# PLAG-Introduction and Literature Review

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# REAL TIME IMPLEMENTATION OF OPTIMAL PATH PLANNING FOR AUTONOMOUS ROBOT

PROJECT REPORT

Submitted in the partial fulfilment of the
requirements for the award of the degree
of
**Bachelor of Technology**
In
**Instrumentation and Control Engineering**

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# List Of Abbreviations

DC - Direct Current

V - Volts

LIDAR  - Light Detection and Ranging

IR - Infrared

PIR – Passive Infrared

USB – Universal Serial Bus

LED – Light Emitting Diode

ICSP – In Circuit Serial Programming

IDE – Integrated Development Environment

AI – Artificial Intelligence

GPS – Global Positioning System

IC – Integrated Circuit

IN – Input

OUT – Output

PWM – Pulse Width Modulation

HTML – Hyper Text Markup Language

CSS – Cascaded Style Sheets

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# ***CERTIFICATE***

This is to certify that the project report of B.Tech. major project entitled "**Real Time Implementation Of Optimal Path Planning For Autonomous Robot**" in partial fulfilment of the requirements for the award of the degree of **Bachelor of Technology in Instrumentation and Control Engineering of Dr. B.R. Ambedkar National Institute Of Technology, Jalandhar, India** is an authentic record of our own work carried out during the period from July, 2022 to May, 2023 under the guidance of **Dr. Afzal Sikander** at Dr. B.R. Ambedkar National Institute of Technology, Jalandhar. The matter presented in the report has not been submitted by me/us for the award of any other degree of this or any other Institute.

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**Divya Singh (19112027)**

This is to certify that the above statement made by the students is correct to the best of my knowledge.

**Date: ____________** **Dr. Afzal Sikander**
**(Assistant Professor)**

The B. Tech major project Viva-Voce Examination of above students has been held on ......................

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# ABSTRACT

The aim of the project is to develop an obstacle-avoiding robot that moves from a given source to a destination through the shortest valid path. Path planning or trajectory planning is one of the most important aspects in object picking and placing tasks which are usually performed by autonomous robots. Autonomous robots are one of the most fascinating applications of robotics. They have the ability to make their own decisions and perform tasks without any human intervention. One of the key challenges in autonomous robot applications is optimal path planning. In this project, we aim to implement real-time optimal path planning for an autonomous robot. Autonomous robots having the capability to avoid obstacles can be of great use in hazardous industries, disaster-prone areas, and war-affected environments where navigation difficulties are common. A lot of time, energy, and cost can be saved if the robot moves through the most optimum(shortest) path out of all the possible paths and avoids all the obstacles at the same time.

The robot travels in a rectangular environment consisting of obstacles that are placed at specific coordinates and the robot can move from some restricted paths only. The environment is pre-fed to the robot, which uses recursion and backtracking computations to find the valid shortest (optimal) path from all the valid paths for reaching a destination point from a source point. The shortest path is computed using the concept of Depth First Search. It is computed in the pre-working or pre-movement stage when the environment is given as input to the robot. Depth First Search finds all the paths by exploring each valid path through which it can move and subsequently find the path with the minimum distance the robot can reach from source to destination. This data is passed to the robot which uses an Arduino microcontroller to move through the environment from the computed valid shortest path. The proposed system consists of a robot equipped with sensors, a computer, and a control system. The robot consists of an Arduino-UNO, Ultra-sonic sensor, Bridge motor driver L298, DC Motor, Servo motor, Omni-direction wheel, jumper wires, and 9V battery.

The objective of the project is to develop a technique that solves the problem of robot path planning to have static obstacles avoidances characteristics which will ensure the safety and shortness of the path. The project also includes a user interface that shows

the visual description of the computed optimal path. Future aspects include the technique of data acquisition from image processing using machine learning.

Keywords – Path Planning, Backtracking, Depth-first-search, Obstacle-Avoidance, Arduino-UNO sensor.

# CHAPTER 1: INTRODUCTION

In today's modern world robotics is the one of the fastest growing and fascinating field. Autonomous robots becoming increasingly common in various industries. With the increasing demand for automation, robots are being employed in a wide range of applications. Autonomous robots are one of the most fascinating applications of robotics. They have the ability to make their own decisions and perform tasks without any human intervention. One of the critical challenges in developing autonomous robots is to design efficient and effective algorithms that enable the robots to navigate through complex environments while avoiding obstacles and reaching their goals.

## Overview Of Autonomous Robots

Autonomous robots are designed to perform tasks without any human intervention. They are equipped with sensors, processors, and actuators that enable them to sense their environment, make decisions, and perform tasks. Autonomous robots are being used in a wide range of applications such as manufacturing, logistics, agriculture, healthcare, and space exploration.

## Path Planning and Obstacle Avoidance

Path planning is the process of finding the optimal path from a starting point to a destination point while avoiding obstacles. In autonomous robots, path planning is a critical task that enables the robot to navigate in its environment. Path planning algorithms take into account factors such as the size and shape of the robot, the location of obstacles, and the goal location to generate an optimal path. Obstacle avoidance is one of the most important tasks for various robotics system. Along with obstacle avoidance, path planning is also an important criterion to measure the efficiency of robot in terms of distance travelled by choosing a particular path out of all the available paths. Obstacle avoidance in robots will bring more flexibility in manoeuvring in different environmental conditions and would be much more efficient as continuous human monitoring is not required. So, the robot is designed in a way to traverse through an unknown environment having obstacles at certain coordinates. This problem has several applications in robotics, including autonomous navigation, industrial automation, and military robotics.

The real-time implementation of optimal path planning algorithms involves finding the most efficient path for a robot to travel from its current location to its destination in real-time. This real-time implementation requires the use of algorithms that can quickly compute the optimal path and update it as the robot navigates through its environment.

## Implementation And Methods

The robot is designed using components such as Arduino-UNO micro-controller, Bridge motor driver L298, DC Motor, Omni-direction wheel, jumper wires and 9V-batteries. The overall robot body is designed in compact manner, so it is light-weighted. It will be easily able to move on the floor of a room, tackling all the obstacles of both big and small sizes. The robot uses 2 motors each with its gearbox, 2 wheels per motor and 1 omni-direction wheel which will make the robot change its direction.

Many methods have been developed in this field of robot obstacle avoidance including path-following, wall-following, edge detection and many others. One of the methods uses an ultrasonic sensor mounted in front of robot which detects obstacles in front and send commands to the Arduino micro-controller to direct the robot to another possible path. This robot explores each possible path until it reaches its destination. This is a collision detection technique.

There is another technique called "Collision Avoidance" which is used in this project. In a collision avoidance problem, the end-effector of each manipulator is guided iteratively towards the destination and away from the obstacles using an approximate grid decomposition technique with a greedy Depth-first-Search Algorithm. The Collision Avoidance scheme is an on-line scheme which uses the local knowledge and operates in a cartesian space. The computations for the shortest-path are done in the pre-processing step and this path is used for the traversal by robot.

The advantage of this method is that robot can find a way faster as it has to just traverse from a particular pre-defined path. The environment will be given in the form of grid or matrix where obstacle is represented as a particular integer and empty space as another integer. The algorithm will return the shortest valid path through which robot can move, thereby making the process simpler and faster.

# CHAPTER 2: LITERATURE REVIEW

Autonomous mobile robots performing navigation-based tasks in unknown environments require a mechanism to detect and avoid obstacles to ensure their safety and task continuity. The problem of obstacle detection and avoidance for mobile robots is a challenging task and a well-researched topic in robotics. Various sensors and methods have been proposed in previous works to address this problem. Students and practitioners have built different obstacle detection robot mechanisms to overcome this challenge.

Obstacle avoidance is a crucial function for autonomous mobile robots in real-world environments. To detect and avoid encountered obstacles, a range of sensors and methods have been proposed in the literature. However, despite the extensive research, the problem of obstacle detection and avoidance remains a challenging task for mobile robots.

The problem involves finding the most efficient path for a robot to travel from its current location to its destination whole satisfying certain constraints such as avoiding obstacles and minimizing travel time.

## 1. The Obstacle Avoidance System

Obstacle avoidance bot was developed and designed by Aamir attar, Adil Ansari, Abhishek Desai, to design a robot that detects obstacle in the path and follow the instructions provide by the user. So, this system provides an alternate way to the existing system by replacing skilled labour with robotic machinery, which in turn can handle more things in less time with good accuracy and lower cost.
Autonomous vehicles use radar, GPS, computer vision, odometry and lidar to detect it surroundings.

## This literature review will provide an overview of some of the most common obstacle avoidance systems.

- **Ultrasonic Sensors:**

Ultrasonic sensors are commonly used in obstacle avoidance systems due to their low cost and ease of implementation. Ultrasonic sensors work by emitting high-frequency sound waves that bounce off objects in the robot's environment. The sensors then measure the time it takes for the sound waves to return, which is used to determine the distance to the object. However, ultrasonic sensors have limited range and can only detect obstacles within a few meters.

- **Infrared Sensors:**

Infrared sensors are also commonly used in obstacle avoidance systems. They work by emitting infrared light and measuring the amount of light that is reflected back from objects in the environment. Infrared sensors have longer range than ultrasonic sensors, but they can be affected by ambient light and may not work well in bright sunlight.

- **Lidar Sensors:**

LIDAR (Light Detection and Ranging) sensors are becoming increasingly popular in obstacle avoidance systems. LIDAR sensors work by emitting laser beams and measuring the time it takes for the laser beams to reflect back from objects in the environment. LIDAR sensors have long range and high accuracy, making them ideal for use in autonomous vehicles. However, LIDAR sensors are relatively expensive and may not be suitable for use in low-cost robots.

- **Computer Vision:**

Computer vision is another approach to obstacle avoidance that is gaining popularity. Computer vision systems use cameras to capture images of the robot's environment and then use image processing techniques to detect obstacles. Computer vision systems have the advantage of being able to detect a wide range of obstacles, but they can be affected by changes in lighting conditions and may not work well in low light.

- **Hybrid Systems:**

Hybrid obstacle avoidance systems combine multiple sensors and techniques to improve accuracy and reliability. For example, a system may use LIDAR sensors for long-range detection and computer vision for short-range detection. Hybrid systems can provide robust obstacle detection and avoidance, but they can be more complex and expensive to implement.

In conclusion, there are several obstacle avoidance systems available, each with its own advantages and limitations. The choice of system will depend on the requirements of the specific application and the available budget. Ultrasonic sensors and infrared sensors are low-cost options, while LIDAR sensors and computer vision systems offer high accuracy and range. Hybrid systems can provide the best of both worlds but may be more complex and expensive to implement. Ultimately, the goal of obstacle avoidance systems is to ensure the safety and efficiency of autonomous robots and vehicles.

## 2. Obstacle-Avoiding Robot with IR And PIR Motion Sensors

It was developed by Aniket D. Adhvaryu et al. In this robot, platform is general wheeled autonomous platform. These robots can be used in educational field, research etc. Many students used it to learn various skills such as C++, Arduino Uno 1.6.5 compiler, etc.

These robots had very flexible design. It is observed that PIR sensors are more sensitive compared to IR sensors.*[1]*

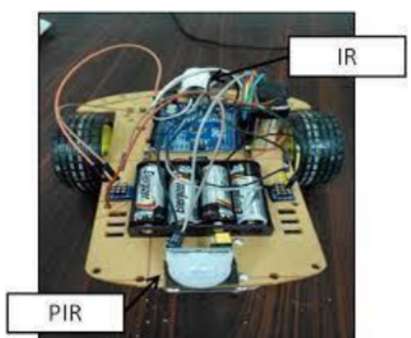


**Fig 2.1 - Prototype of obstacle avoiding robot using IR and PIR motion sensors [1]**

The obstacle-avoiding robot with IR and PIR motion sensors is a popular and effective system that utilizes both infrared (IR) and passive infrared (PIR) sensors to detect obstacles and avoid collisions. This literature review will provide an overview of the obstacle-avoiding robot with IR and PIR motion sensors, including its design, features, and limitations.

In conclusion, the obstacle-avoiding robot with IR and PIR motion sensors is a popular and effective system for obstacle avoidance in autonomous robots. Its low cost and simplicity make it accessible to hobbyists and enthusiasts, while its ability to navigate through a variety of environments makes it a useful tool for research and development. However, its limitations in range and the ability to detect certain types of obstacles should be taken into consideration when designing and implementing the system.

### 3. Obstacle avoidance robotic vehicle using ultrasonic sensor, android, and Bluetooth for obstacle detection

It was developed and designed by Vaghela et. Al. While designing object avoidance robotic vehicle various methodologies are analysed and reviewed along with their pros and cons. Ultrasonic sensors was used to design the robot that provide various features such as light weight, portability etc. it needs to acquire more focus in relevant areas of applications like home appliances, wheelchairs, artificial nurses, tabletop screens etc. in a collaborative manner. *[2]*

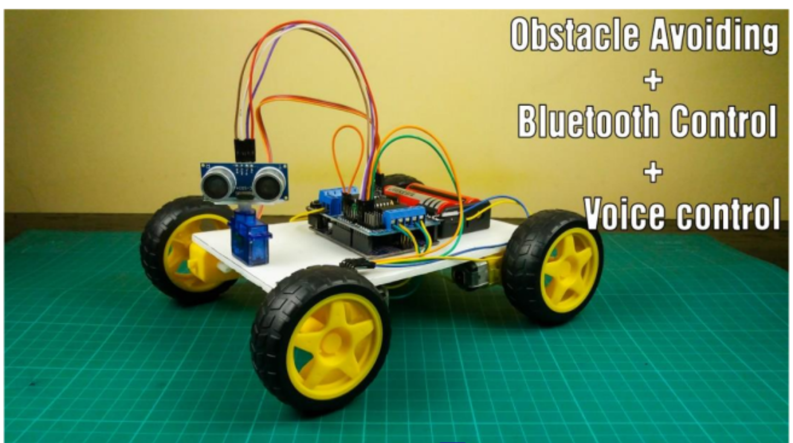


**Fig 2.2 - Prototype of obstacle avoiding robot using ultrasonic sensor, android and Bluetooth for obstacle detection [2]**

Several algorithms have been proposed in the literature for optimal path planning, and the real-time implementation of these algorithms has been investigated extensively. In this literature review, we will provide an overview of the various algorithms used in optimal path planning and their suitability for real-time implementation.

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