Nominal of Money and Colour Detector for the Blind People

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Abstract. Blind people often face a detection to identify the colour object. One of important of inability from the blind is to identify a nominal of money. It is very likely occurrence of undesirable things, such as the possibility of exchanged money, or even act of fraud. It is necessary to design an equipment that allows for detecting a colour and a nominal of money. This tool is designed using TCS3200, RGB LED, LDR as the sensors, Arduino Nano as the controller and speaker. The sensors will detect the colour of the money, then sensors will transforms the colour into analog data and Arduino Nano will process this analog data into a digital data. Arduino Nano will convert the data into the form of audio as the output result. The speaker will release the audio according to the money or colour which detected, the audio output will be identified by the blind people.

1. Introduction
Blind people often face a detention to identify the colour of an object. One of important of inability from the blind is to identify a nominal of money. So far the blind identify a nominal of money by making a fold or arrange their money with help by the other people, but it has a weakness, that if blind forget with the fold or honesty from people who make a transaction with them giving a right nominal or not [1]. From this case, it is necessary to design an equipment that allows for detecting a colour and nominal of money to support the blind. This paper describes the design of nominal of money and colour detector using a sensor and microcontroller.

2. Methods

2.1. List of materials
Table 1 is List of Materials (LoM) required in this research.

| Materials      | Specification       | Quantity |
|----------------|---------------------|----------|
| Arduino        | Arduino Nano        | 1        |
| Colour Sensor  | TCS3200             | 1        |
| RBG LED        | Common cathode      | 1        |
| Resistor       | LDR                 | 1        |
| TP4056         | 5 V, 1A             | 1        |
| Amplifier      | PAM8403             | 1        |
| Materials     | Specification                          | Quantity |
|--------------|----------------------------------------|----------|
| Switch       | 2 pin                                  | 1        |
| Batterry     | Li-ion 18650 4,2 V, 1200 mAh rechargeable | 1        |
| Mp3 module   | DFPlayer mini                          | 1        |
| Acrylic      | 2mm, size A4                           | 1        |
| Micro SD Card| 4 Gb                                   | 1        |

2.2. Block diagram
The block diagram of this tools is represented by figure 1.

![Figure 1. Block diagram.](image)

2.3. Flowchart
The flowchart of this tools is represented by figure 2.

![Figure 2. Flowchart.](image)
2.4. Circuit diagram

Figure 3 show the circuit diagram of this tool.

![Figure 3. Circuit diagram.](image)

2.5. Arduino nano

The controller of this tool is using Arduino Nano, the specification of Arduino Nano is represented by Table 2.

| Specification       | Component                  |
|---------------------|----------------------------|
| Microcontroller     | ATMega328                  |
| Architecture        | AVR                        |
| Operating Voltage   | 5 V                        |
| Flash Memory        | 32 KB                      |
| SRAM                | 2 KB                       |
| Clock Speed         | 16 Mhz                     |
| Analog I/O          | 6                          |
| Digital I/O         | 14                         |
| DC Current Per I/O  | 40 mA                      |
| Input Voltage       | 7-12                       |
| Weight              | 7 g                        |

Arduino Nano could be easily programmed by using Arduino IDE with another electronic device such as a computer by using USB port [2, 3].
2.6. Colour sensor
Colour sensor is a component that could identify the colour of the object to be electrical value. In this research, we use TCS3200. It has two main components: a photodiode and a frequency converter [4, 5]. The photodiode will release a current whose value is proportional to the colour detected, this current will be converted into a signal whose frequency is proportional to its current. TCS3200 has 4 filter modes: red filter, clear, green filter, and blue filter [6]. TCS3200 identifies the colour and gives a serial output in RGB value to the Arduino Nano [7]. To set the filter mode, we use S2 and S3 pins as shown in Table 3 [6]. Figure 4 is the pin of TCS3200.

| S2 | S3 | Photodiode |
|----|----|------------|
| L  | L  | Red        |
| L  | H  | Blue       |
| H  | L  | Clear      |
| H  | H  | Green      |

![Figure 4. TCS3200.](image)

2.7. RGB led and LDR (Light Dependent Resistor)
Both of these components could be used as an RGB sensor to detect the colour of an object. At first, the RGB led will emits red, green, and blue alternately to the object that will be detected. The reflected colour will affect the value of resistance of the LDR and is expressed in the RGB output. Figure 5 is the schematic diagram of the RGB sensor with LDR.

![Figure 5. Schematic of RGB led and LDR.](image)

2.8. TP4056
TP4056 is a module used to recharge the battery. This module has 2 LED indicators, which are red and blue. The red LED indicates that the battery charging is still going, while the blue LED indicates that the battery is full. When the battery is fully charged, the system will cut off, so the current does not flow to the battery. TP4056 works with USB and adapter [8].
2.9. DFPlayer mini
DFPlayer mini is a module that used for the music player. This module could work alone (standalone) or work with another microcontroller with serial communication RX/TX [9].

2.10. PAM8403
PAM8403 is an amplifier that can be used for a sound amplifier, the power of this amplifier is 3 watts with 5 volt DC source. The magnitude of this amplifier can be adjusted with potentiometer contained in this module [10].

2.11. Design
This equipment is using acrylic 16 cm x 5 cm x 7 cm for the case, all materials will be inserted in this case. The case looks like as the follows. Figure 6 is the design and component position of this tools.

![Design and component position](image)

Figure 6. Design and component position.

3. Results and discussion

3.1. Sensor recitations and data mapping
To read the sensor recitations is by using serial communication in Serial Monitor from Arduino IDE. Sensors recitation is done for 4 times to get ADC value for each position. The output from TCS3200 are R, G, B meanwhile the output of LDR are RL, GL, and BL. There are 4 positions of money, it has 4 possibilities positions. This tool is tested with Rupiah 2016 emissions. The left table is the ADC of the money or colour, and the right table is the mapping data of ADC. Mapping of ADC is by making an interval of data (See in Table 4 until Table 19).

| Table 4. ADC of Rp.1000. |
|--------------------------|
| **Position** | R | G | B | RL | GL | BL |
| 1st | 58 | 59 | 51 | 23 | 31 | 64 |
| 2nd | 63 | 68 | 56 | 18 | 23 | 64 |
| 3rd | 56 | 63 | 60 | 18 | 26 | 53 |
| 4th | 61 | 66 | 59 | 22 | 29 | 62 |

| Table 5. Mapping ADC of Rp.1000. |
|-------------------------------|
| **1st Position** | **2nd Position** | **3rd Position** | **4th Position** |
| 56≤ R ≤60 | 61≤ R ≤65 | 54≤ R ≤59 | 59≤ R ≤63 |
| 57≤G ≤61 | 66≤ G ≤71 | 61≤ G ≤66 | 64≤ G ≤68 |
| 49≤ B ≤54 | 58≤ B ≤63 | 58≤ B ≤63 | 57≤ B ≤62 |
| 21≤RL≤26 | 16≤ RL ≤22 | 16≤RL ≤21 | 20≤ RL ≤26 |
| 31≤GL≤37 | 21≤ GL ≤27 | 24≤GL ≤30 | 27≤ GL ≤32 |
| 62≤BL≤68 | 48≤ BL ≤53 | 51≤ BL≤58 | 60≤ BL ≤67 |
### Table 6. ADC of Rp.2000.

| Position | R  | G  | B  | RL | GL | BL |
|----------|----|----|----|----|----|----|
| 1<sup>st</sup> | 63 | 70 | 61 | 20 | 27 | 61 |
| 2<sup>nd</sup> | 60 | 65 | 57 | 20 | 26 | 51 |
| 3<sup>rd</sup> | 58 | 64 | 57 | 25 | 31 | 58 |
| 4<sup>th</sup> | 66 | 68 | 57 | 23 | 30 | 62 |

### Table 7. Mapping ADC of Rp.2000.

| Position   | 1<sup>st</sup> Position | 2<sup>nd</sup> Position | 3<sup>rd</sup> Position | 4<sup>th</sup> Position |
|------------|--------------------------|--------------------------|--------------------------|--------------------------|
| R          | 61≤ R ≤66                | 58≤ R ≤62                | 56≤ R ≤60                | 64≤ R ≤68                |
| G          | 68≤ G ≤72                | 63≤ G ≤68                | 62≤ G ≤667               | 66≤ G ≤71                |
| B          | 59≤ B ≤64                | 55≤ B ≤60                | 55≤ B ≤59                | 55≤ B ≤60                |
| RL         | 18≤ RL ≤25               | 18≤ RL ≤24               | 22≤ RL ≤27               | 22≤ RL ≤27               |
| GL         | 25≤ GL ≤31               | 24≤ GL ≤30               | 29≤ GL ≤33               | 28≤ GL ≤33               |
| BL         | 59≤ BL ≤65               | 49≤ BL ≤56               | 56≤ BL ≤62               | 60≤ BL ≤66               |

### Table 8. ADC of Rp.5000.

| Position | R  | G  | B  | RL | GL | BL |
|----------|----|----|----|----|----|----|
| 1<sup>st</sup> | 58 | 60 | 60 | 17 | 24 | 57 |
| 2<sup>nd</sup> | 56 | 57 | 52 | 15 | 25 | 55 |
| 3<sup>rd</sup> | 50 | 64 | 60 | 19 | 28 | 61 |
| 4<sup>th</sup> | 59 | 70 | 62 | 21 | 31 | 61 |

### Table 9. Mapping ADC of Rp.5000.

| Position   | 1<sup>st</sup> Position | 2<sup>nd</sup> Position | 3<sup>rd</sup> Position | 4<sup>th</sup> Position |
|------------|--------------------------|--------------------------|--------------------------|--------------------------|
| R          | 56≤ R ≤60                | 54≤ R ≤58                | 48≤ R ≤59                | 57≤ R ≤62                |
| G          | 58≤ G ≤68                | 55≤ G ≤65                | 62≤ G ≤67                | 68≤ G ≤72                |
| B          | 58≤ B ≤62                | 50≤ B ≤60                | 58≤ B ≤62                | 60≤ B ≤65                |
| RL         | 15≤ RL ≤21               | 13≤ RL ≤18               | 17≤ RL ≤22               | 19≤ RL ≤24               |
| GL         | 22≤ GL ≤27               | 23≤ GL ≤28               | 26≤ GL ≤32               | 29≤ GL ≤34               |
| BL         | 55≤ BL ≤61               | 53≤ BL ≤60               | 59≤ BL ≤65               | 60≤ BL ≤66               |

### Table 10. ADC of Rp.10,000.

| Position | R  | G  | B  | RL | GL | BL |
|----------|----|----|----|----|----|----|
| 1<sup>st</sup> | 63 | 71 | 56 | 20 | 32 | 59 |
| 2<sup>nd</sup> | 59 | 67 | 52 | 18 | 26 | 45 |
| 3<sup>rd</sup> | 57 | 60 | 47 | 18 | 27 | 48 |
| 4<sup>th</sup> | 62 | 69 | 54 | 24 | 31 | 53 |

### Table 11. Mapping ADC of Rp.10,000.

| Position   | 1<sup>st</sup> Position | 2<sup>nd</sup> Position | 3<sup>rd</sup> Position | 4<sup>th</sup> Position |
|------------|--------------------------|--------------------------|--------------------------|--------------------------|
| R          | 61≤ R ≤66                | 57≤ R ≤62                | 55≤ R ≤60                | 60≤ R ≤65                |
| G          | 69≤ G ≤73                | 65≤ G ≤70                | 58≤ G ≤63                | 67≤ G ≤72                |
| B          | 54≤ B ≤59                | 50≤ B ≤55                | 45≤ B ≤49                | 52≤ B ≤54                |
| RL         | 18≤ RL ≤25               | 16≤ RL ≤21               | 16≤ RL ≤23               | 22≤ RL ≤26               |
| GL         | 30≤ GL ≤35               | 24≤ GL ≤30               | 25≤ GL ≤30               | 29≤ GL ≤34               |
| BL         | 57≤ BL ≤64               | 43≤ BL ≤49               | 46≤ BL ≤51               | 51≤ BL ≤58               |
Table 12. ADC of Rp.20.000.

| Position | R  | G  | B  | RL | GL | BL |
|----------|----|----|----|----|----|----|
| 1st      | 60 | 59 | 51 | 18 | 22 | 47 |
| 2nd      | 52 | 52 | 48 | 20 | 23 | 48 |
| 3rd      | 52 | 61 | 59 | 18 | 22 | 48 |

Table 13. Mapping ADC of Rp.20.000.

| 1st Position | 2nd Position | 3rd Position | 4th Position |
|--------------|--------------|--------------|--------------|
| 58≤ R ≤63    | 50≤ R ≤54    | 50≤ R ≤60    | 63≤ R ≤67    |
| 57≤ G ≤62    | 50≤ G ≤56    | 59≤ G ≤63    | 62≤ G ≤66    |
| 49≤ B ≤53    | 46≤ B ≤50    | 57≤ B ≤60    | 54≤ B ≤58    |
| 16≤ RL ≤21   | 18≤ RL ≤22   | 16≤ RL ≤22   | 21≤ RL ≤28   |
| 20≤ GL ≤25   | 21≤ GL ≤26   | 20≤ GL ≤26   | 27≤ GL ≤32   |
| 45≤ BL ≤51   | 46≤ BL ≤52   | 46≤ BL ≤52   | 65≤ BL ≤72   |

Table 14. ADC of Rp.50.000.

| Position | R  | G  | B  | RL | GL | BL |
|----------|----|----|----|----|----|----|
| 1st      | 63 | 62 | 50 | 24 | 28 | 58 |
| 2nd      | 60 | 60 | 51 | 20 | 23 | 42 |
| 3rd      | 63 | 60 | 52 | 20 | 26 | 48 |
| 4th      | 71 | 68 | 52 | 26 | 30 | 60 |

Table 15. Mapping ADC of Rp.50.000.

| 1st Position | 2nd Position | 3rd Position | 4th Position |
|--------------|--------------|--------------|--------------|
| 61≤ R ≤65    | 58≤ R ≤63    | 61≤ R ≤65    | 69≤ R ≤74    |
| 60≤ G ≤64    | 58≤ G ≤63    | 58≤ G ≤66    | 66≤ G ≤71    |
| 40≤ B ≤53    | 49≤ B ≤53    | 50≤ B ≤55    | 50≤ B ≤56    |
| 22≤ RL ≤27   | 18≤ RL ≤23   | 18≤ RL ≤24   | 24≤ RL ≤29   |
| 26≤ GL ≤32   | 21≤ GL ≤27   | 24≤ GL ≤30   | 28≤ GL ≤34   |
| 56≤ BL ≤61   | 40≤ BL ≤46   | 44≤ BL ≤50   | 58≤ BL ≤64   |

Table 16. ADC of Rp.100.000.

| Position | R  | G  | B  | RL | GL | BL |
|----------|----|----|----|----|----|----|
| 1st      | 56 | 68 | 56 | 18 | 28 | 53 |
| 2nd      | 51 | 64 | 52 | 15 | 25 | 46 |
| 3rd      | 57 | 67 | 55 | 15 | 27 | 48 |
| 4th      | 54 | 67 | 54 | 19 | 32 | 62 |

Table 17. Mapping ADC of Rp.100.000.

| 1st Position | 2nd Position | 3rd Position | 4th Position |
|--------------|--------------|--------------|--------------|
| 54≤ R ≤58    | 49≤ R ≤54    | 55≤ R ≤59    | 52≤ R ≤57    |
| 66≤ G ≤71    | 62≤ G ≤66    | 65≤ G ≤70    | 65≤ G ≤72    |
| 54≤ B ≤58    | 50≤ B ≤56    | 53≤ B ≤58    | 52≤ B ≤56    |
| 16≤ RL ≤22   | 13≤ RL ≤17   | 13≤ RL ≤19   | 17≤ RL ≤22   |
| 26≤ GL ≤31   | 23≤ GL ≤28   | 25≤ GL ≤30   | 30≤ GL ≤36   |
| 51≤ BL ≤57   | 44≤ BL ≤49   | 46≤ BL ≤52   | 60≤ BL ≤67   |
### Table 18. ADC of colour.

| Colour     | R  | G  | B  |
|------------|----|----|----|
| Red        | 45 | 90 | 70 |
| Yellow     | 48 | 57 | 57 |
| Green      | 71 | 53 | 62 |
| Light green| 50 | 47 | 47 |
| Blue       | 90 | 73 | 50 |
| Dark blue  | 100| 93 | 64 |
| Orange     | 33 | 79 | 6  |
| Pink       | 32 | 78 | 54 |
| Black      | 103| 109| 87 |
| White      | 43 | 46 | 36 |

### Table 19. Mapping ADC of colour.

| Colour         | RL   | GL  | BL   |
|----------------|------|-----|------|
| Red            | 43≤RL≤47 | 89≤GL≤93 | 69≤BL≤73 |
| Yellow         | 46≤RL≤50 | 55≤GL≤59 | 65≤BL≤70 |
| Green          | 69≤RL≤75 | 50≤GL≤55 | 60≤BL≤66 |
| Light green    | 48≤RL≤53 | 45≤GL≤49 | 45≤BL≤50 |
| Blue           | 88≤RL≤93 | 71≤GL≤76 | 48≤BL≤52 |
| Dark blue      | 98≤RL≤103 | 90≤GL≤100 | 60≤BL≤68 |
| Orange         | 30≤RL≤40 | 77≤GL≤80 | 61≤BL≤72 |
| Pink           | 30≤RL≤35 | 75≤GL≤84 | 52≤BL≤58 |
| Black          | 102≤RL≤107 | 108≤GL≤113 | 85≤BL≤93 |
| White          | 40≤RL≤50 | 43≤GL≤54 | 33≤BL≤45 |

3.2. Trial

This tool is tested by using some different sample of rupiah 2016 emission and some colour, this trial is 4 times for each colour or money. Table 20 is the result of the sensing colour trial, and Table 21 show the result of trial sensing of nominal.

### Table 20. Result of colour.

| Colour  | Result  |
|---------|---------|
| Red     | Red     |
| Red     | Red     |
| Red     | Red     |
| Pink    | Pink    |
| Pink    | Pink    |
| Pink    | Pink    |
| Green   | Green   |
| Green   | Green   |
| Green   | Green   |
| Light green | Light green | Light green |
| Light green | Light green |
| Light green | Light green |
| Blue    | Blue    |
| Blue    | Blue    |
| Blue    | Blue    |
### Table 20. Cont.

| Colour  | Result |
|---------|--------|
| Dark blue | Dark blue  
Dark blue  
Dark blue  
Dark blue |
| Orange  | Orange  
Orange  
Orange |
| White   | White  
White  
White |
| Yellow  | Yellow  
Yellow  
Yellow |
| Black   | Black  
Black  
Black |

### Table 21. Result of nominal detector.

| Money    | Result            |
|----------|-------------------|
| Rp.1000  | Undetected(error) |
|          | Rp.1000           |
|          | Rp.1000           |
|          | Rp.1000           |
| Rp.2000  | Rp.1000 (Error)   |
|          | Rp.2000           |
|          | Rp.1000 (Error)   |
|          | Rp.2000           |
| Rp.5000  | Rp.5000           |
|          | Rp.5000           |
|          | Rp.5000           |
|          | Rp.5000           |
| Rp.10.000| Rp.10.000         |
|          | Rp.10.000         |
|          | Rp.10.000         |
|          | Rp.10.000         |
| Rp.20.000| Rp.20.000         |
|          | Rp.20.000         |
|          | Rp.20.000         |
|          | Rp.20.000         |
| Rp.50.000| Rp.50.000         |
|          | Rp.50.000         |
|          | Rp.50.000         |
|          | Undetected(error) |
| Rp.100.000| Rp.100.000       |
|          | Rp.100.000       |
|          | Rp.100.000       |
|          | Rp.100.000       |
The result of the trial for the colour is always true for 4 time trial, but the tool has a some error to detecting a nominal of money, it is because the data ADC of money with different nominal is almost same. Sensing of nominal money depends on the physical condition of money. 

\[
error = \frac{\text{total error}}{\text{total trial}} \times 100\%
\]

\[
error = \frac{4}{28} \times 100\% = 14.3\%
\]

4. Conclusions

Based on the test that has been done can be taken several conclusions:

- The design of colour and nominal of money detector works well but has some error.
- This tool has an error if the nominal value of money included in the box is the 2004 emission money, this is because the ADC value of the nominal of money 2004 has the same ADC value at different nominal on emissions 2016 banknotes.
- Sensing of money depends on the physical condition of the money to be detected.

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