Detection of Water Clarity Level with OpenCV Image Processing Method

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Abstract
Water is the most important compound for the survival of living organisms on Earth. Clean water is essential for human activities. Clean water is characterized by various physical parameters, one of which is water clarity or turbidity. Image processing can be implemented to determine the clarity of water. Advances in image processing technology have made it possible to detect objects and colors in them, supported by libraries such as OpenCV, which provides color spaces. Thus, this research experimentally detects the clarity of water using the HSV and HSL color spaces. This research show significant differences in color for different levels of water clarity using the HSV and HSL color spaces.

Keywords: Detection, Water clarity, Image processing, OpenCV

INTRODUCTION

Water is the most important compound for the survival of living organisms on Earth. According to the US Geological Survey, the total amount of water on Earth is almost 326 million cubic miles. However, 97% of this water is saline and unsuitable for consumption. Clean water is characterized by various physical and chemical parameters that must be met, such as water temperature, light penetration, light intensity, dissolved oxygen (DO), oxygen saturation, turbidity, biological oxygen demand (BOD), chemical oxygen demand (COD), water pH, nitrate, phosphate, and fecal coliform.

The clarity or turbidity of water can be detected using image processing methods. Advances in digital image processing technology can be utilized to detect an object. Object detection can be done in many ways, including by color. RGB color will be used as a benchmark in detecting the object because RGB color is the basic color of all objects in daily life and is also often used in image processing. Therefore, in the experiment on this project will detect the clarity of water using image processing methods with OpenCV.

RESEARCH METHOD
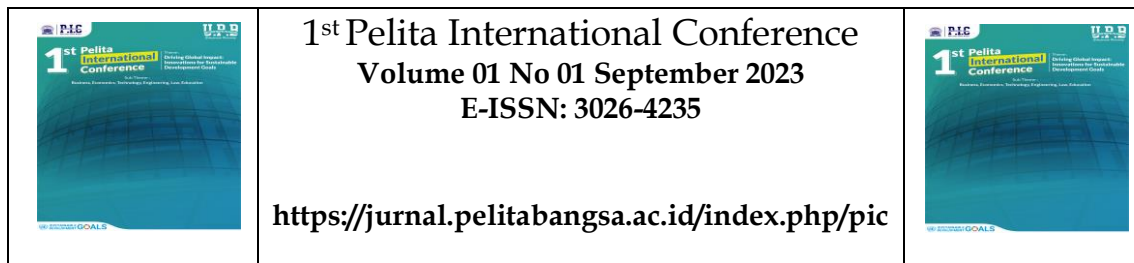**Software Design**

Figure 1. Block diagram
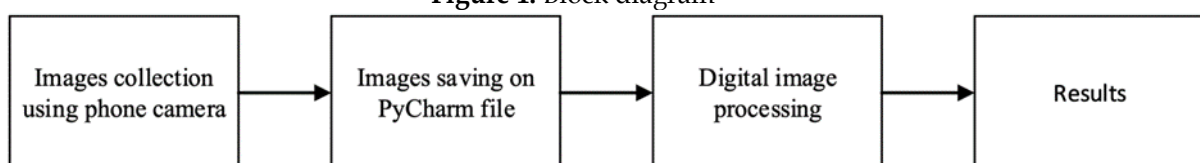
Figure 1 shows the workflow of the water clarity detection process using image processing methods with OpenCV. In the image acquisition step, a white background is used to facilitate image detection. If the image size is too large, image compression is needed to ensure a clear display of the processed image. The image is then saved in a PyCharm file. The OpenCV library detects the object's color and converts the object's RGB color into other color spaces.

Theoretical Background
Object Tracking
Literally, tracking means following a path, or in other words, it is an activity of following the footsteps of an object. Tracking systems are systems that are capable of tracing or searching for something by providing information about it. Tracking techniques are often applied in the field of image processing to automatically track objects, making work easier.

Some factors that often interfere with object tracking are loss of information due to 3-dimensional projection in a 2-dimensional image, noise in the image, non-rigid or natural articulation of the object, object obstructed by another object, complex object shape, drastic changes in lighting(194080-ID-Use-Water-Turbidity-Monitoring-System, n.d.).

Real-time processing requirements. Object tracking techniques require a reference to +the object being tracked. The reference for tracking is usually based on the object's color and shape.

Turbidity Level
Turbidity or cloudiness in water is caused by suspended matter, such as clay, silt deposits, colloid organic particles, plankton, and other microscopic organisms (Kusumanto & Tompunu, 2011). Water clarity or turbidity level is a measure of water quality. According to the Regulation of the Minister of Health of the Republic of Indonesia No. 416/MENKES/PER/IX/1990, the requirements for clean water can be reviewed from physical, chemical, microbiological, and radioactive parameters that are present in drinking water. One of the physical parameters in clean water is temperature, pH, and turbidity. The turbidity of water can be seen from its color. The more colored the water is, the higher the level of turbidity, making it unsuitable for use (Cianci-Gaskill et al., 2023).

Digital Image Processing
Image is one of the multimedia components that can provide visual information. Image can also be in the form of a still image (photo) or moving image (from a webcam). Digital image processing is a process of manipulating images or pictures using a computer to improve their quality and make the information they convey more clear to human eyes.

OpenCV
OpenCV stands for Open Source Computer Vision and was initially developed by Intel Corporation. OpenCV is a free platform library for real-time image processing that has become the de facto standard tool for everything related to Computer Vision. OpenCV is applied to areas such as segmentation and recognition, 2D and 3D feature identification, object identification, face recognition, motion tracking, gesture recognition, image stitching, High Dynamic Range (HDR) imaging, and augmented reality (a technology that overlays computer-generated images onto a user's view of the real world, providing a combined view).

Color Spaces
Human visual system is capable of distinguishing hundreds of thousands of colors. To obtain this information, the human retina has three types of color-sensitive cone photoreceptor

cells, which respond to incident radiation. Therefore, most human color perception can be generated with three numerical components called primaries (García, n.d.).

RGB is an additive model in which an image consists of three independent or channel images: red, green, and blue (and optionally, a fourth channel for transparency, sometimes referred to as the alpha channel). To determine a specific color, each value indicates the amount of each component present at each pixel, with higher values corresponding to brighter pixels. This color space is widely used because it matches the three photoreceptors in the human eye. Note: The default color format in OpenCV is often referred to as RGB, but it is actually stored as BGR (channels reversed) (Jurnal Dasar Pemograman Python STMIK, 2018).

The HSV color space is included in the group called hue-oriented color coordinate systems. The HSV color space has three components, namely H (HUE) represents the dominant wavelength or the size of the spectral composition of color, S (Saturation) represents the purity of the dominant wavelength, V (Value) represents the intensity. The color conversion codes for converting between RGB and HSV in OpenCV using cvtColor are COLOR_BGR2HSV, COLOR_RGB2HSV, COLOR_HSV2BGR, and COLOR_HSV2RGB.

In grayscale, the value of each pixel is represented as a single value that only carries intensity information, forming an image exclusively composed of various shades of gray. The color space conversion code to convert between RGB and grayscale (Y) in OpenCV using cvtColor is COLOR_BGR2GRAY, COLOR_RGB2GRAY, COLOR_GRAY2BGR, and COLOR_GRAY2RGB [7].

The CIE XYZ system describes color with a luminance component Y, which is related to the human visual sensitivity to brightness, and two additional channels, X and Z, standardized by the Commission Internationale de L'Éclairage (CIE) using statistics from experiments with several human observers. This color space is used to report colors from measuring devices such as colorimeters or spectrophotometers, and it is useful when consistent color representation across different devices is needed. The main issue with this color space is that colors are scaled in a non-uniform way. This fact led CIE to adopt the CIE Lab* and CIE Luv* color models. The color conversion codes to convert between RGB and CIE XYZ in OpenCV using cvtColor are COLOR_BGR2XYZ, COLOR_RGB2XYZ, COLOR_XYZ2BGR, and COLOR_XYZ2RGB.

YCrCb, also known as Y'CbCr, is a color space derived from the RGB color space. It has three components, namely Y represents luminance, Cr represents the difference between the red channel (R) and Y indicating how far the red component is from the luminance, Cb represents the difference between the blue channel (B) and Y indicating how far the blue component is from the luminance. This color space is widely used in video and image compression schemes, such as MPEG and JPEG.

The HLS color space is part of the group of color coordinate systems that are oriented towards color tone. It is similar to the previously explained HSV color model. This model was developed to determine the hue, lightness, and saturation values of a color in each channel. The difference compared to the HSV color model is that the pure brightness determined by HLS is the same as medium gray brightness, while the pure brightness determined by HSV is the same as white brightness. The color space conversion codes to convert between RGB and HLS in OpenCV using cvtColor are COLOR_BGR2HLS, COLOR_RGB2HLS, COLOR_HLS2BGR, and COLOR_HLS2RGB.

The Lab* color space has three components, namely L represents the lightness of the color (intensity), a represents the color component ranging from green to magenta, b represents the color component ranging from blue to yellow. The Lab* color space has the following properties: A perceptually uniform color space that approximates how we perceive color, Device independent (capturing or displaying), Widely used in Adobe Photoshop, R elated to the RGB color space with complex transformation equations. The color conversion codes to convert

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between RGB and CIE Lab* in OpenCV using cvtColor are COLOR_BGR2Lab, COLOR_RGB2Lab, COLOR_Lab2BGR, and COLOR_Lab2RGB.

CIE Luv* color space is the first standardized uniform color space by CIE. It is a simple transformation to calculate CIE XYZ space and white reference point, which attempts to uniformize color perception (Jurnal Dasar Pemograman Python STMIK, 2018). Like the CIE Lab* color space, it was created to be device-independent. The Luv* color space has three components, namely L represents the brightness of the color, u indicates the color component between green and red, v indicates the color component between blue and purple. This color space is useful for additive color mixing due to its additional linearity properties. The conversion code for converting between RGB and CIE Luv* color space in OpenCV is COLOR_BGR2Luv, COLOR_RGB2Luv, COLOR_Luv2BGR, and COLOR_Luv2RGB.

Python is a programming language that can perform a number of multi-functional commands focused on design that involve code readability and can operate on several systems such as Windows, Java Virtual Machine, Palm, Linux/Unix, and others. Python also comes with a comprehensive standard library to access system functionality. Python can be used and obtained for free and open source. Python applications are developed for various software such as web applications, games, and scientific programs that use Python.

Pycharm is one of the popular Integrated Development Environment (IDE) for learning Python developed by JetBrains which has high capability and intelligence in editing, problem-solving, and automation tools. PyCharm software has two editions which are PyCharm Professional Edition and Community Edition. Here are some differences in features and specifications between PyCharm Professional Edition and Community Edition (Features - PyCharm, n.d.)

RESULTS AND DISCUSSIONS
Real Images

| **Figure 2.** Experiment 1 | **Figure 3**. Experiment 2 | **Figure 4.** Experiment 3 | **Figure 5.** Experiment 4 |
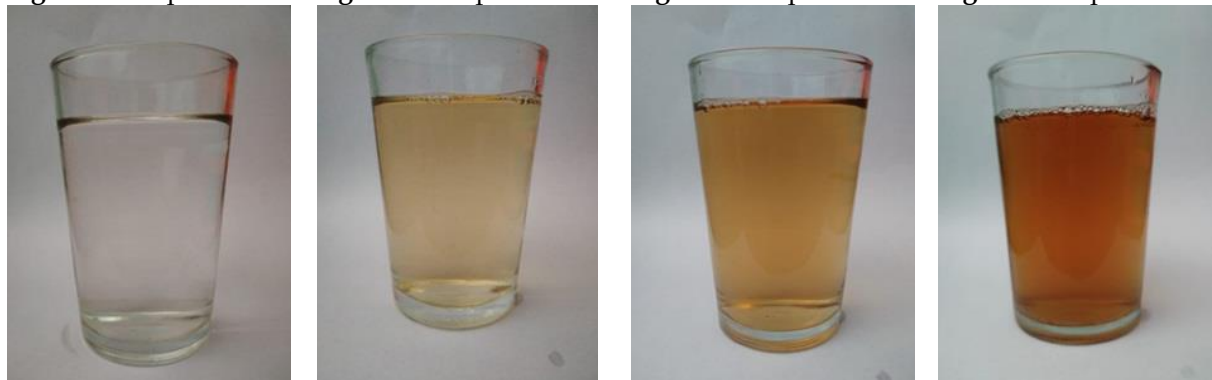
Program on PyCharm

```
import cv2
import numpy as np
from cv2.cv2 import WINDOW_AUTOSIZE

img = cv2.imread('uji 1.jpeg')
img2 = cv2.imread('uji 2.jpeg')
img3 = cv2.imread('uji 3.jpeg')
img4 = cv2.imread('uji 4.jpeg')

hsv = cv2.
```
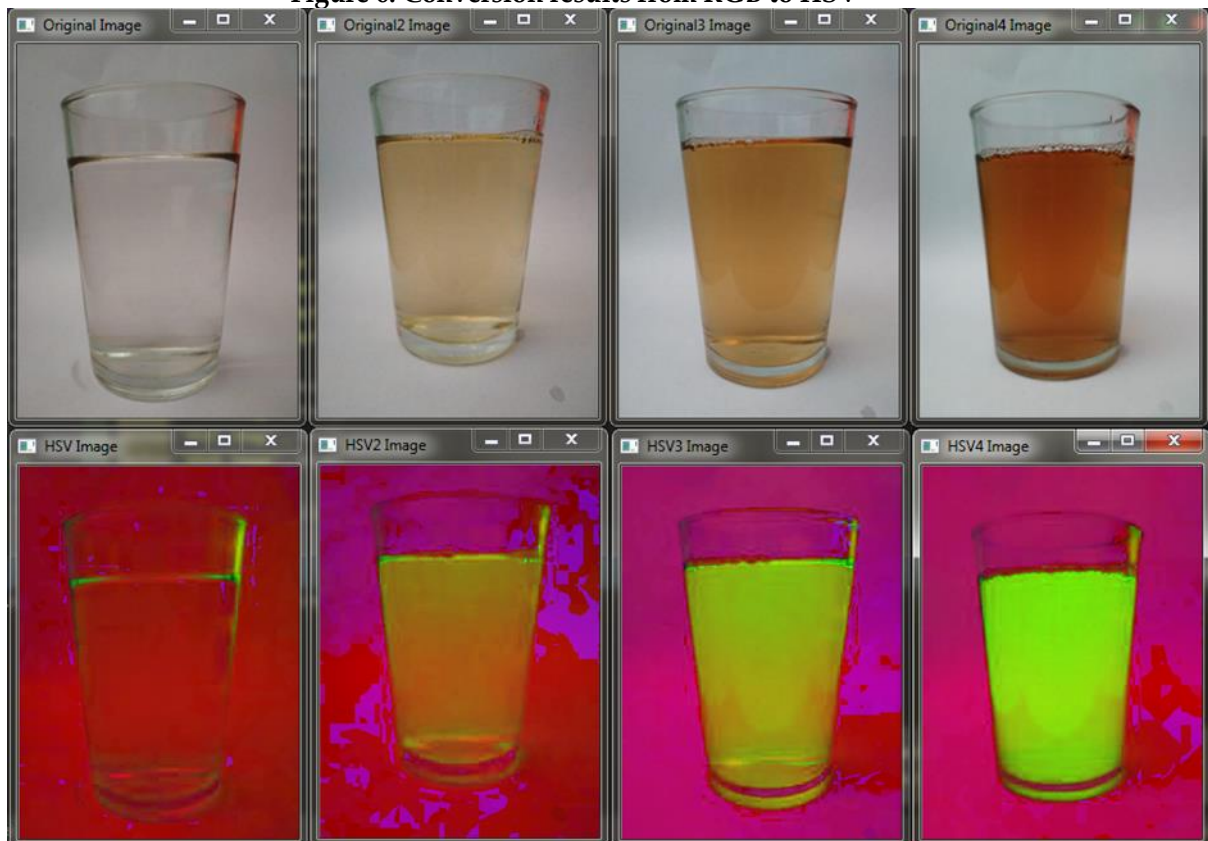
Color Spaces

In this experiment, we will classify the results of converting images from RGB to other color spaces into 4 levels of clarity: very low, low, high, and very high.

HSV

Figure 6. Conversion results from RGB to HSV

The HSV color space is widely used in computer vision applications, especially if we are interested in tracking the color of several objects in an image. HSV is widely used to make color comparisons because H is almost independent of variations in light. Based on Figure 6, it proof that the "HSV Image" result image has the same color for the water and the background. This indicates that the clarity level is very high. The "HSV2 Image" result image has slightly yellowish-green color for the water. This indicates that the clarity level is high. The "HSV3 Image" result image has a greenish-yellow color for the water. This indicates that the clarity level is low. The "HSV4 Image" result image has a green color for the water. This indicates that the clarity level is very low

Grayscale

In the result of converting RGB images to Grayscale, there are not significant differences because Grayscale only produces one color, which is gray. However, we can still see the differences in clarity level in each image. In the "GRAY Image" the clarity level of the water is very high. In the "GRAY2 Image" the clarity level of the water is high. In the "GRAY3 Image" the clarity level of the water is low. In the "GRAY4 Image" the clarity level of the water is very low.

XYZ

The "XYZ Image" result shows that the color of the water is the same as the background color, indicating a very high level of clarity. The "XYZ2 Image" result shows that the color of the water has a slight blue tint, indicating a high level of clarity. The "XYZ3 Image" result shows that the color of the water is blue, indicating a low level of clarity. The "XYZ4 Image" result shows that the color of the water is a dark shade of blue, indicating a very low level of clarity.

YCrCb

In the image result of converting RGB to YCrCb, there is not a significant difference in color in each image, making it difficult to identify the clarity level of water in this color space. This is because the YCrCb color space is usually used for data and video compression, resulting in reduced image resolution.In the above images, the significant color is visible in the "YCrCb Image" which has a very high clarity level and in the "YCrCb4 Image" which has a very low clarity level.

HLS

The "HLS Image" result shows that the clarity level is very high. The "HLS2 Image" result shows that the clarity level is high The "HLS3 Image" result shows that the clarity level is low. The "HLS4 Image" result shows that the clarity level is very low.

Lab

In the RGB to Lab color space conversion image, the resulting colors in each image are not significantly different. In the images above, the significant color is seen in the "Lab Image", which has a very high level of clarity, and in the "Lab4 Image", which has a very low level of clarity.

Luv

In the image resulting from the conversion of RGB to Luv, the colors produced in each image are not too significant.In the images above, the significant color can be seen in the "Luv Image" which has a very high level of clarity, while the "Luv4 Image" has a very low level of clarity.

CONCLUSION

In this research, we can conclude that the detection of water clarity using image processing methods with OpenCV is significant in the HSV and HSL color spaces

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