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 error of 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 disappearing from the views of camera before, ±2 second. Finally it can be concluded that the use of PID control and linear regression method make the tracking system become more stable and real time.

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

1. Introduction

Real-time object tracking is the critical task in many computer vision applications such as surveillance, perceptual user interfaces, augmented reality, smart rooms, object-based video compression, and driver assistance. Segmentation and tracking of an 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].

A tracking object system using CMU Camera 2 coupled by a 2 DOF joint mechanism proposed [2] is one of the examples. This camera has feature to process the image internally, so the controller will receives object RGB coordinate directly. One of problems exists in such tracking system is that the system could not performed tracking correctly when the system losing the object and can't found object immediately.

There are two goals in this research. First is to develop a more stable control system for object tracking with some color specification. Secondly is to invent a method for predicting the new object position when object suddenly become disappear or undetected by the camera.

Some limitations are used to make the system simpler. Those are:

1. Mechanical system can be rotate 180° in horizontal and 80° in vertical.
2. Object is an orange color ball with 6 cm diameters.
3. Object performing only linear movements.
4. Maximum distance between object and camera is 200 cm.
5. No other object with the same color exist in the camera view

2. Methodologies

There are 2 methods 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 it suddenly undetected.

2.1 PID control

The PID controller calculation 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 output is weighted sum of these three actions is used to adjust the process via a control element, for instance, to adjust position of a control valve

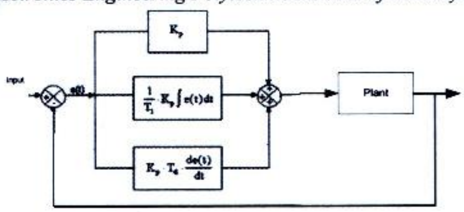

Figure 1. PID System Plant

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

Figure 2 shows the system diagram block. The system comprises CMU camera 2 as optical sensor and 2 servos that move the camera in horizontal (pan) and vertical (tilt) direction. The pan movement can covered from +90 to -90 degree, while tilt can move from -40 to +40 degree.

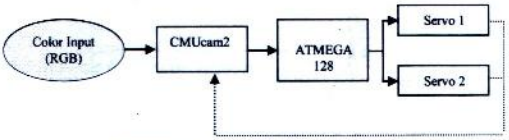

Figure 2. Diagram block system

3.1 Mechanical design

Figure 3 and figure 4 show the mechanical design of the tracking system which use a 2-DOF manipulator with a minimum arm length to minimize mechanical weight and center the rotation.

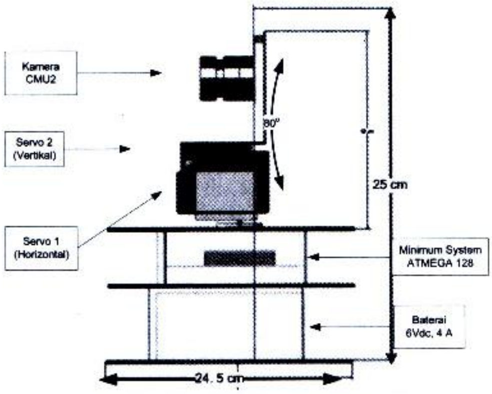

Figure 3. Mechanical system (right side)

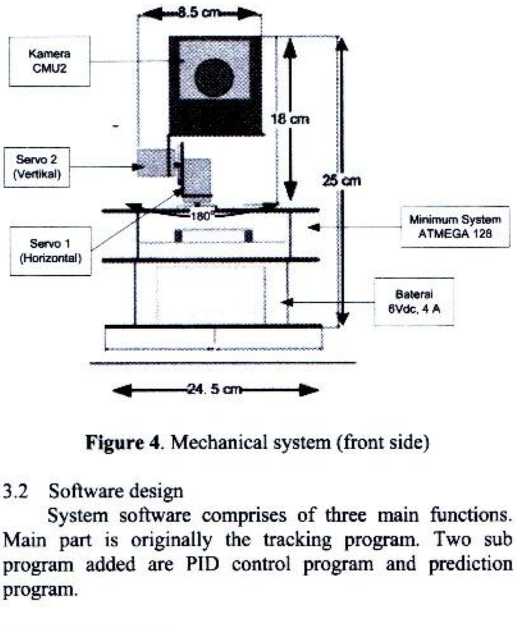

Figure 4. Mechanical system (front side)

3.2 Software design

System software comprises of three main functions. Main part is originally the tracking program. Two sub program added are PID control program and prediction program.

3.2.1 Main program

The main program is the object tracking programs which 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. Flowchart of the tracking system is as shown in figure 5.

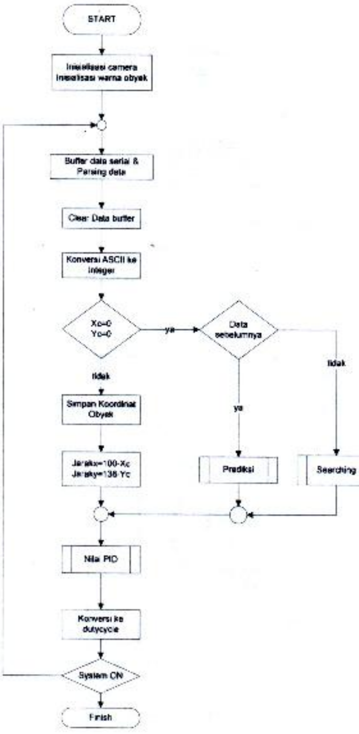

Figure 5 Tracking system flowchart

3.2.2 PID control in tracking system

Figure 6 shows the use of PID control in the tracking system. The PID controller acquire position error from actual object position and the setting center of camera view. 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.

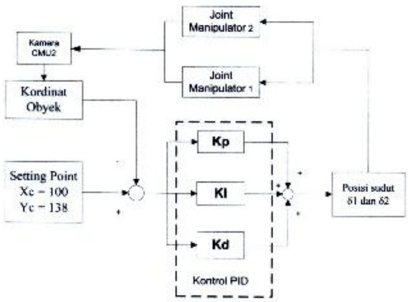

Figure 6. PID control in tracking system plant

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.

$$\Delta x = x_2 - x_1 \quad (3)$$

$$\Delta y = y_2 - y_1 \quad (4)$$

$$x_3 = x_2 + \Delta x \quad (5)$$

$$y_3 = y_2 + \Delta y \quad (6)$$

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.

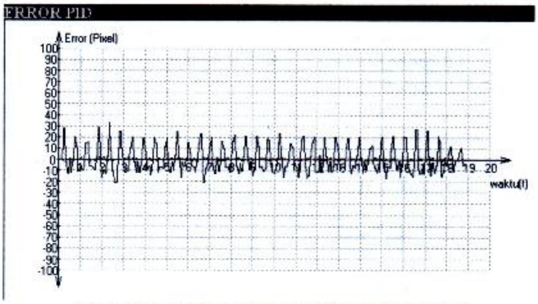

Figure 4.1 System respond without PID control

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.

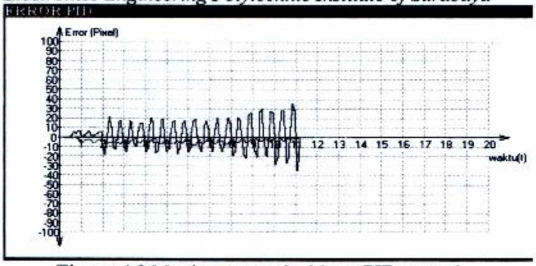

Figure 4.3 Moving respond whitout PID control

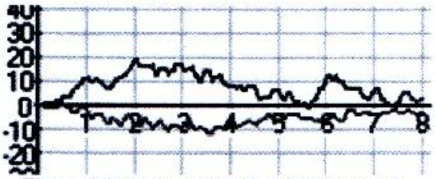

Figure 4.4 Moving respond whit PID control

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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