

Vision System for a Robot Guide System

Yu Wua Wong¹, Liqiong Tang², Donald Bailey¹

¹Institute of Information Sciences and Technology, ²Institute of Technology and Engineering
Massey University, Palmerston North, New Zealand
yuwua.w@gmail.com, L.Tang@massey.ac.nz, D.G.Bailey@massey.ac.nz

Abstract

This paper presents an approach to design a vision system using fuzzy logical control and real time image processing technologies. The system developed is for an autonomous guide robot which is expected to be able to navigate in an unknown environment and search for a given object. There are many considerations necessary for the vision system of a robot due to the complexities in image and vision processing. The processing power required for vision processing is large, which means the image processing speed is largely dependent on the cost and hardware resource constraints. For autonomous robots to be practical in most situations, the vision system must provide vision processing at a sufficiently short time period. As such, image processing methods must be optimised.

Keywords: vision system, robot, image processing, fuzzy logical control

1 Introduction

Computer vision is an important aspect in the extensive field of robotics as it is the most sophisticated way of perceiving the environment for robots, especially mobile and autonomous robots [1]. As individual robots have different objectives, there is no common method or technique to build vision systems for those robots. However, for an autonomous robot to be practical in most situations, its movement must be continuous and at a sufficient speed to complete its given task in an acceptable time period [2]. Hence, there is an emphasis on maximising image processing speed at the minimal cost of the computational power required.

Interest in intelligent robot systems has increased as robots move away from industrial applications and towards service areas such as personal service in home and office, medicine, and public services [3]. For a truly autonomous robot to fulfil the necessary tasks in any service environment, it must be able to interact with people and provide the appropriate response. Hence, many robots have been designed to mimic human behaviour and form.

Currently, there is an ongoing project to build an autonomous robot guide system which aims to provide services for searching in an unknown office environment. Given a name, the robot is able to enter a corridor, search for office doors, and then read the name on the nameplate and compare it with the name entered in the database. The robot carries on searching if a match is not found.

This project aims to design a vision system for the robot using a combination of fuzzy logic control and image processing techniques, which will enable it to identify objects such as doors and nameplates and recognise target object. The development of the vision system mimics the human vision system in regards to

the search process a person undertakes when looking for an unknown object.

A door and the robot position relative to the door can be identified using image processing and fuzzy logic; the edges of the door is identified and the position of the robot is decided as either on the far left, left, centre, right, or far right. It is assumed the robot has the capability to position itself in the centre of the corridor.

2 Robot vision systems

There are many service robots currently being developed or have been developed. Robotics is a popular area of interest to many researchers and engineers as the application of autonomous robots move from the manufacturing and inspection fields to the service sector. In the service sector, there are many fields in which autonomous robots can be applied in; it can range from medical to fast food to home and domestic, as there are a variety of services and tasks that is unappealing or dangerous for humans, but are suitable for robots. As such, there currently a lot of interest and research into different computer vision methods.

As computer vision methods are highly adapted to meet each robot's objectives, there are various adaptations to each vision system. The image processing methods used for each vision system can differ, but the aims of the vision systems usually coincide.

Cokal and Erden [1] developed an image processing system for a mobile robot which is able to detect and move through doors with narrow clearance. A Neural Network (NN) is then used to interpret door status for the overall system.

The *HERMES* robot [4], a humanoid service robot, was designed to transport objects. The visual system

provides navigation for *HERMES* by detecting objects such as doors, corridors, tables, work places, junctions, etc, and then recognising obstacle-free areas. By recognising obstacle-free areas first, the robot will have an idea of where obstacles and objects of interest are.

Both vision systems detect and recognise objects, although the robotic systems respond differently.

There has also been further research into other aspects of computer vision such as dynamic vision. In a situation where the robot must deal with a moving target and a changing environment, there are many complexities such as object recognition and tracking, and identifying moving objects [5]. The research work presented is using real time image processing combined with fuzzy logic control to develop a robot guide system.

3 Mimicry of human behaviour

The proposed design of the robot vision system attempts to mimic a human vision system in regards to the way a person searches. This project attempts to build a vision system which will allow the robot to enter a corridor, identify the door, and recognise the name on the door.

It is assumed that the robot will have an interface to accept commands and a database to store the commands such as the name of the person to search for. The robot also has the capability to remember the routes to previously found objects, for instance doors or people. If the robot has already searched and located the same person previously, it will immediately move towards the office. However, if the name entered is unknown, then the robot will search for the office, similar to the way a person would search in an unknown environment.

When a person enters a corridor or a building, they randomly choose a direction to move in. Then, they will move in the chosen direction and search for doors. After a door is found, they will read the nameplate and decide whether it is the correct office depending on which office they are searching for. Similarly, the robot system will move through a corridor, search and identify doors, read the nameplate of the door, and decide whether it is the correct office based on the match between the name on the nameplate and the name it is searching for. An overview of this process is shown in figure 1. Of course, like a person may have a map in his hand, the robot can also have a map in the database to provide a rough guide. But to find the actual object, the robot has to match the image of the object with the content of the command.

The vision system of the robot, much like the human vision system when searching and identifying objects

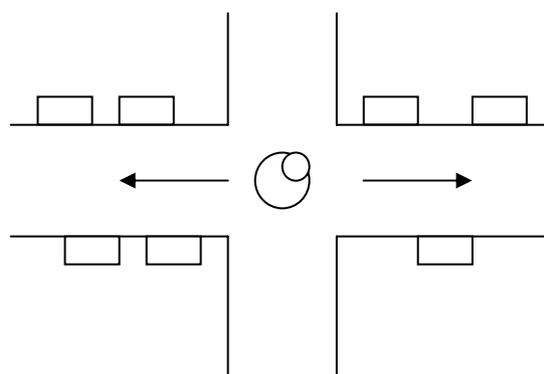


Figure 1: Overview of the vision system requirements

such as doors, does not look too deeply into the details. For example, when a door is identified, it is usually because the human vision system looked at as a whole, and gauged it to similar enough to be a door (e.g. it is rectangular, there is a nameplate, etc.). The human vision system also does not automatically calculate distance of the door from its relative position. Instead, it will gauge whether the door is far away or close, and whether it is on the left side or right side. Therefore, to imitate this type of behaviour, the robot vision system will use a fuzzy logic state controller, which will detect door edges, decide on whether the door is on the far left side, left side, centre, right side, or far right side. This can be shown in figure 2. Depending on which state what position it is in relative to the door, the robot will either move forward until it is centred in front of the door or it will read the nameplate.

Doors will be detected by detecting vertical edges of the images. As there may be additional edges from objects like notice boards or shadows from the lighting in the corridor, the identification of the door edge relies on setting limits for the linearity and length of the edge. If it is above a certain length than it is identified as a door edge, and hence, a door. The difficulty in door identification is detecting the correct edges for the door. However, this problem can be solved by the fuzzy logic state controller, which will have a state to search for the door again if the nameplate is not found.

Initially, the image is first converted from the RGB colourspace to the HSV colourspace. The V-component is then converted into black and white as the contrast between the door and corridor background is sufficient. Edges are detected using a linear filter and a sobel filter. Contrast enhancement and other pre-processing techniques have been applied to the image before conversion into black and white [6].

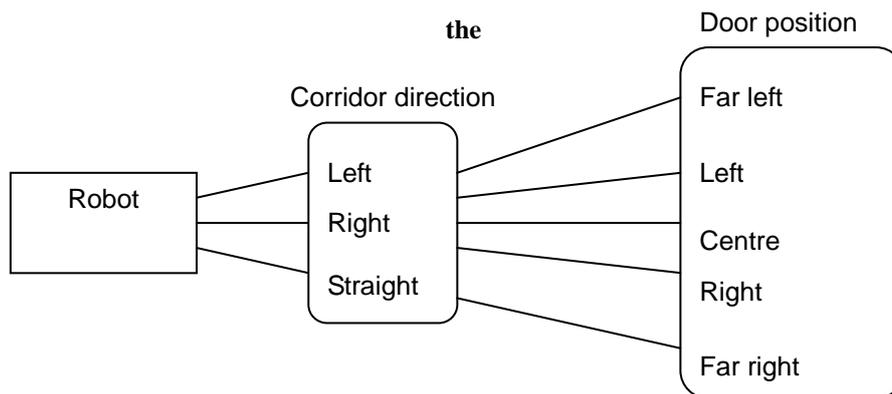


Figure 2: Overview of fuzzy logic door detection

By using the edges of the door, it is possible to infer the region of the nameplate from the significant door outlines and from own knowledge of the nameplate position [6][7]. Once the door is detected, it is assumed that the nameplate is within the upper region of the door. The vertical and horizontal edges of the nameplate is then detected; the nameplate is identified it is a rectangular object within specified area and angle limits. The limits should eliminate any miscellaneous objects such as door notice boards and the articles pinned on it. As the nameplate is standardised with white lettering on a black background, there is sufficient contrast to segment out the nameplate, and then the individual characters. As the robot will position itself in the centre of the door and in front of the nameplate, it is assumed that the segmented nameplate will not be on an angle. This eliminates some of the difficulty in character recognition due to angle skew.

A combination of syntactic pattern recognition and fuzzy template matching will be used for the nameplate reading and recognition [6][7]. The nameplate will be parsed, and using the individual

4 Fuzzy logic for door detection

Fuzzy sets are generalised from conventional set theory, which was introduced by Zadeh in 1965 [8]. It is a mathematical way to represent the vagueness of everyday life. Fuzzy logic is derived from fuzzy sets, dealing with the reasoning of a complex problem.

The vision system captures images in real time. As the robot moves, its position relative to the door is decided by where the closest vertical edge of the door is situated. The progression of door edges as the robot moves through a corridor and searches for a door is shown in figure 3.

Using fuzzy logic, membership functions are created for doors on the left hand side, doors on the right hand side, the position of the door edges (far left, left, centre, right, far right), the camera angle, and the camera pan. Fuzzy rules are implemented to decide where the door is situated at, whether the robot need to centre itself in front of the door, and whether a nameplate is found. Therefore, the state of the robot is controlled by the fuzzy rules.

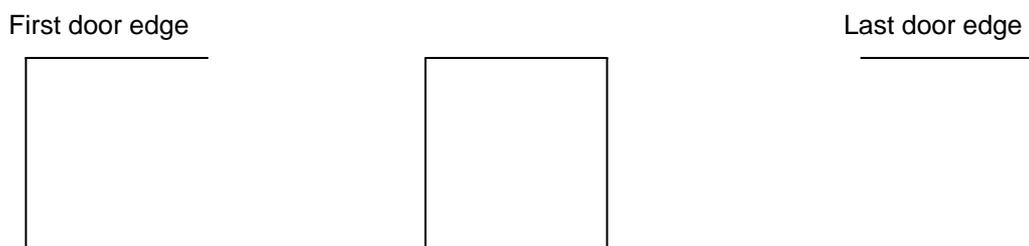


Figure 3: Progression of door edges

line segments which make up each character, will be compared with a set template in the system. As some line segments are common for some characters, a combination of geometry and line segment reuse should decrease the time necessary for processing images.

5 Results

At this stage, doors within corridors can be identified and its position relative to the robot can be measured imprecisely, similarly like the human vision system, which does not calculate its distance from the door, but judges whether it is 'close' or 'far away'.

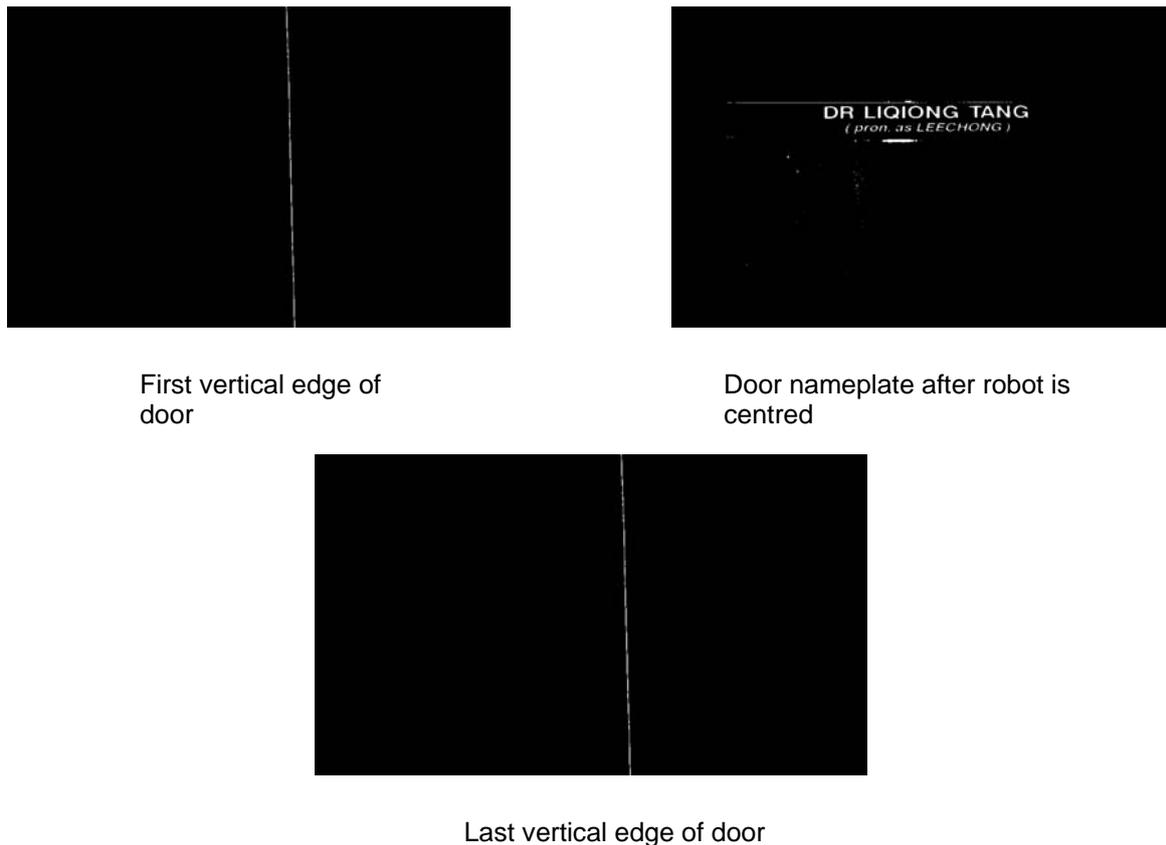


Figure 4: Vision system progression as robot approaches door

The fuzzy logic controls the state of the robot. The robot is able to navigate within the corridor and around corners, and the fuzzy logic controller enables it to move or position itself in the appropriate states.

Images of a door in progressive steps through a corridor were taken. A set resolution was necessary for the lettering of the nameplate to be read clearly. However, at a resolution for clear and readable lettering, half of the door frame is not included in the images. As there are various states for camera pan and controlling camera angles, this should not pose a problem in the vision system as the process for door and nameplate search and identification is the same.

Figure 4 shows the progression of the door edges as the robot moves through a corridor. The vision system detects the door and door position, and aligns the robot in the centre of the door to read the nameplate. If the nameplate does not match the name given to the robot, the robot will continue searching for the next door on either its right or left side.

6 Conclusions

A robot vision system using fuzzy logic control to identify object in real time is presented. The system is able to search and detect doors and door position as the robot navigates within a corridor. The research work is based on fuzzy theory, image processing and real time system optimisation. The output can be

useful for robot real time object searching and identification.

Often vision systems for robot systems are slow due to the computational power required for image processing. To optimise the vision system of a robot guide system that will mimic the human vision system requires much more in depth research using advance methodologies and hardware and software development.

7 References

- [1] E. Cokal, A. Erden, "Development of an image processing system for a special purpose mobile robot navigation", *Proceedings of the 4th Annual Conference on Mechatronics and Machine Vision in Practice*, pp 246-252 (1997).
- [2] J. Barnes, Z.Q. Liu, "Embodied computer vision for mobile robots", *1997 IEEE International Conference on Intelligent Processing Systems*, pp 1395-1399 (1997).
- [3] T. Asada, S. Iwashita, Y. Murase, Y. Yasukawa, S. Kanda, N. Sawasaki, "Developing a Service Robot", *Proceedings of the IEEE International Conference on Mechatronics & Automation*, pp 1057-1062 (2005).
- [4] R. Bischoff, "Advances in the Development of the Humanoid Service Robot HERMES", *Second*

International Conference on Field and Service Robotics (FSR'99), pp 1-6 (1999).

- [5] J.B. Tang, J.P. Liu, H. Zhang, J.X. Shen, L.Y. Zou, X.H. Huang, "Dynamic vision research on modular reconfigurable robotics system", *Proceedings 2003 IEEE International Conference on Robotics, Intelligent Systems and Signal Processing*, pp 970-974 (2003).
- [6] D. G. Bailey, *Image Processing Operations and Algorithm Development*. Massey University, Palmerston North (2007).
- [7] R.C. Gonzalez, R.E. Woods, *Digital Image Processing*. 2nd ed. New Jersey: Prentice-Hall Inc (2002).
- [8] L. A. Zadeh, "Fuzzy Sets and Systems", *Symposium on System Theory*, Polytechnic Institute, Brooklyn, April 20., 21. and 22. (1965).