Simple smart glasses based on microcontrollers as money detector of nominal and authenticity

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Abstract. This study aims to make a detector for the nominal value and authenticity of money (rupiah currency). The working principle of this tool is as follows: UV LED function to provide lighting to objects (money). The light will circulate hidden colours in original money so that you can differentiate original or fake money (money whose authenticity is doubtful). The white LED provides lighting for the object, then the light is received by the TCS3200-DB colour sensor to read its Red, Green and Blue (RGB). Furthermore, the RGB value will be processed by Arduino Mega 2560 to be compared with the RGB values in the program. The mini DF-Player functions to play sound according to the sound that has been recorded with the program. Testing the system is done to determine the percentage of success of the system in distinguishing between original money and the authenticity of money is doubtful. Testing of 5 (five) nominal 2016 emission rupiah, namely 2,000-rupiah (60%), 10,000-rupiah (100%), 20,000-rupiah (80%), 50,000-rupiah (100%) and 100,000-rupiah (66%), so the average percentage of success of the tool is 81.2%.

1. Introduction
The development of the business and economic world has encouraged the emergence of various new and innovative criminal acts, such as the emergence of cybercrime, money laundering, money fake, and other crimes. The government has early realized the importance of money as a legal payment instrument that is general in nature and can be widely accepted by the public. Fake money crimes also have an impact on the country's economy. Nowadays, the use of counterfeit currency is one of the major issues faced throughout the world. The counterfeiters are becoming harder to track down because of their use of highly technical [1,2]. The high advancement of color printing technology has increased the rate of fake currency note printing and duplicating the notes on a very large scale. A few years back, the printing could be done in a print house, but now anyone can print a currency note with maximum accuracy using a simple laser printer [3]. In Indonesia, the government has tried to design legal payment instruments with characteristics that are unique and difficult to imitate by others. Circulation of counterfeit money from year to year has increased. According to the Deputy Governor of Bank Indonesia, Ronald Waas, stated that "fake money has increased in numbers, Bank Indonesia recorded the last found by the police there were 18,000 pieces, already caught by the people" [4].

Government efforts to reduce the circulation of counterfeit money are contained in article 1 paragraph 5 Law No. 7 of 2011 concerning the currency stated that the characteristic of rupiah is a certain sign in every Rupiah that is determined with the aim of showing identity, distinguishing prices or nominal and securing the rupiah from counterfeiting. On paper money, there are visible, tangible, and secure security...
tools that are only visible by using assistive devices in the form of ultraviolet light, infrared light, magnifying glass, and certain plastic tools for viewing scrambled images [5]. The study of the design of counterfeit detection devices has been carried out by several researchers [6]. Porbadi, developed a nominal banknote detection tool for blind people. The purpose of this study is to make it easier for blind people to carry out transactions in goods and services [7]. Alshayeji using the bit-plane slicing technique to extract the most significant data from counterfeit banknote images with the application of an edge detector algorithm [8]. His technique consists of decomposing original images of 256 gray levels into their equivalent 8 binary images. Pilania designed a system that is helpful in recognition of paper currency notes with fast speed and in less time [9]. The system describes an approach for verification of Indian and other countries currency banknotes. The currency will be verified by using image processing techniques. Several of fake money detection developed using image processing [3,10,11]. Verification of currency note is done by the concepts of image processing using MATLAB software.

There are different techniques which are used to distinguish between fake notes and an original one, including by using different components of digital images processing such as image processing, image segmentation, characteristics extraction, comparing images, etc [12]. From previous research, the authors develop and utilize glasses virtual reality that can detect nominal and doubt the authenticity of banknotes with sound output. The use of these glasses uses the TCS3200-DB color sensor, DF-Player, and ultraviolet sound modules. The system will be used by all users, both visually impaired and non-visually impaired person.

2. Methods
The method used by researchers is an engineering method. Engineering techniques have flow consisting of literature study, problem identification, setting goals, analyzing system requirements, designing systems, testing systems and integrating hardware and software. Figure 1 shows a block diagram of the system.

![Figure 1. Block Diagram of the system.](image-url)

Figure 1 describes the work process of the nominal detection glasses system and the authenticity of banknotes. The working method of the system in Figure 1 consists of input, process and output. The input used in this system uses a TCS3200-DB colour sensor that will receive colours Red, Green, and Blue (RGB). The colour received by the TCS3200-DB colour sensor, then it will be processed in the Arduino Mega 2560 control system. UV LED will emit light on the money used to distinguish original or fake money, then RGB will be received by TCS3200-DB colour sensor and processed by Arduino Mega 2560.

LED will emit light on the money used to detect the nominal money used, then RGB will be received by the TCS3200-DB color sensor and processed by Arduino Mega 2560. DF-Player MP3 sound module will play the recorded sound and stored on the SD-Card according to the program that has been made.
before, by using the speaker as a medium to make a sound. Buzzer is used as an indicator of the output of the device which indicates that the system is working properly.

3. Results and discussion

3.1. The results of testing RGB values for real money
To obtain Red, Green and Blue (RGB) values on the nominal banknotes used, Arduino Mega 2560, TCS3200-DB sensors, UV LED, white LED, connected with programs that have been uploaded. The RGB value in the test can be displayed on the serial monitor found on Arduino. The results of testing the RGB values in each nominal 2016 emission original banknotes were obtained by integrating the TCS3200-DB sensor program with Arduino. The results of testing the RGB values for each nominal rupiah banknotes that are doubtful about the authenticity of 2016 emissions are obtained by integrating the TCS3200-DB sensor program with Arduino. To facilitate the testing process, RGB values for each nominal are recorded and tabulated into a table.

Table 1. Testing the RGB value of 100,000-rupiah (original money).

| Testing | Red (Hz) | Green (Hz) | Blue (Hz) |
|---------|----------|------------|-----------|
| 1.      | 54       | 78         | 51        |
| 2.      | 54       | 78         | 51        |
| 3.      | 54       | 76         | 49        |
| 4.      | 54       | 76         | 49        |

Testing RGB values with a nominal value of 100,000-rupiah is carried out using 4 bills with a nominal value of 100,000-rupiah. From the test results it was found that the value of red at nominal 100,000 has the same value, at the number 54, the value of green in the numbers 78 and 76, while the value of blue in the numbers 51 and 49.

Table 2. Testing the RGB value of 50,000-rupiah (original money).

| Testing | Red (Hz) | Green (Hz) | Blue (Hz) |
|---------|----------|------------|-----------|
| 1.      | 63       | 65         | 39        |
| 2.      | 63       | 65         | 39        |
| 3.      | 69       | 68         | 40        |
| 4.      | 69       | 68         | 40        |

Testing RGB values with a nominal value of 50,000-rupiah are carried out using 4 bills with a nominal value of 50,000-rupiah. From the results of the test it was found that the red value in nominal 50,000 has a value of 63 and 69, the green value is in the numbers 65 and 68, while the blue value is in the numbers 39 and 40.

Table 3. Testing the RGB value of 20,000-rupiah (original money).

| Testing | Red (Hz) | Green (Hz) | Blue (Hz) |
|---------|----------|------------|-----------|
| 1.      | 64       | 74         | 55        |
| 2.      | 64       | 74         | 55        |
| 3.      | 59       | 68         | 51        |
| 4.      | 59       | 68         | 51        |

Testing the RGB values with a nominal value of 20,000-rupiah is carried out using 4 bills with a nominal value of 20,000-rupiah. From the results of the test it was found that the value of red at nominal 20,000 has a value in the numbers 64 and 59, the green value in the numbers 74 and 68, while the value of blue in the numbers 55 and 51.
Table 4. Testing the RGB value of 10,000-rupiah (original money).

| Testing | Red (Hz) | Green (Hz) | Blue (Hz) |
|---------|----------|------------|-----------|
| 1.      | 55       | 68         | 38        |
| 2.      | 55       | 68         | 38        |
| 3.      | 57       | 67         | 38        |
| 4.      | 57       | 67         | 38        |

Testing RGB values with a nominal value of 10,000-rupiah is done using 4 bills with a nominal value of 10,000-rupiah. From the test results it was found that the value of red in nominal 10,000 has a value of 55 and 57, the green value is in the numbers 68 and 67, while the value of blue is number 38.

Table 5. Testing the RGB value of 2,000-rupiah (original money).

| Testing | Red (Hz) | Green (Hz) | Blue (Hz) |
|---------|----------|------------|-----------|
| 1.      | 64       | 82         | 58        |
| 2.      | 64       | 82         | 58        |
| 3.      | 64       | 82         | 58        |
| 4.      | 58       | 75         | 52        |

Testing the RGB values with a nominal value of 2,000-rupiah is carried out using 4 bills with a nominal value of 2,000-rupiah. From the test results it was found that the value of red in nominal 2,000 has a value in the numbers 64 and 58, the value of green in the numbers 82 and 75, while the value of blue in the numbers 58 and 52.

3.2. The results of testing RGB values for fake money

Table 6. Testing the RGB value of 100,000-rupiah (fake money).

| Testing | Red (Hz) | Green (Hz) | Blue (Hz) |
|---------|----------|------------|-----------|
| 1.      | 55       | 78         | 53        |
| 2.      | 53       | 78         | 53        |
| 3.      | 55       | 77         | 52        |
| 4.      | 52       | 75         | 52        |

Testing RGB values with a nominal value of 100,000-rupiah is carried out using 4 bills with a nominal value of 100,000-rupiah. From the test results it was found that the red value at nominal 100,000 has a value of 55 and 52, the green value is at 78, 77 and 75, while the blue value is in the numbers 53 and 52.

Table 7. Testing the RGB value of 50,000-rupiah (fake money).

| Testing | Red (Hz) | Green (Hz) | Blue (Hz) |
|---------|----------|------------|-----------|
| 1.      | 67       | 74         | 45        |
| 2.      | 67       | 74         | 45        |
| 3.      | 66       | 73         | 43        |
| 4.      | 65       | 73         | 43        |

Testing the RGB values with a nominal value of 50,000-rupiah are carried out using 4 bills with a nominal value of 50,000-rupiah. From the results of the test, it was found that the red value in nominal 50,000 has a value of 67, 66 and 65, the green value is in the numbers 74 and 73, while the blue value is in the numbers 45 and 43.
Table 8. Testing the RGB value of 20,000-rupiah (fake money).

| Testing | Red (Hz) | Green (Hz) | Blue (Hz) |
|---------|----------|------------|-----------|
| 1.      | 60       | 72         | 54        |
| 2.      | 60       | 72         | 53        |
| 3.      | 62       | 74         | 53        |
| 4.      | 62       | 73         | 55        |

Testing the RGB values with a nominal value of 20,000-rupiah is carried out using 4 bills with a nominal value of 20,000-rupiah. From the test results it was found that the value of red at nominal 20,000 has a value of 60 and 62, the green value is 72, 74 and 73, while the blue value is 54, 53 and 55.

Table 9. Testing the RGB value of 10,000-rupiah (fake money).

| Testing | Red (Hz) | Green (Hz) | Blue (Hz) |
|---------|----------|------------|-----------|
| 1.      | 57       | 71         | 41        |
| 2.      | 57       | 71         | 41        |
| 3.      | 53       | 65         | 40        |
| 4.      | 52       | 64         | 37        |

Testing the RGB values with a nominal value of 10,000-rupiah is done using 4 bills with a nominal value of 10,000-rupiah from the test results it was found that the value of red in nominal 10,000 has a value of 57, 53 and 52, the value of green in the numbers 71, 65 and 64, while the value of blue in the numbers 41, 40 and 37.

Table 10. Testing the RGB value of 2,000-rupiah (fake money).

| Testing | Red (Hz) | Green (Hz) | Blue (Hz) |
|---------|----------|------------|-----------|
| 1.      | 64       | 84         | 59        |
| 2.      | 64       | 84         | 59        |
| 3.      | 63       | 83         | 58        |
| 4.      | 61       | 82         | 55        |

Testing RGB values with a nominal value of Rp. 2,000 is carried out using 4 bills with a nominal value of 2,000-rupiah. From the results of the test it was found that the value of red in nominal 2,000 has a value of 64, 63 and 61, the green value is at 84, 83 and 82, while the blue value is at 59, 58 and 55.

From the testing of several currency values in rupiah, for example if RGB data of 100,000-rupiah is not found in the RGB database on the program, the colour sensor will check whether the money is 50,000-rupiah. If the data on RGB 50,000-rupiah is in accordance with the RGB data of 50,000-rupiah in the database, the program will activate the buzzer as an indicator. Next Arduino will check whether the 50,000-rupiah is authentic or doubtful about its authenticity. If the money is genuine, the program will activate the DF-PLAYER mini to play the "fifty thousand original" sound and "fifty thousand doubtful authenticity" if the money is of doubtful authenticity. Then the program activates the buzzer as an indicator that the money checking process is complete. When the nominal money checking process is completed by the TCS3200-DB colour sensor, and the buzzer is active, the program will loop to the TCS3200-DB colour sensor to be checked again.

The results of testing RGB values show that, the RGB value obtained is different in each nominal money used. This difference is based on the factor of use of money in the community, the difference in colour in each nominal and the difference in the brightness of the colour at the nominal money used. The use of TCS3200-DB colour sensor as input serves to provide RGB data obtained on Arduino and then compared with RGB databases on Arduino. The use of buzzer as an output that functions as an indicator that the tool used is functioning properly. To find out that this tool can work properly, the voltage must be tested and a voltage of 5.0 volts is obtained as an input used by Arduino to work.
mini DF-player and SD Card serve as a medium for playing and storing sound as the final output of this nominal and fake or original money detection system.

4. Conclusions
From the results of tests that have been conducted on several genuine and fake rupiah paper currencies, the following conclusions are taken: 1) hardware modifications have been made using virtual reality glasses, TCS3200-DB colour sensor module, DF-PLayer module Mini, Buzzer, UV LED, white LED, and Arduino Mega 2560 microcontrollers, 2) percentage of success of the tool in detecting nominal and doubts about the authenticity of banknotes varies, this is due to the condition of the money used and the colour gradation which results in reading the value of Red, Green, Blue (RGB), different from the RGB values contained in the program, and 3) shifts in the position of money and colour sensors, cause changes in the value of RGB on the nominal money and impact on the success rate of the tool.

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