DESIGN AND DEVELOPMENT OF MOBILE ROBOT FOR INTEROFFICE DOCUMENTS DELIVERY

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“ I hereby declare that I have read through this report entitle “Design and Development of Mobile Robot for Interoffice Documents Delivery” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronics Engineering”

Signature : .....

Supervisor’s Name : .....

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“I declare that this report entitle “Design and Development of Mobile Robot for Interoffice Documents Delivery” 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, mobile robot is become increasingly common in our workplace and the development of mobile robot has become one of the crucial factors that able to help worker doing simple repetitive task such as delivery documents from one department to another. The mobile robot not only helps worker reduced the heavy workload, they can even protect their physical and mental health that comes from the work-related-stress. However, navigation of mobile robot in an indoor environment is a challenging task to accomplish and it also required to avoid any nearby obstacle during the way to the target destination. This makes the design and development of mobile robot become more difficult to achieve. In this project, the objectives are to design and develop of mobile robot that able to navigate from one location to another, analyze the accuracy of line following sensor and analyze the trajectory movement of mobile robot. For the methodology, there are some important elements for the mobile robot configuration, which is Radio Frequency Identification (RFID) reader with the passive tag, line following sensor, ultrasonic sensor and acrylic board as a main base for the mobile robot. The first experiment is to determine the accuracy of line following sensor towards different width of masking tape whereas the second experiment is to identify the feasibility of navigation method by using the Radio Frequency Identification (RFID) reader and passive tag for mobile robot. Besides that, there are two sections in experiment 3 where first part focus on testing the effective angle of ultrasonic sensor while second part focus on the obstacle avoidance of mobile robot. In conclusion, the experimental result shows that the proposed method can be done successfully with the supported data.

ABSTRAK

Pada masa kini, robot telah menjadi semakin biasa di tempat kerja dan pembangunan robot telah menjadi salah satu faktor penting yang dapat membantu pekerja melakukan tugas yang berulang-ulang yang mudah seperti dokumen penghantaran dari satu jabatan yang lain. Robot bukan sahaja membantu pekerja mengurangkan beban kerja yang berat, mereka juga boleh melindungi kesihatan fizikal dan mental mereka yang datang dari yang berkaitan dengan kerja-kerja. Walau bagaimanapun, navigasi robot dalam persekitaran yang tertutup merupakan satu tugas yang mencabar untuk mencapai dan ia juga diperlukan untuk mengelakkan sebarang halangan berdekatan semasa perjalanan ke destinasi sasaran. Ini menjadikan reka bentuk dan pembangunan robot menjadi lebih sukar untuk dicapai. Dalam projek ini, objektif adalah untuk mereka bentuk dan membangunkan robot yang mampu untuk navigasi dari satu lokasi ke lokasi lain, menganalisis ketepatan sensor dan menganalisis pergerakan trajektori yang robot. Untuk kaedah ini, terdapat beberapa elemen yang penting untuk konfigurasi robot, yang merupakan Radio Frequency Identification (RFID) dengan tag pasif, talian berikut sensor, sensor ultrasonik dan papan acrylic sebagai asas utama untuk robot. Eksperimen pertama adalah untuk menentukan ketepatan talian berikut sensor ke arah lebar yang berbeza pita pelekat manakala percubaan kedua adalah untuk mengenal pasti kemungkinan kaedah navigasi dengan menggunakan Radio Frequency Identification (RFID) dengan tag pasif untuk robot. Selain itu, terdapat dua bahagian dalam eksperimen 3 di mana bahagian pertama tumpuan terhadap menguji sudut yang berkesan sensor ultrasonik manakala bahagian kedua tumpuan kepada mengelakkan halangan robot. Kesimpulannya, hasil eksperimen menunjukkan bahawa kaedah yang dicadangkan boleh dilakukan dengan jayanya dengan data yang disokong.

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RFID	-	Radio Frequency Identification
PWM	-	Pulse Width Modulation

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CHAPTER 1

INTRODUCTION

1.1 MOTIVATION

According to the Health and Safety Executive (2005), the statistics revealed that in the UK more than 500,000 people experiencing stress related to work and this level of stress can lead to illness. In the previous of 12 months, 245,000 people feeling anxiety when they first dealing with work-related stress. In addition, the results show that 15% people thought their job was very stressful or extremely stressful as shown in Figure 1.1. The main factor that causes work-related stress is workload which means the amount of work need to be done by worker. According to the Trades Union Trends Survey (2004), it can be seen that the workload have the highest percentages among the four different years as compared to other factors of work-related stress as shown in Figure 1.2. Hence, this project aim to design and develop a mobile robot for the benefit of worker in order to help them reduces workload.

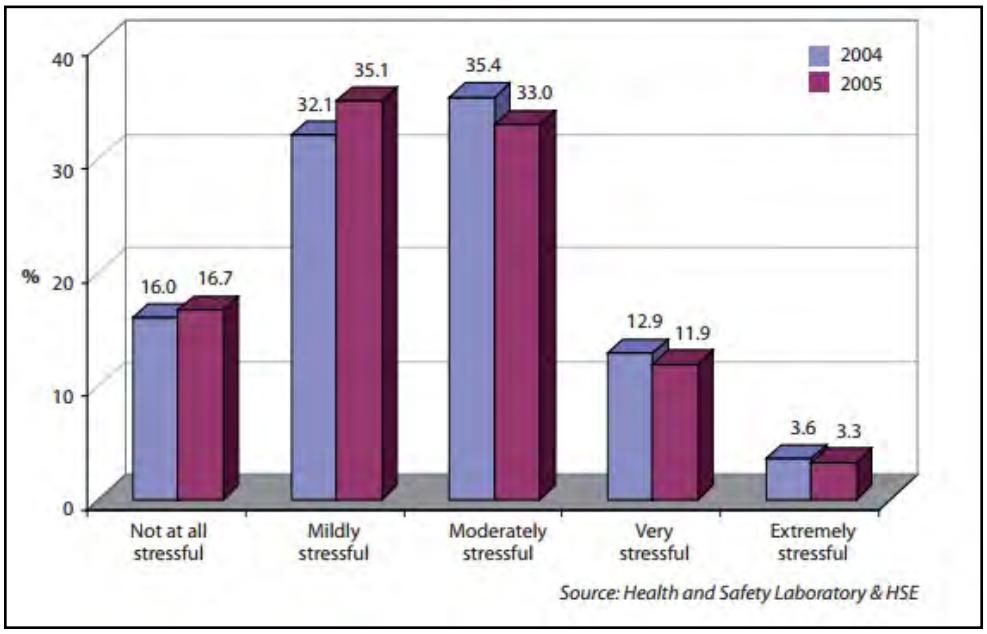
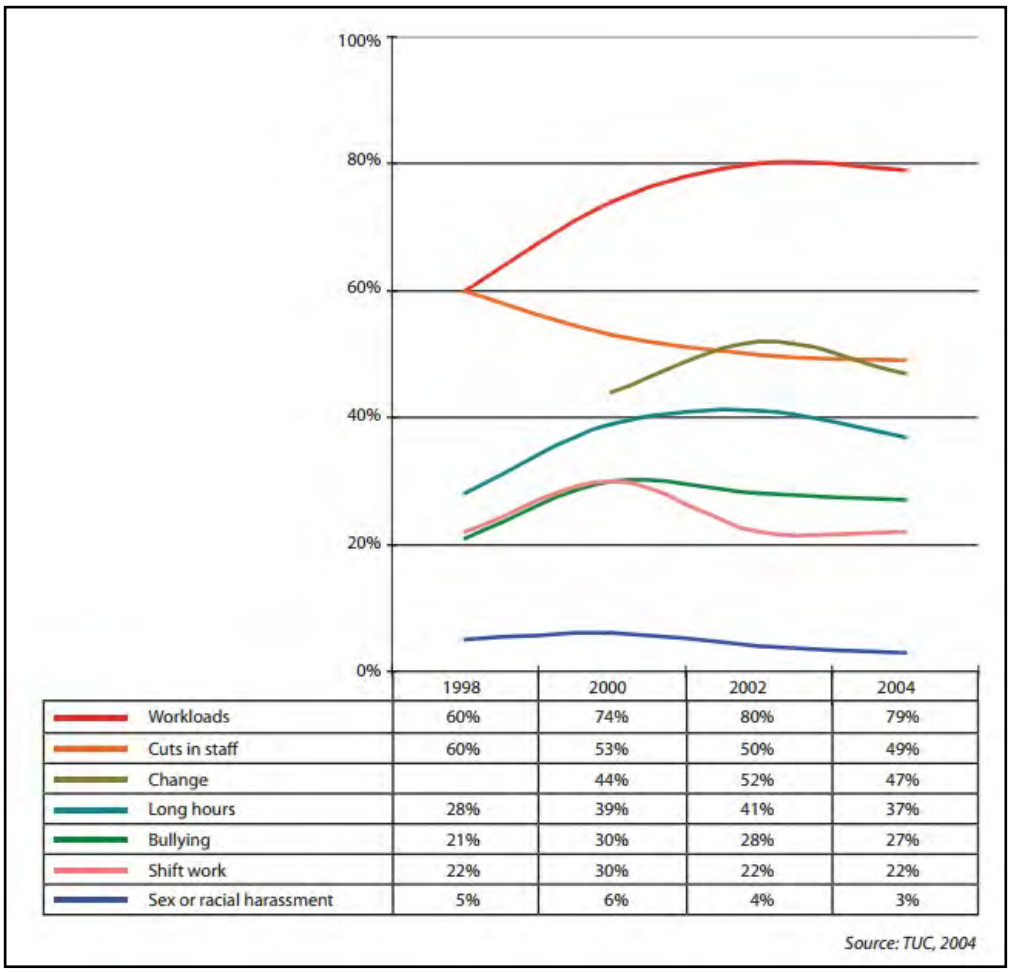


Figure 1.1: The level of stress among UK workers [1]



	1998	2000	2002	2004
Workloads	60%	74%	80%	79%
Cuts in staff	60%	53%	50%	49%
Change		44%	52%	47%
Long hours	28%	39%	41%	37%
Bullying	21%	30%	28%	27%
Shift work	22%	30%	22%	22%
Sex or racial harassment	5%	6%	4%	3%

Figure 1.2: Factors of work-related stress [1]

1.2 PROBLEM STATEMENT

Work-related stress is a growing problem around the world and most challenging issue in the occupational safety and health. Work-related stress that affects not only the mental health and well being of employees, it will also subsequently affect the productivity of an organization. Workload is a most critical factor that linked to work-related stress due to the excessive of workload, it has became a leading source of work-related stress for employees, thus makes them have poor performances in workplace. A safe and healthy working environment will lead to increase working efficiency in order to have a greater job satisfaction. For that reason, mobile robot is developing for interoffice documents delivery to improve the performance and efficiency of employee while create a systematic work environment in order to makes the job more pleasurable and satisfying. Apart from that, navigation of mobile robot in indoor environment is a challenging issue to accomplish. The problem of navigation of mobile robot has been widely discussed in recent years in the field of robotics. Such problems have several difficulties and complexities that are unobserved and unidentified, besides the ambiguity of how this can be solved since a mobile robot may encounter various forms of obstacles that must be bypassed in an intelligent manner.

1.3 OBJECTIVES

- To design and develop of mobile robot that is able to navigate itself from one office to another for documents delivery.
- To analyze the accuracy of the line following sensor towards different width of masking tape.
- To analyze the trajectory movement of mobile robot so that it is able to reach the target destination without collision with obstacle.

1.4 SCOPE

The scope of this project is to implement the navigation strategy using the RFID system for the mobile robot to move around in an indoor environment. In addition, the mobile robot is equipped with three line following sensor for the mobile robot to follow a black line path. This mobile robot is applicable to the interoffice documents delivery but limited to one floor only. Moreover, this mobile robot can move only on smooth flat surfaces. During the development stage, the mobile robot is able to handle and carry documents with approximately 500 grams due to the small scale designation. It can be expand to larger scale to handle and carry documents more than 500 grams. Furthermore, the mobile robot is equipped with the ultrasonic sensor to detect and avoid nearby obstacle in order to reach the target destination without collision. Therefore, some stationary obstacles are introduced in the navigation environment in order to satisfy the reliability of the mobile robot during the navigation process.

1.5 CHAPTER OVERVIEW

In Chapter 1, Introduction, this chapter describes the background of the project which includes motivation, problem statement, objectives, and the scope of the project.

In Chapter 2, Literature Review, this chapter describes the previous research work on knowledge sharing. Based on the findings, the element that relevant to my project will be compared and analyzed in order to select the suitable components to be used in the project.

In Chapter 3, Methodology, this chapter describes about research methodology that perform for the development of mobile robot which includes the project planning, system, methods and experimental setup.

In Chapter 4, Result and Discussion, this chapter explained about the findings based on the data taken in experiment. The findings for each of the experiment will required to achieve the objectives of the project.

In Chapter 5, Conclusion and Recommendation, this chapter discussed about the achievement of the project and recommendation for future improvement.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Navigation of mobile robot has been widely discussed in the past few years and this issue can be consider as a huge challenge to be accomplish in the field of robotics. There are many researchers over the world have developed numerous method to navigate their mobile robot reach the goal location for indoor and outdoor environment while at the same time avoid any nearby obstacle on the path to target destination. For localization in outdoor environment, Global positioning System (GPS) have been widely used in tracking people and asset as well as a navigation system for transportation since it provide accurate coordinate and information about a certain place. However, GPS does not perform well in indoor localization because the satellite cannot penetrate through the building thus making the GPS useless in indoor localization [2]. There is a lot of indoor localization and navigation system such as Infrared Radiation (IR), Radio Frequency Identification (RFID), Bluetooth, Ultra wideband (UWB) and WiFi to address the inadequacy of GPS inside a closed environment [3], [4], [5], [6], [7]. Besides that, obstacle avoidance is a one of the crucial factor in designing the mobile robot as it makes the mobile robot reach the target destination without any collision with obstacle. By using different types of sensor such as infrared sensor, ultrasonic sensor and laser range finder can used to detect and avoid the nearby obstacle [8].

Other than that, mobile robot needs to navigate from one place to another place to perform task within an indoor environment, so that, well designed mobile robot locomotion able to help maintain the stability of the structure and smoothen the motion of sensor and thus increase the performance of the mobile robot. Several designs of wheel robot chassis such as two-wheel chassis, mecanum four wheel chassis and ball wheel chassis are used in designing the base of the mobile robot [9]. This chapter will be further discussed about the important element of mobile robot in terms of navigation system, obstacle avoidance sensor, and wheel robot chassis.

2.2 NAVIGATION SYSTEM

Based on the research, Radio Frequency Identification (RFID) is a most suitable system used for localization and navigation of mobile robot due to its ease of use, inexpensive cost and flexibility. Although Global Positioning System (GPS) is a good positioning system for outdoor environment, however, poor coverage of satellite signal in indoor environment hence making it useless for indoor positioning [10]. Since the network infrastructure available in every building, Wi-Fi positioning system has more advantages compared with UWB and RFID [11]. However, the interference with electronic devices that operate in 2.4GHz band will affected the strength of signal, hence makes the signal unstable thus lower the accuracy of positioning. In addition, the Wi-Fi tags are more expensive than RFID tags in terms of cost and price. Compared with RFID, Ultra-Wideband (UWB) provides better positioning accuracy which makes it better for high precision positioning in indoor environment [13]. However, the cost of UWB infrastructure and hardware are relatively expensive hence making it difficult used for wide-scale. As a conclusion, RFID is a best system used for localization and navigation of mobile robot in terms of cost, power consumption and performance [12]. The summary of localization and navigation system is shown in Table 2.1.

Table 2.1: Summary of localization and navigation system

Title	System	Accuracy	Coverage	Power consumption	Cost	Remark
Survey of Wireless Indoor Positioning Techniques and Systems [10]	GPS	5 - 10m	Good outdoor Poor indoor	High	High	(1) Satellite based Positioning. (2) Processing time and computation is slow.
Indoor Localization and Tracking: Methods, Technologies and Research Challenges [11]	Wi-Fi	1 - 10m	Indoor	High	High	(1) Initial deployment is expensive. (2) Interfere possible with other appliances in the 2.4 GHz band.
An Intelligent Mobile Robot Navigation Technique Using RFID Technology [12]	RFID	1 - 5m	Good Indoor	Low	Low	(1) Real time location system. (2) Response time is high.
An Ultra-Wideband Local Positioning System for Highly Complex Indoor Environments [13]	UWB	1cm - 1m	Good Indoor	High	Very High	(1) High cost of infrastructure deployment. (2) High precision in positioning.

2.3 OBSTACLE AVOIDANCE SENSOR

In the field of robotics, obstacle avoidance is the concern for mobile robot to act in an unknown or dynamic environment as it is the most crucial criteria to accomplish the objective without collision to the subject. There are various research studies regarding the issue of obstacle avoidance in designing the mobile robot platform so that it can be more reliable performed obstacle avoidance. Besides that, the price of sensors can be from low to high depend on the performances of sensors for different application. In addition, each of the sensors has its own unique and specification to carry out the various task based on the given situation.

Based on the research, ultrasonic sensor is a most suitable method used for obstacle avoidance within an indoor environment. Unlike laser rangefinder and infrared sensor, the ultrasonic sensor has relatively wide working angles. The effective working angles of ultrasonic sensor have approximate 30^{o} which is large compared with infrared sensor and laser rangefinder [14]. Since the ultrasonic sensor is mounted on a servo motor on the front end of mobile robot, it is able to scan the surrounding environment more thoroughly and effectively to avoid any nearby obstacle. Although laser rangefinder have better performance in terms of accuracy and maximum range, but the cost of laser rangefinder is relatively expensive compared with ultrasonic sensor and infrared sensor [15]. Furthermore, the measurement of ultrasonic sensor is very reliable in any lighting conditions whereas infrared sensor is very vulnerable to changes in ambient light. In addition, ultrasonic sensor use sound instead of light for ranging to detect the nearby obstacles, making this a good choice compared with infrared sensor [16]. As a conclusion, ultrasonic sensor is a best method used for obstacle detection and avoidance in terms of cost, performance and wide angle. The summary of obstacle avoidance sensor is shown in Table 2.2.