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Obstacle Detection Using Ultrasonic Sensor For Amphibious Surveillance Robot

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Abstract: *Obstacle detection is highly significant in remotely operated surveillance devices. In the proposed paper a sensing system using ultrasonic sensor is developed for obstacle detection in an amphibious robot. The sensor used is JSN-SR04T. Using this sensor the device can detect the obstacles in the path for both land and water areas. This sensor is a different version of the conventional and widely used HC-SR04 ultrasonic sensor. It follows the same principle as the orthodox ultrasonic sensor. It can detect any object up to a range of 2-4 meters which is highly effective for a small scale underwater drone. The proposed model is controlled by a Raspberry Pi 3 module. It has been designed for static and dynamic obstacle detection.*

Keywords – *Surveillance, Navigation, Ultrasonic sensor, ROV, Amphibious, Obstacle detection.*

I. Introduction

Sensor is a module or a mechanical device that can sense the slightest fluctuations in its surrounding environment and send the information to other devices. A sensor is always used with other electronic devices, whether as elementary as a light or as advanced as a computer. Sensors are seen in everyday objects like elevator buttons (tactile sensor) and lamps which fade or glow when touching the base, besides innumerable applications of which most people are never aware.[1] Due to the rapid strides made in easy-to-use microcontroller platforms, the applications of sensors have increased way beyond the conventional pressure or temperature measurement.

In this project the emphasis is on the amphibious surveillance device. This model is expected to survey and continuously monitor the aquatic and terrestrial environments. To ensure proper navigation and surveillance obstacle detection is a must. To detection any obstacle, a simple ultrasonic sensor can be used. This sensor works on the principle of SONAR. Any ultrasonic sensor would have suited this purpose however, for underwater detection; there is a requirement of a different, robust sensor.[2] In this paper we have introduced this idea of using a JSN-SR04T sensor for the amphibious detection of any hurdles.

This is a range based system. For a range of 2-4 meters, detection can be done. Beyond that nothing is observed. For system to be more robust, we can use more advanced sensors that can detect anything up to 15-20 meters. The idea is to inform the device, about any object nearby so that the robot can change its direction of navigation. The ultrasonic sensors are preferred because they provide a method of detection which can work even in difficult conditions. This is because; the sound waves get reflected almost in all conditions with a few exceptions. This is the major reason why ultrasonic sensors are preferred for many military and industrial applications.[3] Ultrasonic sensors are also widely used for depth measurement and they provide a high amount of precision.

II. Need For Sensors In Monitoring And Surveillance

With the implementation of various surveillance and monitoring devices for multipurpose applications, sensors are becoming a key element in these projects. Sensors provide the aid in navigation and also for data accumulation. For applications such as geographical or a physiological survey of any area, drones are being implemented.[4] These drones possess sensors which are highly accurate and can record even the minutest changes. Sensors are becoming a key element in the various autonomous and semi-autonomous vehicles developed for a myriad range of purposes. Ultrasonic waves have a frequency which is not audible for the human ear. They have a frequency of more than a 20 KHz.[5] The utilization of sound waves instead of light waves ensures that they can function in the presence of uneven surfaces, liquids, clear objects and dusty environment.[6] They can be easily fit into electronic devices are compatible for most devices. Also they do not distort the functioning of any electronic device and are highly directional in nature. This makes them really useful and versatile for a multiple applications.

Ultrasonic sensors are expected to play a major role in the automobile industry to ensure the safe navigation of the vehicles and to prevent the number of accidents. This underlines the growing importance of ultrasonic sensors for navigation and obstacle detection purposes. Various surveillance and monitoring drones

are mandatorily including the sensors due to their reliability and flexibility.[7] Programmable sensors are developed to suit the requirements of the devices. They can be modified and adapted as per the suitable system compatibilities and limitations.

III. Ultrasonic Sensor

The ultrasonic sensor used in this model is similar to HC SR04 ultrasonic sensor. The transmitter terminal sends 8 bursts of directional 40 KHz ultrasonic wave. The timer turns on when the sound waves are transmitted. The transmitted pulses keep on travelling till they encounter any object. Obstacle causes the sound wave to get reflected to the receiver. This is called as the echo. The ultrasonic receiver would detect the reflected wave and stop the timer.[8] The velocity of the sound waves is 340m/sec. in air. The formula to calculate the distance from the obstacle is expressed as:

$D = (V \times T)/2$

Where D is the distance covered by the sound wave from the transmitter back to the receiver. V is the speed of sound wave which is known to us. T is the time taken by the wave to travel the distance D. We divide the value of (VxT) by 2, because the waves get reflected. The entire process can be seen the figure below.

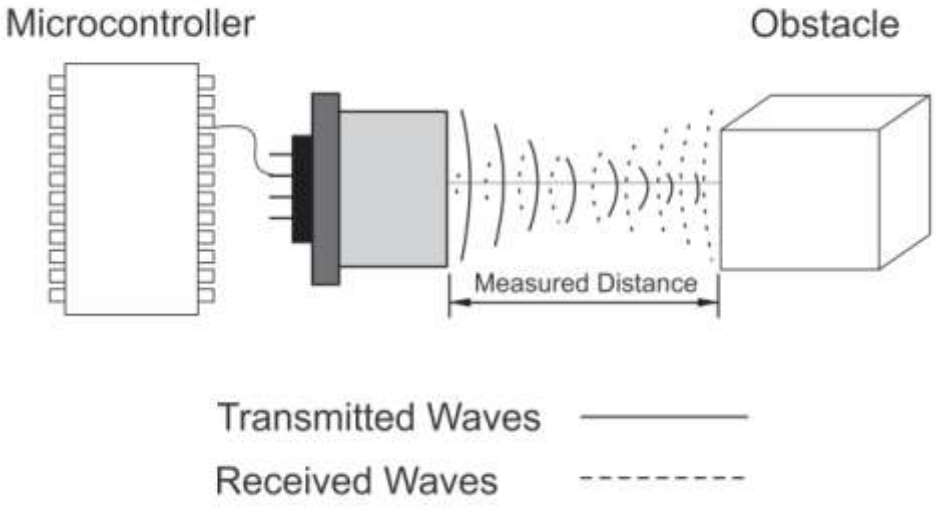

Fig. 1 working of an ultrasonic sensor JSN-SR04T

The microcontroller is the Raspberry Pi 3 in this model. Sensory data is received by the Raspberry Pi. We can see the data stream in the Raspberry terminal. We have used JSN-SR04T for this model. It is similar to the generic ultrasonic sensors; however it can be used for underwater as well. This is a feature which is very vital for submersible systems. The sensor used in this model is expected to function underwater without any kind of a lag or delay.[9] The JSN-SR04T module gives us the value of the nearest distance. Also it has a detection range of 25cm to 450 cm. If the obstacle is out of range then the value 0 is received. Also if the object is closer than 20cm, then garbage values are received. This garbage values are to be ignored.[10]

The module has 4 pins. 2 pins for voltage supply and ground. It requires 3.5 V for operation. There is a Trigger pin for the Receiver terminal. Another pin for the Echo at the transmitter terminal. The sound wave is transmitted at the Echo terminal. The received wave is received at the Trigger terminal. Module transmits 8 pulses of 40 KHz.

A linear ultrasonic pulse is transmitted at time 0, which gets reflected by the object. The signal is received by the sensor and converted to electric signal. After the echo fades, the next pulse is transmitted. The time period is called is the cycle period. The general recommended cycle period is 50ms.[11] When no obstacle is present, the output pin will provide a 38ms high level signal.

IV. Conceptual Design

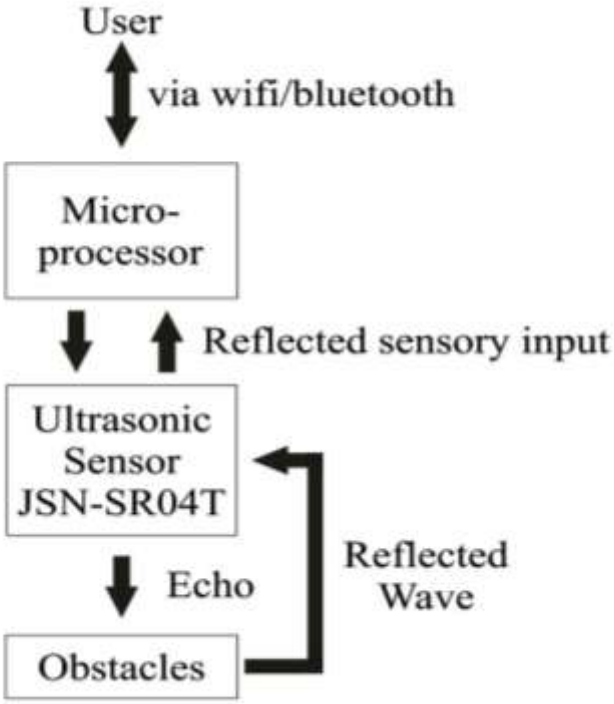

Fig. 2 Block diagram of obstacle detection using an ultrasonic sensor JSN-SR04T

This is the conceptual design of the obstacle detection system to be used in the amphibious surveillance device. User can send commands to the system by using android applications or any computer. At the user's end a window will be displayed which shows all the sensory input values taken by the sensor. Even garbage values having a negative sign or absurdly large values are displayed when the object is outside the range or when it is too close to the sensor. The user sends the command to the sensor to get started. Any kind of a microprocessor can be used for the command and control of the sensor module.[12] But the compatibility must be verified before selecting the kind of microprocessor to be used. If the microprocessor like arduino is used then an extra Bluetooth or a Wifi module must be connected to the processor to transmit the commands wirelessly.

Once the sensor is ON it shoots the echo pulses after certain fixed time intervals. The sound waves get reflected and the trigger pin gets the input. This is nothing but the sensory input provided by the sensor. The sensory input is visible on the window at the user end.[13] This window displays all the serial values of the distance that is measured in real time. It allows the user to know how far the obstacle is. To protect and steer the device from the obstacle, we can change the direction of the device as soon as we know that the obstacle is too close.[14] This is how obstacle detection is expected to help this amphibious device in navigation.

Since sound waves are used, this conceptual design can be applicable in various conditions. Sensory module used in this design has been chosen specifically because it is waterproof and can sustain a certain amount of pressure underwater.[15] The module to be used, can be varied as per requirements. For the programming of the microprocessor, we need C programming.[16][17] The Echo value is taken as the input variable and the Trigger value is the variable input. The programming on different platforms is done using different languages. For Raspberry Pi python is used. However the variables and the setup of the programs is generally the same. Delay of the system can be set or altered in the program itself. Distance values to be displayed can be in centimeters or inches, by making the required changes in the program.[18]

V. Advantages

This is a conceptual model .Hence it is not equipped for high end applications. The model has been designed amphibious surroundings for a shorter range of a few meters. Its advantages are as follows-

1. Low cost.
2. Software compatibility.
3. Compact design.

VI. Results

Fig. 3 The set up for obstacle detection.

In this setup we have placed an obstacle in front of the ultrasonic sensor. The sensor is connected to the Arduino microprocessor. The program is uploaded in the processor. As we vary the position of the obstacle, values of distance measured vary. If detected value is less than the minimum range value, then we get garbage values in the output window. In Fig. 4, values shown are the measured by varying the obstacle distance from the sensor. In the next figure, we have brought the obstacle distance to less than 15 cm. This gives us garbage values as shown in the figure.

Fig. 4: Obstacle distance value measured by varying the distance.

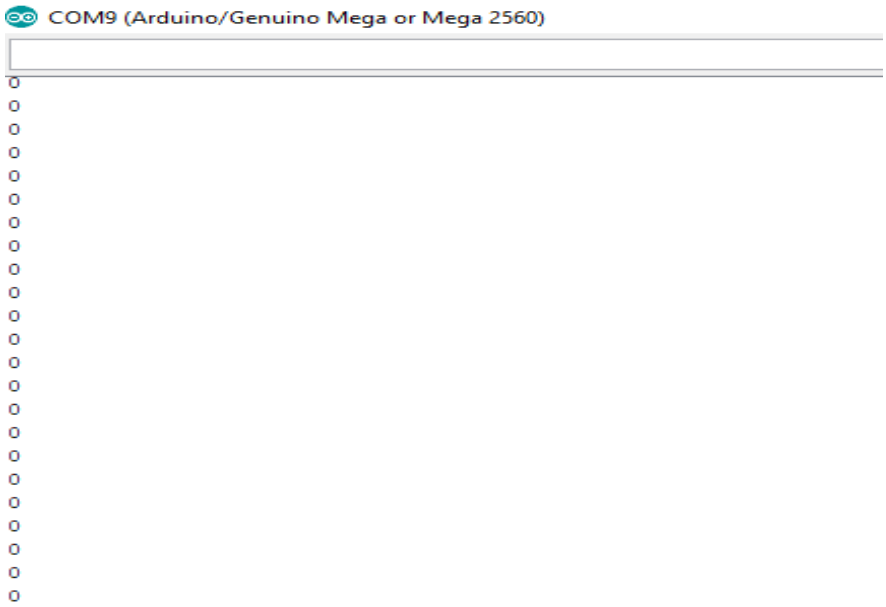

Fig. 5: When the obstacle is closer than 15 cm or less, garbage values are detected.

VII. Conclusion

In the proposed paper, we have used JSN-SR04T sensor module for obstacle detection. It is waterproof and can be used for submersible purposes. It has an advantage over standard HC-SR04 ultrasonic sensor which is not waterproof and has a limited range of 2 cm to 400 cm. Any object that falls within the sensor range is effectively detected by this model. If the object distance is less than minimum range value then a garbage value gets displayed on the output window. If the object is out of the sensor's range, then it is not detected. This sensing system is suitable for underwater sensing models.

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