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作品名稱　Design a program on identifying Proliferation rate of HABs

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Design a program on identifying Proliferation rate of HABs

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1. abstract

Due to global population growth and industrialization, excessive inflow of causative nitrogen into rivers, and the increase in water temperature due to global warming, the occurrence of harmful algal blooms (HABs) is increasing. HABs can cause not only ecological destruction but also various social and economic problems. Additionally, consuming water from lakes with abundant toxic cyanobacteria can lead to liver damage, vomiting, abdominal pain, and even death if consumed over a long period. The first recorded occurrence of animal mortality due to HABs was in Australia in 1878, and since then, livestock and wildlife have suffered damages from HABs worldwide. Furthermore, the United States' Lake Erie has experienced frequent HAB occurrences since 2011, and in 2007, China faced social disruption when a massive HAB outbreak in Lake Tai, one of the freshwater lakes, resulted in a suspension of the water supply.

In order to address these HAB occurrence issues and assess the severity of HAB events, several systems have already been established and potential solutions have been proposed. However, these systems have limitations such as being highly systematic and advanced in terms of equipment and configuration. They

are often located only in periodically affected areas, and they involve substantial costs. Therefore, we aim to overcome these limitations and design a system that can effectively manage HABs.

2. Main Body

2.1 Causes of Harmful Algal Blooms (HABs) and Current Issues in HAB Management

2.1.1 Causes of HABs

HABs refer to the phenomenon in which the abundance of phytoplankton and cyanobacteria in eutrophic lakes or slow-flowing rivers increases significantly, turning the water green. The main cause of HABs is often the excessive growth of cyanobacteria. For example, when nitrogen enters the water, usually from fertilizers used in surrounding agricultural areas, in a condition where eutrophication occurs, specific cyanobacteria or algae can experience a significant growth. This results in an explosive increase in the number of cells of certain species, leading to a change in the color of the water.

2.1.2 Issues in HAB Management

In order to address the issues of HAB occurrence and assess the severity of HAB events, several systems have been established and potential solutions have been proposed. However, these systems, although appearing highly systematic and advanced in terms of equipment and configuration, have several limitations. Observation research institutes are mostly located in periodically affected areas, and the equipment itself is expensive and primarily designed for marine weather observations rather than specifically for HAB phenomena. As a result, the observation coverage area is limited, and the deployment of observation equipment is relatively small-scale. Additionally, these systems simply indicate the distribution of HABs without providing direct indicators of the underlying factors causing HABs, such as water temperature, oxygen saturation, humidity, etc. The information displayed is limited to a simple classification of "high occurrence, low occurrence, no occurrence." Therefore, even during periods when HABs are not highly prevalent but showing an increasing trend, there is no information available regarding the severity of the situation.

One of the methods for assessing the severity of HAB events is through algal monitoring systems. Monitoring the composition, frequency, and density of algae can provide important indicators of water quality and can be useful in alert systems when algal levels rise to harmful levels. Traditional algal proliferation monitoring utilizes the measurement of chlorophyll-a (Chl-a) concentration, which is one of the photosynthetic pigments used as an indicator of algal biomass, through on-site sampling. However, on-site sampling for chlorophyll-a measurement in algal monitoring often faces issues of temporal and spatial resolution due to various factors such as rain and wind, which can cause dramatic changes in the composition and location of large-scale algal blooms within a short period. Therefore, the measured algal concentration in a specific area cannot represent the overall distribution and concentration of algal blooms in the entire region. Furthermore, the algal alert systems also rely on manual measurement methods, which have limitations in providing real-time pollution monitoring effectively.

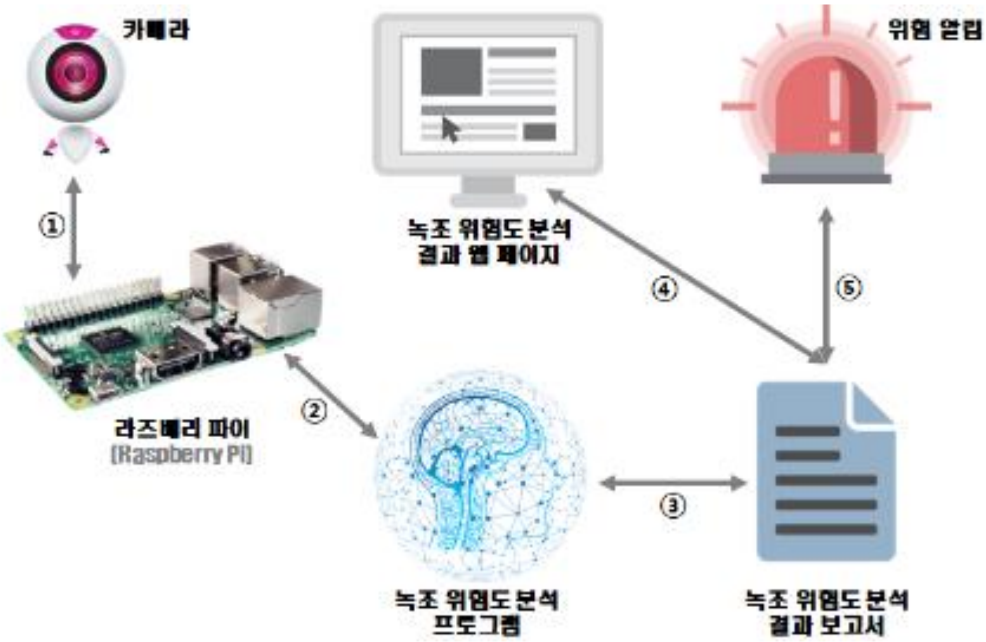
System Design

2.2.1 Exploration and Design of Monitoring System Using Raspberry Pi and Research Results

2.2.1.1 System Design

Now, I will provide a detailed explanation of the overall flow and specific design aspects of the system, as well as the research results.

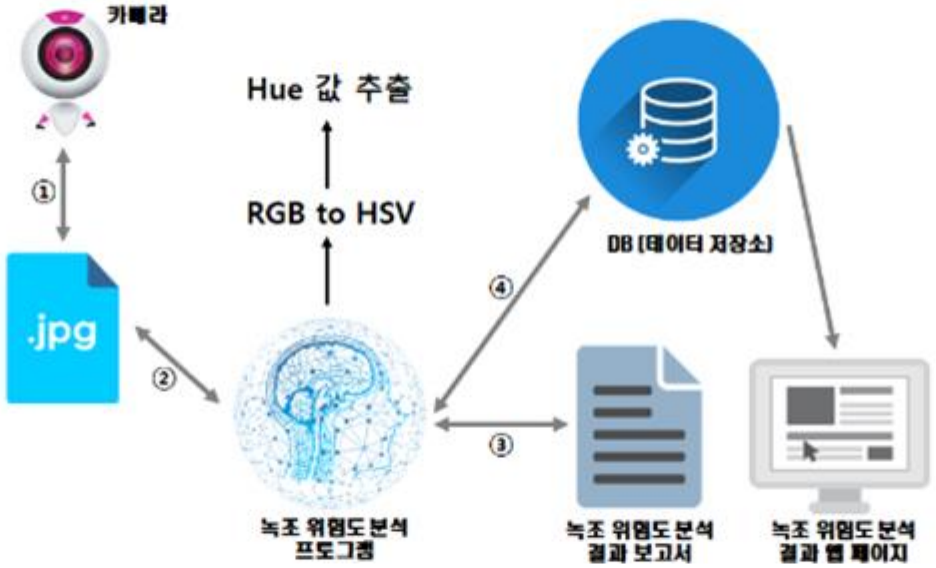
The proposed system follows the flowchart shown in Figure 1.



[Figure.1] the proposed system

When receiving an image to check the number of green algae through the camera, such as the system flowchart, the image received from the raspberry pie is captured and stored as a photo. A green algae risk analysis program stored in a raspberry pie analyzes the risk percentage of previously stored photos. A detailed flow chart for analyzing the risk of green algae will be presented below. If the risk percentage of algae is low in the picture, the captured picture is deleted without being delivered and stored in the result report, and if the percentage is high, the report is saved as a file as a result of analyzing the risk using the analyzed data. After the report process, the analysis results are uploaded to the web page in real time to provide the service user with the risk of algae in the river and river, and when the risk is high, a risk notification is issued to cope with the algae.

The internal design of the system was configured to capture images to measure the risk of green algae and collect and store data on risk figures and dates through a database. The video being taken by the camera is ordered by the program and the scene is saved as a picture. After converting RGB into HSV values through the green algae risk analysis program, this conversion value is extracted as HUE values. We analyze green algae risk with extracted HUE values and leave a result report. In this process, if the risk of green algae is high, it is considered dangerous and the data is stored. It was designed and implemented to show the results obtained using the stored data on the web page.



[Fig. 2] Detailed blueprint

The detailed plan is as shown in Fig. 2. The process of collecting into the database through the process shown in Figure 2 is as shown in Figure 3, Figure 4.

#	이름	데이터 유형	길이/설정	부호 없음	NULL 허...	0으로...	기본값
1	num	INT	11	☐	☐	☐	기본값 없음
2	Percentage	VARCHAR	50	☐	☐	☐	''
3	DATE	VARCHAR	50	☐	☐	☐	''

[Fig. 3] Table plan


algae.algae_data: 1 행 (총) (대략적)

다음 | 모두 보기 | 정렬 (1) | 열 (3/3) | 필터

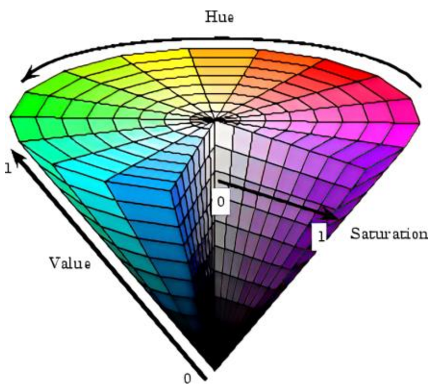
num	Percentage	DATE
1	70.3	2022-12-24

[Figure 4] Extracted data

The proposed system uses two tables as shown in Figure 3. One consists of a table that stores when the value of the percentage of risk is high, and the other is a table that stores the date when the data was recorded.

2.2.1.2 HSV Color Model

When developing the HAB management program, the most crucial aspect is determining the presence or absence of HABs through monitoring and analyzing color changes that occur during HAB occurrences. While the RGB color model is commonly used, it is not suitable for devices such as displays and printers as it does not separate luminance and color elements. In this study, a color model similar to human visual perception, namely the HSV (Hue, Saturation, Value) color model, is utilized for image processing in the system. The HSV color model represents color using the coordinates of hue, saturation, and value, providing a more intuitive way to specify specific colors.



[figure 5] HSV

In the HSV color model, the H channel represents the type of color and has a value ranging from 0° to 360°. The S channel ranges from 0 to 255, where a value of 0 represents achromatic (no color) and 255 represents the most vibrant and saturated color. The V channel also ranges from 0 to 255, where lower values indicate darker colors and higher values indicate brighter colors.

$$H = \cos^{-1}\frac{\frac{1}{2}[(R-G)+(R-B)]}{\sqrt{(R-G)^2+(R-B)(G-B)}}$$

$$S = 1 - \frac{3}{(R+G+B)}[MIN(R,B,G)]$$

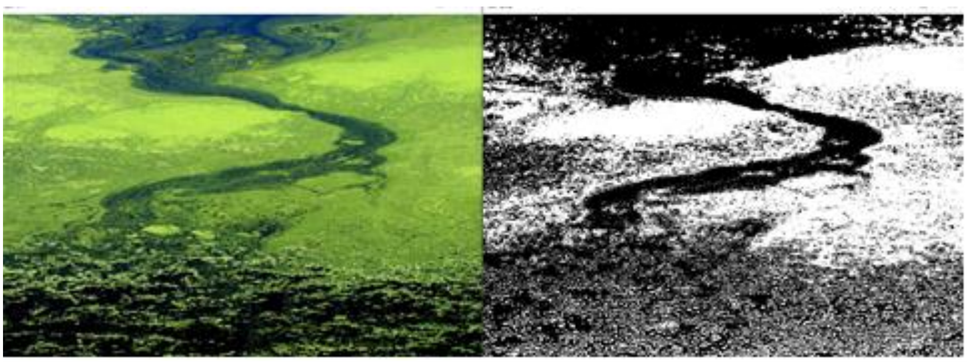
$$V = \frac{1}{3}(R+G+B)$$

[figure 6] conversion equation

The method for converting the RGB color space to the HSV color space is as shown in equation (6) and figure (6).

2.2.1.3 System Exploration Results

Based on the previously stated content, the green algae risk analysis system proposed in this paper was implemented as follows. Fig. 7 shows the results of extracting only green areas by converting RGB values into HSV values in the green algae risk program.



[Fig. 7] RGB to HSV Implementation Results

As shown in Figure 8, if the risk analysis result is determined to have a high risk value through the program, the data value is stored in the result report.

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이미지 이름 : noc.jpg
녹조 위험도 : 40.31 %
녹조 유무 : Y
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[Fig. 8] Green algae hazard results report

The values analyzed by the above system were implemented so that the user could recognize them through the web page risk signal.

3. Results

We present an experimental model that designs and implements a program that can continuously monitor algae status using Raspberry Pi, an open platform for applying IoT technology. After extracting images and photos with a camera using the proposed system, the risk was measured through a green algae risk analysis program and notified on the web page. When the measured risk is high, it was intended to reduce the number of damage cases by storing it in a database and notifying web service users of risk notifications.

The algae of the river contrasts with the temporary mass breeding of harmful birds in the marine environment, and if the model of this study is modified a little, it can be developed as a model that can monitor the red tide status of the ocean.

Like the proposed system, the system can be expanded to convert RGB into HSV values through a risk analysis program, and the green algae risk pattern can be analyzed according to temperature, and the green algae risk can be predicted based on the analyzed data.

References

[1] Yuna Shin, Suwoong Lee, “Unwelcomed Algal Blooms, Prevented by Scientific Countermeasures”, THE MAGAZINE OF THE KOREAN SOCIETY OF CIVIL ENGINE, pp. 1-10, July, 2018
[2] Minseok Kim, Hyungwook Park, Heonjung Jo, Enju Kim, “A Research of Algal Early Forecasting Method using Deep Learning”, The Korean Operations Research and Management Science Society, pp. 1-2, June, 2021
[3]Park Cheol Woo, Jeon Jong Ju, Moon Yong Ho, and Eom Il Kyu, “Green Algae Detection Using Water Body Extraction and Color information”, journal of The Institute of Electronics and Information Engineers Vol.56, NO.5, pp. 1-4, May, 2019

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1. The work employs image processing techniques to analyze the risk of green algae and the proliferation rate of HABs.

2. The results can potential be useful for environmental monitoring.

3. The collection of data, the establishment of ground truth, the procedure of training, and the analysis of the results can be further improved.