A Study of Detecting Fish Robot Position using the Comparing Image Data Algorithm

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이미지 비교 알고리즘을 이용한 물고기 로봇 위치 탐지 연구

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ABSTRACT

In this paper, the designed fish robot is researched and developed for aquarium underwater robot. This paper is a study on how the outside technology merely to find the location of fish robots without specific sensor or internal devices. This model is designed to detect the position of the Robotic Fish in the Mat lab and Simulink. This intends to recognize the shape of the tank via a video device such as a camera or camcorder using an image processing technique to identify the location of the robotic fishes. Here, we are applied the two methods, one is Hom - Schunk Method and second one is newly proposed method that is the comparing image data algorithm. The Horn - Schunck Method is used to obtain the velocity for each pixel in the image and the comparing image data algorithm is proposed to obtain the position with comparing two video frames and assumes a constant velocity in each video frame.

1. Introduction

Engineering design of Robots often had inspired by the nature; recently had developed bio-inspired robots accurately imitate various aspects of their live counter parts [1]. We are developing a new culture, science and technology content; these two are linked by a robotic fish.

In this paper, the designed fish robots DOMI Ver 1.0 is researched and developed for aquarium underwater robot as shown in the figure 1.The presented fish robot consists of the head, 1'st stage body, 2'nd stage body and tail which is connected two point driving joints of the Carangiform as shown in the figure 2.The Model of the robot fish is analysis to maximize the momentum of the robot fish and the body of the robot is designed through the analysis of the biological swimming. Also, Light hill was applied to the kinematic analysis of robot fish swimming algorithm. We are applied to the approximate method of the streamer model that utilizes techniques to mimic the biological fish [2].The swimming robot has two operating - modes such as manual and autonomous operation modes. In manual mode the fish robot is operated by using the RF transceiver. In autonomous mode the Robot is controlled by the microprocessor board, which consist PSD sensor for object recognition and avoidance. In order to submerge and emerge, the robot has the bladder device in a head portion and also the control system of fish robot as shown in the figure 3. Here, two servo motors and three PSD sensors are used in the fore head of fish to detect obstacles. Air bladder device and communication port are designed to swim, float and to obtain data by sliding methods. The power of fish robot is determined by robot's temporary swimming in the water tank [3].

In this paper, the newly first proposed method-comparing image data algorithm in the world is applying to the fish robot to detect the position to analyze the motional behavior of fish robot. The image comparing algorithm works fully based on the frames of image and video. The frame is composed of picture elements just like a chess board. Here, picture elements has some coordinates, no pixel coordinate would not match on the screen. So that, comparing image data algorithm compare the two frames and finding the position of the object because every object has some particular pixels when image captured by camera, that would not change continuously, so, can detect the position of robotic fish.

In summary, the robotic Fish is considered in this study seeks to analyze the motional behavior and detect the position by using the Mat lab and Simulink Model.

2. Modeling of Detecting Object

The Optical Flow block estimates the direction and speed of object motion from one image to another image and from one video frame to another video frame using the "Horn – Schunck Method" and "Comparing image data algorithm"[4][5]. This model has drawn in Simulink as shown in the figure 4 and it consists of several major blocks such as:

(1) Multimedia file

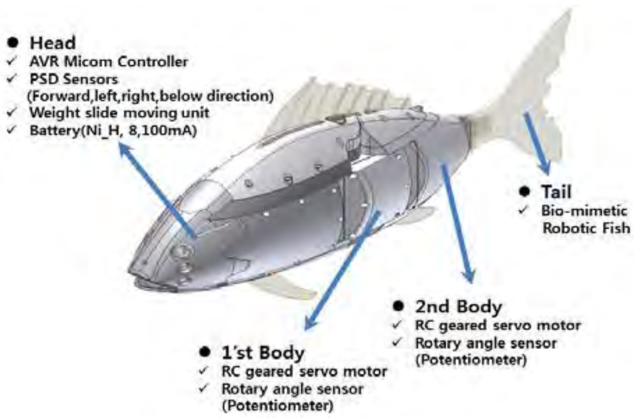
This is the video file captured from the Sony camera and uploaded to this block is double click on the block → select the browse button → select ok. The output of this block is image and given as input to the second block that is RGB to Gray.

(2) RGB to Gray: This block takes the color data and converts into the gray color by using the color codes which starts from 000 to 255.

(3) Histogram equalization: This method is used to improve the contrast of images with backgrounds and fore grounds that are both bright or both dark. In this, the converted image is given as input to the optical flow block**.**

(4) Optical flow: This optical flow is the pattern of apparent motion of objects, surfaces, and edges in a visual scene caused by the relative motion between an observer (an eye or camera) and the scene. In this, the velocity of each frame will be estimated by using Horn-Schunck method and newly proposed method.

(Figure 1) The designed fish robot (DOMI ver1.0)

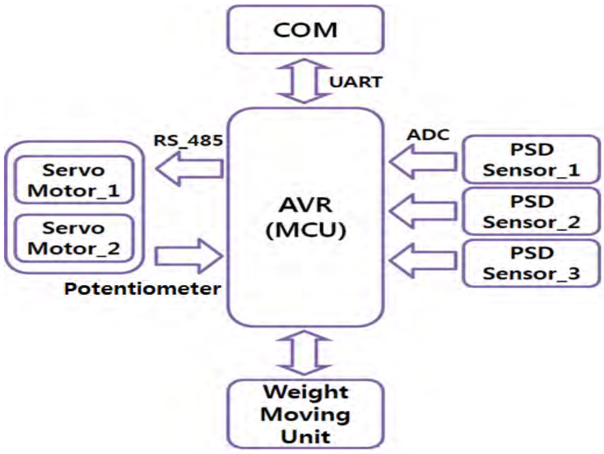


(Figure 2) The Configuration of fish Robot

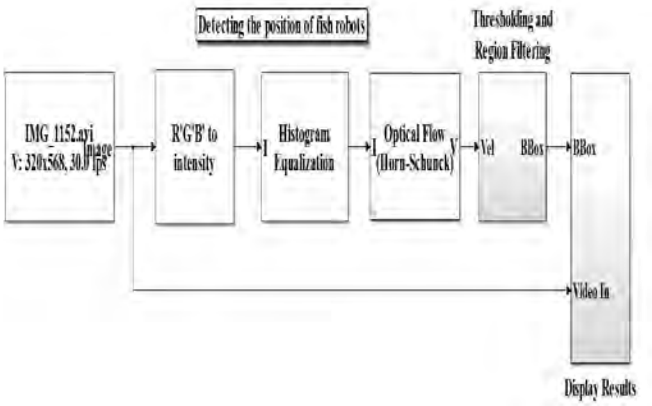
(5) Thresholding and Filtering

This block thresholds the image and filters the image from original image. This model locates the fishes in each binary image using the Blob Analysis block. Then, it uses the Draw Shapes block to draw a green rectangle around the fishes.

(6) Display Results: The Results window shows the position of number of fishes around green rectangle in the region of aquarium.



(Figure 3) The overall system of Fish Robot



(Figure 4) The proposed method of the position detecting of fish robot

3. Detecting fish robot position

3.1 Recognition pattern of fish robot

Robotic Fishes are swimming in the specially designed water tank to analyze the motion of the fish experimentally. This designed robotic fishes for aquarium is tested to analyze the motion and flow of Robotic fish. When this robotic fish passes a particular location value on a server, we communicate with the server, giving them an order to specific coordinates while this fish swim free. To send a specific x, y coordinates to the fish, the size of the whole tank have to assign as coordinates.

The position of the robotic fish is analyzed by using the Horn - Schuck Method and Comparing image data algorithm.

3.2. The Proposed Method

The Optical Flow block estimates the direction and speed of object motion from one image to another or from one video frame to another using the Horn-Schunck Method.

To calculate the optical flow between two images, you must solve the following optical flow limitation equation is shown in equation (1).

$$I_x u + I_y v + I_t = 0 \quad (1)$$

Where I_x, I_y, and I_t are the spatiotemporal image brightness derivatives, where u is the horizontal optical flow and v is the vertical optical flow.

3.2.1. Horn - Schunck Method

By assuming that the optical flow is smooth over the entire image, the Horn-Schunck method calculates an approximate direction of the velocity field, $[u, v]^T$, that minimizes the following equation[4][5] is

$$E=\iint (I_x u+I_y v+I_t)^2 dxdy+ \alpha \iint \left\{\left(\frac{\partial u}{\partial x}\right)^2+\left(\frac{\partial u}{\partial y}\right)^2+\left(\frac{\partial v}{\partial x}\right)^2+\left(\frac{\partial v}{\partial y}\right)^2\right\} dxdy \qquad (2)$$

In this equation $\frac{\partial u}{\partial x}$ and $\frac{\partial u}{\partial y}$ are the spatial derivatives of the optical velocity component, u, and α scales the global smoothness term. The Horn-Schunck method minimizes the previous equation to obtain the velocity field, [u v], for each pixel in the image. This method is given in the following equations (3)(4)

$$u^{k+1}_{x,y}= \bar{u}^{k}_{x,y}- \frac{I_x[I_x\bar{u}^k_{x,y} +I_y\bar{v}^k_{x,y}+I_t]}{\alpha^2+I_x^2+I_y^2} \qquad (3)$$

$$v^{k+1}_{x,y}= \bar{v}^{k}_{x,y}- \frac{I_y[I_x\bar{u}^k_{x,y} +I_y\bar{v}^k_{x,y}+I_t]}{\alpha^2+I_x^2+I_y^2} \qquad (4)$$

In these equations, $[u^k_{x,y} , v^k_{x,y}]$ is the velocity estimate for the pixel at (x, y), and $[\bar{u}^k_{x,y} , \bar{v}^k_{x,y}]$ is the neighborhood average of $[u^k_{x,y} , v^k_{x,y}]$, when k = 0, the initial velocity is 0.

Calculate u and v by following steps.

(1).Calculate I_x and I_y using the Sobel convolution kernel, [−1 −2 −1; 0 0 0; 1 2 1], and its transposed form, for each pixel in the first image.

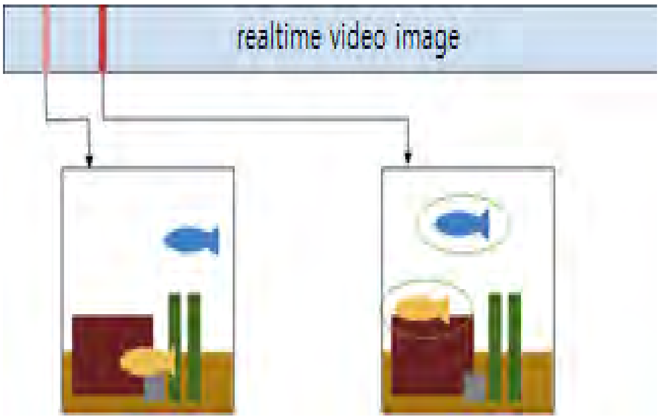
(2).Calculate I_t, between images 1 and 2 using the [−1 1] kernel.

(3).Assume the previous velocity to be 0, and calculate the average velocity for each pixel using [010; 1 0 1; 010],as a convolution kernel.

(4).Iteratively solve for u and v.

3.2.2. The proposed method of comparing image data algorithm

In this method, the video is divided into the different number of frames and every position of the frame has allocated with different coordinates. The following figure shows real time video and its two frames, like frame n-1, frame n respectively. Let us consider the time period of two frames be t1 and t2 seconds respectively. In the real time video, it is the continuous process of moving images from start time to stop time. If look at frame n-1, the position of the object is differs from the position of object of frame n. In the figure 5, showing images are different frames and they will have assigned different coordinates, when compare n-1 frame and n frame the position will be changed but pixel coordinates of the of object will remain same, so that the position of object will be detected.



(Figure 5) The proposed method of comparing image data algorithm

In order to solve the optical flow constraint equation for u and v, the proposed method divides the original image into smaller video frames and assumes a constant velocity in each frame to compare two frames to detect the position. Then, it performs a weighted least-square fit of the optical flow constraint equation to a constant model for $[u, v]^T$ in each frame Ω, where u is horizontal flow and v is vertical flow. The method achieves this fit by minimizing the following equation is:

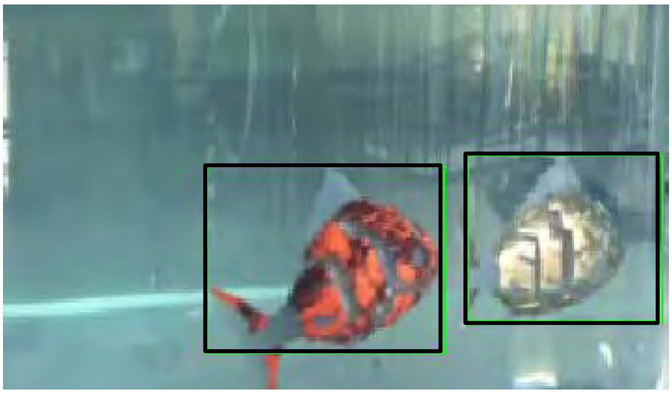
$$\sum_{x\in\Omega} W^2[I_x u+ I_y v+I_t]^2 \qquad (5)$$

W is a window function that emphasizes the constraints at the center of each frame. The solution to the minimization problem is shown in the following equation (6)

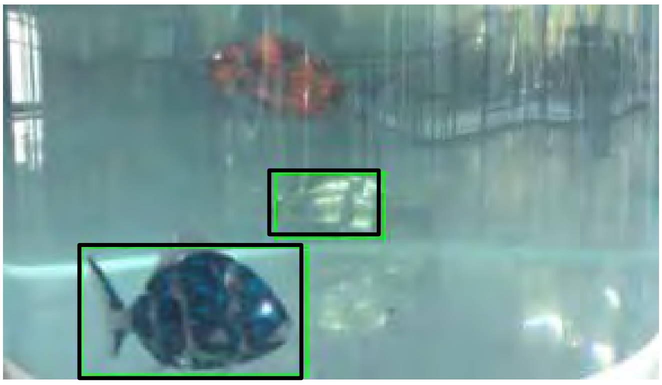
$$\begin{bmatrix}\sum W^2 I_x^2 & \sum W^2 I_x I_y \\ \sum W^2 I_y I_x & \sum W^2 I_y^2\end{bmatrix} \begin{bmatrix} u \\ v \end{bmatrix} = -\begin{bmatrix}\sum W^2 I_x I_t \\ \sum W^2 I_y I_t\end{bmatrix} \qquad (6)$$

4. Experiment Result

The experiment consists of specially designed temporary water tank, Sony camera, fish robot and personal computer. The designed fish robot was controlled by driving the servo motor using a battery and the continuous motion of fish robots were captured by using the Sony camera, and then it sent to the personal computer. To acquire the data, the captured video file is uploaded to the Simulink Model as shown in the figure 4.Then, we acquired the video data and analyzed by using the proposed methods 1 and 2.In the analysis, the performance of experiment result is satisfactory by using the comparing image data algorithm and experimental results were as shown in the figures (6) (7) and (8).In the following figures are indicating the position change around thick rectangular shape with calculated coordinates of fish robot in the aquarium. Let us consider orange fish robot is first robot, blue fish robot is second, and silver fish robot is third and its coordinates are (x1,y1,z1),(x2,y2,z2) and (x3,y3,z3) respectively, as shown below the experimental result.



(Figure 6) Position detection of fish robots (x1, y1, z1:82.08, 110.6, 0; x3, y3, z3:177.9, 159.7, 0)



(Figure 7) Position detection of fish robots (x2, y2, z2:60.86, 162.9,0;x3,y3,z3: 116.1, 67.6,0)

(Figure 8) Position detection of fish robots (x1, y1, z1:89.24, 163.2,0;x3,y3,z3: 154.7, 112.8,0; x2,y2,z2:31.38, 159,0)

5. Conclusion

In this paper, the designed fish robot is used the Simulink Model to display the coordinates of the robotic fish to analyze the position of the fish robot.We have to solve all these problems including some fish that is not detected with these subtle skills, fishes that are detected as multiple objects and inevitably detected reflections of people and objects. For these problems, we need to improve this algorithm and exception solver solutions. In future, our final aim is to exhibit the natural motion of the robotic fish with 3D fish hologram at the National Science Museum. In order to do this, read the coordinates of the fish robot and send to the server via RF communication, and the server has to be tried to obtain the coordinates of 3D fish to project these two without meet each other. It is satisfied the performance of experimental result of the fish robot.

References

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