Development of Resistive Imaging Techniques to Classify Underwater Sediments

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Abstract*- Through this project, we aim to develop a resistive imaging technique to classify underwater sediments. We will compare the results obtained from two commonly used measurement techniques to classify underwater sediments which are ultrasonic sensor based and resistive imaging measurement techniques. Using resistive imaging measurement technique, electric current is sent through electrodes, from this, resistivity of each sediment layer below the surface is obtained.*

I. INTRODUCTION

Identification, segregation and classification of underwater sediments is essential to understand the topology of a given geographical area. This requirement gives rise to the need to study different techniques used for the above mentioned process and develop a technique to do it accurately.

The different methods used for land and water-covered areas include: conventional methods like multielectrode resisitivity systems towed by boats, 1, 2 and 3 dimensional electrical resistivity methods developed by Griffiths and Barker and Loke and Barker in 1993 and 1996 respectively, static systems with electrodes in ground used for shallow water and mobile systems used by Sorenson 1996, Panissod et al.1998, bernstone and Dahlin 1999.

The two main methods we will be using in this project include, electrical resistivity measurement using electrodes and measurement using ultrasonic sensors. Data is collected using underwater sediments form river and lake basins. Resistivity of the sediments and other parameters are measured and recorded. This data will then be processed in MATLAB using different signal processing tools and algorithms. A mathematical model will be developed to process this data and estimate the sediment characteristics and concentration. The results obtained from the model will then be validated against actual measurements.

II. LITERATURE REVIEW

M.H.Loke, John W.Lane have worked on "Inversion of data from electrical resistivity imaging surveys in water-covered areas", for which field surveys were conducted in Australia by the University of New South Wales Groundwater centre (mixed electrode survey), along a section of the Redas river in Belgium (underwater electrode survey) and along the Thames river in Connecticut, along the northeast seaboard of the United States (floating electrode survey).

In this paper, the authors have surveyed the conventional and existing methods for survey of land surface, with a specific view of adapting these techniques to water-covered areas. They have also presented a model based on mathematical inverse modeling of electrical resistivity imaging data.

They have proposed an iteratively re-weighted smoothness constrained least-squares optimization method for data inversion. Inversion of data is carried out to determine resistivity of model cells so that misfit between calculated and apparent resistivity values and measured field data is small. Numerical simulations conducted by them have shown that, the water layer largely affects the measured apparent resistivity values as it usually has a much lower resistivity than the subsurface.

Water layer resistivity and geometry are considered as fixed parameters during the inversion process and inversion program is used to determine resistivity of sub-bottom materials. By fixing known parameters, effect of water layer on inversion result is reduced. Nature of subsurface resistivity variations, whether smooth or abrupt is considered.

For inversion model, to accommodate water bottom topography, a distorted finite-element grid is used to calculate apparent resistivity values. First few rows of elements are used to model the water layer and the lower part of the grid is used for sub-bottom resistivity distribution. The resistivity of the sub surface can then be accurately recovered in the inversion process. The focus of this paper is on the incorporation of water column resistivity and geometric constraints into the above mentioned algorithm. [1]

N.Crook, A.Binley, R.Knight, D.A.Robinson, J.Zarnetske and R.Haggerty have worked on "Electrical resistivity imaging of the architecture of sub stream sediments”. During this project, the authors have demonstrated that Electrical Resistivity Imaging (ERI) coupled with inversion methods and modifications provides an indispensible method for determining sediment characteristics underlying stream channels.

They placed electrodes directly in the sediments of the streambed and obtained high resolution images of sub surface sediment architecture, directly beneath the water column.

The surveys were conducted at two sites which are across the floodplain at river Lmbourn site and behind the debris dam of Mac Creek in H.J.Andrews research forest. [2]

T.Hies, H.H.Nguyen, J.Skripalle have studied “Analysis of multi-frequency backscattering signals for sediment concentration measurements”, a detailed model based on a typical Sonar has been developed which allows to determine the sediment concentration of non-cohesive suspended sediments without any calibration needs.

The model runs in real-time and calculates the suspended sediment concentration (SSC) and mean grain size simultaneously and estimates the particle size distribution (PSD) based on the backscatter signal strength of four ultrasonic frequencies ranging from 0.5MHz to 4MHz.

The analysis can be done at a fixed distance or along the acoustic path of ultrasound signals up to a profiling range of 2m.

The range will be sequenced into cells and the parameters PSD, mean grain size and SSC can be determined for each measurement cell. [3]

III. EXPERIMENTAL METHEDOLOGY

A) Experimental apparatus

Experiments were performed in a controlled environment with a test tank. A set-up consisting of a test tank with sliding plates to move the electrodes across the length of the tank, a pair of electrodes suspended from the plates, a function generator to supply an electric current to the electrodes and a digital multi meter for measurements. The tank is first filled with a predetermined amount of sediment, water is then poured into the tank until it reaches a predetermined value. The experimental set-up is shown in Fig.

B) Experimental process

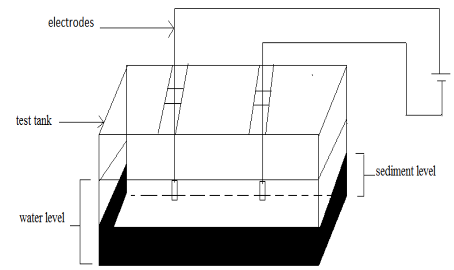

Figure 1.

A layer of sediment of thickness ‘x’ cm is first deposited in the tank. Water is then filled into the tank up to ‘y’ cm. Two sets of readings are taken: one with the probes at a horizontal separation of ‘z’ cm and the other set with the probes ‘z/2’ cm apart. The sediment thickness is then reduces to ‘x/2’ cm and two sets of readings are noted using the same procedure mentioned above.

The level of water in the tank, the height of probes immersed in water and the input voltage of the Sine wave are kept constant throughout the process.

The readings noted in each case are: the resistance of the circuit, the capacitance effect of the circuit and the output voltage is noted by varying the input frequency of the Sine wave from 100Hz to 20 kHz.

The input signal applied through the function generator is a AC Sine wave of input voltage (Vin) of magnitude 5v and frequency varying between 100Hz to 20 kHz.

IV. ADAVANTAGE AND LIMITATION

A) Advantage

1. By identifying underwater sediments we can understand the topology of a given geographical area.
2. Size of hardware is convenient and portable.
3. Electronic method is used so that fast response can be obtained.

B) Limitation

1. Physical parameter affecting the system such as moving water surface and depth of water is varying as we increase distance between the electrodes.

V. CONCLUSION

Underwater sediments can be classified using resistive imaging technique by inserting electrodes into the water and measuring the corresponding resistance of sediment and according to that classification is done.

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