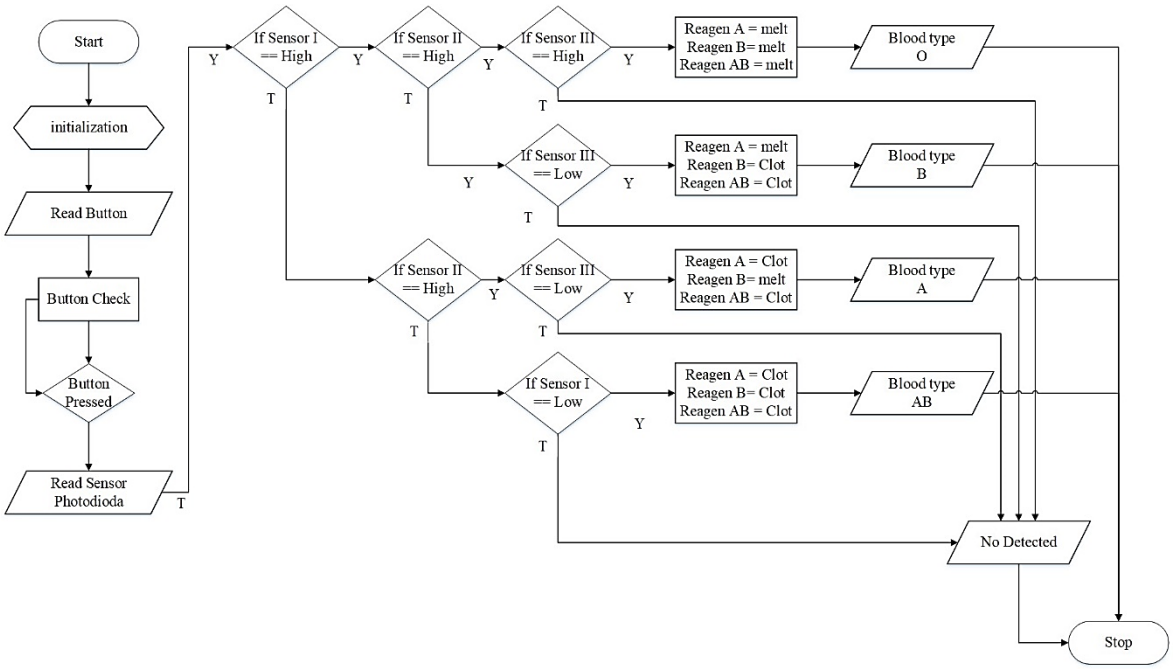

Figure 4. Flowchart system

The flowchart in Figure 4 is explained starting with start and initialization, in which the device was active and initializes the pins of each component attached to the microcontroller. The machine then inserted the button reading after reading it. The state of the button, whether pressed or not. The system then went through the process of checking the button. The system continued to read the sensor when the button was pressed. When the button was not pressed, the system returned to the reading mode. The photodiode sensor was then read, and the system took readings on each sensor and the determined combination. When sensor I was HIGH (melts), sensor II was HIGH, and sensor III was HIGH, the system performed the process and displayed blood type O on the LCD. When sensor I was HIGH, sensor II was LOW (clumping), and sensor III was LOW, the system would process and displayed blood type B on the LCD. When the sensor was I LOW, the system ran the process and displayed an LCD output for blood type A. When the sensor II was HIGH, the system displayed an LCD result for blood type B. When the sensor I was LOW, II LOW, or III LOW, the system performed the process and displayed the blood group on the LCD. AB. The LCD output was not noticed when the sensor read another combination on the sensor. And finally, the system had completed its function.

4. RESULT AND DISCUSSION

The sensor must be calibrated in order to function properly. Calibration was performed by acquiring a sample of human blood combined with reagents, as indicated in Figure 5. Figure 5 showed that the mixture produces lumpy (Y) and non-lumpy (X) outputs. If agglomeration occurs, there was a light gap that could be captured by the photodiode module; if agglomeration did not occur, no light could be collected. The collected light could be changed by turning the trim pot on pointer A, as shown in Figure 2. So that the photodiode module output was as shown in Table 1, where photodiode modules II and III received light while photodiode module I did not, and the distance between the LED and the photodiode module was 0.5 cm.

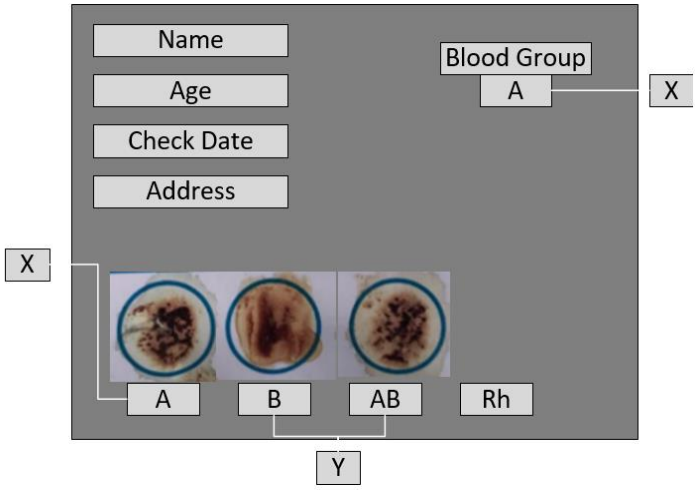

Figure 5. Mixed results between reagents and human blood samples

Table 1. The quantity of photodiode module output voltage

Photodiode module	Voltage (V)
Photodiode I (Anti - A)	2.808
Photodiode II (Anti - B)	0.136
Photodiode III (Anti - AB)	0.106

Following that, it was programmed into the program that voltages greater than 1 volt were high (not clot) and voltages less than 1 volt were low (lump). As a result, Table 2 was created, which was the conclusion of the research results on establishing the blood type of the ABC system using reagents after being converted to high and low logic forms, which were utilized as a reference for the system to work.

Table 2. Sensor reference for identifying blood group

Blood type	Anti-A	Anti-B	Anti-AB
A	low	high	low
B	high	low	low
O	high	high	high
AB	low	low	low

Following that, system trials and evaluations were carried out, with the goal of achieving the highest accuracy value from detected blood group samples. Based on the number of samples and the measurement distance, this test is performed to obtain the most accurate findings possible. In this test, the sensor will detect blood type based on the measurement distance between the LED and the photodiode module (the test paper is above and touching the photodiode module, while the blood sample is facing the LED), and the results of this detection will be displayed in the form of blood group type. Begin by preparing as many as 12 different human blood samples. Then it is mixed with the appropriate reagent, then the medical staff performs direct visual observation, and the results of each are written down on the test paper, as shown in the Z pointer in Figure 5. So there is one person for blood group A, three for blood group B, one for blood group AB, and seven for blood group O. Tables 3 to 5 show system readings. Deviations from system observations and direct visual observations based on blood type were collected from the three studies, as indicated in Tables 6 to 9.

Table 3. The first trial results from observations by the system

The distance between LED and photodiode module (cm)	The number of blood types (person)			
	A	B	AB	O
0.3	1	4	2	5
0.5	2	2	1	7
0.7	2	2	2	6
0.9	0	0	5	7

Table 4. The second trial results from observations by the system

The distance between LED and photodiode module (cm)	The number of blood types (person)			
	A	B	AB	O
0.3	2	2	1	7
0.5	1	3	1	7
0.7	2	1	3	6
0.9	0	0	6	6

Table 5. The third trial results from observations by the system

The distance between LED and photodiode module (cm)	The number of blood types (person)			
	A	B	AB	O
0.3	0	4	1	7
0.5	1	3	1	7
0.7	1	2	2	7
0.9	0	0	6	6

Table 6. Observational deviations for blood type A

The distance between LED and photodiode module (cm)	Experiment			Average deviation
	I	II	III	
0.3	|1-1|=0	|1-2|=1	|1-0|=1	0.667
0.5	|1-2|=1	|1-1|=0	|1-1|=0	0.333
0.7	|1-2|=1	|1-2|=1	|1-1|=0	0.667
0.9	|1-0|=1	|1-0|=1	|1-0|=1	1

Table 7. Observational deviations for blood type B

The distance between LED and photodiode module (cm)	Experiment			Average deviation
	I	II	III	
0.3	|3-4|=1	|3-2|=1	|3-4|=1	1
0.5	|3-2|=1	|3-3|=0	|3-3|=0	0.333
0.7	|3-2|=1	|3-1|=2	|3-2|=1	1.333
0.9	|3-0|=3	|3-0|=3	|3-0|=3	3

Table 8. Observational deviations for blood type AB

The distance between LED and photodiode module (cm)	Experiment			Average deviation
	I	II	III	
0.3	|1-2|=1	|1-1|=0	|1-1|=0	0.333
0.5	|1-1|=0	|1-1|=0	|1-1|=0	0
0.7	|1-2|=1	|1-3|=2	|1-2|=1	1.333
0.9	|1-5|=4	|1-6|=5	|1-6|=5	4.667

Table 9. Observational deviations for blood type O

The distance between LED and photodiode module (cm)	Experiment			Average deviation
	I	II	III	
0.3	|7-5|=2	|7-7|=0	|7-7|=0	0.667
0.5	|7-7|=0	|7-7|=0	|7-7|=0	0
0.7	|7-6|=1	|7-6|=1	|7-7|=0	0.667
0.9	|7-7|=0	|7-6|=1	|7-6|=1	0.667

Thus the total average deviation for each of these distances is as follows:

- Distance to 0.3 cm was (0.667+1+0.333+0.667)/4=2.667/4=0.667
- Distance to 0.5 cm was (0.333+0.333+0+0)/4=0.666/4=0.167
- Distance to 0.7 cm was (0.667+1.333+1.333+0.667)/4=4/4=1
- Distance to 0.9 cm was (1+3+4.667+0.667)/4=9.334/4=2.334

As a result, the average deviation is smallest at a distance of 0.3 cm. And this is utilized as the distance between each LED and the photodiode module in order for it to function properly.

5. CONCLUSION

This study discusses the making of a prototype of an agglutinin-based human blood group type detector using photodiode technology and a microcontroller. Agglutinin itself is a protein found in human blood and is responsible for blood clotting reactions. The purpose of this research is to speed up and facilitate the blood group testing process and reduce errors in traditional manual testing. In this study, photodiode technology functions to convert light into electrical signals, which will later be sent to the microcontroller for processing and determining the results of blood group detection based on the presence of agglutinins in the blood sample. This blod group detection system can recognize the type of human blood group using a sensor consisting of 3 pairs of LEDs and a photodiode module. This photodiode module works by capturing the light obtained from mixing blood which is illuminated by an LED. If agglomeration occurs, there is a light gap that can be captured by the photodiode module and when there is no agglomeration, then no light can be captured. This system produces the smallest average deviation of 0.167 for a distance of 0.5 cm. Test method with fake blood samples given a mixture of agglutinins in various types of blood groups. It is hoped that the prototype of this agglutinin-based human blood group detector will facilitate and speed up the process of blood group testing in medical laboratories and reduce the risk of errors in testing. In addition, this technology can also be applied in the field, such as during natural disasters or road accidents to help process blood transfusions quickly and accurately.

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