Design of Fuzzy Logic System for Mobile Robot based on Visual Servoing

Un ji Song*, Seog-Hwan Yoo **, Byung-Jae Choi ***
*Daegu University, Korea, songunchi@nate.com
** Daegu University, Korea, shryu@daegu.ac.kr
*** Daegu University, Korea, bjchoi@daegu.ac.kr

Abstract – This paper describes a visual control scheme, fuzzy logic system for visual servoing of an autonomous mobile robot. An existing communication autonomous mobile robot always needs to keep the object in image to detect the moving object. This is a problem in an autonomous mobile robot for spontaneous activity. To solve it, some features for an object are taken from an image and then use in the design of fuzzy logic system for decision of moving location and direction of visual servoing contrivance(apparatus). So continuous tracking is possible by moving the visual servoing contrivance. We present some simulation results and further studies in the Section of Simulation and Concluding Remarks.

Keywords: visual servoing, FLS, mobile robot, tracking, pan-tilt

1 Introduction

These visual sensors receive many information compare with other sensors. Usually using for autonomous mobile robot replaced human eyes. This is to obtain whole information about shape, movement, position, motion state of object. Using this obtained information we are apply to several part(field) like tracking welding line, exactness electronics accessories manufacturing, tracking conveyer, remote control universal space robot, drive and collision avoid.[1][2] These are include robotics field because of control and manufacture the robot and machine.

Usually control the end-effectors using jachobian in these robotics field but, this is system parameter function and basically(essentially) different value as robot position so we can't obtain correct value(It is difficult to obtain correct value). The other method to approach these problem is visual servoing that nearest regard method. This is unknown mechanism and system parameter but predict continuous jachobian using input image from camera. This estimated jachobian make by (slow) degrees convergence from features of image to desired feature. Accordingly it can control more efficiently in real time system that need to a high speed calculation.[1]

Using such a visual servoing make tracking system to moving object on real time. Using by USB web cam of low cost on pan-tilt of 2-DOF(Dimension of Freedom) receive data of moving object and then analyze the received image. So control the pan-tilt. This is more dynamic drive than an existing mobile robot using landmark, beacon that static recognition object.[3][4]

I'll embody that auto mobile robot using the (this) advantage with pan-tilt. From Acquired image's x, y change variable is input and then they are out motor control promote. In this time output, motor drive parameter received from suggested FLS(Fussy Logic System).

On this paper's architecture configuration is tile next. At first describe about image process area system architecture of visual survey and object extra method, system environment at the second section. And then show out enquired image and processing image result. Add to that pan-tilt system's architecture and role after image processing servoing. At section 3, describes design FLS for motor drive parameter that control pan-tilt. Last section 4, check the simulation result or afterwards lea search direction.

2 Visual Servoing System

2.1 Image Processing System

We are receiving input of designed FLS. This is state of object from acquired image that using low-cost USB web cam.

Figure 1 show real input image. As this Figure we can see the image difference when same camera, that is light, circumference efficient and white balancing of camera.

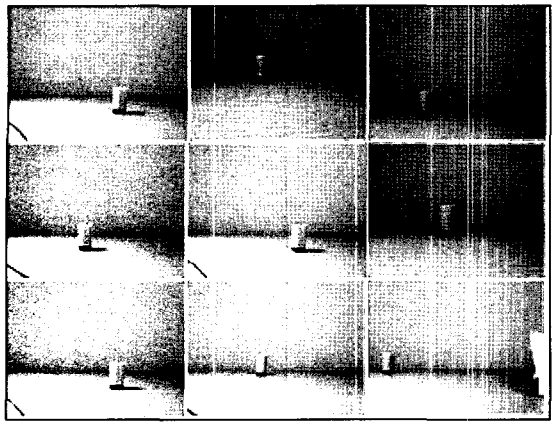


Figure 1. Acquired image

Like this when we tracking object by image have an effect wrong division because of circumference effect, this situation need to overcome by image processing system. And need to close center of object and center of image.

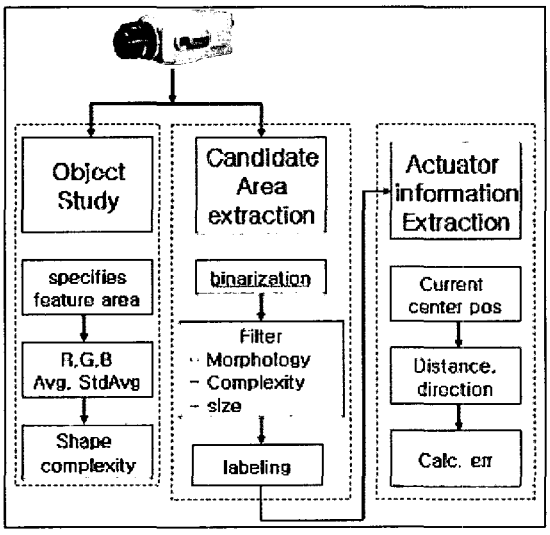


Figure 2. Organization of image process system

Figure 2 is show organization of image processing system that need to former situation satisfy, appoint (assignment) object for tracking that using input image form camera as figure 2. Calculate mean and standard deviation of appointed (assigned) object's R, G, B each channel, mean and standard deviation I s use for binarization threshold, also configuration complexity use next equation 1. this is use object's area and circumference rate. So, it cans reduce noise and similar color objects.

$$Complexity = \frac{area}{perimeter^2} \quad (1)$$

Binarize input image after leasing object by simple structure and then extract candidature area from result image by morphology, complexity, size.[6] extracted candidature area melee a area through labeling process. Gain center of object from this area. Gain again from distance and direction from gained center of object and center of image(screen).

Figure 3 show us the result of a previous series process.

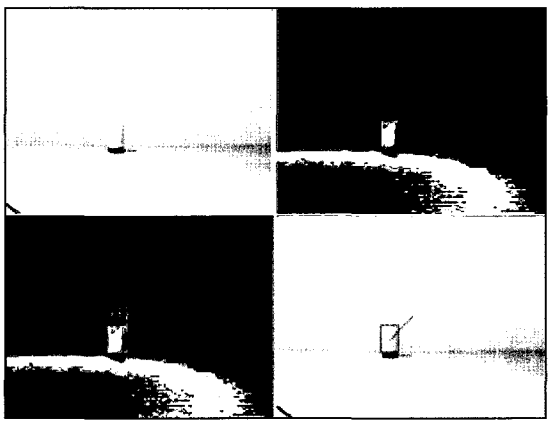


Figure 3. Result of image process

The upside show us result of input image binarization and right upside show us left upside, we can see the result that variety noise more large of small than object created, because of effect of light. It solve by filter that using in this paper, the result show n left downside, us only center of object that is we want result processed image.

We use USB web cam that common in out circumference and it has 15 from/sec speed. It can process real-time by Pentium IV 2.8GHZ, RAM 512 environment.

2.2 Pan-tilt Architecture

We are use pan-tilt of 2-Do F. So we can tracking object in input image that is 2 dimension. This is control the motor for tracking that control x axis area and Y axis area (domain) through acquired image from USB web cam on pan-tilt.

Pan-tilt is controlled by step motor that moving 1.80 per a pulse so it can control detail. And it have no accumulation error so it can control correctly in pan-tilt that feed-back system using image signal delivery motor drive by suggested FLS.

Suggested FLS get the motor drive parameter about distance variable of amount object. Therefore according to object's distance, motor drive pulse different, when it was big then auto drive pulse fast and when it was small then motor drive pulse slow. This is receive input information through input image each a frame, then distance variable amount of object too have each a frame on a unit consequently motor drive parameter for pan-tilt control must delivery before receive a next frame. It looks like motor controlled by acceleration and deceleration according to motor dive parameter fast and slow in a unit time that is a frame, next chapter in traduce FLS that control motor drive of pan-tilt

3 Fuzzy Logic System

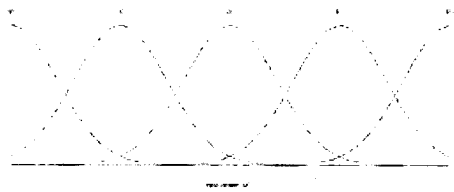
We can get output of pan-tilt control motor using distance variable data in image's object from web cam. Basically we are use moving object's initial center position in image and then into the FLS's input each frame's x axis, y axis variable so it a process vagueness boundary area of near the image center position.

An existing numerical value control delivery motor control signal continuously when it was not correctly each data, so this detailed moving are effect to cam. Cam receives this chattering it effect to image again. FLS solve this problem liked chattering problem by unnecessary motor control. Also it can stable tracking when suddenly fast motions of object that existing genral system fale track object.

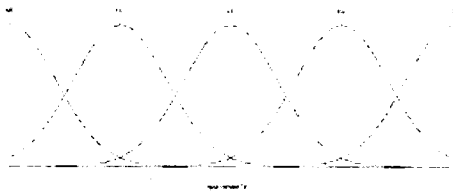
We can get input data for FLS by S, Y axis more position from web cam image. After we can get Δx , Δy that is X axis, Y axis moving variable data. These are moving object's center position variable data and position variable value is pixel data in image actual value. Using Δx , Δy we can get motor drive parameter by suggested FLS.

Figure 4 show Δx , Δy membership function. Figure 4 (a) is Δx that between -100 and 100 by NB, NS, ZE, PS, PB. Figure 4 (b) is Δy that between -120 and 120 by NB, NS, ZE, PS, PB.

These are taking 100 in X axis, but a actual data is 160. That is why X axis moving area covers wide area than actual angle. Also Y axis get 120 same as actual image pixel because of proportion on perpendicular moving position variable value.



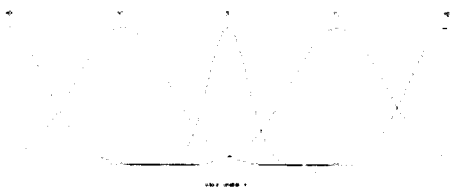
(a) Δx



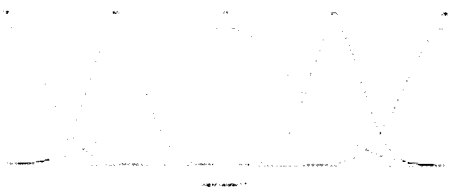
(b) Δy

Figure 4. membership function for input linguistic variable

Figure 5's (a) show us ZE part is reduce a half and NS, PS part is wider. These are describe nearest area with image center ZE control X axis motor speed very slow or stop. Without ZE part NS, PS part control motor by stable speed. NB, PB part more narrow that NS,PS part so control the motor maximum speed when longest distance with image center. So it can effectively tracking object.



(a) X



(b) Y

Figure 5. Membership function for output linguistic variable

Output membership function (b) control Y axis motor that moving perpendicular. So regard ZE part without stable part NS, PS. Then it can remove unnecessary motor movement, also it reduce chattering in image. NB,PB part acceleration motor like (a) so tracking object quickly.

Table 1. Rulebase for the direction of X motor

Δx	NB	NS	ZE	PS	PB
X	NB	NS	ZE	PS	PB

Table 2. Rulebase for the direction of Y motor

Δy	NB	NS	ZE	PS	PB
Y	NB	NS	ZE	PS	PB

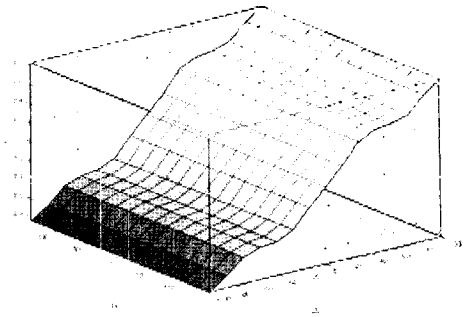
As look at the upside table 1, table 2 that rulebase. Δx have X axis motor, Δy have Y axis motor input linguistic value that show proportion aspect. But these are get out of general proportion by catch sight of change in NB,PB part and ZE part as you see.

4 Simulation and Conclusions

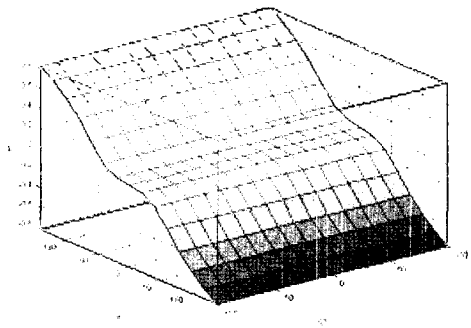
From now on let's look at the relation with input and output using membership function. Figure 6 (a) catch sight of NS, PS part in X axis. And Figure 6 (b) catch sight of ZE part in Y axis. These are show good performance than general proportion control by distance.

It can reduce blurring in image and chattering in motor with pan-tilt controls that Designed FLS. It improves in insensitive in suddenly movement of object. Also it more stable track by pan-tilt acceleration and deceleration control with object movement variable value. But there is no feed-back error algorithm in this system. These are make some problem that it depend on only feed-back value in image data. After need to algorithm for reduce feed-back error.

And now just control a visual part of mobile robot. If there is more time it needs to attach on mobile robot in real environment.



(a) X



(b) Y

Figure 6. Simulation result

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