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Obstacle Detection And Object Size Measurement For Autonomous Mobile Robot Using Sensor

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Abstract - *Sensors of different types are often fused to acquire information which cannot be acquired by a one sensor. Sensor fusion is applicable for mobile robots for object detection and navigation. The techniques is been developed so far for detecting an obstacle are costly. A new technique is use to detect an obstacle, judge its distance and measure the size of the obstacle using one camera, raspberry pi, motor, display and one ultrasonic sensor. The technique is cheap in terms of computational cost and in terms of sensors cost.*

Key Words*: *ultrasonic sensor, autonomous mobile robot, obstacle detection, navigation, camera, raspberry pi

1. INTRODUCTION

Different sensors such as sound sensor, vision sensor, temperature sensor etc. allows the extraction of information which cannot be acquired by a single sensor. The different type of sensors work differently and they have their weaknesses and strength. One sensor cannot provide all the necessary information. Sensor combines the strength of different sensor to overcome the drawbacks of the other. [1, 2].

For an autonomous mobile robot,the sensor is important to perceive its environment. Without knowing the surroundings it is not possible to navigate around. An the autonomous robot moves unsupervised. It obtains information of the surrounding environments using its sensors and decides its course of action according to its the programming without any external help. If the information provided is a inaccurate or incomplete, it becomes hard for the robot to decide its next action. Information from the one sensor alone is not enough to give accurate information. A food may be look good but without the sense of a smell and the taste it cannot be determined whether the food is a still edible or not. So our task is to fuse the some sensors for the purpose of object detection and size measurement which is cost effective.

Robotics is a leading branch of engineering which is demands knowledge of hardware, sensors, actuators and programming. The result is a system which can be made to do a lot of different things. However, to develop such a system is expensive and difficult. So, we have come up with a plan to build an autonomous mobile robot which is less expensive. There are many works had done for object detection. Those robots are efficient in the purpose of accuracy. But they are very costly. So we move in a direction where we can have a robot that is a cost effective and the good enough in its accuracy.

1.1 Robot Navigation and Sensor Fusion

Robot navigation algorithms are classified as global or local, depending on surrounding environment. In global navigation, the environment surrounding the robot is known and the path which avoids the obstacle is selected. In local navigation, the environment surrounding the robot is unknown, and sensors are used to detect the obstacles and avoid collision. [3]

2. RELATED WORKS

The goal of this program is to drive High Mobility Multipurpose Wheeled Vehicle autonomously on the road. The abilities of this program are to drive autonomously with 10mph, detect obstacles on the road and avoid them, overall data collection for the goal.

In local environment, the robot does not know about the surrounding environment aside from its sensor readings. It has to relay on it sensor for information about its location. Since a single sensor is not capable of doing the task, sensor fusion rises in importance. Information from different sensors are obtained and combined to find the location of the robot, detect obstacle and avoid it.

There are many different types of sensors available such as, infra-red sensors, ultrasonic sonar sensors,motor driver etc. For obstacle detection and avoidance many of the above sensors can be used to generate a map of the local environment. Obstacle detection can be classified into two types:

- Ranged-based obstacle detection.
- Appearance-based obstacle detection.

In ranged-based obstacle detection, sensors scan the area and detect any obstacle within the range and the sensors also try and calculate the range between the robot and the obstacle. In appearance based obstacle detection, the physical appearance of the obstacle is detected from the environment, usually by image processing [10]. In this paper we propose the combination of both ranged-based and appearance-based obstacle detection technique to measure obstacle size and distance from the autonomous robot.

3. PROPOSED SYSTEM

We propose a sensor fusion technique which is less costly both in terms of economically and computationally, that will allow an autonomous robot to detect an obstacle, find the distance and also measure the size of the obstacle. Our system uses a camera,raspberry pi,display,motor and an ultrasonic transceiver device to achieve this. We use the range data collected by the ultrasonic sensor with the image captured by the camera for object detection and object size measurement. Figure 1 below is the block diagram of the proposed system.

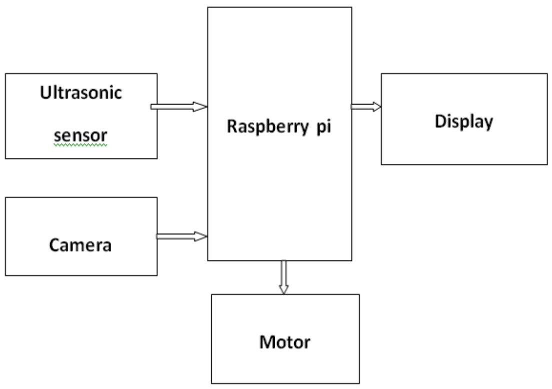

Figure 1: Schematic diagram of the proposed system

Human eye have a fixed angle of vision i.e. the lateral range of area, covered by the eye is limited to a fixed angle. The same is true for the camera. The field of view for a camera is also fixed. Everything the camera sees is squeezed into the image. Although the image has a fixed resolution, the size of an object in the image varies with respect to distance from the camera as well as with respect to the size of the object itself in real life. If the object is placed at two different distances from the camera in two different images, the appearance of the object in the image, where the distance between the object and the camera is less, is larger. If there are two objects of different sizes at the same distance, in the image it would appear that the larger object seems larger in the image. This geometric similarity is used to find the size of an object.

3.1 Object Detection: Using Ultrasonic Sensor

Using an ultrasonic sensor we can easily detect of presence of an object. Our robot will follow the technique of bat to detect obstacle in its path. The ultrasonic sensor will always release ultrasonic wave. If the wave collides with an obstacle in front of the robot, the wave will bounce back to the sensor. If the receiver receives this reflected wave then we can be sure that there is an obstacle in front of the robot. The time difference between the transmission of the ultrasonic wave and the reception of the reflected wave is calculated. Since we know the speed of the sound wave we can calculate the distance of the obstacle.

Distance = speed x time … … … (1)

3.2 Object size measurement

This is done in two parts. The first part consists of taking visual information of the object. We are using a camera to take images and we would use various image processing techniques to extract the object from the image. The second part consists of taking the range information of the object. We are using an ultrasonic sensor for this job.

For a fixed field of view in figure 2, the horizontal and vertical distance the camera can see is constant at a particular distance. If the angle of vision is known, then we can find the area if we know the distance.

x = distance between camera and object.

h = horizontal viewing length on a 2D plane perpendicular to *x*.

theta = horizontal field of view

h=2x tan(theta/2)… … … (2)

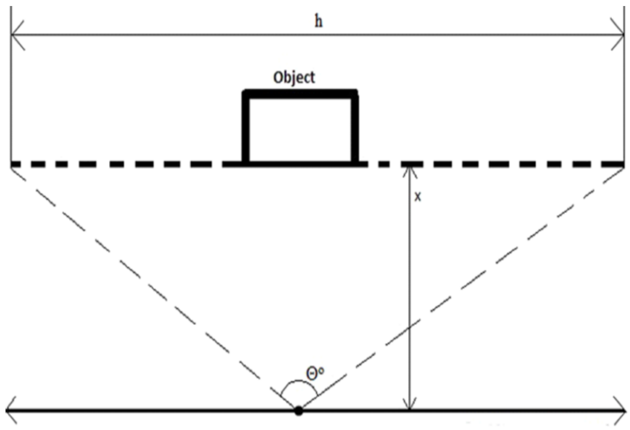

Figure 2: Field of view

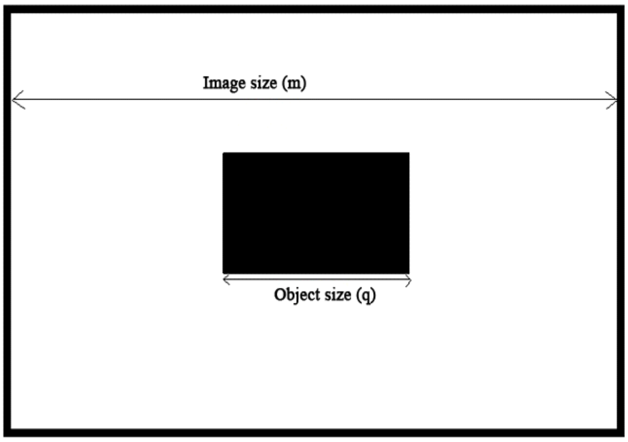

Figure 3: The image captured by the camera

This distance h is squeezed into the image. If the image is m x n pixels in size, m is the horizontal pixels and n is the vertical pixels. The camera can horizontally see as far h in reality. In the image h is represented as m as shown in figure 3.
If an object is present at distance x, and the horizontal length of the object is p in real life, in the image it takes up q pixels. As because, there exist a geometric similarity between the image and the real life scene, the ratio of object length in the image is equivalent to image length. Since we can calculate the values of q, m, h we can also calculate the value of p. If,
q = object length in image
m = image length

p = is the object length in real life, and
h = is the horizontal distance
then, q/m=p/h hence, p=hq/m
For vertical measurements, we use the same procedure with different values; the angle of vision becomes (alpha, α). The equation for vertical distance is:
v=2x tan(alpha/2)… … … … (3)
The similarity equation becomes:
s/n=t/v… … … (4)
Where s is the vertical height of the object image in terms of pixel and t is the vertical length of the object in real life.

4. HARDWARE REQUIREMENTS

4.1 The Camera

The camera can be a standard web cam of any resolution. However, it is preferred that the resolution is not too great, since a larger size of image would require more computation power.
In our experiment we have used a Canon 550D camera to take image and used PYTHON for processing of that image.
In PYTHON we have taken the image as input; we have converted the colour image to grayscale image for computational simplicity. Grayscale is an image in which the value of each pixel carries only intensity information. Images of this sort are composed exclusively of shades of gray, varying from black at the weakest intensity to white at the strongest [14]. After conversion to gray scale we have performed thresholding on the image to separate the object from the back ground. Thresholding is a simple method of segmentation. Thresholding can be used to convert grayscale images to binary images [15]. Following the thresholding, we perform opening and closing on the image to eliminate all noises from the image.
The term opening means to perform erosion followed by dilation on the image and closing is dilation performed before erosion. Opening removes small objects from the foreground of an image, placing them in the background, while closing removes small holes in the foreground. [16]
After isolating the object in the image we measure the dimensions of the object in the image. The horizontal length of the object is found by the equation:
P=hq/m… … … (5)
The vertical height of the object is found by the equation:
T=vs/n… … … (6)

4.2 The Ultrasonic Sensor

The ultrasonic sensor has the following features:

- Electrical Parameters- HC-SR04 Ultrasonic Module
- Operating Voltage- DC-5V
- Operating Current- 15mA
- Operating Frequency- 40KHZ
- Farthest Range- 4m
- Nearest Range- 2cm
- Measuring Angle -15 Degree
- Input Trigger Signal -10us TTL pulse
- Output Echo Signal- Output TTL level signal, proportional

with range

- Dimensions-45*20*15mm

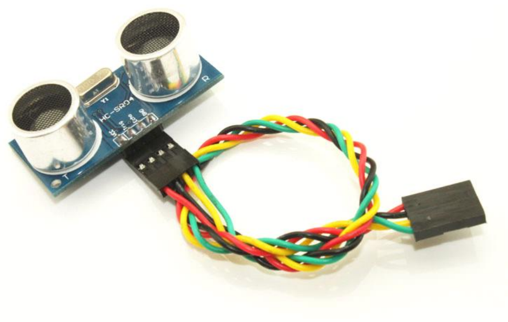

Figure 4: HC-SR04 Ultrasonic sensor

Set low the Trig and Echo port when the module initializes , firstly, transmit
at least 10us high level pulse to the Trig pin (module automatically sends eight
40K square wave), and then wait to capture the rising edge output by echo port,
at the same time, open the timer to start timing. Next, once again capture the
falling edge output by echo port, at the same time, read the time of the counter,

which is the ultrasonic running time in the air. According to the formula: test
distance = (high level time * ultrasonic spreading velocity in air) / 2, you can
calculate the distance to the obstacle [17].

4.2 Raspberry pi Model B

The Raspberry Pi® is a single-board computer developed in the UK by the Raspberry Pi Foundation with the intention of stimulating the teaching of basic computer science in schools. The Raspberry Pi is a credit-card sized computer that plugs into your TV and a keyboard. It's a capable little PC which can be used for many of the things that your desktop PC does, like spreadsheets, word-processing and games. It also plays high-definition video. The design is based around a Broadcom BCM2835 SoC, which includes an ARM1176JZF-S 700 MHz processor, VideoCore IV GPU, and 512 Megabytes of RAM. The design does not include a built-in hard disk or solid-state drive, instead relying on an SD card for booting and long-term storage. This board is intended to run Linux kernel based operating systems.
As typical of modern computers, generic USB keyboards and mice are compatible with the Raspberry Pi. The Raspberry Pi use Linux-kernel based operating systems. The Raspberry Pi does not come with a real-time clock, so an OS must use a network time server, or ask the user for time information at boot time to get access to time and date info for file time and date stamping. However a real time clock (such as the DS1307) with battery backup can be easily added via the I2C interface.

5. CONCLUSION

The error in length and width is the influence of several factors, the error in calculating the distance is a key factor, and also the distortion of the lens plays a key role in determining the size of the object. Some information about the object might have been lost when applying different image processing techniques. Regardless, the error percentage is small enough to be acceptable.

6. FUTURE WORK

The future prospect of the project includes improving the accuracy of the system. We will use more efficient image processing techniques and algorithms to reduce the computational complexity and to detect and measure the size of an object more accurately. Different algorithms will allow us to work on color image domain, we would be able detect, identify and track objects better.
We can introduce machine learning, so that the robot can learn by itself and navigate around without colliding with obstacles. The robot will learn to identify obstacles and objects.

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