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Development of acoustic backscattering system for object classification

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ABSTRACT

Sediments are mostly natural occurring materials that forms by the process of weathering or erosion. They settle down beneath the water surface. We can find a number of things under water including metals, rocks, gravels, etc. Having the knowledge of what's beneath the surface is of great significance for several fields like Eco hydrological process, the operation of hydrotechnical facilities and research on varied lake sediments. In this paper, we are discussing the outcomes of two different techniques one using sonar sensor and another through resistive method.

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I. INTRODUCTION

A system which can classify under water objects based on their reflection frequencies and provide us with a reliable output. Sediment classification using high frequency acoustic instrument is difficult when sediments are non-homogenous in size, shape and material. The use of acoustic backscatter to classify objects is an attractive alternative to analysis of objects because it is very sensitive to object surface roughness. Here a system is proposed based on embedded as well as signal processing principle which gets the signal reflections from objects and display them on computer screen in form of graph with precision.

Underwater object classification using Acoustic backscattering system plays a significant role in marine geology, hydro-graphic, marine engineering, environmental science, etc. The sensor we are using is a transceiver which will transmit ultrasound waves and receives the echo. It transmits a wave of 30kHz and receives according to the object. The sensor we are using has a range of 50cm to 5m. the embedded system used for analysis of received wave.

Transceiver will transmit sound waves and will receive reflected echo. Based on the frequencies received, classification will be done with the data provided to controller. Final output will be in the form of graphs.

II. LITERATURE SURVEY

[1] M. SelvaBalan, Aditi Awasthi, Dr.(Mrs.) S. S. Lokhande have worked on the project titled "Classification of underwater sediments using acoustic signal processing method". in his project an acoustic system is developed through which reflections are noted. Based on these reflected signals the sediments are classified. A database is created using the reflections. This method shows that using acoustic signals is a good idea but a little slow.

[2] Phillip Muller, Heiko Thoss, Lucas Kaempf and Andreas Gunter has worked on "A Bouy for Continuous Monitoring of Suspended Sediment Dynamics". A bouy is an anchored float used to mark hazards. Mostly used in navigation. The bouy made was more stable in terms of

continuous operation, energy management and sensor logging.

[3] Y. Saatyanarayana, Sanjeev Naithani, R. Anu has worked on "Seafloor Sediment Classification from Single Beam Echo Sounder Data Using LVQ Network". In this project they have tried to use the artificial neural network (ANN) and learning vector quantization (LVQ). These techniques were used to develop a network which further tested the different size of neurons..

[4] A. Moldovanu, P. Boueri, A.M.E Rolea has worked on "Ultrasonic Measuring System for Deposition of Sediments in Reservoirs". In this paper, an ultrasonic method is used to continuously calibrate the sediment deposition process. It uses array of sensors for measuring and plotted graph which shows process of deposition and generated equation regarding measurements .

[5] D. Buscombe, P.E. Grams and M.A. Kaplinski has worked on "Characterizing Riverbed Sediment using High-Frequency Acoustics: 1. Spectral Properties of Scattering". Echoes have been collected and analyzed to plot graph of depth vs velocity to classify sediments. Also it shows the spectral properties of sediments which describes the variety of sediments.

[6] T.Hies, H.H.Nguyen, J.Skripalle have studied "Analysis of multi-frequency backscattering signals for sediment concentration measurements", a sonar system has been developed which measures the sediment concentration. This is a case study works on the method predefined and used for management of sediment level in sensitive water areas.

III. METHODS

A) ULTRASONIC

Ultrasonic sensors are also called transceivers when able to transmit as well as receive waves. The Ultrasonic sensor transmit a high-frequency sound waves and then measures echo of the signal from object. The sensor has two horns on its front. One opening transmits ultrasonic waves, the other receives these signals.

We first started with using the ultrasonic sensor **HC-SR04**. to trigger the sensor, we applied a pulse wave. That gave square wave as output.

1. working voltage: DC 5V
2. working current: 15mA
3.working frequency: 40KHz
4. range: 2cm to 4m
5. trigger input signal: 10us TTL pulse
6. dimensions: 45*20*15 mm

Limitation of this sensor is that it doesn't work under water. This makes it unpractical for it to use for sediment classification.

B) SENSOR- HRXL-MAX_MB7334

The HRXL-Max_MB7334 sensor is used for applications where range finding, microwave transmission and acoustic operation is required. This sensor is a single horn trans-receiver used for ultrasonic operations measurement. It generates ultrasonic waves which works on Doppler and reflection effect. this sensor provides high accuracy and high resolution ultrasonic proximity detection and operated underwater. It gives readings in PWM and analog form which has data varied according to object roughness.

Because of use in under water and high resolution and sensitivity, it makes this sensor a perfect device for this project. Turning on and controlling of sensor is very easy and data collection can have done precisely.

1.Resolution of 1-mm
2.Distance sensor from 50-cm to 5-meters
3. Operation with good noise rejection
4.Pulse width, 1uS/mm resolution
5.Analog Voltage, 5-mm resolution

IV. BLOCK DIAGRAM

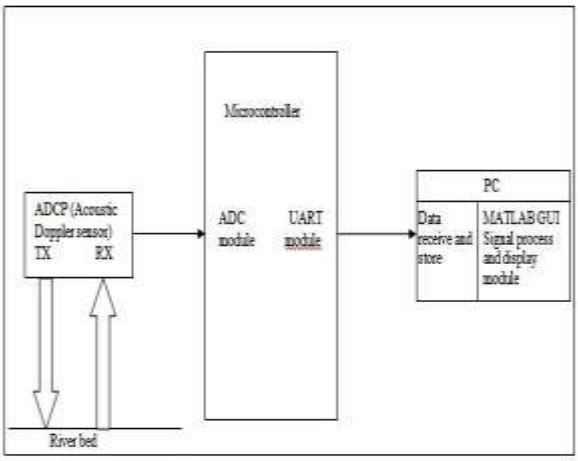


Fig. 1: Block Diagram

We have started with the embedded system. Next, we triggered the sensor and took the output signal with respect to different objects. Different features like power, distance, total energy and flatness are then extracted from the scanned data and classification is made from obtained result. Next, we plan to use signal processing techniques like data extracting, noise filtering, to display the graph which shows objects

V. WORKING PRINCIPLE

An ultrasonic transceiver has both transmitter and receiver in a single unit. The principle of operation of this sensor is that it emits an ultrasonic signal with frequency of 30KHz into the medium. This wave propagates through the medium till it reaches the bottom surface and then gets reflected from it in the opposite direction to result in another wave called echo. By observing the characteristics of this echo signal like its frequency, voltage, time of travel etc., we get an idea about the type of sediment, its concentration and other characteristics.
These sensors continuously transmit a series of pulses, and based on the echo from each pulse, calculate the distance between source and target and also give us information about the time taken for the signal to get reflected back. From this data, other relevant data related to the type of sediment can be inferred.

For this purpose, multibeam ultrasonic sensors are used.

By making connections we tested number of different sediments like sand, soil, rock, gravel, wood, thermocol.
We measured output which is different for different sediment. Output pulse width representation of a distance with a scale factor of 1µs per mm. The pulse width output is sent with a value within 0.5% of serial output.

1. Gravel
f(x) = p1*x + p2
Coefficients (with 95% confidence bounds):
p1 = 0.05459 (0.05133, 0.05786)
p2 = -0.4069 (-0.6921, -0.1218)

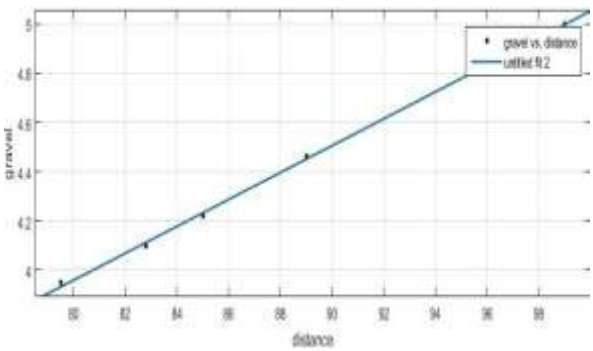


Fig. 2: Graph of Gravel

2. Rock
f(x) = p1*x^3 + p2*x^2 + p3*x + p4
Coefficients (with 95% confidence bounds):
p1 = 9.922e-05 (-0.001273, 0.001472
p2 = -0.02608 (-0.3912, 0.3391)
p3 = 2.338 (-29.93, 34.61)
p4 = -66.97 (-1014, 880.5)

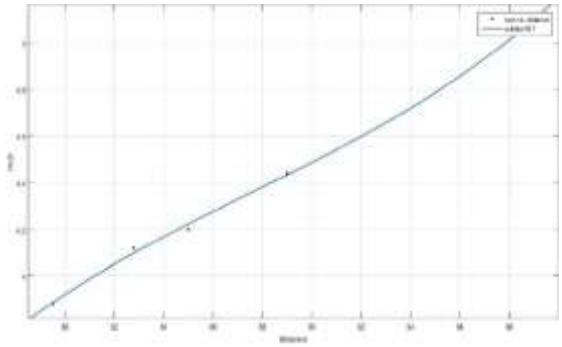


Fig. 3: Graph of Rock

3. Soil (sample 1)
f(x) = p1*x^3 + p2*x^2 + p3*x + p4
Coefficients (with 95% confidence bounds):
p1 = 0.0002024 (-0.002702, 0.003106)
p2 = -0.05311 (-0.8258, 0.7196)
p3 = 4.689 (-63.6, 72.98)
p4 = -134.9 (-2140, 1870)

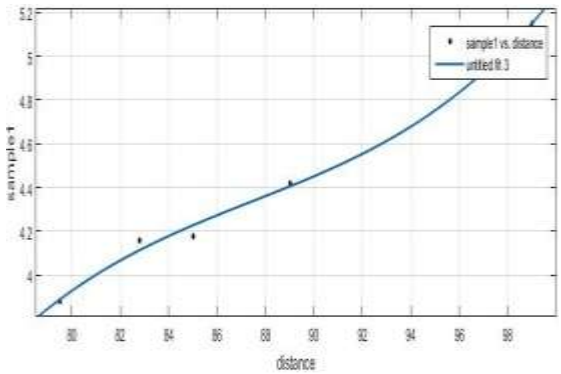


Fig. 4: Graph of Soil (sample 1)

4. Soil (sample 2)
f(x) = p1*x^3 + p2*x^2 + p3*x + p4
Coefficients (with 95% confidence bounds):
p1 = -1.87e-05 (-0.002644, 0.002607)
p2 = 0.006506 (-0.692, 0.705)
p3 = -0.6533 (-62.39, 61.08)
p4 = 24.2 (-1788, 1837)

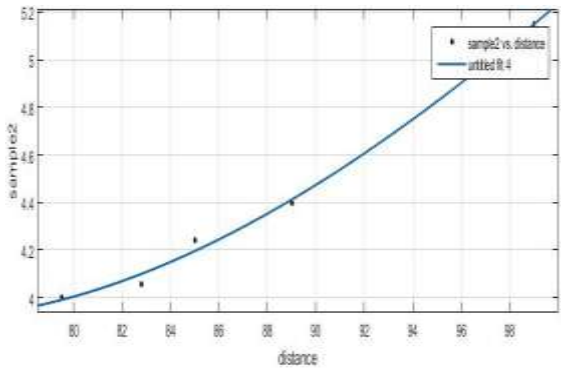
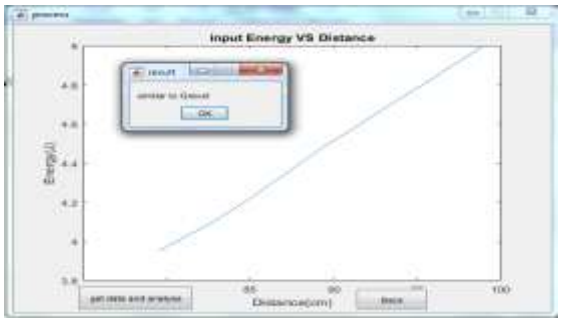


Fig. 5: Graph of Soil (sample 2)

The graphs are plotted sample vs distance. It indicates how received energy changes with change in distance. For different material, the variation is different.

In GUI, Real time input has been fetched and stored in fixed location and then compare with all database to get matched output. Hence there is a program which analyzes input and shows output according to comparison which tells type and characteristics of sediments



VI. ADVANTAGES & DISADVANTAGES

A) Advantages

1. Ultrasonic sensor gives very precise output and detection is unaffected by target materials and colors.
2. Noise in received input is relatively very less.
3. System can determine the quality of water which is of great importance.
4. Fast response due to use of electronic methods.
5. Covers large area into one output graph due to calibration procedure.
6. Since we are using conditioning circuit, noise will be removed.
7. User friendly system due to GUI.

B) Disadvantages

1. While implementing the project, there will be some physical parameters affecting the system. These physical factors can be,
    - Water velocity
    - Noise in received signal
    - Atmospheric conditions
2. As the depth of water bodies increases, cost of system will increase. The sensor we are using is of low range.

VII. CONCLUSION

The method we presented uses ultrasonic sensor to transmit and receive microwave signals which will analyse to get properties of different sediments. this will useful to find graph and mathematical equation to classify different sediment types.

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