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BATHYMETRY DATA ANALYSIS AND DEPTH MEASUREMENT

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Abstract— There is a significant demand for underwater communication systems as a direct result of the rise in the number of contemporary human activities that take place underwater. Data obtained from bathymetry are used to determine the depth of an inland body of water or a reservoir. Bathymetric data is useful for hydrographic surveys, volume calculations, and the creation of 3D graphs because it can be interpolated using various techniques. Producing interpolation plots and performing volumetric analysis are two possible applications for the depth data values that are gathered from the water source by the depth sensor. Bathymetric data obtained from SONAR is not reliable and needs to be cleaned up because of the addition of multipath noise to the signal. In order to circumvent the shortcomings of SONAR, the proposed system makes use of a variety of filters and interpolation methods to cut down on the number of multipath errors that occur during the volume calculation process. A prototype that is based on the assembly of physical hardware is used to introduce the proposed work. An action can be carried out by a graphical user interface by means of a number of buttons that have been coded through the process of software simulation assembly.

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

I. INTRODUCTION

When waves travel through shallow water, the ocean floor begins to exert some of its influence on them. The free-orbiting motion of the water is disrupted because the particles of water that are moving in an orbit are prevented from returning to their starting positions. As the water becomes shallower, the swell grows taller and more steeply as it moves toward the shore, eventually taking on the shape of a recognisable pointed-crested wave. When a wave breaks, it morphs into a wave of translation, which has the effect of hastening the process by which the ocean floor is worn away.

The depth of water that is suitable for navigation is made shallower when dredged channels, berths, and anchorages in the vast majority of ports and harbours become clogged with sediment. In most cases, the maintenance dredging process will involve the removal of only very thin layers. Because of this, having an accurate determination and modelling of the seafloor levels is absolutely necessary in order to avoid unnecessary over-dredging and additional costs. When it comes to cleaning up polluted sediments in the environment, the level of precision that is required is exceptionally high. Reservoirs are among the most important sources of water resources that can be used as surface water. Because of rising living standards and an expanding population, there is a greater demand for potable water. This calls for a more effective and cautious approach to the management of water resources.

For this reason, having a solid understanding of reservoirs, including their depth, volume, sedimentation, and so on, is absolutely necessary. Within the scope of the proposed research are the computation of volume and the three-dimensional depiction of bathymetry data.

In today's world, there are many different types of analytical systems in use; however, each one has significant problems. However, many dams continue to perform their analyses by hand. The value that was predicted is extremely off. Unfortunately, there is no support for the 3D display system. To understand GUI, you need to be technically minded. Greater than 85% accuracy is not provided by any of the systems that are currently in use. The vast majority of them consist of a manually operated boat with two members of a technical crew. A wonderful illustration of technology is the Z-boat, which is a system that already exists. The Z-boat is a self-navigating vessel that makes use of Google Maps, cutting-edge GNSS technology, and highly accurate depth sonar.

The Z-cost boats and their availability, on the other hand, are both detriments[1]. In most cases, single-beam echo sounders (SBES) or multi-beam echo sounders (MBES) are utilised in order to make estimates of depth. The SBES is still the instrument that is most commonly used for port and harbour surveys. Only the area immediately below the transducer will have its sounding recorded by the SBES. The line spacing between the survey lines is determined by the scale of the final product as well as the required resolution, and the lines themselves run in a direction that is perpendicular to the slopes of the undersea terrain. Tie lines, also known as longitudinal lines, are used as a quality control cross-check on the field data that is collected. These lines are run parallel to the main survey lines, but with a larger spacing between them. The most significant limitation of SBES is that it can illuminate the ocean floor in only a limited region. Even though MBES is capable of providing continuous coverage, the bathymetric data it produces will not include the depths that exist between the survey lines [2].

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Interpolation refers to the process of determining the expected values for a function by utilising pixels for which values are already known [1-3]. Downsampling is a spatial resolution technique in which the image is reduced by half as a result of a reduction in the sampling rate. Upsampling is a process that increases the spatial resolution of an image, while downsampling is the opposite of this. The following are explanations of some of the more common types of interpolation: 1) The method of using the closest possible neighbour 2) The bilinear technique 3) Utilizing a bicubic formula 4) TIN. Denoising, also known as wavelet shrinkage, is an additional step that can be taken to eliminate noise after the wavelet packet coefficients have been expanded into them. The algorithm that provides the best possible basis for local discrimination has been outlined [9]. This method has the benefit of being based on the wavelet packet transform, which is a fast and linear decomposition process. Additionally, it utilises a binary search tree, which only needs to be searched once due to the fact that the selection and discriminating criteria are additive.

II. SYSTEM BLOCK DIAGRAM

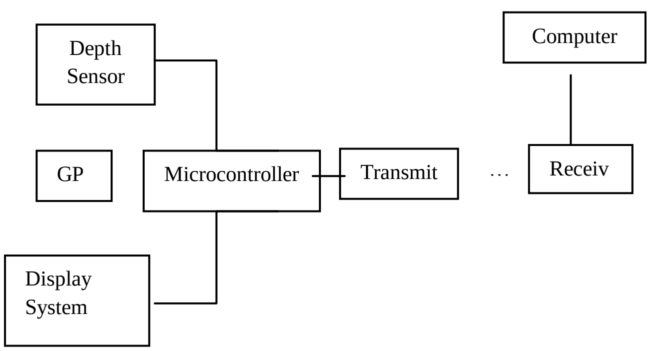

Fig.1. System Block Diagram

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

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

2) Sense of Position: The other input to the system would be a sensor that can determine its position in relation to where it started. This task can be accomplished by using any sensor, including GPS.

In accordance with the modifications made to the project, additional sensors might be added.

3) Procedure Step 1 The microcontroller of the sensor will gather data and carry out the procedures listed below, including displaying the gathered information on the display system. The information should be sent to the computer.

4) Display System The display system may consist of a liquid crystal display (LCD), an organic light emitting diode (LED), or even a seven-segment display.

5) Data transmission to computers There are many different methods that can be used to send data to computers at this time. Xigbee, Bluetooth, and GSM are some examples, but there are many others.

6) Step Two of the Process The data that was sent by the controller is initially stored in a file at the computer end of the process. After the computer has finished processing the data and correcting any errors it may have found, the next step is for it to interpolate the locations of any unknown intermediate points. After the points have been interpolated, a three-dimensional picture of the body of water and a rough calculation of its volume can be produced.

III .THE DESCRIPTION OF EQUIPMENT

A microprocessor with ARM Cortex-M3 and 32 bits of memory known as the LPC1768

For embedded applications that require a microcontroller with a high level of integration and low power consumption, the LPC1768, which is based on the ARM Cortex-M3 architecture, is an excellent choice. The ARM Cortex-M3, which is a core of the next generation, offers improvements to the system, such as enhanced debugging tools and more comprehensive support block integration. The LPC1768 is capable of supporting a maximum CPU frequency of up to 100 MHz. The LPC1769 is capable of supporting a maximum CPU frequency of up to 120 MHz. The central processing unit (CPU) that is used by ARM is based on a Harvard design. This design includes a three-stage pipeline, independent local instruction and data buses, and a third bus for peripherals. Additionally, speculative branching is supported by the built-in prefetch unit of the ARM Cortex-M3 central processing unit (CPU). The peripheral complement of the LPC1768 includes up to 64 kB of data memory, up to 512 kB of flash memory, Ethernet MAC, USB Device/Host/OTG interface, 4 UARTs, 2 CAN channels, 2 SSP controllers, SPI interface, 3 I2C-bus interfaces, 8-channel 12-bit ADC, 10-bit DAC, motor control PWM, quadrature encoder interface, 4 general-purpose timers, and ultra-low power consumption The ARM7-based LPC236x microcontroller family and the ARM7-based LPC1768 share a total of 100 pins between them. The LPC1768 block diagram can be found displayed in Figure 2.

Advantages and capabilities:

CPU options include the LPC1768 or an ARM Cortex-M3 running at 120 MHz, with a maximum frequency of 100 MHz (LPC1769).

Memory Protection Units provide support for eight distinct locations (MPU).

• The Nested Vectored Interrupt Controller, which is built right into the ARM Cortex-M3 (NVIC).

• On-chip flash memory capable of up to 512 kilobytes for programming A more capable flash memory accelerator makes it possible to operate at 120 MHz at high speed and without any wait states.

• Through the utilisation of the on-chip bootloader software, in-system programming (ISP), and in-application programming (IAP).

• On-chip SRAM has 32/16 kilobytes of SRAM on the CPU and a local data/code bus for expedited access to the CPU. On-chip SRAM is also available.

Utilize two or one 16 kB SRAM block with independent access pathways in order to achieve a higher throughput.

These SRAM blocks can serve not only as general-purpose CPU instruction and data storage but also as Ethernet memory, USB memory, and DMA memory. In addition, they can be used as DMA memory.

• An eight channel General Purpose Direct Memory Access controller (GPDMA) on the AHB multilayer matrix that supports memory-to-memory transfers in addition to SSP, I2S-bus, UART, Analog-to-Digital and Digital-to-Analog converter peripherals.

Through the utilisation of the multilayer AHB matrix interconnect, each AHB master is provided with their own individual bus. A few examples of AHB masters include the central processing unit (CPU), the general purpose DMA controller, the Ethernet media access controller, and the USB interface. Communication can take place at any given moment because of this connection's assistance.

• A standard JTAG debug interface that can be used with any of the tools that are currently available. There is a selection of available options for serial wire debugging and tracing. The Boundary Scan Description Language, also known as BSDL, is not supported by this particular device.

• The Emulation Trace Module makes it possible to trace the execution of instructions in real time and at high speeds while remaining unobtrusive.

• When in the Sleep, Deep Sleep, Power-down, or Deep Power-down modes, the Integrated PMU (Power Management Unit) will make adjustments to the internal regulators to reduce the amount of power that is consumed.

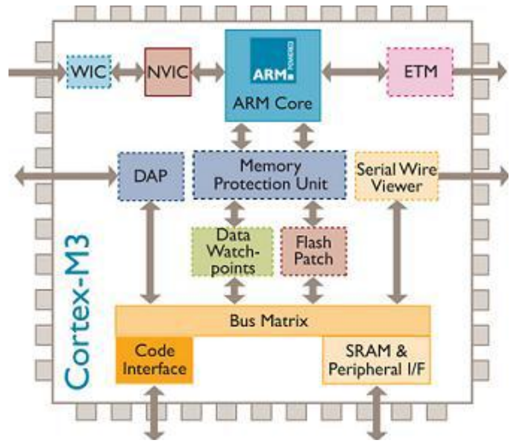

Fig.2. Block Diagram LPC1768

B .The HRXL-MaxSonar WRS Series

High-Resolution Ultrasonic Snow Depth Sensor with IP67 Weather Resistance and Model Number MB7334

As shown in figure 3, the HRXL-MaxSonar-WRS sensor line is a space-saving, low-cost, low-voltage, and low-cost option for applications that require precise rangefinding. Additionally, it is certified as having IP67 weather resistance. Those who use this sensor component module in conjunction with other, more pricey precision ultrasonic snow depth measurement rangefinders can cut the cost of their systems without sacrificing the performance of their instruments by doing so. In addition, the availability of this sensor line makes it possible for designers working with limited budgets to upgrade from other sensors that have inferior performance to this precise sensor. The HRXL - MaxSonar-WRS sensor family offers excellent accuracy and high resolution ultrasonic proximity detection and ranging in air. This is made possible thanks to the sensor family's weather resistance rating of IP67. This sensor series has a resolution of 1 millimetre, target-size and operating voltage adjustment for improved accuracy, enhanced rejection of external noise sources, internal speed-of-sound temperature compensation, and an optional external speed-of-sound temperature compensation.

All of these features can be combined with an optional external speed-of-sound temperature compensation. The HRXL-MaxSonar-WRS sensors have a maximum range of 5 metres in each direction.

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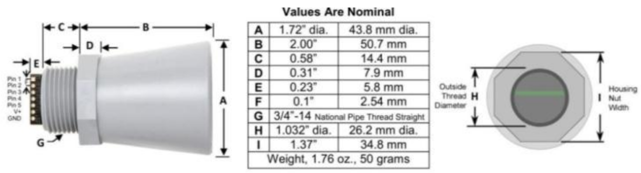

Fig.3. HRXL-MaxSonar®-WRS™ Mechanical Dimensions

A reasonably priced ultrasonic rangefinder that has a detection range of 5 metres, a resolution of 1 mm, and distance sensors ranging from 50 centimetres to 5 metres. Activated operation that provides data on the current range in real time. The operation is free run, and it has excellent noise rejection.

Operating voltage range of 2.7V to 5.5V; 5V is recommended for use in snow applications; nominal current demand of 2.3mA at 3.3V and 3.1mA at 5V; IP67 rating; available in RS232 or TTL 4 formats AN EXPLANATION OF THE APPLICATION THAT IS BEING USED

The bathymetric data obtained from echo sounders often contain a significant amount of multipath noise. Using techniques that involve wavelet packet decomposition, multipath noise can be eliminated. After the noise has been removed, the image is reconstructed using interpolation techniques using MATLAB. After that, MATLAB is used to make the volume calculation. The implementation of the proposed system can be broken down into its component parts using the methodology flowchart shown in Figure 4. The scientific programming language MATLAB, which is used for the implementation of algorithms, provides a robust mathematical and numerical basis. [Case in point:] [Case in point:] The basics of image processing are broken down and demonstrated with the help of MATLAB examples. Denoising's primary goal is to get rid of noise, which can be achieved through filtering in either a linear or non-linear fashion, depending on the circumstances. It is possible to use it to determine the polynomial that will be utilised in the process of interpolating a given set of points. It is a powerful software tool that can be understood in a relatively straightforward manner and enables rapid prototyping and testing of various strategies. It is a one-of-a-kind software package that was developed specifically for your needs; it comes pre-loaded with a wide variety of useful features; and it is significantly simpler to operate than other high-level languages.

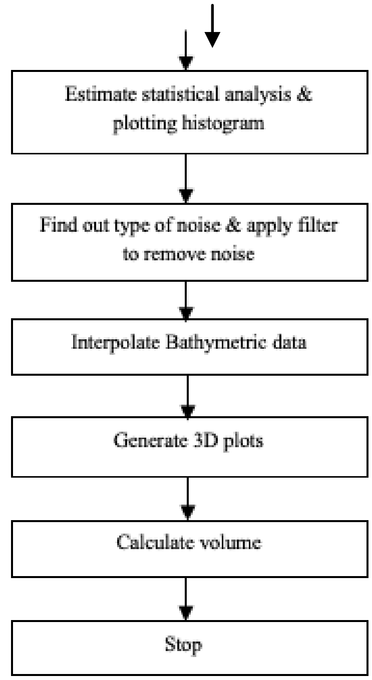

Fig.4. Flowchart for Methodology

V. Data statistics

We examine estimates for the most prevalent statistics used in hydrological estimations, projections, and testing. Here, data statistics are utilised to identify the type of noise in the data. It is presummated that the sample is a time series of length n with items corresponding to time instances, i.e.

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

$$X = \frac{\sum_{i=1}^{n} X_I}{n} \tag{1}$$

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.

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

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.

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

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. OUTCOMES

Bathymetric data is XYZ-coordinated depth value information for reservoirs or gaps. Table II displays the original bathymetric data, which does not include smooth points on the reservoir top or the lack of the bottom. To identify noise patterns in acquired data, estimation is carried out. To obtain noise-free data, interpolation is done after noise removal techniques have been applied. And MATLAB is used to create a 3D plot at the very end.

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.

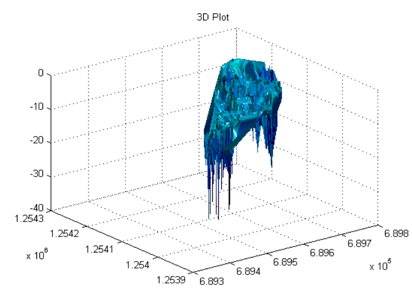

Fig.5. 3D Plot

VII. CONCLUSION

Active sonar and multi-beam echo sounders are utilised for the purpose of obtaining bathymetric data in XYZ coordinate format for use in underwater communication. Statistical analysis is performed so that any noise in the data that was provided can be uncovered. A 3D plot is created with MATLAB, and various interpolation methods are utilised during the picture reconstruction process. After that, either the volume of the reservoir or the deficit is calculated, and the results can be compared to those obtained by using software that is comparable to SURFER 8.

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