Robot Control Based On Image Processing To Follow The Target

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Abstract:

For the purpose of solving the problem of identification and following the target (object), a method of robot control based on image processing to follow the target is proposed. Based on the algorithm of pattern matching from the sample image and converting the obtained target coordinates to the rotation angle, the control unit is equipped with a laser light to direct the target. The control system was simulated by LABVIEW software. Actual results have shown the correct and stable operation of the system.

Keywords: *Robot, target, image processing, pattern matching, sample image, rotation angle.*

I. INTRODUCTION

In the robot systems detecting and tracking the moving target, the camera is equipped to be able to recognize the target, combined with image processing algorithms to determine the exact location of the target. In practice, image recognition and processing applications are a focus of research by many scientists in most fields, with the results showing that the image processing methods are quite modern and stable control methods such as sustainable adaptive control, fuzzy control, etc. Therefore, mobile target tracking systems are greatly improved in terms of quality. Using experimental methods that researchers around the world have conducted research very early. S.H. Han and associates (2001) tested with A Study on Feature-Based Visual Servoing Control of Eight Axes-Dual Arm Robot by Utilizing Redundant Feature [1], then some authors such as G. Feng (2015) researched about Active persistent localization of a three-dimensional moving target under set-membership uncertainty description through cooperation of multiple mobile robots [2]. H.Y. Chung (2015) researched about Indoor intelligent mobile robot localization using fuzzy compensation and Kalman filter to fuse the data of gyroscope and magnetometer [3]. In this article, to solve the problem of object tracking in particular, use open source libraries on the basis of algorithms built in the basic functions. Through functional blocks, pairing and giving reasonable parameters for each block on specialized software, helping the target control systems to be more stable, accurate and durable when the system operates in The actual environment is under the influence of noise and parameter model changes.

The objective of this research is to design and manufacture a robot system that follows the target moving on a shield opposite the camera, the target coordinate data is transmitted to the microcontroller to control the actuator. The actuator consists of two RC Servo motors mounted to operate in two independent axes X and Y, from which the rotation angle of the servos is calculated and then the control program is presented on the adruino. The image processing software used is Labview.

II. A ROBOT MODEL

Diagram of the robot system is described as follows:

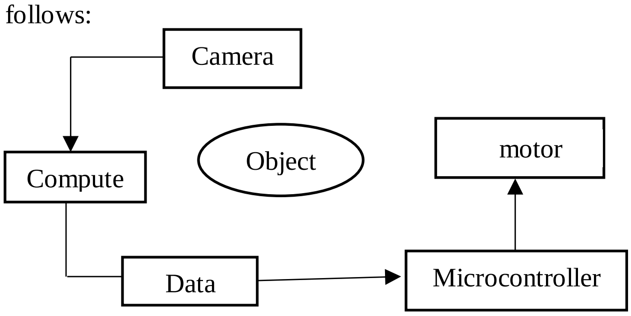


Figure 1: Diagram of the robot system and fixed camera

The model was built for the purpose of following the moving target on a shield opposite the Camera. Target coordinates data is transmitted to the microcontroller to control the actuator. The actuator consists of 2 RC Servo motors mounted to operate in 2 independent axes X and Y. At the top of the Y axis motor is a laser light attached to the target. That is, the target will move where the Laser light will follow.

III. CONTROL ALGORITHMS

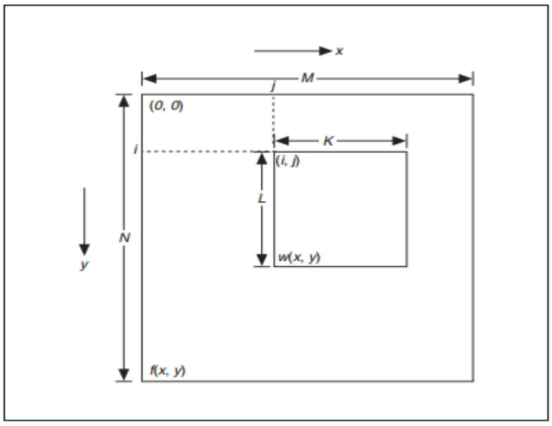
Normalized Cross-Correlation

The following is the basic concept of correlation [4]: Consider a subimage w(x, y) of size K × L within an image f(x, y) of size M × N, where K ≤ M and L ≤ N. The correlation between w(x, y) and f(x, y) at a point (i, j) is given by:

$$C(i,j) = \sum_{x=0}^{L-1} \sum_{y=0}^{K-1} w(x,y) f(x+i, y+j)$$

Where i = 0,1,…M – 1,
j = 0,1… N – 1, and the summation is taken over the region in the image where w and f overlap.

Figure 2 illustrates the correlation procedure. Assume that the origin of the image f is at the top left corner. Correlation is the process of moving the template or subimage w around the image area and computing the value C in that area. This involves multiplying each pixel in the template by the image pixel that it overlaps and then summing the results over all the pixels of the template. The maximum value of C indicates the position where w best matches f. Correlation values are not accurate at the borders of the image.



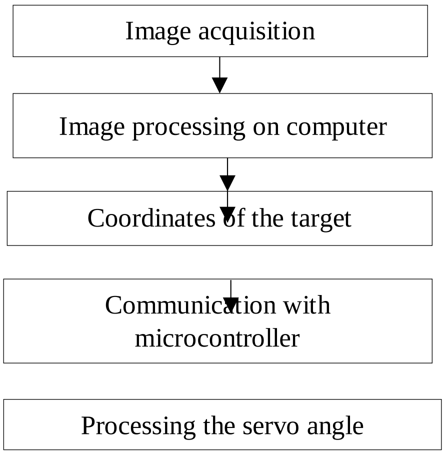
Basic correlation is very sensitive to amplitude changes in the image, such as intensity, and in the template. For example, if the intensity of the image f is doubled, so are the values of c. You can overcome sensitivity by computing the normalized correlation coefficient, which is defined as:

$$R(i,j) = \frac{\sum_{x=0}^{L-1}\sum_{y=0}^{K-1}(w(x,y)-\bar{w})(f(x+i,y+j)-\bar{f}(i,j))}{\left[\sum_{x=0}^{L-1}\sum_{y=0}^{K-1}(w(x,y)-\bar{w})^2\right]^{\frac{1}{2}}\left[\sum_{x=0}^{L-1}\sum_{y=0}^{K-1}(f(x+i,y+j)-f(i,j))^2\right]^{\frac{1}{2}}}$$

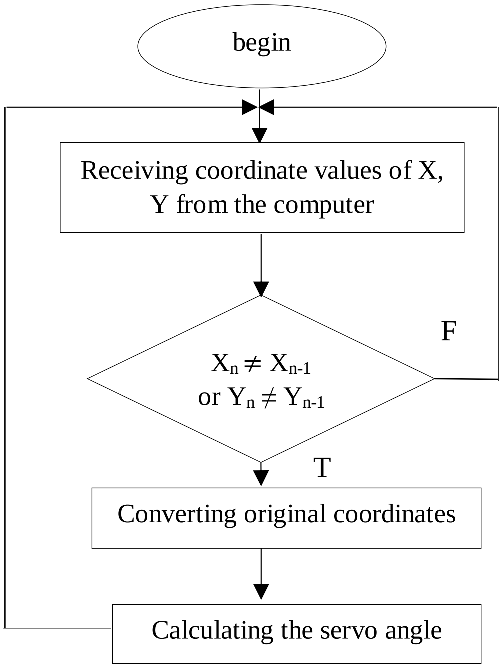
where w (calculated only once) is the average intensity value of the pixels in the template w. The variable f is the average value of f in the region coincident with the current location of w. The value of R lies in the range –1 to 1 and is independent of scale changes in the intensity values of f and w.

IV. CONSTRUCTION OF REAL MODEL

The image processing steps are described in the diagram below:



Algorithm flowchart for microcontroller:



Servo motor control

In modern Servo RCs, the mechanical rotation angle is determined by the width of an electrical pulse transmitted to the control wire. This is a form of pulse width modulation. The typical RC Servo is expected to see a pulse every 20 ms, however this may vary over a wide range different from one servo to another. The width of the pulse determines the speed of the motor.

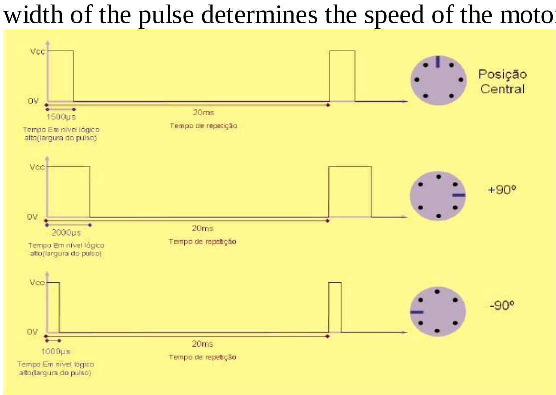


Figure 3: Servo control pulse

Calculating the rotation angle of servo motors

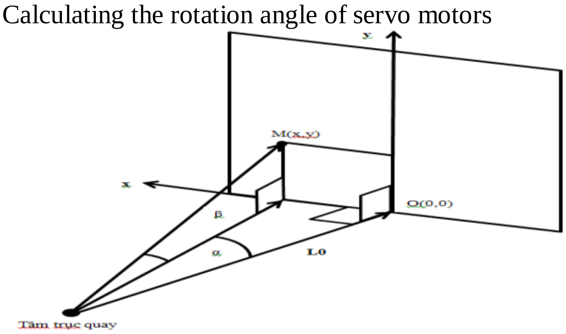


Figure 4: Describing the position of the real object

Suppose that the point coordinates M (x, y) are the coordinates of the moving target center

$$\alpha = \arctan \frac{x}{L0};\ \beta = \arctan \frac{y}{L0/\cos(\alpha)};$$

Where: L0 is the distance between the center axis of rotation to the plane containing the target.

α, β is the angle to be put in order to control the servo in turn for two axes x, y.

Reference between coordinate axis under consideration and the coordinate axis in pixels of Camera

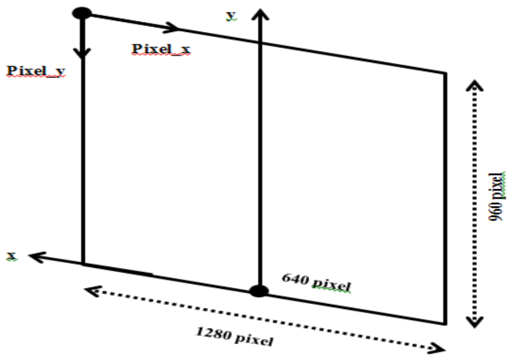


Figure 5: Reference from the camera coordinates into coordinates work

The two components y and pixel_y have an inverse relationship, with resolution

pixel_y max = 960, we have y = 960 - pixel_y.

With the original coordinates at point x = 0, we take:

pixel_x = 640, x = 640 - pixel_x.

Thus x will have both positive and negative values.

In fact, we choose center O (x, y) with the rotation angle of Servo respectively 78° and 99°, we will change the angle from this coordinates.

V. SIMULATION AND DISCUSSION

With the mathematical model of Robot was built in figure 1, the algorithm diagrams shown in figure 2, and calculating the rotation angle of servo motors as shown in figure 5,6. The simulation on LABVIEW obtained coordinates of the target's points that are shown from figure 6 to figure 9.

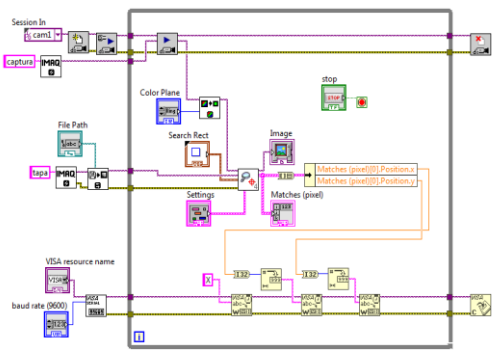


Figure 6: Labview Diagram of connecting function blocks on Labview

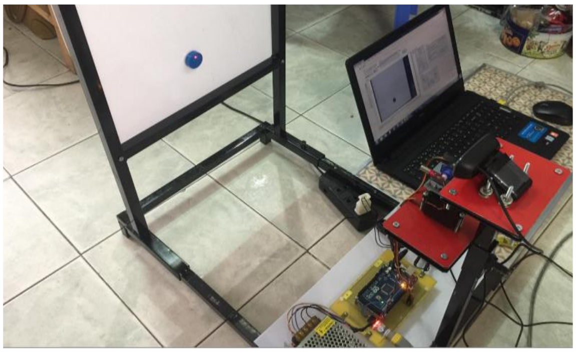


Figure 7 : Real Model

Figure 8: Controller and motor shaft

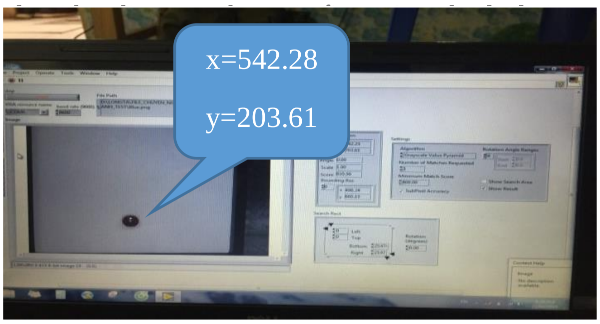


Figure 9: Target coordinates on the shield

VI. CONCLUSION

Through the design and manufacture a robot to follow the target based on image processing, we can draw the following conclusion: The simulation results on the LABVIEW software and on the real model have proved that the system works stably, following the target correctly, the target catching speed is quite fast. The model is quite simple and cheap. Designing image processing module to control target tracking, going into depth to study object tracking theory theory, control structure, target image processing algorithms.

VII. ACKNOWLEDGEMENTS

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VIII. REFERENCES

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