Design and Development of an Advanced Multi-Dimensional Ultrasonic Sensor with Enhanced Precision

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Abstract – *A multidimensional ultrasonic sensor can be used in all applications where the generic ultrasonic sensors are used. The enhanced ultrasonic sensor not only returns the time difference between the transmitted and the received wave but also is capable of reconstructing the obstacle in the surroundings. This sensor is an array of ultrasonic sensors operating in different frequencies with help in predicting the obstacle in the specific direction. The view of the reconstructed image in that very instance helps to take further actions or ignore or dodge the obstacle and it colour mapping the reconstructed image of the obstacle identifies the motion of the obstacle either towards or away from the sensor.*

Key Words**: Ultrasonic sensor, Obstacle, Multi-dimensional, Frequency, Band pass filter, Transmitter, Receiver, Greyscale.**

1. INTRODUCTION

Ultrasonic sensors which transmit ultrasounds in the frequency range of 20 kHz to 200 MHz are used to calculate the distance between the transmitter and the obstacle in the scope of the sensor. In the ultrasonic frequency spectrum, the frequency range from 20 KHz to 2 MHz is used for medical and destructive purpose while the frequency spectrum from 2MHz to 200MHz is used for diagnostics and NDE (Non-Destructive Evaluation).The generic ultrasonic sensor detects the obstacle within its narrow scope. In case if the obstacle is behind the sensor, it fails to detect the obstacle. So we cannot get the complete picture of the surroundings. Design and development of a sensor capable enough to detect obstacles around it in any axis or direction are important.

This enhanced ultra-sonic sensor not only calculates the distance but tries to get the shape of the object so that the operator can recognise the obstacle and take necessary actions.

2. Proposed Work

The spherical design of the sensor helps to embed more trans-receivers on the surface of the sensor. Each trans-receiver on the surface of the sphere transmits the ultrasonic signal of different frequency simultaneously. As soon as the obstacle is hit, the emitted ultrasonic signal is reflected towards the trans-receiver.

2.1 Working Principle

The generic ultrasonic sensor emits a signal in the ultrasonic range and when the signal hits an obstacle it reflects back towards the receiver. The difference in time between the transmitted signal and the received signal is used to calculate the distance of the obstacle.

The receiver of each sensor has a band-pass filter receiving only the particular band of frequency emitted by its transmitter. So that there no possibility of any false reading within a collection of the trans-receivers. The reflecting waves can also be a result of small obstacles which should be neglected or the result of the flash effect is handled by comparing the data with the neighbouring values. [3] A Gaussian-shaped bandpass filter with appropriate bandwidth and centre frequency located in the lower part of the passband of the received signal spectrum can extract the flaw information.[2]On the other hand, a bandpass filter centre+-d at the upper-end of the received signal will retain mainly grain noise and hence reduce the detectability of the signal. [2]

The bandpass filter is designed using the formula

f = 1/(2*pi*R*C), where f is the frequency,
R is the resistance,
and C is the capacitance of the filter.

The sensor's data is read as an array and the data in each index represents one of the trans-receivers mounted on the surface of the sensor. Each data in the array is mapped to a grayscale value between intensity 0 to 255(RGB colour scheme) based on the distance between the obstacle and the trans-receiver. The closer the obstacle lower the intensity value. Finally, to extract the shape of the obstacle the array is rearranged as a matrix.

The ultrasonic sensor results approximately similar results with an exemption of rippled cloth with have low negative correlation compared to wood, paper, plastic and metal. [1]

Table -1: Multiple co-relation between few materials.

	Wood	Paper	Cloth	Plastic	Metal
Wood	1.00				
Paper	1.00	1.00			
Cloth	-.48	-.45	1.00		
Plastic	1.00	1.00	-.46	1.00	
Metal	1.00	1.00	-.47	1.00	1.00

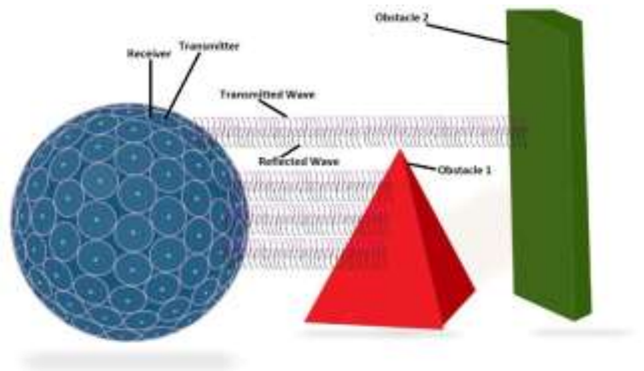

Fig -1: Trans-receiving waves from multiple obstacles in a single instance.

Fig -2: Image retrieved from the output array

3. Applications.

1. The sensor can be deployed to predict the contour of an indoor environment in an instance of emergencies like finding and rescuing hostages.
2. This multi-axial sensor provides an increase in accuracy in detecting obstacles in all the dimension for the lightweight flying machines.
3. Multi-dimensional ultrasonic imaging and health monitoring systems.

4. CONCLUSION

This new enhanced ultrasonic sensor gives the capability to detect obstacles all around the body which increases the ability to dodge the obstacle coming towards the body in any direction (especially useful in case of lightweight flying machines). The conversion of array values to image pixels in a grayscale helps to identify the obstacle and their distance from the body which help to carry out further steps.

REFERENCES

[1] Christofer N. Yalung and Cid Mathew S. Adolfo "Analysis of Obstacle Detection Using Ultrasonic Sensor "
[2] Rashmi Murthy, Nihat M. Bilgutay and Jafar Saniie "APPLICATION OF BANDPASS FILTERING IN ULTRASONIC NON-DESTRUCTIVE TESTING ".
[3] Munipalli UmaMaheswararao and Bala Brahmeswara Kadaru "Seeing Through Walls Using Wi-Vi".