Atlantis Highlights in Engineering, volume 7
Proceedings of the 4th Forum in Research, Science, and Technology (FIRST-T1-T2-2020)

Increasing Sensitivity of pH Detection Using Computer Vision Based Biosensors

Sujito[1,2,*] Faiz Syaikhoni Aziz[1] Aji Prasetya Wibawa[1,2] I Made Wirawan[2]
Aripriharta[1,2] Abdullah Iskandar Syah[2] Tran Huy Duy[3]

[1] *Electrical Engineering Postgraduate, Universitas Negeri Malang, Indonesia*
[2] *Electrical Engineering Department, Universitas Negeri Malang, Indonesia*
[3] *Electrical Engineering Department, Dalat University, Vietnam*
[*]*Corresponding author. Email : sujito.ft@um.ac.id*

ABSTRACT
This study presents an increase in pH detection sensitivity using computer vision based biosensors. Butterfly pea flower is used as a biosensor to detect pH. Computer vision uses Raspberry Pi 4, camera, and LCD. To increase the sensitivity of biosensor and computer vision, 2 ways will be used. First, increase the similarity color sensitivity of the biosensor by utilizing the extraction composition. The second is to increase the sensitivity of computer vision accuracy in taking biosensor images using computer vision hardware that is printed using 3D material which is designed in a closed manner so that light from outside does not enter. Lighting is taken from a LED light that is placed close to the camera. The results of this study, the color sensitivity of the biosensor increased when using 3 drops of biosensor extract, and biosensor images could be taken using computer vision as well. while using computer vision hardware the sensitivity increased by 13.6% compared to without using computer vision hardware.

Keywords: *Increasing Sensitivity, pH, Computer Vision, Biosensors.*

1. INTRODUCTION

Maintaining a pH balance is necessary to maintain a healthy human body. The normal pH level of human blood ranges from 7.30 to 7.45 [1]. The pH imbalance causes disturbances in the digestive tract, circulatory system, nausea, decreased immune function, skin diseases, disorders of the reproductive system, and urinary tract [2]. Therefore, many researchers have begun to innovate in pH detection using biosensors that utilize plants that are widely grown in Indonesia. Biosensors are obtained from biological components and physicochemical components [3]. One of the many plants that grow in Indonesia and can be used as a biosensor to detect pH is the butterfly pea flower. Butterfly pea flowers can detect pH because they have anthocyanin compounds [4].

Research on using butterfly pea flowers in detecting pH has been done by previous researchers. In the study [5], the sensitivity of color change to detect pH produced from butterfly pea flower extract had similar colors at pH 0.04-3.3, pH 3.9-6.7, pH 7.4- 8.5, pH 9.0-10.0, and pH 11.5-12.0. In research [4], the color sensitivity produced by butterfly pea flowers in pH detection was similar at pH 1- pH 4, pH 5- pH 8, pH 9 - pH 11, and pH 12- pH14. In research [6], the sensitivity of pH color change using butterfly pea flower resulted in similarities at pH 1-3, pH 4-8, pH 9-11, and pH 12-14.

Based on previous research, the color sensitivity of butterfly pea flowers has poor quality and is difficult to distinguish. Therefore, to facilitate pH detection using computer vision. The use of computer vision has been done in previous studies. In the study [7], lighting variations made the image quality less good when the image was taken outdoors. In [8] research, the color component of the image will change when there is a change in lighting so that lighting has an important role in determining the quality of the image. In the researcher [9], using a pH level based on the color of the results of image processing using a knowledge-based system and computer vision still has a weakness in

detecting pH levels based on colors that have changing background brightness. In the researcher [10], measuring the pH level using lighting in the captured solution using a fiber optic pH sensor which is still constrained by changes in solution temperature due to lighting causes the pH measurement to be inaccurate. In the researcher [11], using a smartphone as an optical spectrometer sensor as a color detector of pH, which still has the weakness of the resolution produced by the optical sensor. In researchers [12], detected pH using a fiber-optic fluorescence sensor connected to a smartphone, which still has the disadvantage of exposure sensitivity.

Referring to the problems in previous researchers, this study aims to increase the pH color sensitivity which will take advantage of the concentration of the biosensor extract composition. Meanwhile, to increase the sensitivity of computer vision in detecting pH, it will use 3D material that is designed in a closed manner so that light from outside does not enter. Exposure is taken from an LED lamp that is placed close to the camera according to careful calculations so that the image-taking process has high sensitivity and accuracy.

2. MATERIAL AND METHOD

2.1 Material Biosensor

Tools used to increase the biosensor's sensitivity include 2 measuring cups, 14 glass glasses, a digital pH meter, a pipette, heating plate, magnetic stirrer, filter, and a set of supporting devices. While the materials used were 10 grams of a dried butterfly pea flower, distilled water, 0.1 M HCL, O.5 M HCL, 1 M HCL, 2M HCL 0.1 M NaOH, 1 M NaOH, 5 M NaOH.

2.2 Extract Biosensor

The method of extracting the butterfly pea flower biosensor was using the research method [6], which was modified to produce a good extract sensitivity. How to extract the biosensor is 10 g of a dried butterfly pea flower, cut into 1-2 mm, and added with 100 ml of distilled water and heated at 60 ° C for 40 minutes. After that, the extract is filtered to separate the butterfly pea flower and the extract solution.

2.3 Butterfly Pea Flower Biosensor for pH Detection

To detect pH using a butterfly pea flower biosensor using a research method [13], which will be modified to produce pH color sensitivity that has high accuracy. To get a pH value 1- pH 14, use an acid and base solution, namely 0.1 M HCL, O.5 M HCL, 1 M HCL, 2M HCL 0.1 M NaOH, 1 M NaOH, 5 M NaOH. which will be mixed with distilled water (15 mL) and 3 drops of butterfly pea flower biosensor extract.

2.4 Material Computer Vision

Materials Computer vision materials used to increase pH detection sensitivity using a 5-megapixel resolution Logitech C2720 camera, raspberry pi 4, LCD, 5-volt power supply, LED, and 3D printer.

2.5 Hardware Design

Design in pH detection is made with 3D printing technology that will be installed with computer vision. There are 5 devices made in the hardware design, namely the LCD place, biosensor glass, the Raspberry Pi 4 place, the LED place, and the camera focus room. The hardware design can be seen in figure 1. To increase the sensitivity of computer vision in detecting pH, the hardware design will be designed in a closed manner so that light from outside cannot enter. The light source is obtained from the LED.

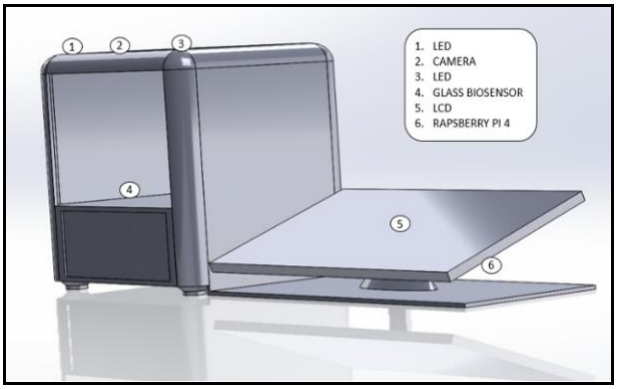


Figure 1 Hardware design

2.6 Data Processing

Processing in this study starts from reading the pH color of the biosensor extract by the camera to get the RGB value. After that, the image will be extracted from the Red, Green, and Blue (RGB) color space by looking for the average value. After getting the RGB average value, the RGB value will be the feature value for each reference pH data and test pH data.

3. RESULT AND DISCUSSION

This study serves to increase the sensitivity of pH detection. There are two tests used to increase the sensitivity of pH detection. The first test increased the sensitivity of the biosensor butterfly pea flower by utilizing the titration composition. The second test increases the sensitivity of computer vision by utilizing a closed 3D material, the lighting will be taken from the LED light which is placed close to the camera according to careful calculations.

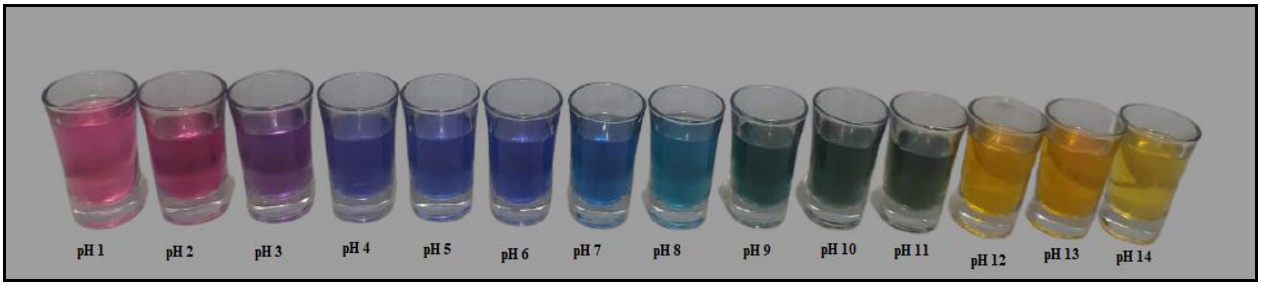


Figure 2 Color change sensitivity pH 1-pH 14

3.1 Biosensor Sensitivity Testing

The sensitivity of the biosensor butterfly pea flower in detecting pH was influenced by the composition of the extract used. The extract of the biosensor butterfly pea flower has a black-blue base color in the form of a concentrated liquid due to the anthocyanin compound, which consists of hydroxyl and methoxy groups that dissolve in water. The results of the extract biosensor butterfly pea flower can be seen in figure 3.

Figure 3 Extract biosensor butterfly pea flower

The process of obtaining a pH value of 1- pH 14 is carried out by adding the biosensor extract butterfly pea flower to an acid and base solution 0.1 M HCL, O.5 M HCL, 1 M HCL, 2M HCL 0.1 M NaOH, 1 M NaOH, 5 M NaOH. The sensitivity test is carried out in 4 stages with the extraction composition of 15 drops, 10 drops, 5 drops, and 3 drops. The results of the sensitivity test using the extraction of 15 drops, 10 drops, 5 drops, the resulting color are too black, so computer vision is difficult to detect. While the results of the sensitivity test with 3 drops of biosensor extract butterfly pea flower resulted in 14 pH colors that could be classified by computer vision, as shown in figure 2.

3.2 Computer Vision Sensitivity Testing

Computer vision sensitivity testing functions to determine the increased sensitivity of computer vision accuracy in detecting pH using a biosensor. There are two tests in this study. The first test is using computer vision hardware as shown in figure 4 and the second test without using computer vision hardware.

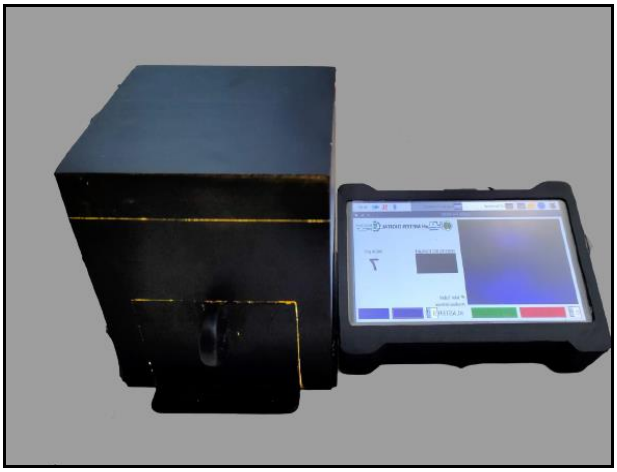
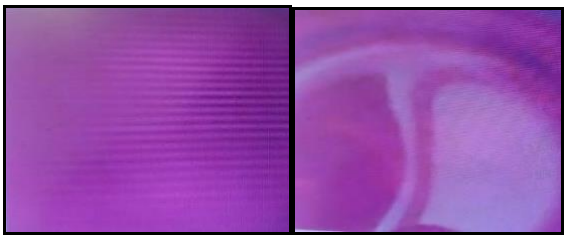


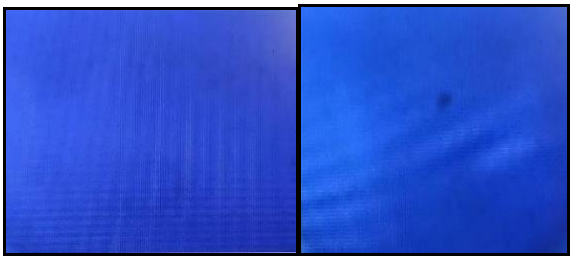
Figure 4 Hardware computer vision

The computer vision sensitivity test was carried out with different pH, namely pH 2, pH 5, pH 9, and pH 12. The sensitivity test results can be seen in figure 5, figure 6, figure 7, and figure 8.



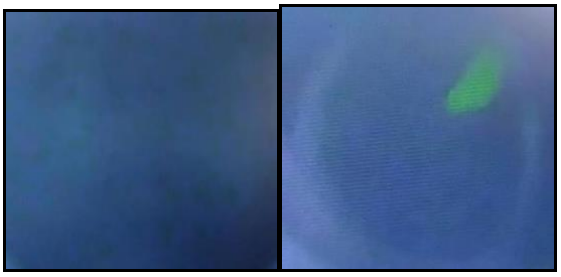
(a) (b)

Figure 5 pH 2 sensitivity test (a) using computer vision hardware (b) without using computer vision hardware



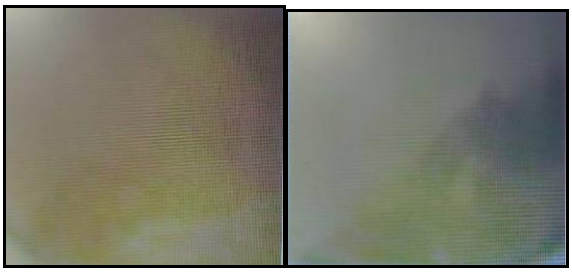
(a) (b)

Figure 6 pH 5 sensitivity test (a) using computer vision hardware (b) without using computer vision hardware



(a) (b)

Figure 7 pH 9 sensitivity test (a) using computer vision hardware (b) without using computer vision hardware



(a) (b)

Figure 8 pH 13 sensitivity test (a) using computer vision hardware (b) without using computer vision hardware

The results of the computer vision sensitivity test with the butterfly pea flower biosensor composition the same has a different color. Colors captured using computer vision hardware are of good quality while the colors produced without using computer vision are of poor quality due to the appearance of variations in lighting on the image surface. The appearance of variations in luminance results in a loss of true color in the image. The color component of the image will change when there are variations in lighting so that lighting has a very important role in increasing the sensitivity of image quality with computer vision. The results of pH detection using computer vision based on increased accuracy are shown in table 1.

Table 1. Test results using computer vision hardware based on accuracy

PH Value	Accuracy (%)	Error (%)
2	88.8	11.2
5	90.8	9,2
9	87.2	12.8
13	89.2	10.8
Average	89	11

Table 2. Test results using computer vision hardware without based on accuracy

Nilai pH	Accuracy (%)	Error (%)
2	68.5	31.5
5	87.7	12.5
9	73.6	26,4
13	72.3	27.7
Average	75,4	24.6

Based on table 1.The results of the sensitivity test using computer vision hardware got an average accuracy value of 89 % and an average error value of 11 % in 4 tests. Meanwhile, based on table 2. the test results without using computer vision hardware get an average accuracy value of 75.4 % and an average error value of 24.6 %. Because it can be concluded that the use of computer vision hardware can increase the accuracy by 13.6 %.

4. CONCLUSION

Conclusion of this research is to increase the sensitivity of pH detection using computer vision-based biosensors. The first test is to increase the sensitivity of the similarity in color produced by the butterfly pea flower biosensor. The second test increases the sensitivity of computer vision. The results of the butterfly pea flower biosensor sensitivity test increased when using the composition of 3 drops of extract and computer vision can detect pH well. while using computer vision hardware the sensitivity increased by 13.6% compared to without using computer vision hardware.

ACKNOWLEDGMENTS

Research and development Increasing Sensitivity of pH Detection Using Computer Vision Based Biosensors were funded by PNBP Research Fund, State University of Malang. We would like to thank Dalat University for being helpful in this research.

REFERENCES

[1] M. R. R. Khan, A. V. Watekar, and S. W. Kang, “Fiber-Optic Biosensor to Detect pH and Glucose,” *IEEE Sens. J.*, 2018, doi: 10.1109/JSEN.2017.2786279.

[2] M. Z. Qalbi, M. Irrahmah, and A. Asterina, “Perbedaan Derajat Keasaman (pH) Saliva Antara Perokok dan Bukan Perokok pada Siswa SMA PGRI 1 Padang,” *J. Kesehat. Andalas*, 2018, doi: 10.25077/jka.v7i3.886.

[3] H. H. Nguyen, S. H. Lee, U. J. Lee, C. D. Fermin, and M. Kim, "Immobilized enzymes in biosensor applications," *Materials*. 2019.

[4] B. Wiyantoko and A. Astuti, "Butterfly Pea (Clitoria Ternatea L.) Extract as Indicator of Acid-Base Titration," *IJCA (Indonesian J. Chem. Anal.*, 2020, doi: 10.20885/ijca.vol3.iss1.art4.

[5] R. Abdullah, P. M. Lee, and K. H. Lee, "Multiple color and pH stability of floral anthocyanin extract: Clitoria ternatea," in *CSSR 2010 - 2010 International Conference on Science and Social Research*, 2010, doi: 10.1109/CSSR.2010.5773778.

[6] N. M. Saptarini, D. Suryasaputra, and H. Nurmalia, "Application of Butterfly Pea (Clitoria ternatea Linn) extract as an indicator of acid-base titration," *Journalof Chem. Pharm. Res.*, 2015.

[7] X. Liang and Z. Jiang, "Segmenting ripe tomato pictures based on the illumination irrelevant images," in *Proceedings - International Conference on Natural Computation*, 2013, doi: 10.1109/ICNC.2013.6818204.

[8] Y. Hold-Geoffroy, A. Athawale, and J. F. Lalonde, "Deep sky modeling for single image outdoor lighting estimation," in *Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, 2019, doi: 10.1109/CVPR.2019.00709.

[9] R. B. G. Luta, A. C. L. Ong, S. J. C. Lao, R. G. Baldovino, N. T. Bugtai, and E. P. Dadios, "A noncontact pH level sensing indicator using computer vision and knowledge-based systems," in *HNICEM 2017 - 9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management*, 2017, doi: 10.1109/HNICEM.2017.8269474.

[10] F. Ferrero *et al.*, "pH measurements using simple fiber-optic instrumentation and luminescence detection," in *Conference Record - IEEE Instrumentation and Measurement Technology Conference*, 2005, doi: 10.1109/imtc.2005.1604395.

[11] P. Hu, Y. Chen, and S. Sonkusale, "Low cost spectrometer accessory for cell phone based optical sensor," 2016, doi: 10.1109/vcacs.2015.7439566.

[12] T. Liu, W. Wang, H. Ding, and D. Yi, "Smartphone-Based Hand-Held Optical Fiber Fluorescence Sensor for On-Site pH Detection," *IEEE Sens. J.*, 2019, doi: 10.1109/JSEN.2019.2926153.

[13] L. Nur Faezah Syahirah *et al.*, "A comparative analysis of clitoria ternatea linn. (Butterfly pea) flower extract as natural liquid pH indicator and natural pH paper," *Dhaka Univ. J. Pharm. Sci.*, 2018, doi: 10.3329/dujps.v17i1.37125.