A Literature Survey On Obstacle Detection For Mobile Robots

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Abstract: Nowadays many industries are using robots due to their high level of performance, reliability, ability to navigate in a risky environments, huge work hours with accuracy which is a great help for human beings. The obstacle avoidance robots are capable of detecting obstacles and avoiding collision during navigation. For any mobile device such as robot, the ability to navigate in its environment is important because proper navigation enables the robot to achieve a desired task that it is designed for. Robot navigation might be necessary for either avoiding a path or following a path. The design of obstacle avoidance robot requires the integration of many sensors according to their task. The obstacle detection is primary requirement of this autonomous robot. The robot gets the information from surrounding area through mounted sensors on the robot. Some sensing devices used for obstacle detection like bump sensor, infrared sensor, ultrasonic sensor etc. Ultrasonic sensor based obstacle detection method has been discussed and analysed in this paper.
Keywords: *obstacle detection, obstacle avoidance, robot navigation.*

I INTRODUCTION

Obstacle detection is one of the ways of enhancing the visual mechanism of any robotic system. Obstacle detection is a primary requirement of any autonomous mobile robot. Obstacle detection and avoidance Robot is designed to allow robot to navigate in unknown environment by avoiding collisions. Obstacle avoiding robot senses obstacles on its path, avoid it and resumes its running. There are some very famous methods for obstacle detection robot. Some sensing devices used for obstacle detection like bump sensor, infrared sensor, camera, and ultrasonic sensor. A more general and commonly employed method for obstacle avoidance is based on ultrasonic sensing mechanism. The choice of the mechanism depends on the nature and effectiveness of the image required as well as the physical environment in which the detection is to be applied. The obstacle detector works on the principle of SONAR.

II REVIEWED LITERATURE

[1] Explained that varieties of sensors are available which can be used for the detection. In [2], the autonomous surface vehicle (ASV) developed by Heidarsson and Sukhatme in 2011 employed a single-beam mechanically scanning profiling sonar to detect obstacles under water. The profiling sonar has the ability to produce cone-shaped beam, which is ideal for detecting near surface obstacles. One of the objectives of their work was to investigate the suitability of using sonar near the water-air boundary for which the study found promising results.

THE ULTRASONIC SENSOR

The ultrasonic transducers is one of the sensors used for obstacle detection. The two major components of an ultrasonic ranging system are the transducer and the drive electronics. The drive electronics have two major categories - digital and analog. The digital electronics generate the ultrasonic frequency. The system requires an isolated power supply: 10-30 VDC, 0.5 amps. A drive frequency of 16 pluses at 52 kHz is used in this application. In the sonar ranging system, [4] a short acoustic pulse is first emitted from a transducer. The transducer then switches to the receiver mode where it waits for a specified amount of time before switching off. If a return echo is detected, the range R, can be found by multiplying the speed of sound by one half the time measured [4]. The time is halved since the time measured includes the time taken to strike the object, and then return to the receiver, where c is the speed of sound and t is the time in seconds. $R = \frac{ct}{2}$

The speed of sound, c, can be found by treating air as an ideal gas and using the equation, $c = \sqrt{nR_1T}\,m/s$

Where c is the speed of sound measured in m/s ,$n = 1.4$, T is absolute temperature measured in Kelvin. Substituting in the values, the equation reduces to: $c = 20\sqrt{T}\,m/s$

The speed of sound is thus proportional to the temperature. At room temperature (20°C, 68°F) the values are:

$c_m = 342m/s,\ c_f = 1126.3f/s$

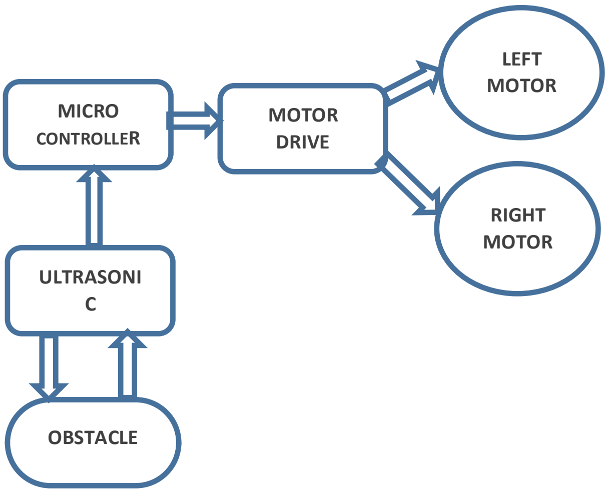

Fig. 1: Block diagram of the System

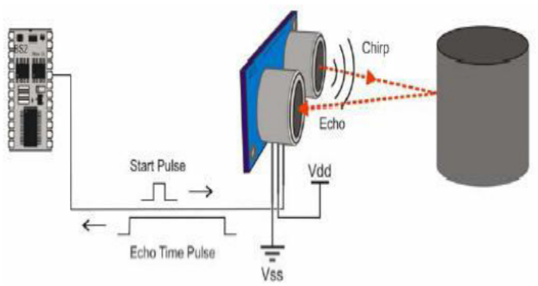

Fig 2: Schematic Diagram of the System

MICROCONTROLLER

The microcontroller serves as the main device used for automation in robot control. The output of the ultrasonic sensor is connected to the microcontroller so that the measured distance can be used to control the actuators based on the preset distance limit for detection and avoidance. The choice of the microcontroller depends on:

1. Cost effectiveness

2. The nature of the task requirement for the robot

3. Reliability and efficiency

OBSTACLE DETECTION METHODS

There are various obstacle detection techniques and sensors available for obstacle detection. Some of them are explained below.

CCD CAMERA

A CCD camera is a passive sensor that contains a charged-coupled device (CCD), which is a transistorized light sensor on an integrated circuit. A CCD device converts or manipulates an electrical signal into some kind of output, including digital values. In cameras, CCD enables them to take in visual information and convert it into an image or video. The digital nature of CCD Camera's output allows it to be used for obstacle detection in control system. When two cameras are used together, stereovision is accomplished. Stereovision gives us what we want most: range-to-target. Stereovision is used extensively for obstacle detection in numerous research projects. Chahl [5] used a single CCD camera in conjunction with a spherically shaped curved, reflector that enables ultra-wide angle imaging with no moving parts. Bischoff [6] used cameras to navigate a humanoid service robot indoors. Apostolopoulos [7] used cameras to aid in navigation and obstacle detection for a robot searching for meteorites on the Antarctic continent. However, CCD Camera has some drawbacks, which are: the need for good light, high computation cost and, its difficulty in differentiating a background from an obstacle.

ULTRASONIC SENSORS

Ultrasonic distance sensors generate high frequency sound waves and evaluate the echo, which is received back by the sensor, measuring the time interval between sending the signal and receiving the echo to determine the distance to an object. An ultrasonic transducer emits pulses at regular intervals, the interval being a function of the speed of travel. A receiver block listens to the echo. This application measures range in terms of physical distance and controls the speed of the motors with the help of duty cycle variation made possible through the output pulse from the microcontroller interfacing the electric motor. Sonar is the most widely used sensor for obstacle detection because it is cheap and simple to operate. Their use ranges from the robot hobbyist to the serious researcher. In [8] and [9] sonar is used in vehicle localization and navigation respectively. One of the drawbacks in the use of ultrasonic sensor for obstacle detection is the fact that one; a sensor can be used for a particular distance reading at a point in time. In other words, many sensors have to be used in an application where an efficient picture of the environment is needed. It also another drawback of frequent misleading due to ultrasonic noise of stray reflection from neighbouring sensors when multiple of the ultrasonic sensors are used together in the same project. More also, it is not suitable for detecting a very big obstacle as the ultrasonic signal will not be able to cover the whole obstacle during reflection due to a large incident angle between the incident ultrasonic signal and the normal to a large smooth obstacle. This can lead to the obstacle not detected at all or detected poorly making obstacle avoidance inaccurate. Despite its drawbacks, it is still very useful in outdoor obstacle avoidance, as it is not affected by light, dust or snow.

SCANNING LASER

Another type of detection sensor is a scanning laser. Scanning lasers use a laser beam reflected off a rotating mirror. The beam reflects off the mirror and out to a target and then is returned to the sensor for range calculations. Two main types of scanning lasers are used. The first emits a continuous beam and from the return of that beam range. Torrie used a laser of this type, provided by Acuity Research Inc., in a different CSOIS project [10].

The second type is a pulsed laser that sends out many laser pulses and averages the range data on each pulse to determine the range to an object. This type of laser is considered a class 3 and is better because it is eye safe. Scanning lasers give better results for range data with far less computational constraints compared to camera detection and the resolution is considerably better than ultrasonic sensors.

The scanning laser like other sensors has its own drawbacks. Among others, the most not notable is that the scans are planar, meaning to say that if an obstacle is above or below the scanning plane then nothing is detected. The sensors also suffer from rain, dust and blowing snow, causing false readings as noted by Foessel [11], who operated his robots in polar environments.

RADAR SENSORS

Radar sensors use Frequency Modulated Continuous Waves (FMCW) radar to detect stationary or moving objects. Lower frequency radars can see high dielectric objects very well including cars even in extreme weather conditions where snow, dust may be present. Higher frequency radar can see a wider array of objects making it more robust than the ultrasonic sensor in most applications. Radar sensors use radio waves for detection.

Table 1: Comparism Of The Sensors

	Weather	**Light**	**Response time**	**Detection distance**
CCD Camera	Not suitable for dust or snow period	Not suitable in dark environment	It depends on the image processing speed of the computer	It has detection distance of about 15m and above
Ultrasonic sensor	Suitable for dust or snow period	Suitable for dark environment	It has a fast response time	It has a maximum detection distance of 5m
Scanning laser	Not suitable for dust or snow period	Not Suitable for dark environment	3D laser and 2D laser have 80s and 17ms to 1s respectively	It has detection distance of up to 15m and above
Radar sensor	Suitable for dust or snow period	Suitable for dark environment	It has a fast response time	It has detection distance of up to 15m and above

MOTOR DRIVE

Motor Driver ICs are primarily used in autonomous robotics only. Also **most** microcontrollers operate at low voltages and require a small amount of current to operate while the motors require a relatively higher voltages and current. Thus current cannot be supplied to the motors from the microcontroller except a motor drive is interfaced with it. This is the primary need for the motor driver IC.

DC MOTORS

The actual mechanical motion of the robot is achieved by the output of the microcontroller. Drive motor selection for use in robotics is a serious consideration and DC motors have certain capabilities that make them a desirable choice. A DC motor converts direct current electrical energy into mechanical energy. This differs from an AC motor, which applies alternating current to the electric motor. At the most basic level, DC motors work well in robotics because they allow the robot to be battery powered, which offers great advantages for a variety of robotic applications, particularly mobile and collaborative robots.

III EXPECTED RESULTS

1. To design an obstacle detection mechanism in a sampled environment using ultrasonic sensors as the detection device capable of detecting obstacles like bumps, stone, and is achieved by adjusting the linear speed and angular speed of the motors.
2. A prototype of the design is constructed that measures the detection of an obstacle that is 2m away from the robot.
3. To enable effective robot navigation in a new environment without a prior knowledge of the positions and distances of the obstacles from the robot.

IV CONCLUSION

A survey of the different obstacle detection techniques have been made. In this survey, the advantages and the drawbacks of the various obstacle detection methods have been compared. More also, a detailed explanation of the ultrasonic distance sensors from which we would be able to find the distance of the obstacle like potholes or humps and control robot's navigation in an obstacle prone environment so that the robot can carry out a desired task without any collision with such obstacles have been discussed.

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