Flow Direction Prediction of The Ball Movement for Humanoid Robot Soccer Goalkeeper

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***Abstract* — In Robocup, The most important sensor on humanoid robot soccer is a camera. The camera serves as the eyes of the robot as well as in humans. This camera is used by the robot to detect the ball. The task of Humanoid Robot Soccer as a Goalkeeper is to keep the goal and must be able to block a ball that came directly to the goal from many directions so the ball is not got into the goal. As already been known, the results of the camera image captured is always later than the pictures that has been taken, moreover if the shooting process is added with image processing such as adjusting contrast, brightness, etc. then the delay in image capture will be even greater. This causes late in reaction to the Humanoid Robot Soccer Goalkeeper when it's blocking the ball that coming from any direction. Therefore we need a computer vision technique to estimate the direction of movement of the ball so there is no delay in reaction to the robot in blocking the ball. In this paper is discussed the flow direction prediction of the ball movement for Humanoid Robot Soccer Goalkeeper. The processing of ball movement prediction is obtained by comparing the previous ball data detection and the latest data detection to get the direction of the ball movement. This robot is a second generation of humanoid robot called EFuRIO soccer (Fußball EEPIS Robot IO).**

***Keywords* : Robocup, humanoid robot soccer goalkeeper, computer vision, flow direction prediction, EEPIS Fußball Robot IO (EFuRIO)**

I. INTRODUCTION

Humanoid Robot Soccer is a human-shaped robot developed specifically for the game of football. As Goalkeeper, robot must have camera to capture image around robot that use for tracking ball. The method is widely used to detect the object is to use a color code on the image to determine the detected [1].

Image according to Webster's dictionary, is a representation, resemblance, or imitation of an object or objects. The image is the picture in two dimensions. Seen from a mathematical standpoint, the image is a function of light intensity continue on two-dimensional plane. An image obtained from the catching power of light / light reflected by objects through optical instruments such as cameras, eye, scanners and so on.

While the image processing is a process where the input and output of images [2]. In early development, image processing is done only to improve the quality of the image, but with the development of science and technology world of computing that is characterized by increasing memory capacity and processing speed computers, as well as the development of computer science that allows people to get information from an image then the image processing can't be released to the field of computer vision.

Computer Vision is often defined as one branch of science that studies how computers can recognize objects that were observed / observed through the sensors (cameras, etc.) [3]. Field of science is to develop a variety of approaches by combining the techniques of Image Processing and Pattern Recognition / Object. Computer Vision System (CVS) is expected to have a high level of capability as the Human Visual System (HVS). Research on computer vision has produced a method that can be used to scale, orientation and affine invariant gradient image features to determine the characteristics of the object in the image [4].

Computer vision is closely connected with other fields. To support the task of computer vision then there is some support functions to the system [3]:

- Process the image capture / image (Image acquisition)
- The processing of image / image (Image processing)
- Analysis of the image data / image (Image analysis)
- The process of understanding the image data / image (Image understanding)

In this paper, computer vision use to predict flow direction of ball movement by comparing the previous ball data detection and the latest data detection to get the direction of the ball movement.

This paper is organized as follows. Section II explains the design and dynamic model of humanoid

robot goalkeeper and flow direction prediction of the ball movement . Section III shows several experimental results of EFuRIO 2nd generation and section IV concludes the paper.

II. CONSTRUCTION

A. Mechanical Construction

Mechanical construction is one of very important factor in this study because if the design is appropriate and whether the results will be good as well and in accordance with the original purpose of submitting this paper. Before we show EFuRIO 2nd generation's mechanical construction, let us show EFuRIO 1st generation's mechanical construction. EFuRIO 1st generation's mechanical construction will be shown by **Figure 1** as follows.

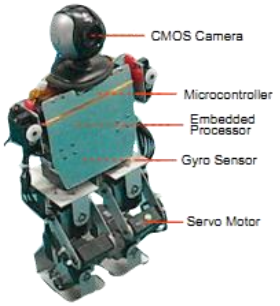


Figure 1. Humanoid Soccer Robot EFuRIO 1st generation (Sulistijono, I. A. et all. 2010)

Now we'll show the EFuRIO 2nd generation's mechanical design and construction in **Figure 2** and **Figure 3** as follows.

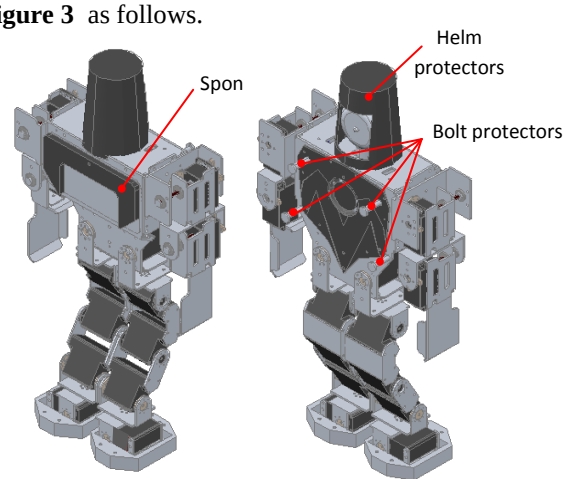


Figure 2. Humanoid Soccer Robot EFuRIO 2nd generation's mechanical design using software Autocad

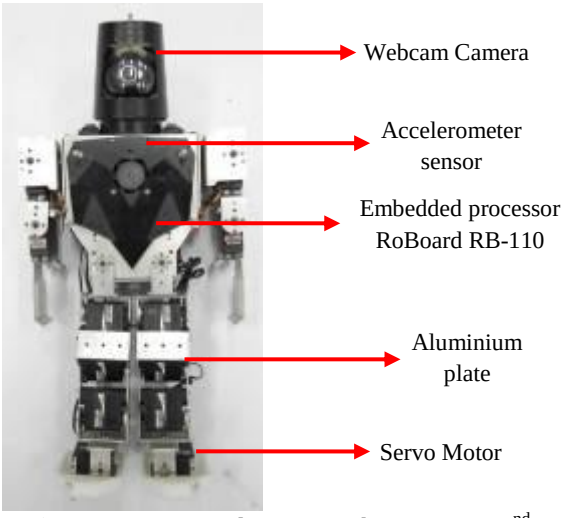


Figure 3. Humanoid Soccer Robot EFuRIO 2nd generation

There are many changes in the mechanical and system control between the designs and construction of the first generation to second generation. This is done because for the first generation doesn't act as goalkeeper, but acts as an attacker (striker) while the 2nd generation acts as goalkeeper indeed. This is also distinguishes the movement that generated between the two of them.

B. EFuRIO

EFuRIO that stand for EEPIS Fußball Robot IO is the third generation of humanoid soccer robots developed in our lab. The previous work is T-HEX's, a biped walking robot that won a prize of "Best Innovation" in 2009 Indonesian Fire Fighting Robot Contest Senior Legged Category [6]. We use different kind of servo motors as the actuators, it depends on the function and location of each installation of the servo motors. We use two different sensors in this study, the first is single webcam camera to catch every information such as human eyes. And the second sensor is accelerometer which is used to get any information about positions and movements of the humanoid robot goalkeeper. RoBoard RB-110 was selected as the embedded processor because it's simple to use and very powerful to collect data from sensors and process data to actuators [7]. EFuRIO 2nd generation is constructed out of 1.8mm aluminum plate, with servo motors are used as structural components in the design. Furthermore, EFuRIO 2nd generation intends to compete at the international humanoid robotic competitions such as RoboCup and FIRA HuroSot. This means that EFuRIO 2nd generation should be able to balance the body not only for walking but also while performing other activities except when it wants to make safe and block the ball by activating the falling motion .

C. Flow direction prediction of ball movement

Flow direction prediction is used to predict the direction of movement of the ball toward the goal. As we all know, that speed can't capture real time. Speed is always too late from the original capture, or it could be said t-1. And if the program is too much delay could capture images of t-five or more. Therefore, a program to predict the movement of the ball is very important, so the ball into the net which would have been anticipated earlier.

To get coordinat of midpoint object and increase speed of processing image, scanning pixel image capture is just using RGB color without any complex image processing. It's because will only slow process. Scanning pixel process to get coordinat ball will be shown by **Figure 4** as follows.

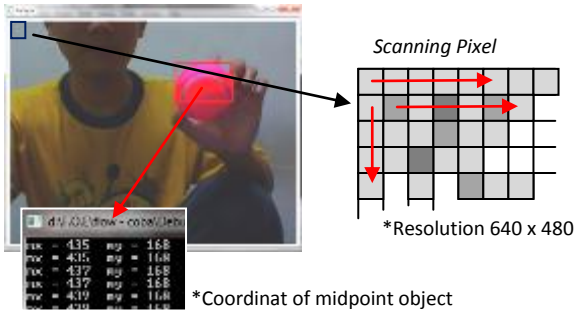


Figure 4. Scanning pixel process with RGB color

The most important thing of flow direction prediction is coordinate value of midpoint object data. There are two coordinates are the most important data are coordinate data previous and the latest coordinates data. From both these data is that predictions can be searched at the direction of movement of the ball by comparing two of them.

There are two coordinat data, latest data and previous data. Both of them contain X and Y coordinat. So, to get movement prediction is by compared both of two data.

Coordinat latest data ⟶ (X_L,Y_L)
Coordinat previous data ⟶ (X_P,Y_P)

If($X_L > X_P$) then "ball move to left"
Else if ($X_L < X_P$) then "ball move to right"
Else "ball stastis to the axis X"

If($Y_L > Y_P$) then "ball move to up"
Else if ($Y_L < Y_P$) then "ball move to bottom"
Else "ball stastis to the axis Y"

long of arrow prediction is calculate by resultan from latest data and previous data

To more clearly know the workings of flow direction prediction will be shown by **Figure 5** as follows.

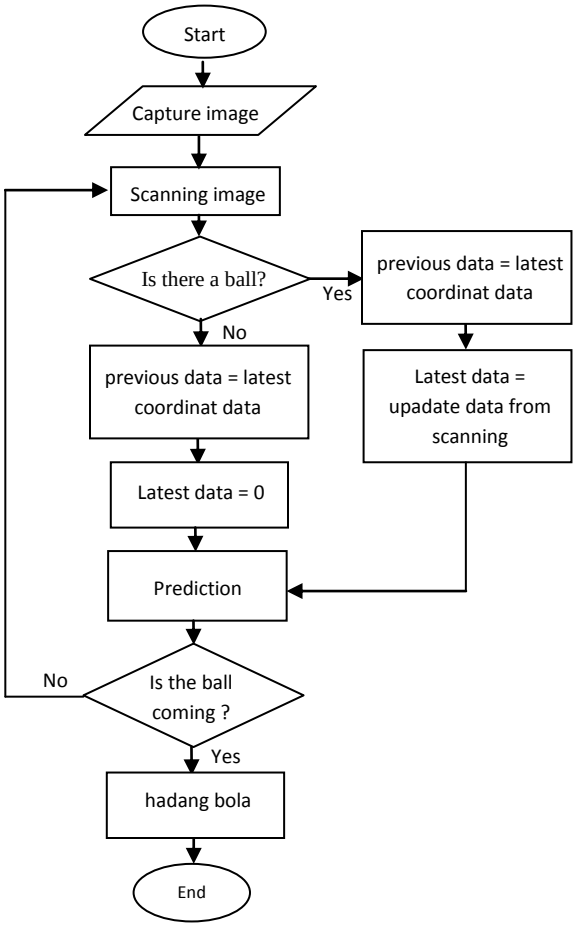


Figure 5. Flowchart of flow directon prediction

Program of flow directon prediction will be shown by **Figure 6** as follows.

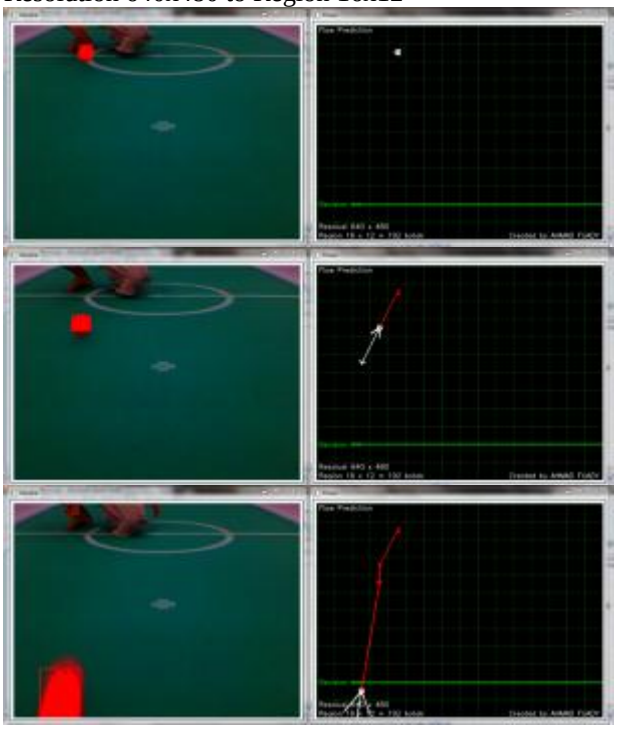
Figure 6. Flowchart of flow directon prediction

Movement of the trajectory is marked with red arrow and for the prediction of the ball movement is marked with white arrow. Short and length of the arrow of the ball movement prediction is depend on velocity of the ball. If the movement of the ball quickly, then the arrow of prediction will be length and if the movement of the ball slowly, then the arrow of prediction will be short.

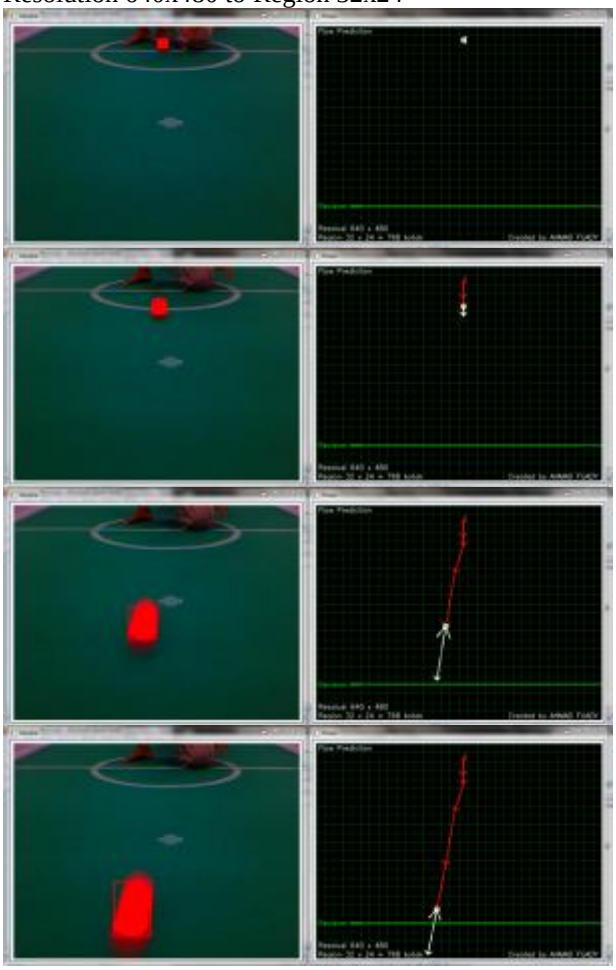
III. EXPERIMENTAL RESULT

Next, it will be shown the results of three experiments that have different characteristics. First figure is converting the image from 640 x 480 pixel size to 16 x 12 of resolution region, second figure is converting the image from 640 x 480 pixel size to 32 x 24 of resolution region, and the last one is converting the image from 640 x 480 pixel size to 64 x 48 of resolution region. At the beginning, when the ball is not moving then the ball is only seen as a point at resolution region. When the ball moves, so it appears two vector lines that have different color each other where the red one is the vector of the trajectory of the ball while the white is the direction prediction of the ball movement. And from the image that's showed, the white line will always be in front of the red line so that the data information of the ball movement that received is faster than ever. Although the data information of the ball movement that received is faster but it is still not free from error.

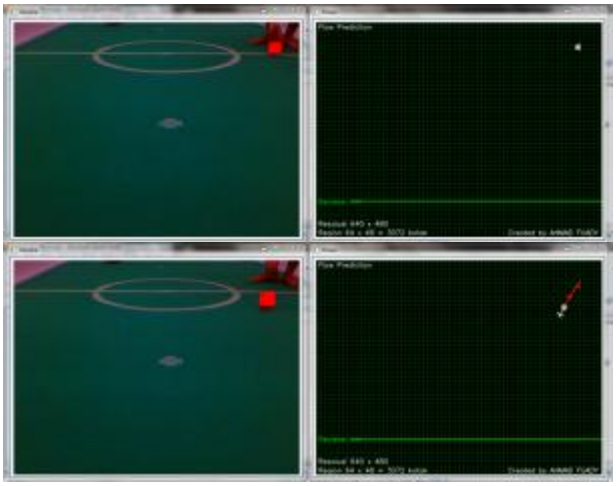
Resolution 640x480 to Region 16x12

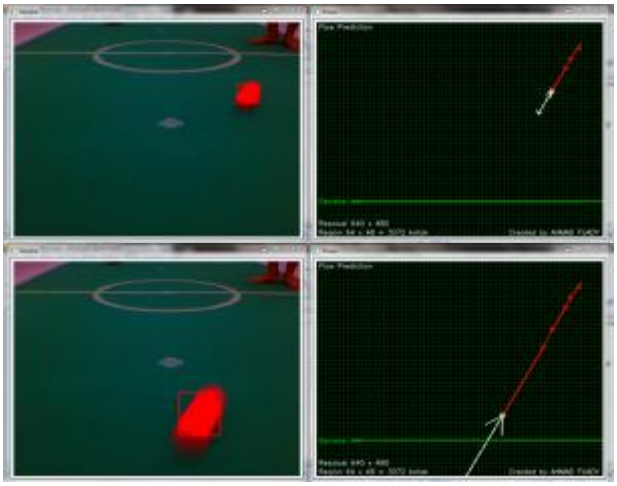


Resolution 640x480 to Region 32x24

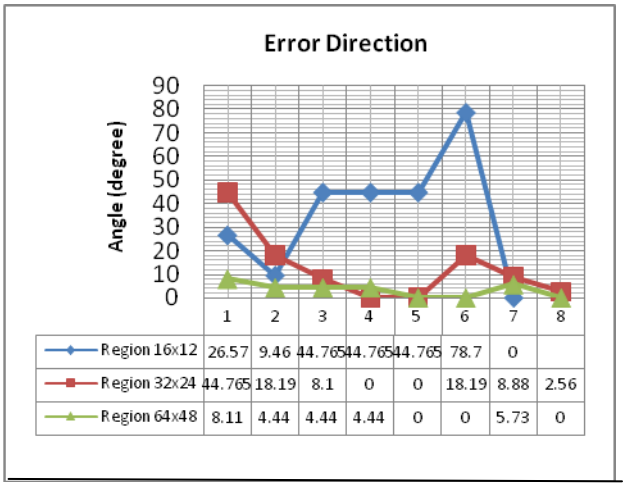


Resolution 640x480 to Region 64x48





The error that obtained is in the form of angle, the error is generated by the different directions of motion of the vector of actual movement and the direction of motion vector prediction. From the three experiments below, error is always there but the magnitude of errors that appear different from one another. And it turns out that the greatest error is when the size of the region resolution of 16 x 12 and the smallest error is when the size resolution of 64 x 48 region. The result of error direction will be shown as follows.



IV. CONCLUSION

This method has been proposed and applied to predict the direction of movement of an object. In other words, this method can be read where the next direction that the object will ahead is, and also this method has the ability to read data faster than just waiting for the actual movement of the object. However, with this capability this method still cause side effect, it is called error direction. The Magnitude of error that occurs is depending on the determining size of the resolution region. The greater the resolution region is determined the error that occurred is getting smaller. Otherwise, if the resolution region is getting smaller and smaller, the error that occurred is getting greater and greater.

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