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Image Processing System for pH Classification Using Biosensors

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ABSTRACT
The biosensor in this study used a butterfly pea flower. Butterfly pea flowers require a classification system because the colors produced in detecting pH are similar. The method used in this research is using image processing to get the RGB value to be analyzed using the Raspberry Pi 4. The operation and results of the pH classification will be displayed on the TFT LCD. The hardware design is designed in a closed manner with LED lighting. The results of this research on the hardware function well because it can take the pH color of the biosensor with the lighting obtained from the LED. While the results of the classification system with 10 trial samples of mineral water, soft drinks, water, detergent, clothes perfume, and chemical solutions obtained an accuracy of 88.55%. and can display on the TFT LCD.

Keywords: *Images Processing, pH, Classification, Biosensors*

1. INTRODUCTION

The increasing population of humans has resulted in the exploitation of natural resources. The impact of the exploitation of natural resources causes environmental pollution. Environmental pollution will have an impact on changes in pH value. The pH value plays an important role in human life and needs to be monitored for quality control of pharmaceutical, cosmetic and food products [1]. PH conditions in body fluids need to be monitored to determine the level of quality of body health [2]. The condition of pH as a parameter of water quality needs to be monitored for the survival of organisms such as drinking water consumption, monitoring pond water, aquarium water, or water in aquaculture ponds [3].

One of the latest innovations in controlling pH conditions by utilizing biosensors. A biosensor is a bio-analysis device which has a biomolecular layer connected to a transducer to generate an electronic signal [4]. According to researchers [5], the butterfly pea is a plant that can be used as a biosensor to detect pH. Butterfly pea contains anthocyanin compounds that have benefits as an indicator of acid and alkaline titration [6]. Anthocyanin compounds can change color at a certain pH due to the presence of chromophore and autochrome groups.

In developing the use of butterfly pea to detect pH, according to researchers [7], the color produced by butterfly pea as an indicator of acid-base has similarities between pH 1- pH 4 pink, pH 5- pH 8 blue, pH 9- pH 11 colored. purple and pH 12- pH 14 is yellow. In a study [8], the color change to detect pH resulted from butterfly pea had similar color at pH 0.04- pH 3.3, pH 3.9- pH 6.7, pH 7.4- pH 8.5, pH 9.0-pH10.0 and pH 11.5-pH12. 0. In research [9], it was found that the results of pH detection using butterfly pea produced similar color changes at pH 1-pH 3, pH 4-pH 8, pH 9-pH11, and pH 12-pH14.

Based on previous research on the similarity in color produced by butterfly pea in detecting pH, this research will create a classification system that functions to obtain a more accurate pH value with image processing users. Research using image processing has been done by previous researchers. Researcher [10], used RGB color for the classification of buildings, agriculture, forest, and water. From this research, it is found that

using RGB color has good accuracy. Researcher [11], used RGB color to classify the types of plastic bottles with testing data of 200 bottles. The results of the classification of the plastic bottles, RGB color, have an accuracy of 93.33%. Researcher [12], used the RGB and HSV methods in the classification of mango fruit maturity. The results of the classification of fruit maturity are RGB colors that have an accuracy of 90.4% and HSV colors have an accuracy of 84.2%. Researcher [13], used image processing and classification for urine analysis using RGB color features. The results of this study, the RGB color feature can classify urine with 10 parameters well.

Based on the advantages of previous research, this study will use the RGB color feature for pH color classification. The difference between this study and previous research is in the parameters used. Previous research used parameters of mango fruit maturity, type of plastic bottle, urine color, building, and water, while this study focused more on the classification of the pH color produced by the butterfly pea extract and the system displays the pH value on the TFT LCD.

2. MATERIAL AND METHOD

The purpose of this research is to create an image processing system for pH classification using a biosensor. There are 14 classifications in this study, from pH 1 - pH 14. To achieve these objectives requires a planned and systematic research materials and methods.

2.1 Material

The image processing system is built using Rapsberry Pi 4 as data processing which has 2GB RAM, OpenGL ES 3.0 graphics, 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0 BLE, Gigabit Ethernet, 2 USB 3.0 ports; 2 USB 2.0 ports, 40 pin GPIO, Dual display 2 × micro-HDMI ports [14]. The Logitech C2720 camera is a component for capturing pH colors on a 5 Mega Pixel resolution biosensor, has a microphone, and the maximum image display reaches 720p or HD [15]. TFT LCD to operate the system and display classification results. LED which functions for lighting so that the camera has good accuracy in reading RGB color values. 3D printed material used to print hardware from the system, measuring glass as a biosensor container. The 5 Volt DC power supply is used as a system resource for both the camera, raspberry pi 4, TFT LCD, and lighting from the LED lights.

2.2 Method

The research method used in the research of image processing systems for pH classification using biosensors is hardware design, system design, and system testing design.

2.2.1 Hardware Design

The image processing system in this study was designed in a closed manner using 3D printing so that light from outside does not enter. 3D printing is made based on the size and design of the tool that is simple and easy to operate. 3D printing produces good material, is not fragile and lightweight. There is a place for the TFT LCD which is designed to make it easier to operate the system. The distance between the camera and the sample is 2.5 cm. the distance is designed as close as possible to maximize the accuracy of the camera in capturing images. The lighting from the LED is placed close to the camera to improve accuracy. Hardware design can be seen in figure 1.

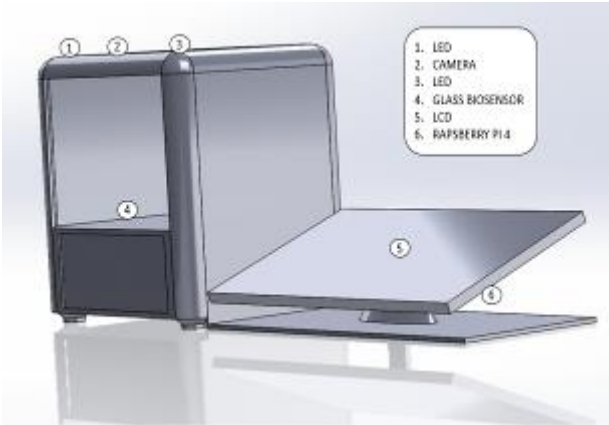

Figure 1 Hardware design

2.2.2 System Design

The design of this image processing system starts from the camera's pH color reader extracted by the Butterfly pea to get the RGB value feature. After taking the image, the colors will be extracted in the Red, Green, and Blue (RGB) color space by finding the average value through the equation below [16].

$$R = \frac{R_1+R_2+R_3}{3} \quad (1)$$

$$G = \frac{G_1+G_2+G_3}{3} \quad (2)$$

$$B = \frac{B_1+B_2+B_3}{3} \quad (3)$$

After getting the RGB average value, the RGB value will be the feature value for each reference pH data and test pH data. To simplify the operation of this system after getting the pH value from the classification results. Then it will be displayed on the TFT LCD. The system planning flow diagram can be seen in figure 2.

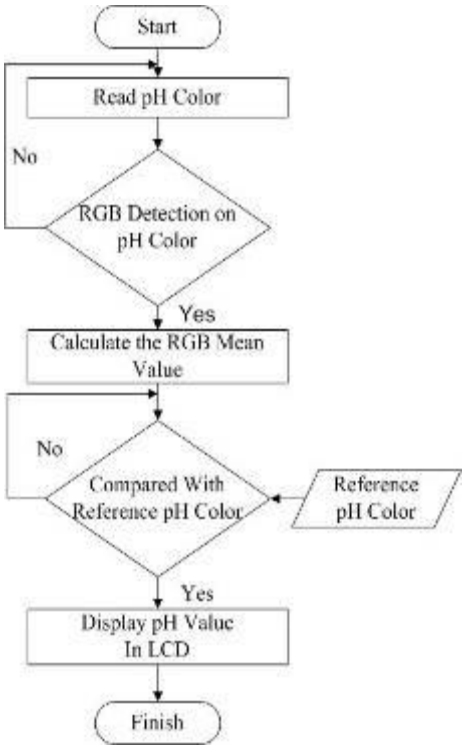

Figure 2 System design flowchart

2.2.3 System Testing Design

This system test is carried out to determine the performance of the image processing system for pH classification using a biosensor to function properly or not. System testing will be carried out in two stages. First hardware testing and second system testing. For system testing, the reading of the tool will be recorded and the percentage of its success will be calculated. To test the performance of the system in detecting pH levels, researchers used 10 samples from several mineral water products, soft drinks, water, detergents, clothes perfume, and chemical solutions to test their pH levels.

3. RESULT AND DISCUSSION

The image processing system is a pH classification system that is produced from a biosensor based on color parameters using a Logitech C270 camera and then processed with python programming on the Raspberry Pi 4. In the development process, there are two stages of testing to determine the performance of the system being developed, namely hardware testing and system testing.

3.1 Hardware Testing Results

Testing is done to validate the system so that it can be used properly. This test is carried out to ensure that the biosensor can be placed on the system so that it is easy to take pictures by the camera and that the lighting from the LED works properly so that the camera gets maximum results.7

This test is done by placing the biosensor onto the glass that is inserted into the system. This test serves to find the best accuracy for the biosensor layout and lighting function of the LED on the camera image results to the biosensor. The results of hardware testing can be seen in figure 3.

Figure 3 Hardware testing

From the test results, it is known that the camera can take biosensor images well with the help of the biosensor glass layout and the lighting is obtained from the LED. This can be seen in figure 3 colors captured by the camera with those shown on the LCD.

3.2 System Testing Results

The test is carried out to validate the image processing system in the pH color classification to obtain an accurate pH value. In this system, there are 14 classifications, namely pH 1- pH 14. In this system, testing is carried out with 10 product samples The product samples used in this study are circulating in the market. To display the pH value and system operation can be seen in figure 4. The results of the pH level classification can be seen in table 1.

Figure 4 TFT LCD operation system

Table 1. System trial results

Product Name	PH value	Accuracy (%)
Mineral water brand a	7	88.69
Mineral water brand b	7	94.52
Mineral water brand c	7	91.21
Mineral water brand d	9	97.02
Soft drink	3	94.10
Non-consumed water	5	81.81
Softener	2	80.97
Perfuming clothes	5	87.37
Shampoo brand a	5	80.09
Dishwasher	5	91.17
Chemical solutions	13	85.14
Average		88.55

Based on the test results that can be seen in table 1, the system can classify and display the pH value on the TFT LCD properly. In this study, the average accuracy of the classification system and detecting pH levels was 88.55 %. It can be concluded that the system can detect pH levels using a biosensor with good accuracy.

4. CONCLUSION

The conclusion of this study is to create an image processing system for pH classification using a biosensor. In this research, the image processing system is carried out by two tests, namely hardware testing and system testing. In hardware testing, the camera can take pictures well because the hardware is designed in a closed manner and the lighting is taken from the LED. While the system test results were carried out with 10 trial samples of mineral water, soft drinks, water, detergent, clothes perfume, and chemical solutions and got an accuracy of 88.55%.

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