Bathymetry Data Analysis and Depth Measurement

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***Abstract*—There is a high demand for underwater communication systems due to the increase in current human underwater activities. Bathymetric data is a depth value of reservoir or inland water bodied. Bathymetric data is useful for hydrographical survey, volume calculation and 3D graph generation using interpolation techniques. Depth sensor captures a depth data values from the water source and these values can be used for plotting interpolation plot and volumetric analysis. Bathymetric data taken from SONAR is not accurate because multipath noise gets added and there is need to remove multipath noise. In order to overcome errors in SONAR the proposed system has used various filters and interpolation techniques in order to minimize multipath errors for accurate volume calculation. The proposed work is introduced with a prototype using hardware assembly. Graphical user interface perform a action through various buttons programmed through software simulation assembly.**

Index Terms— Cortex-M3 microcontrollerLPC1768, HRXL-MaxSonar WRS Series MB7334.

I. INTRODUCTION

When waves travel into areas of shallow water, they begin to be affected by the ocean bottom. The free-orbital motion of the water is disrupted, and water particles in orbital motion no longer return to their original position. As the water becomes shallower, the swell becomes higher and steeper, ultimately assuming the familiar sharp-crested wave shape. After the wave breaks, it becomes a wave of translation and erosion of the ocean bottom intensifies.

Most ports and harbours have dredged channels, berths and anchorages, which suffer from siltation, thereby reducing the depth of water available for navigation. In general the layers thicknesses that will be removed during maintenance dredging are small. Therefore, accurate determination and modelling of the seafloor levels are essential to avoid unnecessary over dredging and extra costs. The required accuracy is increased and becomes critical in the case of environmental dredging of the contaminated sediments. Reservoirs are a major part of the usable surface water resources. Population growth and increasing life standards lead to increased consumption of potable water, which requires more effective and cautious use of water resources. For this knowledge of reservoirs is very necessary i.e. about its depth, volume, sedimentation etc. Proposed study identifies bathymetry data, its 3D plot and volume calculation. There are various existing systems for analysis but they have some problems. Still at many dams manual method is used for analysis. The estimated value is far from accurate. There is no provision for 3D display system. GUI requires technical person to understand. None of existing system gives even 85% of accuracy. Most of them have manual boat with 2 technical persons on it. Rank one existing system 'Z-boat' an awesome display of technology. Z-boat is a autonomous boat which works with Google maps, advanced GNSS and highly accurate depth Sonar. But drawback of Z-boat is its cost and availability[1].

Depths are normally measured using either single-beam (SBES) or multi-beam (MBES) echo sounders. SBES is still the most common tool used in port and harbour surveys. The SBES, as soundings, are only acquired directly underneath the transducer. Survey lines run perpendicular to the underwater slopes and the line spacing between the survey lines is dependent on the scale of the final product and the required resolution. Tie lines (longitudinal lines) are run perpendicular to the primary survey lines but at wider spacing and act as a quality assurance cross-check on the acquired field data. The major disadvantage of SBES is that it illuminates only a narrow portion of the seafloor. Also the depths between survey lines will be omitted from the bathymetric data, while MBES can provide continuous coverage [2]. Interpolation [1-3] is the method of calculating the expected values for a function with known pixels. Downsampling is a spatial resolution technique where the image is scaled by half by reducing the sampling rate and upsamling is a process of increasing the spatial resolution of an image. Some popular interpolation techniques are explained:1) Nearest neighbour technique 2) Bilinear technique 3) Bicubic technique 4) TIN. For noise removal an additional step after the expansion into wavelet packet coefficients can be added, doing denoising by wavelet shrinkage. The best local discrimination basis algorithm [9] has explained. This algorithm has advantage is that it is based

on a fast and linear decomposition algorithm (the wavelet packet transform) and a binary search tree, which has to be searched only once due to the additivity of the selection and discrimination criteria.

II. SYSTEM BLOCK DIAGRAM

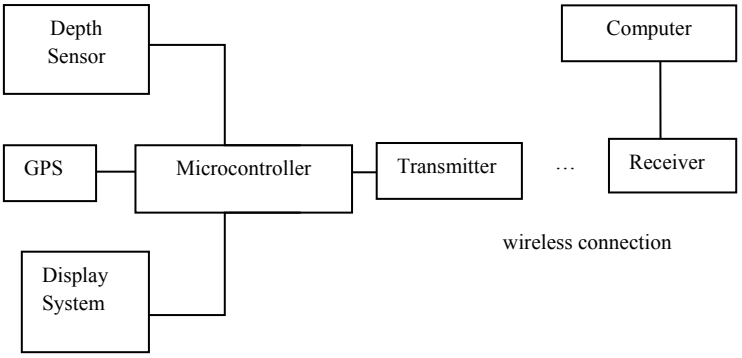

Fig.1. System Block Diagram

Figure 1, shows the block diagram of proposed system. Block description is given as follows:

1) Depth Sense: The input to the system would be depth sensor which can calculate depth of water provide that it assembled on a platform which is floating on water.

2) Position Sense: The other input to the system would be a sensor which can sense its position with respect to the initial position. Any sensor like GPS can do this job.
Some more sensors can be added according to the modification in project.

3) Process Part-1: The microcontroller attached to the sensor will acquire the data and do following things:
Display data on display system.
Transmit data to the computer.

4) Display System: The display system can consist of LCD display, LED display or even seven segment display can work.

5) Transmission to computer: There are multiple technologies available today to transmit the data to computer. Some of them are Bluetooth, GSM, Xigbee and may more.

6) Process Part-2: At computer end the data transmitted by controller is first saved to a file. Then after completion of data acquisition the computer analysis the data, remove error's from it (if any) then comes the interpolation of the unknown intermediate points. Then after interpolating the points a 3D view of the water body can be generated as well as volume of the water body can be estimated.

III. HARDWARE DESCRIPTION

A. LPC1768

32-bit ARM Cortex-M3 microcontroller

The LPC1768 is ARM Cortex-M3 based microcontrollers for embedded applications featuring a high level of integration and low power consumption. The ARM Cortex-M3 is a next generation core that offers system enhancements such as enhanced debug features and a higher level of support block integration. The LPC1768 operate at CPU frequencies of up to 100 MHz. The LPC1769 operates at CPU frequencies of up to 120 MHz. The ARM Cortex-M3 CPU incorporates a 3-stage pipeline and uses a Harvard architecture with separate local instruction and data buses as well as a third bus for peripherals. The ARM Cortex-M3 CPU also includes an internal prefetch unit that supports speculative branching. The peripheral complement of the LPC1768 includes up to 512 kB of flash memory, up to 64 kB of data memory, Ethernet MAC, USB Device/Host/OTG interface, 8-channel general purpose DMA controller, 4 UARTs, 2 CAN channels, 2 SSP controllers, SPI interface, 3 I2C-bus interfaces, 2-input plus 2-output I2S-bus interface, 8-channel 12-bit ADC, 10-bit DAC, motor control PWM, Quadrature Encoder interface, four general purpose timers, 6-output general purpose PWM, ultra-low power Real-Time Clock (RTC) with separate battery supply, and up to 70 general purpose I/O pins. The LPC1768 is pin-compatible to the 100-pin LPC236x ARM7-based microcontroller series. Figure 2, shows the block diagram of LPC1768.

Features and benefits:

ARM Cortex-M3 processor, running at frequencies of up to 100 MHz (LPC1768) or of up to 120 MHz (LPC1769).

- A Memory Protection Unit (MPU) supporting eight regions is included.
- ARM Cortex-M3 built-in Nested Vectored Interrupt Controller (NVIC).
- Up to 512 kB on-chip flash programming memory. Enhanced flash memory accelerator enables high-speed 120 MHz operation with zero wait states.
- In-System Programming (ISP) and In-Application Programming (IAP) via on-chip bootloader software.
- On-chip SRAM includes:
  32/16 kB of SRAM on the CPU with local code/data bus for high-performance CPU access.
  Two/one 16 kB SRAM blocks with separate access paths for higher throughput.
  These SRAM blocks may be used for Ethernet, USB, and DMA memory, as well as for general purpose CPU instruction and data storage.
- Eight channel General Purpose DMA controller (GPDMA) on the AHB multilayer matrix that can be used with SSP, I2S-bus, UART, Analog-to-Digital and Digital-to-Analog converter peripherals, timer match signals, and for memory-to-memory transfers.

- Multilayer AHB matrix interconnect provides a separate bus for each AHB master. AHB masters include the CPU, General Purpose DMA controller, Ethernet MAC, and the USB interface. This interconnect provides communication with no arbitration delays.
- Standard JTAG debug interface for compatibility with existing tools. Serial Wire Debug and Serial Wire Trace Port options. Boundary Scan Description Language (BSDL) is not available for this device.
- Emulation trace module enables non-intrusive, high-speed real-time tracing of instruction execution.
- Integrated PMU (Power Management Unit) automatically adjusts internal regulators to minimize power consumption during Sleep, Deep sleep, Power-down, and Deep power-down modes.

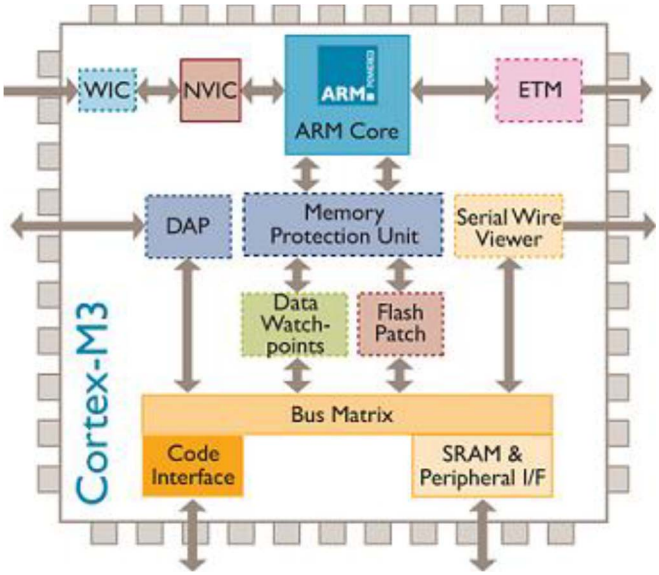

Fig.2. Block Diagram LPC1768

B. HRXL-MaxSonar WRS Series

High Resolution, IP67 Weather Resistant, Ultrasonic Snow Depth Sensor MB7334

The HRXL-MaxSonar-WRS sensor, as shown in figure 3, line is a cost-effective solution for applications where precision range-finding, low-voltage operation, space saving, low-cost, and IP67 weather resistance rating is needed. This sensor component module allows users of other, more costly precision ultrasonic snow depth measurement rangefinders to lower the cost of their systems without sacrificing performance. Additionally, this sensor line allows cost-sensitive designers to choose this precision sensor as a performance upgrade over other lower performance sensors. The HRXL - MaxSonar-WRS sensor line provides high accuracy and high resolution ultrasonic proximity detection and ranging in air, with an IP67 weather resistant rating. This sensor line features 1-mm resolution, target-size and operating-voltage compensation for improved accuracy, superior rejection of outside noise sources, internal speed-of-sound temperature compensation and optional external speed-of-sound temperature compensation. The HRXL-MaxSonar-WRS sensors have a maximum range of 5-meters.

Fig.3. HRXL-MaxSonar®-WRS™ Mechanical Dimensions

Features and benefits:

- Low cost ultrasonic rangefinder
- Detection out to 5-meters
- Resolution of 1-mm
- Distance sensor from 50-cm to 5-meters
- Triggered operation yields real-time range data
- Free run operation with superior noise rejection
- Operating temperature range from -40°C to +65°C
- Operating voltage from 2.7V to 5.5V
- Best operated at 5V for snow applications
- Nominal current draw of 2.3mA at 3.3V, and 3.1mA at 5V
- IP67 Rated
- Available in RS232 or TTL

IV. SOFTWARE DESCRIPTION

Bathymetric data collected from echo sounder contains multipath noise. Wavelet packet decomposing methods remove multipath noise. After noise removal image reconstruction is done by interpolation techniques in MATLAB. Then volume is calculated in MATLAB. Figure 4, shows flowchart for methodology, which consists step involved for proposed system. MATLAB is a scientific programming language that provides strong mathematical and numerical support for the implementation of algorithms. MATLAB examples related to image-processing concepts are given. The goal of denoising is to remove the noise, and this

can be done through filtering, which can be either linear filtering or non-linear filtering. It can be used to determine the interpolating polynomial for a set of points. It allows rapid prototyping and testing of the methods and also it is a powerful software tool which is very easier to understand. It is specially designed software package with many built-in convenient features and is far more convenient to use as compared to other high –level languages.

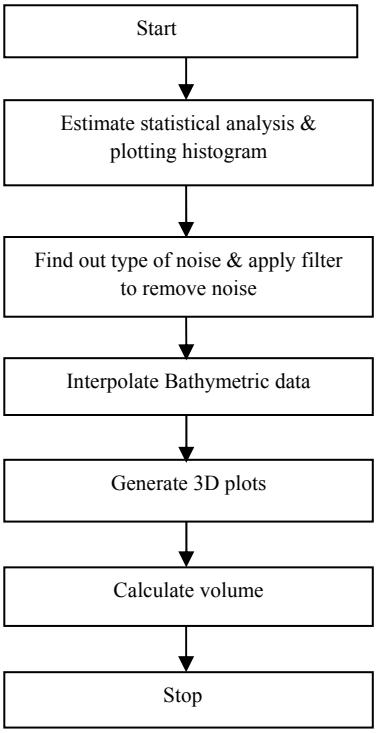

Fig.4. Flowchart for Methodology

V. DATA STATISTICS

Estimations for the most common statistics that are used in hydrological estimations, predictions and testing are studied. Data statistics are used here to know type of noise present in data. It is assumed that the sample is a time series of length n whose items to time instances, i.e. X_1 …, X_n *A. Mean*

This is arithmetic average of the x values and is usually referred to simply as the mean. The formulae for mean are as follows:

$$X = \frac{\sum_{i=1}^{n} X_I}{n} \quad (1)$$

Here n is length of samples and samples is taken for time instant X_1 to X_n and i is from 1,2,….n.

B. Median

Median is the middle value of the given numbers or distribution in their ascending order. Median is the average value of the two middle elements when the size of the distribution is even.

C. Variance

Variance measures how far each number in the set is from the mean. Variance is calculated by taking the differences between each number in the set and the mean, squaring the differences and dividing the sum of the squares by the number of values in the set.

$$S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - X)^2 \quad (2)$$

Here n is length of samples and samples is taken for time instant X_1 to X_n and i is from 1,2,….n, X is mean.

D. Standard deviation

The sample standard deviation is the square root of the mean squared difference between each observation and the sample mean; it is defined by the left-most formula above. This formula is awkward for hand computations, but minimizes round off errors. The equation is usually reorganized into the form on the right for hand calculations.

$$S = \sqrt{S^2} \quad (3)$$

Here S^2 is variance.

Table I shows statistical analysis of bathymetry data. X is longitude, Y is latitude and Z is depth.

Table I. Statistical Analysis

	X	Y	Z
Mean	6.8957e+005	1.2540e+006	-5.6946
Median	6.8958e+005	1.2540e+006	-4.4800
Variance	8.2410e+003	4.3878e+003	15.1786
Standard Deviation	90.7798	66.2405	3.8960

VI. RESULTS

Bathymetric data is depth value data for reservoir or lack which is in XYZ co-ordinate form. Table II shows original bathymetric data which does not give smooth points of bottom lack or reservoir surface. Estimation is done to recognize noise pattern in obtained data. Noise removal techniques are used to get noise free data and interpolation is done. And at final stage 3D plot is generated by using MATLAB.

Table II. Bathymetric Data

X	Y	Z
689505.8	1254012	-4.03
689506.6	1254013	-4.46
689506.9	1254014	-4.23
689507.6	1254015	-4.55
689508	1254015	-4.51
689508.4	1254016	-4.5

Figure 5, shows 3D plot of bathymetric data which is plotted using MATLAB software.

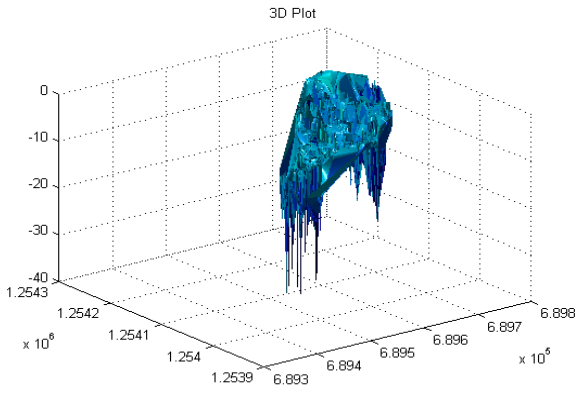

Fig.5. 3D Plot

CONCLUSION

Multi beam Echo sounder and active sonar are used for underwater communication for getting bathymetric data in XYZ co-ordinate form. Statistical analysis is done to recognize noise in presented data. For image reconstruction interpolation techniques are used and 3D plot is plotted using MATLAB. Then volume of lack or reservoir is calculated and results we can compare with SURFER 8 software which is approximately same.

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