Ain Shams University
Faculty of Science

Modelling, Simulation and Implementation of a Robotic System for Wide Range of Applications

Thesis

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Abstract

The development of methods for autonomous navigation of a robot in a real world environment is one of the major areas of interest for current research.

This thesis attempts to develop an autonomous robot using ultrasonic sensors (for sensing the obstacle environment) and Global Positioning System (GPS) and a digital compass (for direction and location).

This work deals with the problems of the navigation of an autonomous robot with known environment that used in different applications such as mine detector. A navigation method based on the behavior of the robot that has been developed, is achieved by means of Fuzzy Logic Control "F.L.CONTROLLER".

This thesis describes the design and development of a low-cost autonomous robot that is targeted. After implementation, we evaluate the performance of the developed robot. Several problems had been identified and possible solutions are proposed.

A design controller is a main component of the proposed system, which has three functions: motion control, obstacles avoidance and self-navigation. The proposed controller is responsible for the navigation of the mobile robot after generating a road with a current point and goal point. As well, it enables the robot to work successfully in the bearing of various obstacle environments with any user built maps.

The complete system operations were simulated using MATLAB software package M-file was created and run to get the data used to plot car position (Lat., Lon.), a car heading (θ_1) and car velocity. Moreover, we

achieved the complete comparison between the data got from the simulation with practical data collected during the actual run of car for 70 Sec.

The the differences between simulated and practical results (data) are also illustrated; it comes out that the practical results were very close to the simulated results.

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1. Introduction and Literature Review

1.1 Introduction

As time goes on, the advancement of technology keeps thriving, consequently, more and more sophisticated solutions are invented. One of the most significant fields of science which has to be taken into consideration is autonomous robot navigation. There are situations where human interference is not an option and there is no other solution but applying autonomous robots to tackle any problems such as; mine detectors, lawn mowing and move into dangerous areas [1].

A mobile robot is an automatic machine that is capable of movement in any given environment. Mobile Robots have the capability to move around in their environment with a certain degree of autonomy and are not fixed to one physical location.

Robots have a high level of autonomy in fields considered dull or dangerous and are increasingly performed by automatic systems.

Autonomous navigation is associated with the availability of external sensors that capture information about the environment through visual images, location, and distance or proximity measurements. The most common sensors are distance sensors (ultrasonic, laser, etc.) capable of detecting obstacles and of measuring the distance from the walls close to the robot path. When advanced autonomous robots navigate within indoor environments (industrial or civil buildings), they have to be endowed with the ability to move through the corridors, to follow walls, to turn corners and to enter open areas of the rooms [2].

Two basic criteria determine the success of robotics work, path planning and navigation. These criteria completely based on the environment known. Usually, this factor (environment knowledge) is the main concern for the robotics designer and programmer.

Having a detailed map with all the obstacles marked seems to be unrealistic for most situations. In many outdoor applications the robots can determine their coordinates by using GPS [3].

Outdoor navigation currently presents the biggest challenge to designers of robotic systems for many factors. These factors include an unstructured environment with uneven terrain, the instability of a sensed environment which is continually changing, and the use and integration of multiple sensors. These problems create uncertainties that cannot be solved with the use of indoor navigation algorithms that have been widely researched in the past and this gap in knowledge currently drives resources to develop future autonomous robots.

1.2 Motivation

The experiments for evaluating new ideas or algorithms for these robots are difficult, since the cost of these real autonomous robots is high. Therefore, many researchers try to work on experiments for evaluating their algorithms or methods on software simulators. However, the effects from using these simulators are not very accurate and the differences between real systems and simulators can be great. Our solution for these problems is emulation, it means that we provide the modeling or imitation to represent the behavior of the hardware of robots. In unknown and dynamic environments the system needs to discover the changes of the environment [4].

Today, several common businesses can be performed in a satisfactory manner by robots, including mine detection, lawn mowing and pool cleaning.

Other tasks such as autonomous transportation and surveillance are only starting to be implemented on a small scale. Possible applications in this field are intelligent robots for services in hospitals, offices, factories or any type of hazardous area. Current gaps between the available technology and the increasing applications for these systems drive investigation towards new techniques for navigation. Still, for robotic systems to be successful at performing these tasks, autonomy in an environment that is not purposely engineered for the robot, has to be achieved.

Currently, different algorithms exist to solve the problems of robot localization and path planning for a mobile robot navigating indoors while the majority of the past research was focused on navigation in structured environments [5]. However, the problem of outdoor navigation is one that is not entirely worked out until now.

Problems encountered outdoors by a robot will be different than those encountered indoors. Type of obstacles outdoors cannot be easily categorized because of their wide variety. Therefore, outdoor autonomy is most easily achieved in the air and sea, since obstacles are less common. On the ground, several issues arise, including terrain, weather, object recognition, random moving obstacles and increase weaknesses of the sensing devices themselves. As an example, computer vision solutions have certain limitation that can make them impractical in an unstructured setting [6].

To overcome sensor limitations, robots combine the use of high end sensors such as cameras, compass, laser rangefinders, global positioning systems (GPS), Inertial Measurement Units (IMU) and sonar. These sensors, along with the hardware and software that have to accompany them, constitute a great cost in investment for the robot. This justifies the need for further research into the implementation of low cost sensors and their ability to provide the necessary information for the navigation of the robot.