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Article

Multi Sensor Fusion Techniques to Acquire Obstacle Avoidance Behaviors for Differential Autonomous Mobile Robot

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A B S T R A C T

Obstacle Detection is the method to find the presence of obstacles, which are in between the path of the robot and the goal location. For obstacle detection many sensors are used. Sensors are the devices which are used for sensing various parameters. In this article different fusion techniques are discussed to acquire the obstacle avoidance behaviors for differential autonomous mobile robot.

Keywords Multi-Sensor Fusion Techniques, Obstacle Avoidance, Autonomous Mobile Robot, Digital Camera, Single Camera Method, Vision Systems

Introduction

Sensors are the devices which are used for sensing different parameters. The below mention are the sensors can detect the wave or the light reflected from an object hence can be used in obstacle avoidance behaviors for differential autonomous mobile robot.

These sensors are as follows

Sensor

- Infrared Sensors (IR)
- Ultrasonic sensors
- Laser range finders
- Common RADAR (Radio Detection and Ranging)

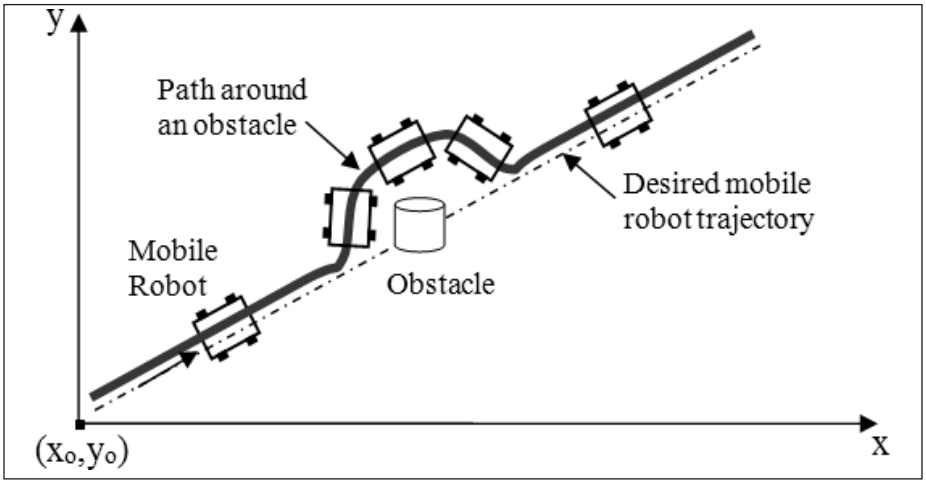

Figure 1.Obstacle Avoidance Behaviors for Autonomous Mobile Robot

- Microwave based radar etc.

Image sensors (Vision system)

- CCD camera
- CMOS camera

Combination of different sensors

- Two Cameras (Stereo vision)
- More than one ultrasonic sensors
- Combination of ultrasonic and IR sensors
- Combination of Camera and ultrasonic sensors
- Combination of Camera and IR sensors
- Combination of Camera and Laser etc.

Infrared (IR) Sensors

Infrared radiation is the bit of Electromagnetic Spectrum. Infrared is imperceptible to natural eyes. Infrared light locale is 0.75 to 1000 µm. Infrared frequency is more prominent than Visible light frequency how ever not exactly the Microwaves frequency. IR sensors have the Infrared radiation. IR sensors distinguish the item comes before its line of way.

This sensor consists and infrared transmitter and an infrared detector. The IR transmitter continuously transmits the light, when an object comes in its path the light is reflected to the IR detector which detects the object.

Depending on the region of IR, they are classified as

Near IR

- These IR has 0.75 to 3 µm region
- These IR are not good for fog conditions

Mid IR

- These IR has 3 to 6 has µm region

Far IR

- These IR has region higher than 6 µm
- These IR has enhanced visibility in fog and heavy rain condition

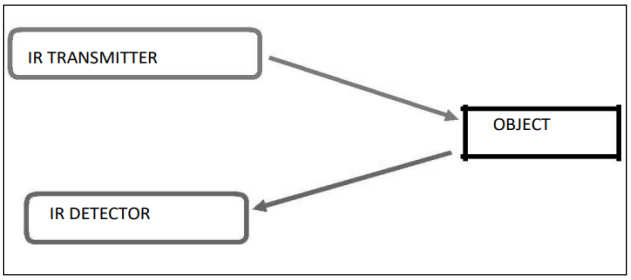

Figure 2.IR Sensor Block Diagram

Advantages of IR Sensors

- It has low power requirements
- It has simple circuitry
- They are small, which is best for robots

Disadvantages of IR Sensors

- They require line of sight
- They had short range
- Transmission is affected by direct sunlight, rain, fog, dust, pollution
- Distance measurement is not possible through these types of sensors

Ultrasonic Sensors

Ultrasonic sensors generate the high frequency sound waves. They are able to both send and receive the sound waves. These sensors calculate the time interval between sending the signal and receiving of the echo by the sensor, to determine the distance to an object.

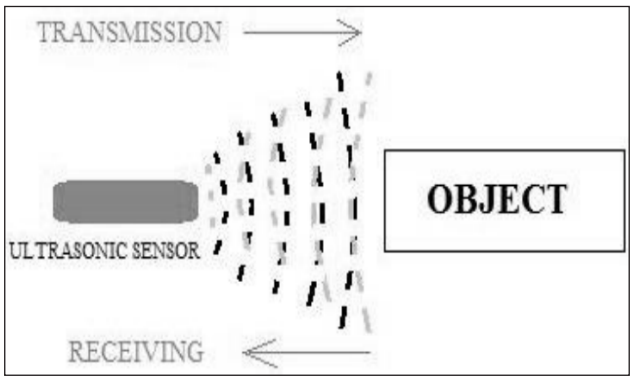

Figure 3.Ultrasonic Sensor block diagram

Advantages of Ultrasonic Sensors

- They can easily detect the distances to static and moving objects
- They are less affected by object color, material, surfaces
- They are resistant to external disturbances like vibrations, noise, infrared radiation etc.

Disadvantages of Ultrasonic Sensors

- They are not able to find the size of the obstacle either it is small or large
- Environment changes like temperature, pressure, humidity etc. affects the ultrasonic response
- Objects of low density like foam, cloths etc. are able to absorb the sound energy, so these materials may be difficult to sense at long range

Digital Camera

Digital Cameras have the image sensors which capture the light and record everything in the form of pixels. The image sensors are of two types:

- CCD (Charge-Coupled Device)
- CMOS (Complementary Metal Oxide Semiconductor)

CCD and CMOS both convert the light into electrons. They have a 2 D array of thousands or millions of tiny solar cells, each of which transforms the light from one small portion

of the image into electrons. Both CCD and CMOS devices perform this task using a variety of technologies. CCD sensors create higher-quality, low noise and more pixels images. They consume as much as 100 times more power than an equivalent CMOS sensor.

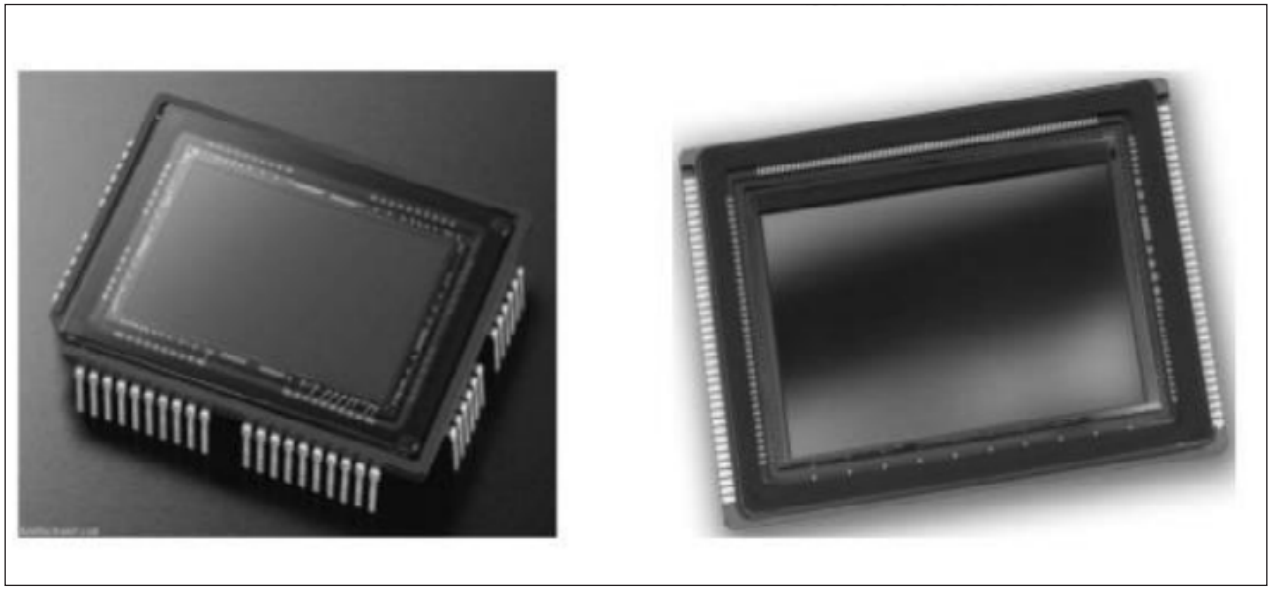

Figure 4.Types of Image Sensors

These sorts of sensors are costly. CCDs utilized in cameras that attention on great pictures with heaps of pixels and astounding light affectability. CMOS sensor are more powerless to clamor. Every pixel on a CMOS sensor has a few semiconductors situated close to it, so the light affectability of a CMOS chip is lower. They burn-through little force.

CMOS are inexpensive compared to CCD sensors. These sensors have reduced value, reduce resolution and reduce sensitivity. CMOS cameras have great battery life. Digital cameras can judge the distances to objects. These sensors provide a lot more information. But the disadvantage is that the computer needs longer time to process the extra information.

Single Camera Method

This article uses single color camera for Object Detection. This algorithm undertakes three theories. They are:

- Obstacle differs in appearance from the ground
- The ground is relatively flat
- There are no overhanging obstacles

Algorithm steps followed in this article are

- Perform noise removal on input image using 5*5 mean filter
- Take reference region area and computes its HSV histogram
- Back projection
- Find pixels that are most likely to be part of obstacle
- Threshold image after getting from back projection to obtain binary obstacle
- Find connected components in the image

Combination of Multiple Sensors

In the third section, this article describes the obstacle detection using TSOP1738 Infrared sensors (2 LEDs and 2 Detectors one on left and another on right). Mounted LEDs in forward direction and as position of detectors is important so mount them as far as possible and tilt them slightly away from LED.

In the fourth section, this article also describes obstacle detection and avoidance using array of 5 Ultrasonic and 4 Infrared sensors, spacing 30 degrees with each other are used to expand scope of robot detection. Back Propagation neural network is used to fuse information of multi sensors for obstacle detection and fuzzy control technology is used for obstacle avoidance.

In the fifth section, the article aims to trace the escape route by avoiding the obstacles. The robot applies the obstacle detection and avoidance by using 2 Ultrasonic transducers one placed in front and another placed behind the robot and 2 infrared transducers placed in left and right of the robot, on an EyeBot board which process the signals generated by the transducers. This configuration also helps the robot to generate escape routes. Detection range of Ultrasonic and infrared transducers are 5cm to 3m and some centimeters. They are provided with 2 Servomotors. They use the C Language for coding in the EyeBot board. This system not only detects distance but also allows obtaining a measurement of the distance to the object found.

In the first section of the article, Ultrasonic sensor and a USB Camera are used. Maximum measuring distance of Ultrasonic sensor is 600 mm. Image resolution of camera is set to 320x240 pixels. These 2 devices are used to get the 3 D information of an obstacle. Using image processing the image is converted into the gray scale image and then converted into the binary image. The height and width of obstacle in real world is measured by both devices. Then it uses the Perspective method concept for calculating obstacle depth. There are 3 cases to calculate the obstacle 3 D size if the obstacle is assumed to be rectangular in shape.

- Case of one surface detection
- Case of two surfaces detection
- Case of three surfaces detection

In all the three cases, the width and height of obstacle varies.

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