LEADER FOLLOWER ROBOT

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Mechatronics Engineering

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I hereby declare that I have read through this report entitle “Leader Follower Robot” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronics Engineering

Signature	**:**	**……………………………………**
Supervisor’s Name	**:**	**……………………………………**
Date	**:**	**……………………………………**

I declare that this report entitle "**Leader Follower Robot**" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	**:**	**……………………………………**
Name	**:**	**……………………………………**
Date	**:**	**……………………………………**

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ABSTRACT

Nowadays, human capacity is limited in a lot of field especially in industry field which some of the tasks is dangerous or impossible. However, cooperation of robots with each other can overcome this kind of problem. The key elements is the ability of robot to follow other robot and concerned on the following tasks of the mobile robot. However, problems that will occur include the accuracy of tracking robot when the leader is moving, distance of avoidance collision between leader and follower robot, capability to avoid obstacle and the ability of the follower to follow the trajectory. In this project, the objectives are to design leader follower robot, determine the sensitivity of sensors used, perform ability of an obstacle avoidance by follower robot, and perform validation test of follower based on leader's trajectory. For the methodology, there are some important components chosen for the mobile robot configuration. The Ultrasonic Sensor HC-SR04, Infrared Sensor Sharp GP2Y0A21, Arduino Uno function as microcontroller, two DC gear motor, 2 Amp Motor Driver Shield L298P and aluminum chassis as the main base for the follower robot are chosen. The first experiment is to determine the sensitivity of the sensor and avoid obstacle or collision between leader robot using IR sensor while the second experiment is to carry out the sensitivity of ultrasonic sensor to track the robot. The third experiment, carried out to analysis angle of turning of the mobile robot. In last experiment, the results show the analysis of trajectories for straight line, S-shape, U-shape and Zigzag for both with and without obstacles. As conclusion, the follower robot can performed the following task and obstacles avoidance.

ABSTRAK

Pada masa kini, kapasiti manusia adalah terhad dalam banyak bidang terutamanya dalam bidang industri mengandungi tugasan yang berbahaya dan mustahil dijalankan oleh manusia. Walau bagaimanapun, kerjasama robot dengan satu sama lain boleh mengatasi masalah ini. Unsur yang terutama ialah keupayaan robot mengikuti robot lain dan mementingkan bahawa tugasan mengikuti robot tersebut. Walau bagaimanapun, masalah yang akan berlaku termasuk ketepatan robot apabila pemimpin yang sedang bergerak, jarak mengelakkan perlanggaran antara pemimpin dan pengikut robot, keupayaan pengesanan untuk mengelakkan halangan dan keupayaan pengikut robot mengikut trajektori. Dalam projek ini, objektif adalah untuk mereka bentuk robot pemimpin pengikut, menentukan sensitiviti sensor digunakan, melaksanakan keupayaan pengelakan halangan oleh pengikut robot dan menjalankan ujian pengesahan pengikut berdasarkan trajektori pemimpin. Untuk kaedah ini, terdapat beberapa komponen penting yang dipilih untuk konfigurasi pengikut robot. Ultrasonic Sensor HC-SR04, Infrared Sensor Sharp GP2Y0A21, Arduino Uno fungsi sebagai pengawal mikro, dua DC motor gear, 2 Amp Motor Driver Shield L298P dan aluminium chassis sebagai asas utama untuk robot pengikut telah dipilih. Eskperimen pertama adalah untuk menentukan kepekaan sensor dan mengelakkan halangan atau perlanggaran antara robot pemimpin dengan menggunakan infrared sensor manakala eskperimen kedua adalah untuk menjalankan sensitiviti sensor ultrasonik untuk mengesan robot. Eskperimen ketiga, dijalankan untuk menganalisis sudut beralih oleh pengikut robot. Dalam eksperimen terakhir, keputusan menunjukkan analisis trajektori untuk garisan lurus, S-bentuk, bentuk U dan kesenian untuk kedua-dua yang ada halangan dan tanpa halangan. Kesimpulannya, robot pengikut boleh menjalankan tugasan untuk mengikut robot pemimpin dan dapat mengelakkan halangan.

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CHAPTER 1

INTRODUCTION

1.1 Motivation

Nowadays, mobile robots are becoming more heavily used in environments especially in industry field where human involvement is limited, dangerous or impossible. Different levels of complexity of the robots are built to perform multiple tasks that are required. These robots perform in more dangerous and strenuous human tasks and lead to greater efficiency and accuracy, saving both time and resources [1].

Robots are best at performing the same job every time repeatedly. Such jobs are programmed and the performance is reliable and consistent. Humans usually will get worn out from repetitive jobs and suffer from repetitive motion injuries. Human's tiredness and error will lead to fatal accidents and drop the performance of the tasks.

AME BC and PDAC have collected information on fatal incidents in mineral exploration by searching information from exploration companies working in Canada. The Figure 1 illustrates the data of fatalities in mineral exploration in Canada from 1980-2012. These data is clearly incomplete and misleading. The graph shows that there were 91 fatalities cases in mineral exploration in Canada since 1980. With the passage of time, the current trend is no clear indication. There are only 10 cases of the past 33 years including year 2010 which had zero fatalities. The higher numbers of fatal incidents is year 2011 since year 1980. The data shows that industry has not managed to make a significantly safer way for exploration although increased safety awareness over time. This fact is a challenge for all concerned to take action [2].

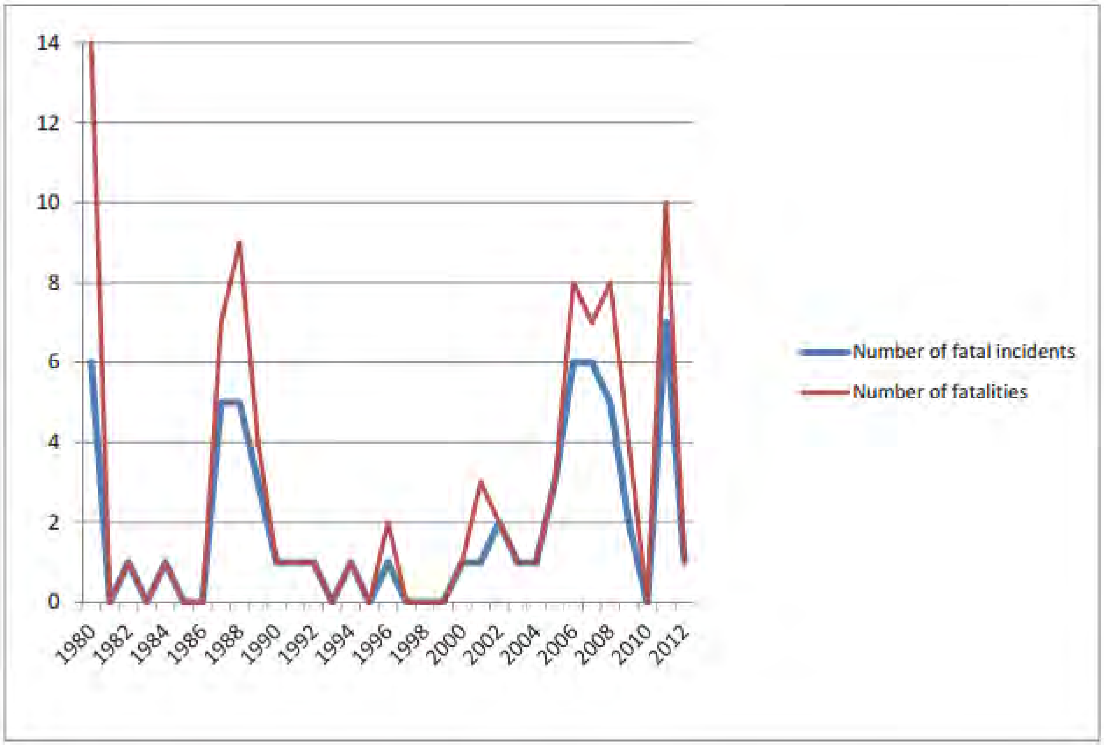


Figure 1.1: Fatalities in Mineral Exploration in Canada 1980 – 2012 [2]

To overcome this problem, robots are required to cooperate with each other to replace human tasks. One of the key elements for the multiple robots to work together is the ability of robot to follow other robot. This element leads to study of leader and follower behavior.

1.2 Problem Statement

Nowadays, robotic technologies have become very important since many industries are trying to improve their performance. This technology has developed many years to make sure an excellent impact. Recently, the robots have been invented to help peoples running their daily life to get the better life.

The main task for the concept of leader follower robot is the following tasks. The following task is important for the mobile robot since the target can be static or dynamic object. However, there are many problems occur when designing a robot to perform a following task. These problems include the accuracy of tracking the robot when the leader is moving, the distance to avoid collisions between leader and follower and the capability to avoid the obstacles. Besides, the response time of the follower when the moment the leader is moving.

1.3 Objectives

1. To design leader follower robot.
2. To determine the sensitivity of sensors used.
3. To implement the concept of an obstacle avoidance and collision avoidance with leader.
4. To perform validation test of follower based on leader's trajectory.

1.4 Scope

1. To implement the ultrasonic sensors and infrared sensors.
2. The collision avoidance with only one leader.
3. The leader and follower robot are run on flat floor.
4. Able to avoid a small size obstacle.
5. The robot are able to turn left, right, forward and reverse.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter review some of the robots that were built to perform the task following. The advantages and disadvantages for each of the robot are also included in the review.

2.2 Coordinated Control of Mobile Robots Based On Artificial Vision

According to [3], in this project, is a coordinated control strategy of multiple robots based on artificial vision to measure the relative position between them, in order to achieve and maintain the specified formation. A leader robot is given that moves about an unknown trajectory and unknown speed. In order to maintain the robots with certain distance between the leader, a controller is designed by using visual information about the position of the leader robot. At equilibrium point, the control system is proved to be stable which achievement of the navigation objective. Experimental results with a leader robot and a follower robot, are included to show the performance based on the vision control system.

Odometric sensors, sonar sensors, gyros, laser and vision and its fusion are commonly used for robot localization and environmental modelling. Vision used because of its ability to capture information. The leader has a pattern mounted on the back, which is observed by the follower robots in order to obtain information about their relative position information to the leader. This is used to control their positions, in order to achieve the specified information. To obtain the visual information, by looking ahead camera mounted on each follower robot. Geometric descriptions of the mobile robot are calculated for the robot position, orientation angle, angular velocities and distance between two driven wheels.

The image of four pattern marks square of know side length that mounted on the leader will be captured by the camera. The image's height of the horizontal median of this square is coinciding with height of the image's camera centre. The location of the leader and the relative position between the leader and a follower robots can be calculated from the image captured by vision system.

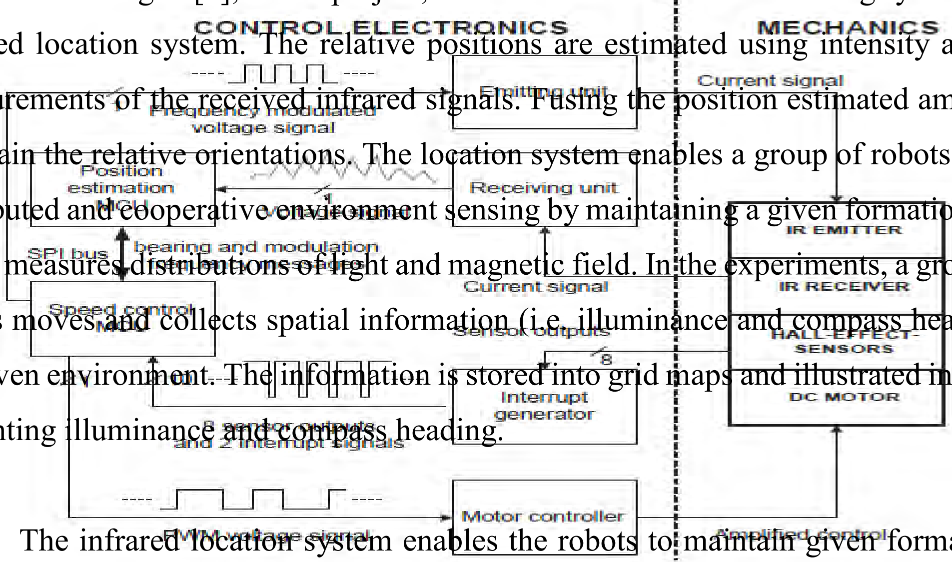
Experiments were carried out with two Pioneer 2DX Mobile Robots which has its own control system. The vision system includes a frame grabber PXC200 that allows capturing the images from a camera SONY EV-D30 mounted on the follower robot. These images are transmitted from the follower robot to a Pentium II-400 MHz PC, in charge of processing the images and of calculating the corresponding control actions. From this image, the centroids of the four projected pattern's marks are calculated and used to compute the variables needed by the controller. Finally, the computed control actions are sent by a transmitter to the follower robot.

However, this method has the limitation that the leader robot mounted with pattern's mark need to be made to coincide with the height of the image's camera centre. The image will not transmit by the follower robot if the centroid of each mark is not capture. The follower robot also could not avoid obstacle if there is obstacle in between the leader and follower robot. The cost will be expensive due to complex hardware need to be implemented.

Figure 2.1: Pioneer 2DX Mobile Robots [3]

2.3 A distributed multi-robot sensing system using an infrared location system

According to [4], in this project, the distributed multi-robot sensing system using the infrared location system. The relative positions are estimated using intensity and bearing measurements of the received infrared signals. Fusing the position estimated among robots to obtain the relative orientations. The location system enables a group of robots to perform distributed and cooperative environment sensing by maintaining a given formation while the group measures distributions of light and magnetic field. In the experiments, a group of three robots moves and collects spatial information (i.e. illuminance and compass heading) from the given environment. The information is stored into grid maps and illustrated in the figures presenting illuminance and compass heading.



The infrared location system enables the robots to maintain given formation while sensing the environment. The relative position can be estimated without data transmission between robots. However, the relative orientation needs the data transmission. Estimation of the radial and angular coordinates, respectively, of the other robots in polar coordinates are using intensity and bearing measurements of the signals received. Each robot can be identified through different frequencies in the received signals.

The components are upward pointing emitter, rotating receiver and two microcontrollers to perform position estimation and rotation speed control of the receiver. A conical mirror is used to reflect the signal from emitter sideways into unified zone. Rotating receiving mechanism called beam collector is used to collect the signals from other robots. Signals are received through a small aperture in the beam collector and reflected to the receiver using a mirror. Scanning the surroundings at a constant rotation speed is realized using a DC motor, Hall-effect-sensors and discrete PID controller.

Figure 2.2: Block diagram of the infrared location system [4]

One microcontroller estimates the position of detected and identified robot using an intensity of the received signal and a bearing of the beam collector. The other controls the speed of the beam collector using a discrete PID controller. The microcontrollers exchange information containing a bearing of the beam collector to be used in position estimation and a modulation frequency setup which defines the identification frequency of the robot.

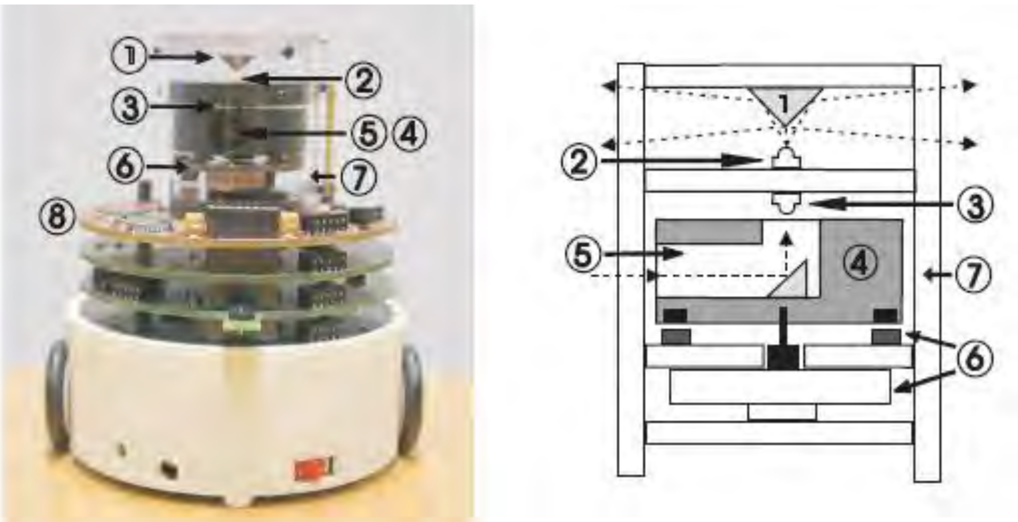


Figure 2.3: The actual system and the illustration of mechanics [4]

There are limitations of this for following behaviour. The measurement range of the location system is limited. Standard deviation for radial coordinate is relative to the distance between a position estimating and a target robot giving the best estimates when only the target is near. Noises in the infrared location system and irregular ground will result in position error. The accuracy of the infrared location system and the leader's odometry will affect the accuracy of the spatial measurements in coordinates. However, there is advantage using infrared sensor method which is low cost compare to vision system. The accuracy of detection for collision avoidance is better that using vision system.

2.4 Low Cost Sensing For Autonomous Car Driving In Highways

According to [5], this project, a car like robot equipped with a system called HANS able to following the road, performing trajectories and safe manner. Besides that, also can keep the safe distance between leader and follower and perform the avoiding obstacles. The experiment was conducted to test the system in both simulation and in a laboratory environment. As a result, these autonomous robots can perform the leader follower behaviour. It is assumed that there are no others car driving faster than HANS vehicle which mean no cars will appear from behind.

HANS using a low resolution web camera located in the centre of the mobile robot behind the rear view mirror and a set of sixteen ultrasonic sensors. The camera functions as a vision system to detect the objects that nearby. It used to detect the side lines that bound the traffic lanes, position and orientation of the robot and distance between robots.

The sixteen ultrasonic sensors are discretized into an occupancy grid as shown in Figure 4. This strategy used to filter the effect that will influence by sonar reflexions. Each of the sonar cones is divided into a number of zones and defined by its distance to the centre of the robot. Each cone or cell, the number of measurement that fell in it is recorded in the occupancy grid. The zone with the highest number of measurements are defined as occupied by an obstacle. Sonars also used to detect the emergency stop.

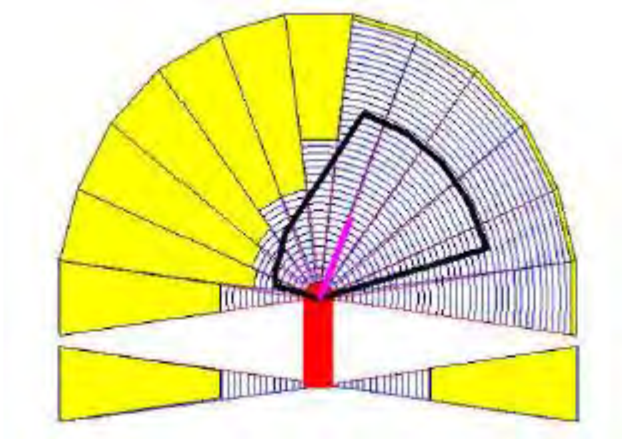


Figure 2.4: Occupancy grid for the sonar data [5]

In this project, the cost is expensive due to use of many ultrasonic sensors. Besides that, the camera is using low resolution web. The low visibility due to light reflection and occlusion due to other vehicles in the road are the common problem.

2.5 The X80 Robot

According to [6], this project presents a control strategy that responds to the requirement of the leader following task. The X80 Robot have two discrete PID controllers, located at each wheel's motor and the data used by the controllers was transmitted from the infrared sensors. When one of the infrared sensors loses the object, an algorithm was conceived to provide the inputs for the controllers. A faulty infrared sensor was detected by using a fault detection scheme that using the information of another sonar sensor. A result of an implementation on the X80 mobile robot was presented.

The robot also has 4 infrared sensors and 4 sonar sensors to perform the following task. It is used to pursuit the direct position of leader robot. The image of the X80 Robot is shown in Figure 5 and the position of each sensor are arranged as shown in Figure 6 respectively. The following task is heavily depending on the infrared sensors only. The measurement of distance return by infrared sensors is checking by the other 3 sonar sensors. The controller used motor to control the angular speed of the two wheels. The linear speed, orientation variation speed and the distance between robots are calculated.

Figure 2.5: The X80 Robot [6]

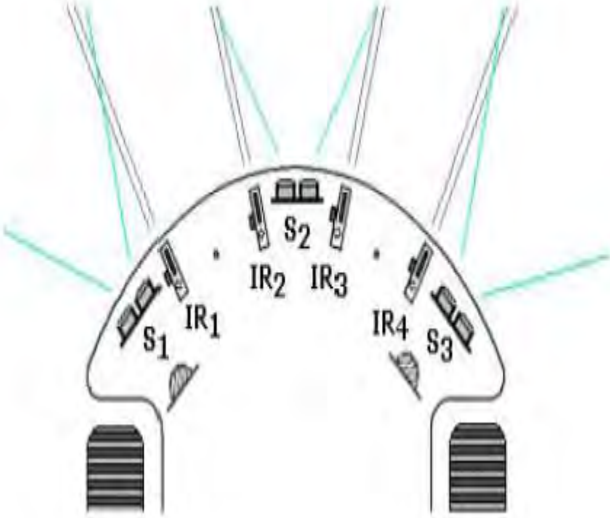


Figure 2.6: IR sensors on X80 Robot

The limitation of the robot is the response of the robot is not fast enough then the follower robots can be lost. The follower will lost the target if the environment space full with the obstacles. Another limitation is that the follower robot needs to stop during when leader is turning direction. Despite its limitation, the X80 robot can follow the leader robot at low speed in free space.

2.6 Vision-based Navigation of Mobile Robot with Obstacle Avoidance by Single Camera Vision and Ultrasonic Sensing

According to [7], this project describes a vision-based navigation method for an autonomous mobile robot, YAMABICO robot, which can perform the obstacles avoidance. In this method, model-based vision system is used for self-localization of the robots and non-stop navigation is achieved through retroactive position correction system. By combination of these two systems, the direction of safe passage can be calculated in the presence of obstacles.

First, the robot will renders an expectation image to estimate the location. Next, extract both model edges for expectation image and camera image and compare through an extended Kalman Filter. Navigate with dead reckoning, meaning that the robot will update its position. The wheel encoders will supply the information to the system. Stationary obstacles are avoided with single-camera vision and moving obstacles are detected with ultrasonic sensors.

The advantage of this method is the view angles of two sensors systems are nearly identical 60 degrees. The ultrasonic sensors can detect obstacles with range of 50cm from robot. Vision sensor detects stationary obstacles at ranges far exceeding 50cm.

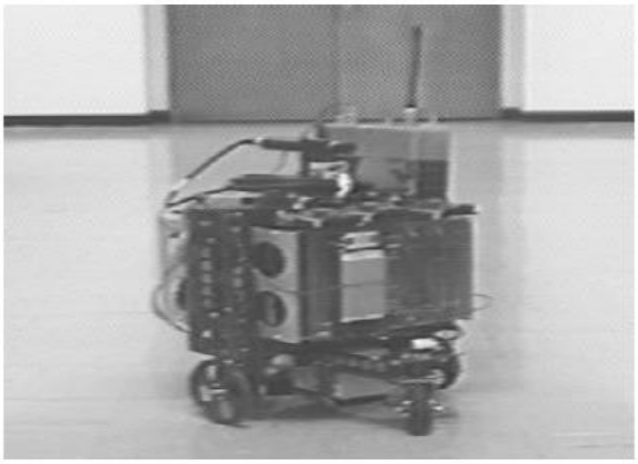


Figure 2.7: YAMABICO robot [7]