International Journal of Engineering & Technology, *7 (2.21) (2018) 410-413*

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Side scan sonar image data mapping with geographic reference system

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Abstract

Many researchers have been done in classifying the surface of the sea floor. Only few concentrated in classifying the sediment layers of the sea floor and the target objects buried. Side Scan Sonar is one such tool, which is used in collecting the images of the seafloor. Sonar equipment transmits a low frequency signal, towards the surface of the seabed for target recognition. It is necessary to locate the area and positioning where the target is located whether it is a ship wreckage or plane crash, mine recognition etc. This paper is proposed to determine the location and position in user friendly matlab software environment, where the sonar image data is collected and is mapped with Global Reference System.

Keywords: *Sediment classification, global reference system, WGS, seabed, target, object recognition, UTM.*

1. Introduction

Many researches have been done in classifying the surface of the sea floor. Only few concentrated in classifying the sediment layers of the sea floor and the target objects buried. Side Scan Sonar is one such tool, which is used in collecting the images of the seafloor. Sonar equipment transmits a low frequency signal, towards the surface of the seabed for target recognition. It is necessary to locate the area and positioning where the target is located whether it is a ship wreckage or plane crash, mine recognition etc[1].

SONAR imaging is the best way to view the sea bed. The images from the sea bed contain many objects that look very similar. It is very important to differentiate the target objects from other objects like rocks, sediments, seafloor, target objects like (mine, and wreckage) etc. This paper is proposed to determine the location and position in user friendly matlab software environment, where the sonar image data is collected and is mapped with Global Reference System.

The study here presented analysis of acoustic sidescan sonar data collected at Bay of Bengals, produced from the 4200 Series High Definition Dual Frequency Side Scan Sonar System to be used for further analysis and classification. Secondly, matlab software was used to process raw data from side scan sonar and to generate mosaic image of the seafloor. Finally, supervised classification is to be performed using the dataset for classifiying different sediment layers and object recognition.

2. literature survey

Caulfield, et.al., (1983) developed a model for estimating the absorption coefficient of acoustic signals, seabed sediments. The reflection coefficients and acoustic impedance of the sediments can be calculated and is used to correct for losses in the bottom of the sediment**[2]**.

Chivers et al., (1990). proposed a novel system for processing echo-sounder signals. The operation, principle and practical implementation of a echo-sounder signal system is very well explained. Using information from the echoes, observed through a dedicated receiver connected across the terminals of the transducer, ground discrimination can be successfully. The authors incorporated the navigational system of the vessel in a digital environment, and performed a detailed survey work and displayed it on a chart on the screen of the computer**[3]**.

Eleftherakis et al., 2012[4] presented Sediment classification of the seabed and riverbed using acoustic remote sensing techniques. The authors discussed the results of riverbed sediment classification and collected data using multi-beam echo-sound on an empirical basis. Two data sets are collected at the Waal River, namely Sint Andries and Nijmegen. This work is a follow-up to the work carried out by Amiri-Simkooei et al. (2009)]. The classification on features of the backscatter strength and depth residuals is done using principal component analysis. Principal components features are extracted and clustering is then applied for sediment classification. The backscatter strength features discriminate between different classes based on the sediment properties, whereas the depth residual features discriminate classes based on riverbed forms such as ripples.

Guillon and Lurton, 2001, [5] worked on low-frequency multi-beam echo-sounders signals. The signals are affected by backscattering from buried layers down to depths of a few meters and by sound penetration inside the upper sediment layers; this leads to serious misinterpretations in the experimental data. The concept of equivalent input backscattering strength (EIBS) is used, which is based on the combination of local backscattering strength and propagation inside fluid layered media. The various contributions are finally added to give the backscattering strength, at the upper interface, which featured the various effects of propagation and attenuation inside the layered structure.

Hughes Clarke et al., 1997 [6] developed a scheme based on the angular response (AR) of the seabed backscatter strength for

sediment classification. The angular response is characterised based on the slope over predefined angular sectors and mean level, and the presence or absence of abrupt changes in slope. A test is performed to recognize the presence of sediment boundaries because the AR is derived from a finite area. The AR curves showed improved discrimination over angle invariant methods.
Kumudham. R et al[14] proposed an algorithm for seabed sediment classification by using the reflectance properties of the sediment. In their work ambient noise is considered and Empirical Decomposition algorithm is used for denoising.

3. Existing methods

Energy based surface model has been developed to classify the sediment layers. The reflection coefficients of the reflected signal is computed sequentially after estimating the geo-acoustic parameters of the previous sediment layers. The reflection coefficient is calculated by computing Rayleigh reflection coefficient, by neglecting multiple reflections from the sediment layers. The calculated reflection coefficient is related to the mean grain size. A portion of the data is considered and the final output is mapped based on the energy distribution of the reflected signal obtained.

Drawback

The existing model only considers single reflection of the signal. It neglects the multiple reflections, which occurs when a signal is trapped between two sediment layers. By including multiple reflections and volume scatters, better results can be achieved.

4. Proposed method

Underwater Images suffer from variations in operating and environmental conditions, target shapes and spatially varying clutter. The researchers developed techniques for underwater image preprocessing, enhancement. It is learnt that the process of getting a high resolved image is yet to be taken up. Hence it is necessary to design a new post processing algorithm for super resolution that is suitable to underwater images.

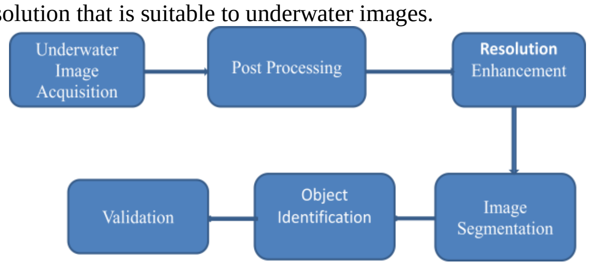

Fig.1: Block Diagram of the proposed work

Data collection

The side scan sonar image data collected from NIOT is acquired by 4200 Series High Definition Dual Frequency Side Scan Sonar System and it is a real time data. The Dual-frequency utilized are (100/400 kHz, 100/600, 300/600, or 300/900 khz). Both high and low frequencies are simultaneously are recorded in Discover software and the image is displayed in Dual-Simultaneous Sonar Display-Waterfall. The image files (16 bit data) are recorded in XTF – Extended Triton File Format.

Post processing

The post processing involves determining the location and Distance of the sonar data collected (recorded in XTF format).

Location

The XTF sonar data is processed in matlab software. The geographic location is determined using World Geodetic System (WGS84) thereby the Latitude and Longitude, are determined [7][8]. The Easting, Northing coordinates are determined from the Latitude and Longitude using Universal Transverse Mercator coordinate (UTM) system. The location of a point is made by specifying the easting, X coordinate and the northing, Y coordinate using Global Reference System.

Distance

The 'haversine' formula is used to calculate the great-circle distance between two points that is, the shortest distance over the earth's surface.

Haversine formula:

$$a = \sin^2(\Delta\Theta/2) + \cos\Theta_1 \cdot \cos\Theta_2 \cdot \sin^2(\Delta\lambda/2)$$
$$c = 2 \cdot \operatorname{atan2}(\sqrt{a}, \sqrt{(1-a)})$$
$$d = R \cdot c$$

Where

Θ *is latitude,* λ *is longitude,*

R *is earth's radius (mean radius = 6,371km).*

Distance and location are the key features in mapping geographic information .The location is obtained in real world coordinate system using Global Reference System. This system provides location on the surface of the globe with points on a map.

Spatial data modelling

Spatial data modelling is very useful to represent the geographic features.

Raster or Grid Based data structure is used to represent the geographical area. The sonar image data is divided into grids to represent area of the seabed

Image intensity value extraction

The intensity values are extracted from the XTF sonar data which is calculated from the amplitude samples as given below

$$I = 20 \times \log10(A) - G$$

Where

'I' represents Intensity Values

'A' represents Amplitude

'G' represents gain.

The intensity values reflect the roughness characteristics of seabed.
The datas are extracted in ASCII format and since the data is sparse, spatial interpolation technique is utilized and raster grid image of 5m pixel size is obtained.
The Sonar image is subdivided since the image data size is large. A portion of the image is taken and quantized so that different intensity levels are differentiated. Each intensity levels has the characteristics of sediment layer such as sand, silt, clay, rock, object buried etc.
The density is calculated and the particle size is mapped with sediment layers.

5. Result and discussion

The real time XTF data is processed in matlab software where the location is mapped with latitude and longitude and the intensity values are extracted.
The location of sonar xtf image Line 14 is determined using matlab software and the latitude: 13.7317° to 13.7365, Longitude: 80.2826° to 80.2894 shown in Fig 2.

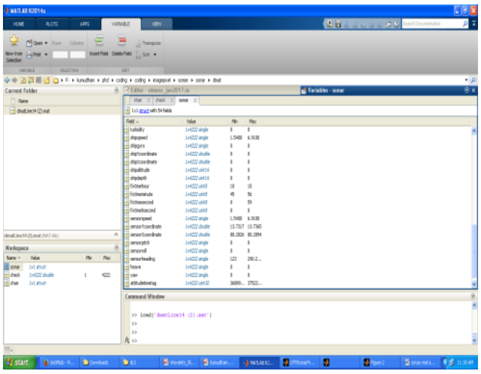

Fig.2: Latitude and longitude of sonar image 14

The sonar image data are processed using WGS84 parameters and the Latitude and Longitude is determined. [9][10].

The location is obtained in real world coordinate system using Global Reference System. This system is used to locate with points on a map. So the sonar image data collected are located at Bay of Bengal are shown in Fig 3. The distance calculated using Havesine Formula is 0.9080 km.

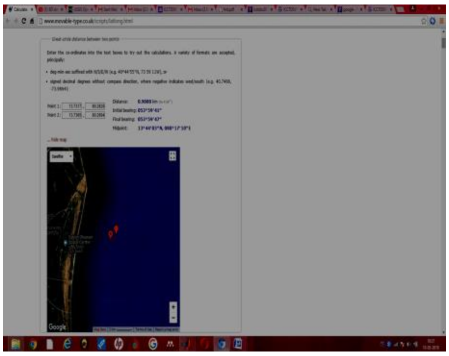

Fig.3: Sonar image 14 sited at bay of Bengal

The raster grid image of resolution of 5m pixel size obtained is shown in Fig 4.

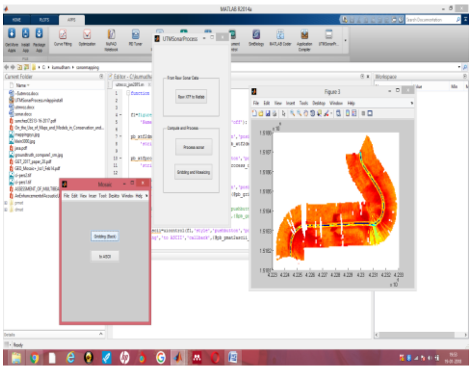

Fig.4: Raster grid image

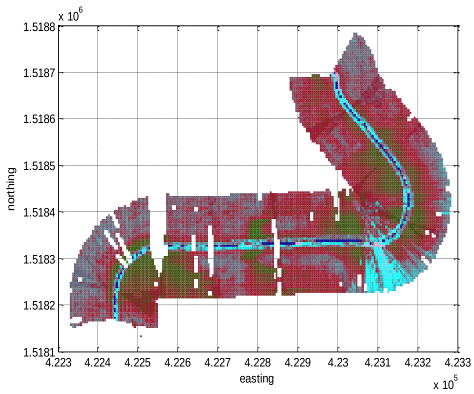

Fig.5: Raster grid image with easting and northing coordinates

Raster or Grid based data representation is utilized to represent geographic features. Fig 5 shows the Raster Grid Image obtained using the Intensity values, Easting and Northing coordinates where Easting and Nothing coordinates are obtained using the Universal Transverse Mercator (UTM) coordinate system. Raster or Grid based data representation is utilized to represent geographic features.

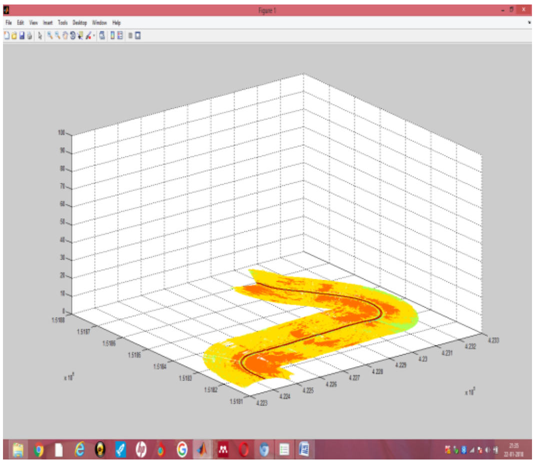

Fig.6: 3-D image surf image

Fig 6 shows the 3-Dimensional Surf image obtained mapping the Intensity values, with Easting and Northing coordinates.

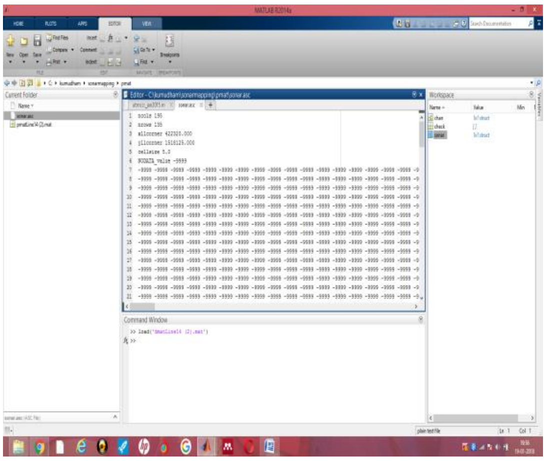

Fig.7: ASCII values obtained for sonar image data 14

Fig 7 shows the sonar image data values in ASCII format for further processing.

The intensity values which shows the characteristics of seabed are obtained from the amplitude samples. Fig 8 shows the distribution of pixel intensity values.

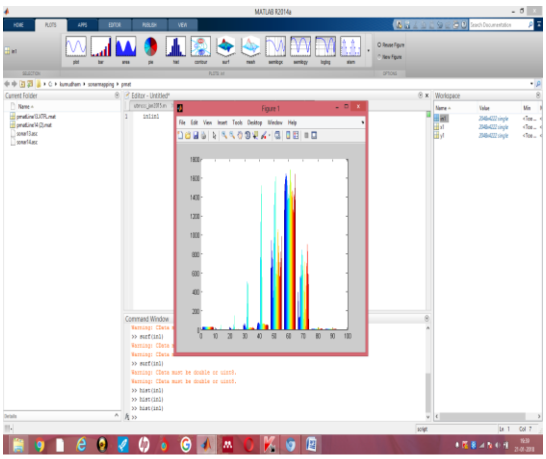

Fig.8: Pixel intensity values distribution

Fig 9 shows the image created from the intensity values which will taken for future analysis of seabed sediment classification and object recognition.

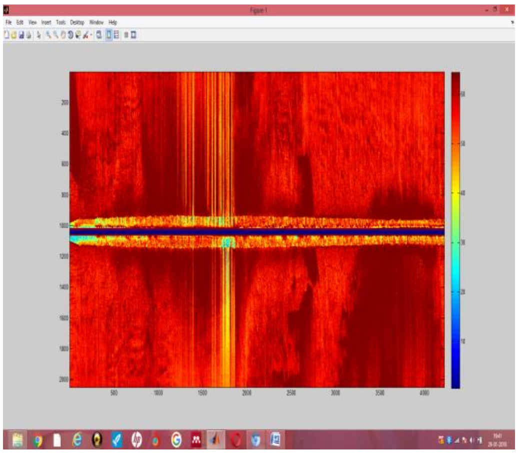

Fig.9: Sonar image 14

6. Conclusion and future work

Thus side scan sonar data is mapped with geographic reference system. The location is determined by using Universal Transverse Mercator System. The intensity values which shows the characteristics of the seabed is obtained. The future work is to classify the sediment by finding the reflection coefficient, density and then by mapping with grain size.

Acknowledgment

The authors would like to thank NIOT, Chennai for providing the Sonar Image Data to carry out the research work. The author also like to thank specially Dr. Basanta Kumar Jena and Dr. V Suseentharan of Coastal and Environmental Engineering Division National Institute of Ocean Technology (NIOT), Chennai for their help in sonar image data acquisition.

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