DESIGN AND IMPLEMENTATION OF AN OBJECT TRACKING SYSTEM CONTROL USING PID AND MOVEMENT PREDICTION

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ABSTRACT

The tracking system usually has some lack of problem, that is unstable system when the object moved so the tracking process can't define the object position well. On the other hands, when the object moves, the system can't track object suddenly along to the direction of objects movement. The system will always looking for the object from the first point or its home position. In this paper, PID control was used to improve the stability of tracking system, so that the result became more stable than before, it can be seen from errorof tracking. Otherwise, to looking for again the undetected object, a linier regression method was used in purpose to get more faster in finding the new position of a movement object that was disappear from the views of camera before . When the object on unmoved condition, the system has error value ±15 pixel. For horizontal move condition of servo on slow motion ±9.4 pixel, also on the fast motion, the error values is about ±20.1 pixel. For the servo with vertical movement ,the error value is about ±13.4 pixel for the slow motion and ±45.7 pixel for fast motion. The process on finding the object that was disappear from the views of camera before, ±2 second. Finally it can be concluded that the add of PID control and linear regression method, make the tracking system become more stabile and real time.

Keyword *: tracking object, PID control, regression method, real time system.*

1. Introduction

Object tracking has many applications in video and image processing systems. Robotic vision, security cameras, video editing, and smart rooms are some examples of systems that would require such an object tracking system. Segmentation and tracking object within an image enables a system to gain a higher level of comprehension from the seemly random pixel values within the image data[1].

The tracking system usually have the problems like the system is not in real tim,e because the system losing the object and can't found object immediately[2]. In this project use CMU Camera 2 for the implementation purpose. This camera can process the image so the microcontroller will receives object coordinate witht RGB object values as an input.

The targets of the research are to make more stabile tracking process when tracking the object with some color specification. Secondly is to predict a new object position when object became disappear or undetected by the camera immediately.

Some problem limitation are used to make the system more simple. Those are:

1. Mechanical system can be rotate 180^o in horizontal and 80^o in vertical.
2. Prediction system can be used in linear object moving.
3. The object is orange ball with 6 cm diameters.
4. The object and camera maximums distance is 200 cm
5. There is no other orange object in the background.

2. Methodologies

There are 2 method in this project, the first method is PID control to stabilize the positioning control and second method is linier regression to predict the object co-ordinate when undetected suddenly.

2.1 PID control

The PID controller calculation (algorithm) involves three separate parameters; the proportional, the integral and derivative values. The *proportional* value determines the reaction to the current error, the *integral* value determines the reaction based on the sum of recent errors, and the *derivative* value determines the reaction based on the rate at which the error has been changing. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve or the power supply of a heating element.

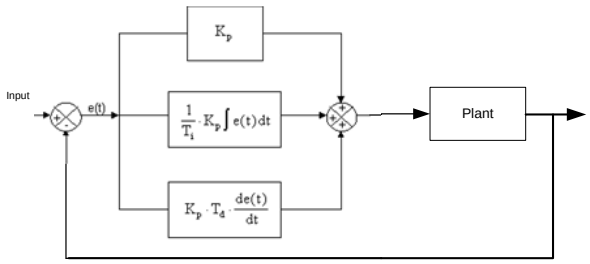

Figure 2.1 PID System Plant

By tuning those three constants in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the set point and the degree of system oscillation. Note that the use of the PID algorithm for control does not guarantee optimal control of the system or system stability[3].

2.2 Linear regression

"Linear regression [LR] is a statistical tool used to predict the future from past data, and commonly used to determine when prices are overextended [4]."

"Linear regression is used to explain and/or predict. The general form is:

$$y = mx + b \quad \text{.....(1)}$$

Where Y is the variable that we are trying to predict, X is the variable that we are using to predict Y, a is the intercept, b is the slope, and u is the regression residual.

$$m = \frac{\Delta y}{\Delta x} = \frac{y(2) - y(1)}{x(2) - x(1)} \quad \text{.....(2)}$$

3. System Design

The tracking system design with CMU camera 2 as optical sensor and 2 servo that can motors move horizontal and vertical to moving the camera. The system design is figure 3.1

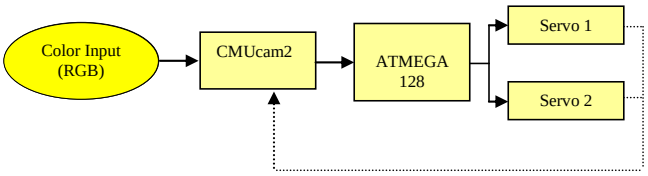

Figure 3.1Diagram block system

3.1 Mechanical design

Mechanic design the tracking system is used 2 DOF Manipulator with minimums arm length to minimize mechanical weight.

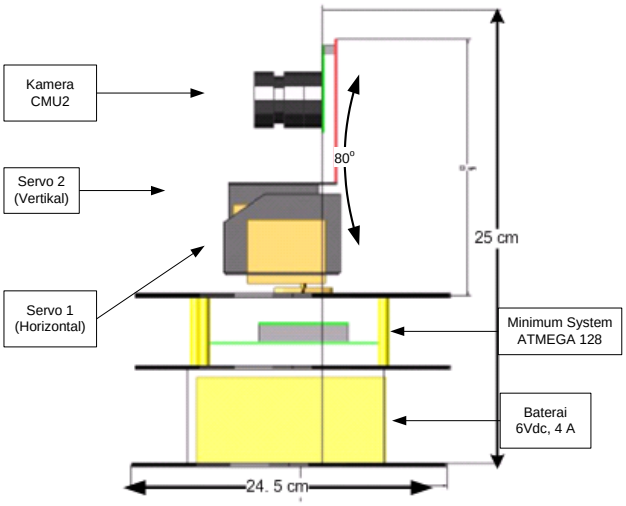

Figure 3.2 Mechanical system from right side

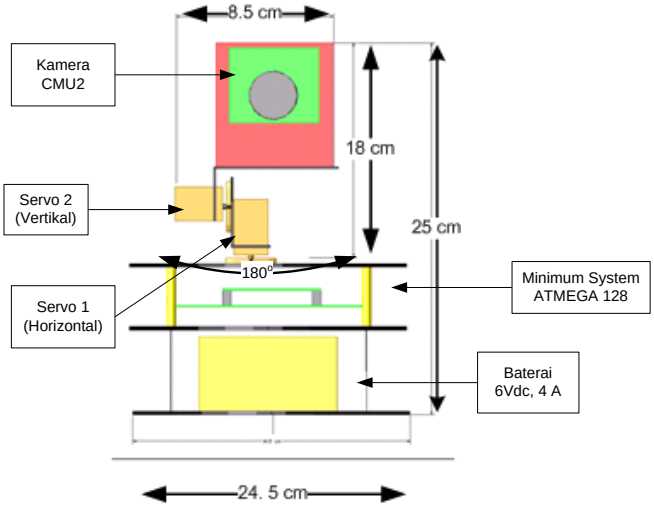

Figure 3.3 Mechanical system from front side

3.2 Software design

There are 3 Software design in this system is 1 main program is Tracking system software and 2 subprogram are PID control and prediction system.

3.2.1 Tracking system flowchart

The main program is tracking system is put RGB object value and get data co-ordinate from CMU cam 2 and process the data to get PWM signal that have equal duty cycle. The flowchart tracking system is figure 3.3.

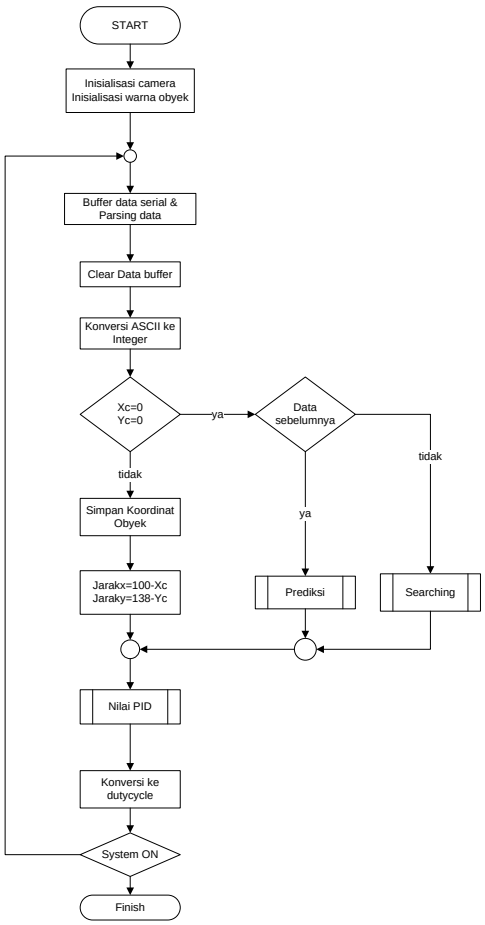

Figure 3.3 Tracking system flowchart

3.2.2 PID control in tracking system

PID control in tracking system getting error position from the CMU camera, so the give error value continued. And previous error co-ordinate to get new positioning. Plant system of PID control is figure 3.4.

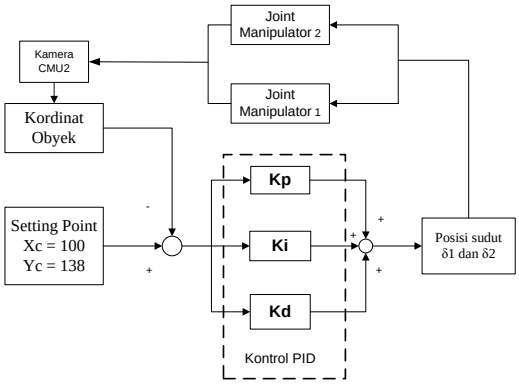

Figure 3.4 PID control in tracking system plant

3.2.3 Prediction with linier regression

The prediction we used is linier regression with 2 point, this method use line equation so the system can predict the object that linier moves. And this method can predict quickly because is simple and not using many iteration.

$$\Delta x = x_2 - x_1 \quad \text{.....(3)}$$
$$\Delta y = y_2 - y_1 \quad \text{.....(4)}$$
$$x_3 = x_2 + \Delta x \quad \text{.....(5)}$$
$$y_3 = y_2 + \Delta y \quad \text{.....(6)}$$

4. System Testing

To know the System respond we must test system, the system testing such as tracking object positioning respond, tracking moving object and prediction system respond. The blue line is vertical servo and red lines is horizontal servo.

4.1 Tracking object positioning respond

2 system that using PID control and without PID control must be compare to know the different and to know the PID control can decrease error system. The object puts in front of camera with 50 cm distance.

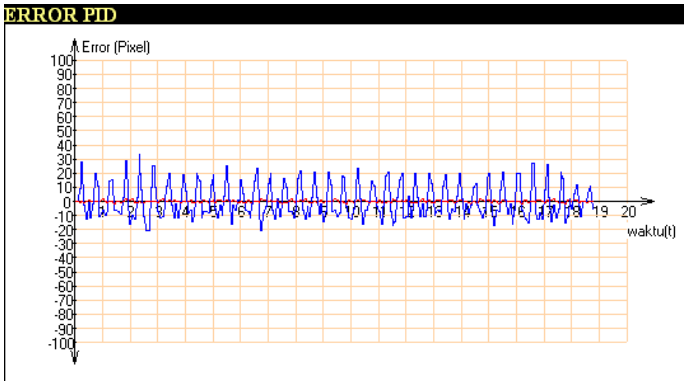

Figure 4.1 System respond without PID control

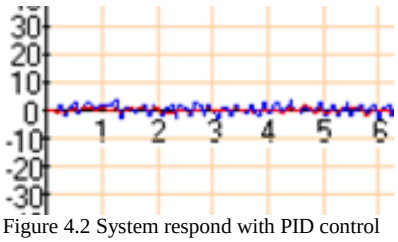

Figure 4.2 System respond with PID control

4.2 Tracking moving object respond

Tracing moving object test is used to know PID control respond if object moving so we can compare with system not used PID control. The tested by moving object manipulate in front of the CMU camera whit distance object and camera is 50 cm.

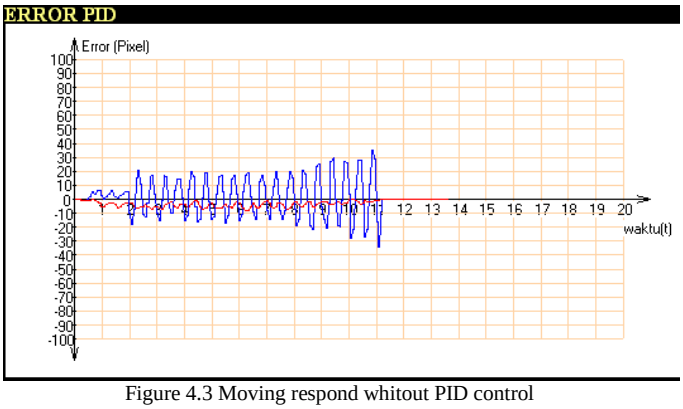

Figure 4.3 Moving respond whitout PID control

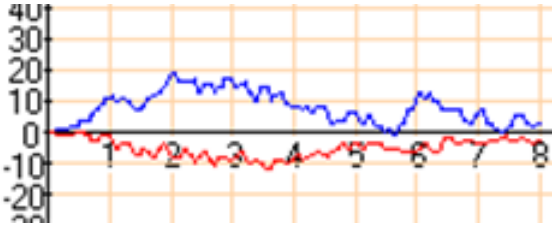

Figure 4.4 Moving respond whit PID control

And many test to know respond quality in table 4.1. in this table the system whit PID control have better respond than without PID control.

Table 4.1 Respond Table

No	Movement	Without PID (Pixel)		Whit PID(Pixel)	
		Horizontal	Vertical	Horizontal	Vertical
1.	unmoved	25.7	3.4	0.5	0.5
2.	Horizontal				
	slow	15.4	56.2	9.4	2.5
	fast	38	67.3	20.1	13.4
	Very fast	Object Loss			
3.	Vertical				
	slow	21.4	0.5	18.7	0.5
	fast	25.8	0.5	45.7	1.5
	Very fast	Object loss			
4.	Manipulate				
	slow	21.4	5.3	16.8	7.6
	fast	3.4	51.8	22.8	48.9
	Very fast	Object loss			
	average	21.58	26.42	19.14	10.7

4.3 moving prediction testing

The moving prediction test is used to know respond after using moving prediction by how long the system can found the object again.

Table 4.2 Searching object time Table

No.	Movement	Without Prediction (seconds)	With Prediction (seconds)
1	Horizontal	6.5	1.5
2	Vertikal	20	2.8
3	manipulate	10.4	1.7
	average	12.3	2

5. Conclusion

By using PID control the error system can be decrease until ±1 pixel in tracking object position and the system be more real time because can found the losing object quickly it's about 20 second average. Whit PID control and prediction system the tracking object be more stabile and real time.

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