색상 검출 알고리즘을 활용한 물고기로봇의 위치인식과 군집 유영제어

무하마드 아크바르*, 신규재*
*부산외국어대학교 일반대학원 ICT 창의융합학과
e-mail : akbar23@rocketmail.com, kyoojae@bufs.ac.kr

Position Detection and Gathering Swimming Control of Fish Robot Using Color Detection Algorithm

Muhammad Akbar*, Kyoo Jae Shin*
*Dept. of ICT Creative Design, Graduate School, Busan University of Foreign Studies

Abstract

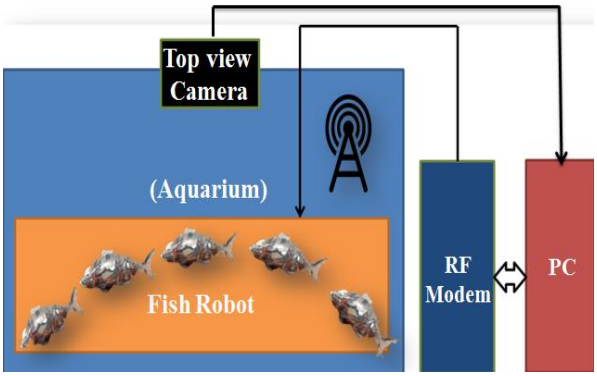
Detecting of the object in image processing is substantial but it depends on the object itself and the environment. An object can be detected either by its shape or color. Color is an essential for pattern recognition and computer vision. It is an attractive feature because of its simplicity and its robustness to scale changes and to detect the positions of the object. Generally, color of an object depends on its characteristics of the perceiving eye and brain. Physically, objects can be said to have color because of the light leaving their surfaces. Here, we conducted experiment in the aquarium fish tank. Different color of fish robots are mimic the natural swim of fish. Unfortunately, in the underwater medium, the colors are modified by attenuation and difficult to identify the color for moving objects. We consider the fish motion as a moving object and coordinates are found at every instinct of the aquarium to detect the position of the fish robot using OpenCV color detection. In this paper, we proposed to identify the position of the fish robot by their color and use the position data to control the fish robot gathering in one point in the fish tank through serial communication using RF module. It was verified by the performance test of detecting the position of the fish robot.

1. Introduction

Engineering design of robots had often inspired by the nature. Recently developed bio-inspired robots have imitated various aspects of human live counter parts. The robotic dynamics is new sub-category of bio-inspired design. It is about learning concepts from nature and applying them to the design of real world engineered systems. More specifically, this field is about creating robots that are inspired by biological systems [1] [2].

In this paper, the designed fish robot was researched and developed for an aquarium underwater robot system. The proposed aquarium world consists of fish robot, PC (Personal Computer), Camera and RF (Radio Frequency) Module as shown in the Figure 1. The fish robot model is analyzed to maximize the momentum of the robot and the body of the robot is designed through the analysis of the biological swimming. The presented fish robot consists of the head, 1st stage body, 2nd stage body and tail which are connected through two-point driving joints of the robot. We had applied the approximate method of the streamer model that utilizes techniques to mimic the biological fish [3][4]. The swimming fish robot has two operating modes such as manual and autonomous modes. In the manual mode the fish robot swimming is operated by using the RF Transceiver. While in the autonomous mode, the fish robot is controlled through microcontroller unit. The fish consists of two servo motors and three PSD (Position Sensitive Detector) sensors in the fore head of fish robot to detect obstacles. Air bladder device in the head portion is used for moving methods and communication port

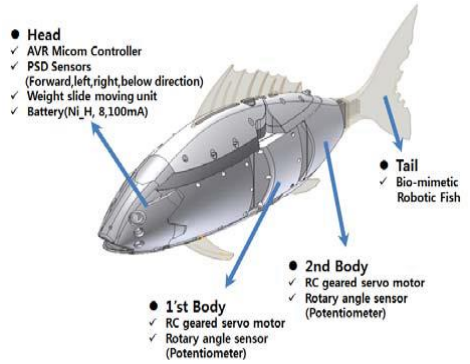
is used to receive data. We had designed an aquarium robot world using fish robot. In order to realize the aquarium robot world, it needs the coordinated position data so that it had researched about the detecting fish robot using the boundary detecting, color weight and Comparing image data algorithm [5][6][9]. In this paper, it has proposed to design the aquarium fish robot world to establish the communication between fish robot and PC. Here, we can control the fish robot swimming motion by using video camera without any other object detecting sensors inside the fish robot. It is possible to find the position by its color and control the motion of fish robot using RF module and control them from the PC. In this paper, we are proposed to realize the motion of fish robot tracking control and position using OpenCV color detection. It was verified by the performance test for the designed aquarium fish robot world.



(Figure 1) The aquarium fish robot world to control the fish robot

2. Model of Fish Robot

The designed of fish robot was researched and developed for an aquarium underwater robot system. The presented fish robot consists of the head, 1st stage body, 2nd stage body and tail, which is connected through two point driving joints as shown in the Figure 2.



(Figure 2) Configuration of Fish Robot

The robot was design through the analysis of the biological fish swimming to maximize the momentum of the robot. Also, it was applied to the kinematics analysis of fish robot swimming algorithms, which is basically light hill dynamics. The center of the fish robot gravity is transferred to a one axis sliding and it is possible to the submerged and emerged of robot by the weight moving unit.

3. Software Architecture

3.1 OpenCV and Color Detection

OpenCV is an open source, cross-platform library that provides the building blocks for computer vision experiments and applications. It provides high-level interfaces for capturing, processing and presenting image data. OpenCV is widely used in both academia and industry [7]. In this paper, we will implement OpenCV color detection using python programming language.

OpenCV has desirable function that allows us to identify a particular color of the object. Instead of using most common RGB color space, here, we are going to use HSV color space. It allows us to identify a particular color only by using a single value, the hue. HSV color space closely emulates models of human color perception [8].

3.2 Convert RGB to HSV Color Space

Genereally image can be formed with RGB color space. It constructs all the colors from the combination of the Red, Green and Blue colors. The red, green and blue use 8 bits each, which consist of integer value from 0 to 255. This value will represents pixel in every image. In this paper, we conducted experiment using HSV color space since it is the most suitable color space for color segmentation. HSV color space model was based more upon how colors are organized and conceptualized in human vision.

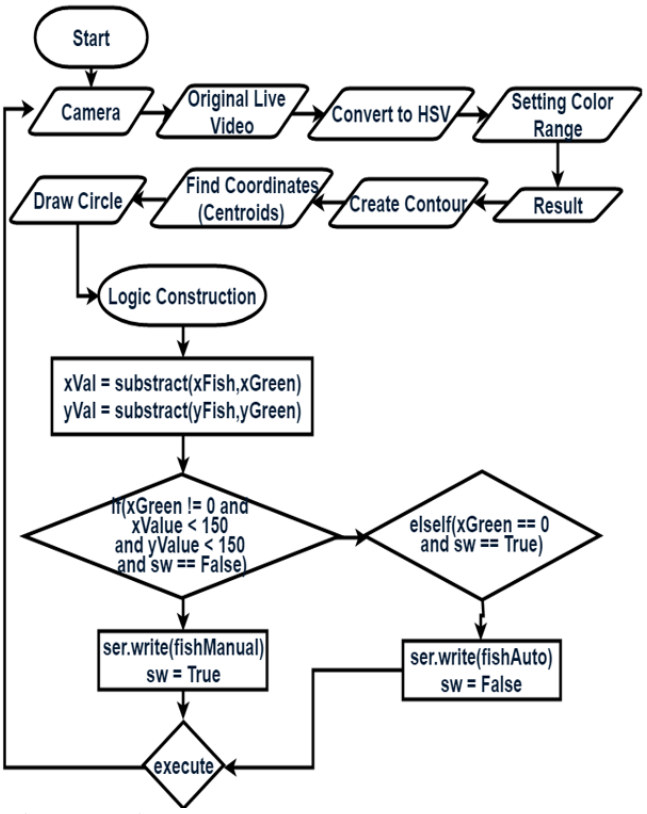
$$V = \max(R,G,B)$$

$$S = \begin{cases} \dfrac{V - \min(R,G,B)}{V} & if\ V \neq 0 \\ 0 & otherwise \end{cases}$$

$$H = \begin{cases} \dfrac{60(G-B)}{V - \min(R,G,B)} & if\ V = R \\ 120 + \dfrac{60(B-R)}{V - \min(R,G,B)} & if\ V = G \\ 240 + \dfrac{60(R-G)}{V - \min(R,G,B)} & if\ V = B \end{cases} \quad (1)$$

The color space conversion code to convert between RGB and HSV in OpenCV using cvtColor is COLOR_BGR2HSV and COLOR_HSV2BGR. In this case, cvtColor first converts it into a floating-point format, scaling the values between 0 and 1. After that the transformation are computed as shown in equation (1). If H < 0, then H = H + 360. Finally, the values are converted to the destination data type [8]. Here we are going to use green, red, blue and yellow color range value as the colors of the fishes and color of the marker control.

3.3 Flowchart of Color Band Control

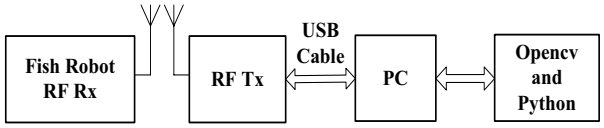


(Figure 3) Flowchart Green Color Band Control

Here, we use web camera to give live video of the fish tank to the application. Then we set the color range for each fish robot to be detected. After we get the desired color, we create contour surrounding of the color which is detected and then find the centroid coordinates of the object. In the experiment, we will use green color for the color mark to control the stop zone of the fish robot. Here, we define 150 as the threshold value and calculate distance between the fish robot and the color mark. If the distance reach the threshold value, the fish will stop at that point. The fish will swim again if the color mark is removed from the fish tank. The full cycle can be seen in the Figure 3.

3.4 The Fish Robot Control Using RF Module

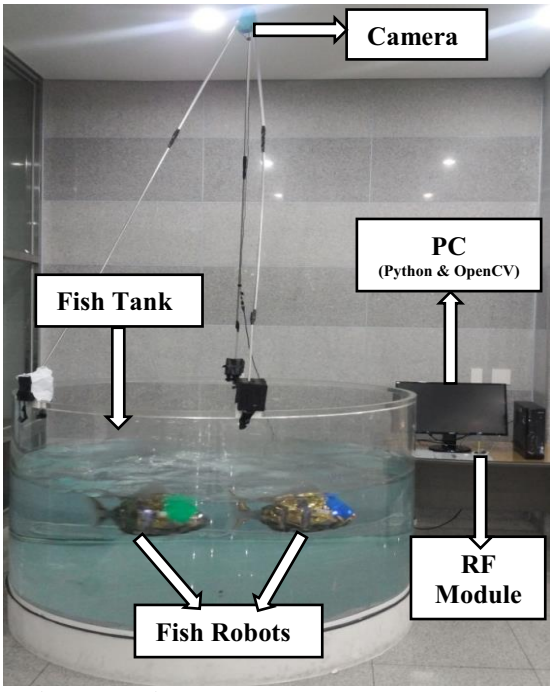
Here,we are going to conduct an experiment to control the motion of the fish robot in the aquarium. This control will be done by using the Opencv and Python through RF Module from the PC. The fish robot has inbuilt RF receiver which is operated in three modes such as manual mode, auto mode and control mode. In the manual mode, we have to give command manually to control the fish robot from application. The fish robot and PC are connected with wireless communication through RF module. The RF module and PC are connected through USB cable and establish the serial communication as shown in the Figure 4.



(Figure 4) Block Diagram of RF module and Fish Robot

4. Experimental Results

The experimental environment consists of camera, fish robot, fish tank and personal computer which RF module connected as shown in the Figure 5. The camera is connected to PC and have to be placed in the proper position to cover the entire fish tank. To remove the unwanted detection, we use black color layer in the bottom of the fish tank.



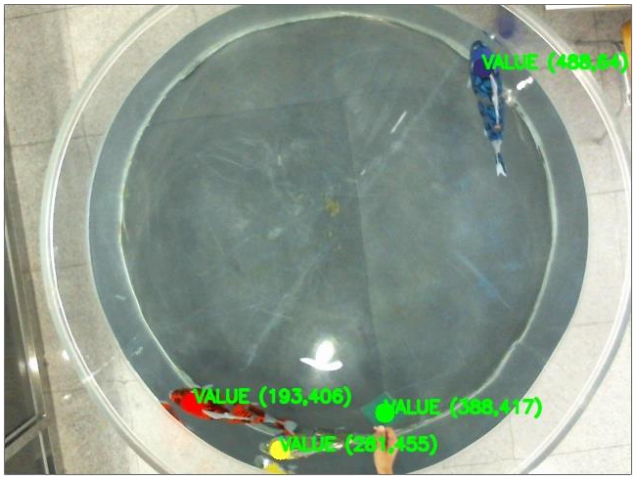
(Figure 5) The experimental environment

4.1 Position Detection of Fish Robot

The fish robot position was detected by using camera to implement color detection algorithm. Color detection algorithm is able to filter particular color of the image. After filtering we are able to define the coordinates of the object. The final result is shown in the Figure 6. While capture the video, we use 640x480 screen resolution. It means, X axis has 640 in maximum value, while Y axis has 480 in maximum value. The result shows that the yellow fish is detected at the position (119,206), red fish is detected at the position (156,270) and blue fish which swim in the opposite direction is detected at the position (356,366). These coordinate values were changing following the fishes motion in the realtime.

(Figure 6) Position Detection of Fish Robots

4.2 Controlling Fish Using Green Color Band



(Figure 7) Green Color Control Mark

After acquiring the coordinates data of the fish robots, we are able to control the fish robot using RF module. Here, we implement the green color mark at the position (388,417). Every fish were stop after crossing the green color mark and fully stop in the different position as shown in the Figure 7.

5. Conclusion

In the conclusion, the object which is fish robot can be detected by its color. Here, we use red, blue, green and yellow colors because of these colors intensity are better than other colors and primely remove the noise of the image. The color detections are able to avoid noise owing by the waves in the aquarium which are produced by fish robot motion. The result shows that this study successfully detecting the position of the fish robot using OpenCV color detection. Furthermore, from the coordinates of the fish robot, we are able to control the motion of the fish robot for a desired application like required standstill position, interval between fish robots and run by external device. Here, we successfully implement the stop point of the fish robot by using green color mark and gather in the desired position. It was verified by the performance test of detecting the position of the fish robot.

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