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Real-time Load Monitoring and Estimation of Waterline in Boat using Load Cell Assembly and Ultrasonic Sensor

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***Abstract*—To justify the need for boat capsize prevention, an indicative compact system is designed for future safety engagement and preventive measures. The system secures its place to simultaneously provide live load accommodation on the boat surface using load cell assembly positioned exactly below the boat deck. The ultrasonic sensors mounted on the periphery of the boat sides strive to depict the water line admired by the boat continuously. Additionally, a humidity sensor senses to superficially scrutinize the moisture levels of the environment. These three parameters readily being depicted on an LCD display and individually configured with Arduino board to be processed reliably in the system.**

***Index Terms*— Load cell sensor, Arduino, water monitoring, Ultrasonic sensor, Capsize prevention.**

I. INTRODUCTION

Water transport in India has played a significant role in the country's overall economy and is indispensable to foreign trade. Safety is the necessity for all, whether it is roaming freely in a park or enjoying a leisurely sport like boating. Accidents in inland waterways in developing country like India are a regular phenomenon throughout the year causing deaths, injuries, monetary loss, and a significant amount of missing people. We hereby aim to enhance inland boat travel and recreational boating activity using this boat safety feature.[1] This research paper inflicts the technology phenomenon with real-time safety parameter monitoring with basic methodology by using load cell and ultrasonic sensor. The paper first briefs about the hardware components of the proposed system, then going to the observation data collection and then the data analysis. Later, reaching out the results and discussing the drawbacks of current approach. Lastly, concluding the paper with enlisting the references.

A. Proposed System

Construction

The System constitutes of an assembly where a cross-shaped wood with wooden pillars on each extremity of the cross. An inflated rubber tube

To maintain overall balance is affixed across the bottom surface of the wooden assembly. A 5V Power supply is

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adjusted beside the Load cell assembly across the wooden cross. The Load cell assembly is mounted on the centre of the wooden cross assembly. Two Ultra-sonic modules are attached to the two opposite pillars and are beamed exactly downwards towards waterline. An Arduino board is mounted on the inner edge of one of the pillars.

Dimensions of proposed model:

- Outer diameter of tube: 50.8 cm
- Inner diameter of tube: 27.4 cm
- Deck length of cross-shaped wood: 47.8 cm
- Wooden pillar height: 17.8 cm
- Wooden pillar thickness: 3.9 cm x 3.9 cm

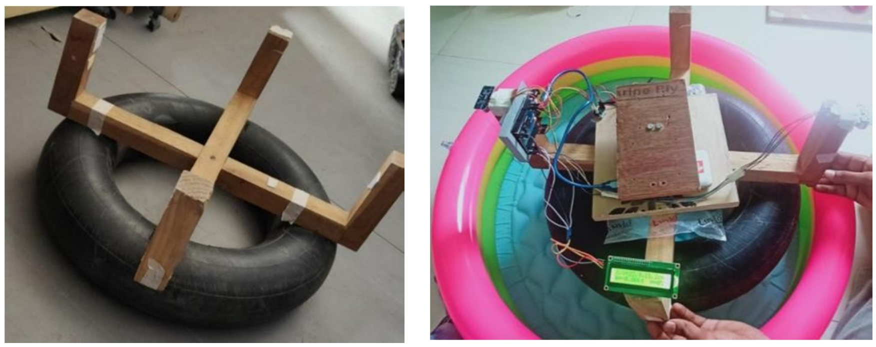


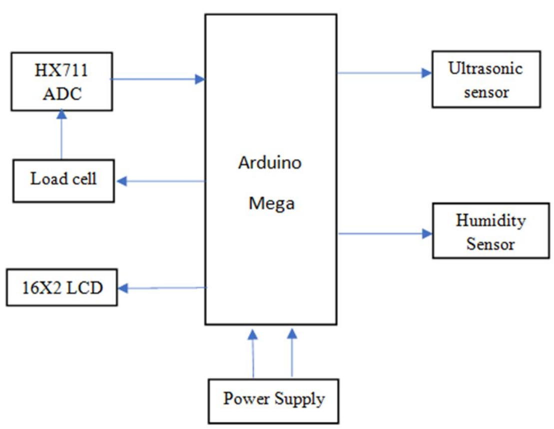
Fig. 1- Prototype

Working:

The Proposed System consisting of Load cell, ultrasonic and an Arduino board defines its working through these three components mainly which work individually configured to the Arduino. As the Load Cell constitutes of an elastic member to which several strain gauges are attached which generates strain due to stress at respective load cell area as a result, two of straingauges are in compression whereas the other two are in tension so, the respected force acting on the load cell is converted into the electronic signal. As we go on loading or unloading the weight on the surface deck, the load cell gives the reading through the configured Arduino on an LCD display.

Two ultrasonic sensors placed on the opposite periphery transmit ultrasonic pulse down to the waterline. This pulse, travelling at the speed of sound gets reflected to the transmitter from the water surface. It measures the time delay between transmitted and received echo signal and the configured Arduino board calculates the real-time distance between the water line and the boat periphery and indicated on the LCD display.

II. SYSTEM BLOCK DIAGRAM



III. HARDWARE DESCRIPTION

A. Load cell

The Strain gauge load cell [2] selected for our prototype has a capability of translation up to 40 kg of force withstand and conversion to electronic signals. The load cell constituting of four strain gauges made from aluminium-alloy each capable of a reading capacity of 10Kg internally hooked up in a Wheatstone bridge formation. The wiring of the load cell follows the colour coding as red: E+, green: O+, black: E- and white: O-. This load cell offers IP65 protection rating featuring four M6 sized through-holes for mounting.

Fig. 2- 40kg Load cell

B. HX711 ADC

HX711 is a precision 24-bit analogue-to-digital converter designed for weigh scales and industrial control applications to interface directly with a bridge sensor. The input multiplexer selects either channel A or B differential input to the low-noise programmable gain amplifier (PGA). Channel A can be programmed with a gain of 128 or 64, corresponding to a full-scale differential input voltage of +-20mv to +-40mv respectively, when a 5V power supply is connected to VDD power pin.

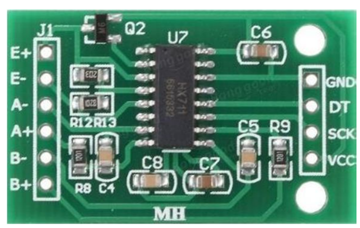


Fig. 3-HX711 ADC

C. Ultrasonic sensor

One of the main components for this project is ultrasonic sensor HC-SR04. Two ultrasonic sensors[3] are attached to the pin no.7,9(trigger) and 6,10 (echo) to the Arduino. It emits short, high-frequency sound pulses at regular intervals. These propagate in the air at the velocity of sound. If they strike an object-here we take a water line as an object-then they are reflected as echo signals to the sensor, which itself computes the distance to the target based on the timespan between emitting the signal and receiving the echo. Whenever, the loads on load cell structure increased the distance from the water line to ultrasonic sensors decreased. Finally, the co-relation between load and distance will establish and the output will display on the 16x2 LCD.

Fig. 4-Ultrasonic sensor

D. 16X2 LCD

The Liquid Crystal Display has sixteen columns and two rows into the display screen viewing the dimensions of 69.5mm x 14.5mm with a single character display size of 5x7 pixels matrix. This LCD is interfaced using two wires with supplied power of 5V and 1.1mA having low power consumption which can feature numbers, characters, symbols, and special characters. As shownin fig.(5) X and Y are distance from the water line and W indicates weight in kg.

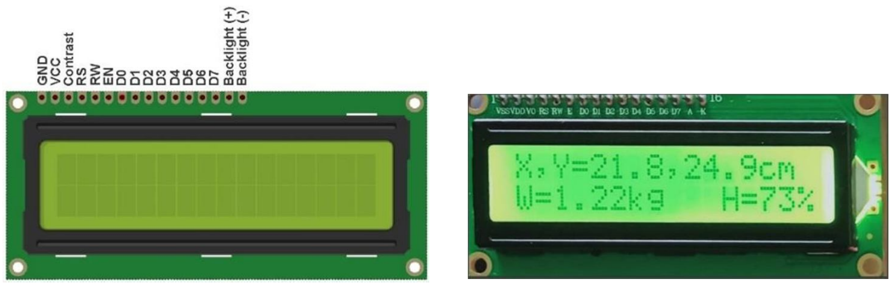


Fig. 5– 16x2 LCD

E. Arduino mega

The Arduino Mega board is a Microcontroller based on ATmega2560 which has the operating voltage of 5V. It has 54 digital I/O pins of which 15 can be used as PWM outputs, 16 analogue inputs, 4 UARTs, 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a reset button. The input voltage of 7-12V (limited to 6-20V), DC current per I/O pin: 40 mA and DC current for 3.3V pin: 50 mA. The flash memory consisting of 256 KB of which 8 KB used by bootloader.

Fig. 6- Arduino Mega board

IV. OBSERVATION TABLE

Calibration Factor: -7600.4
Initial Test Value: distance measured from ultrasonic sensor 1 (x) = 23.5 cmdistance measured from ultrasonic sensor 2 (y) = 20.9 cmweight (w) = 0.00 kg
waterline = 12.5 cmtube height = 25 cm

TABLE I. OBSERVATION

Sr. no.	Actual weightIn Kg(s)	Output (displayed weight)in Kg(s)	Distance (x)in cm(s)	Distance (y)in cm(s)	Average of x and yIn cm(s)
1.	1.22	1.22	21.8	24.9	23.35
2.	1.16	1.15	22.1	23.5	22.8
3.	2.04	2.03	15.8	23.6	19.7
4.	2.38	2.36	19.9	17.7	18.8
5.	4.43	4.38	17.7	28.6	23.15
6.	2.00	2.01	22.06	23.70	22.88
7.	3.00	3.03	19.02	22.38	20.7
8.	5.00	5.02	15.4	20.02	17.7

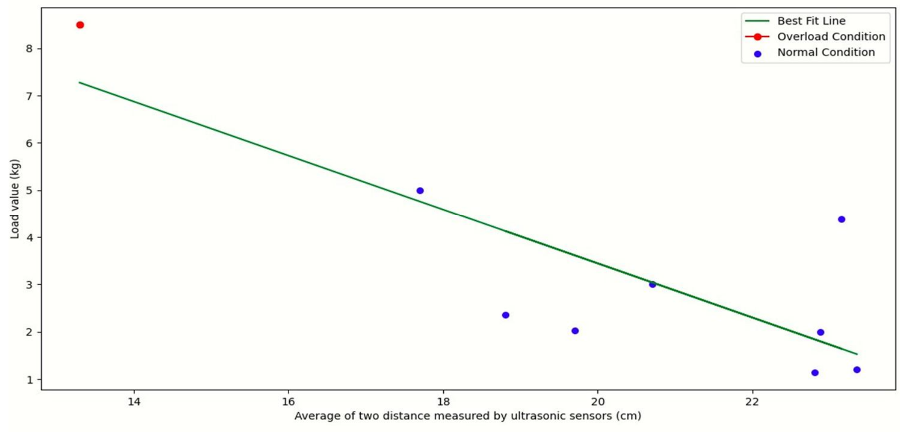


Fig. 7- Relation between load and average distance

Firstly, the calibration of Load Cell Sensor was obtained by setting the calibration factor to -7600.4 in the program in Arduino IDE so that precise load readings were achieved. Also, the two readings obtained from the opposite ultra-sonic sensors were averaged to secure lucid interpretation of the boat capsizing which also nullifies the effect of turbulence of the water surface. From the study of observation table that is obtained by putting different loads on the model. The corresponding readings were noted from Load Cell sensor and ultrasonic sensor using LCD to get a relation between the weight and average distance of ultrasonic sensors. The overload condition in this model was achieved at the load of 8.5 Kg (actual = 9.4 Kg) with distances x and y reaching at 12.7 and 13.9 cms respectively making the average distance of 13.3 cm. Using Linear Regression [5] in Onevariable, the observations were graphed through programming in python that is shown in fig (7). From the study of graph, we can conclude that as the weight of load increases, the average value of distance decreases. So, the output load weight is inversely proportional to the average distance of measurement sensor.

V. Drawbacks

- The conditions of water surface are often important. Some turbulence can be tolerated but foaming will often damp-out thereturn echo.
- As ultrasonic sensor function by emitting ultra-sound waves directly at the liquid surface, always top mounting is a necessarycondition so, other applications or equipment that seek to be bottom or side-mounted are not well suited in cooperation withultrasonic sensor.
- The need of proper water floatation media gives rise to improper floating characteristic for the model.
- The respective constructed model gets wobbled when placed in water media as the alignment with water surface is inappropriate.

VI. Conclusion

As the waters will continue to be one of the indispensable earthen beauties for trade, transport, travel and recreation, capsizing and overloading becomes a crucial facet to be illuminated. This experimental study of real-time monitoring of load cell and ultrasonic sensor in the proposed boat model, establishes perspicuous inverse relation between the waterline and loading through the respective sensors with accurate calibration, programming in Arduino and Python and real-time indication of the target parameters. This fundamental model digs new treasures to the efficient and stable boat structures, factors that strike and variousprinciples to be dignified to deal with the phenomena of overloading and capsizing of the boat. Furthermore, while this research focused on developing the roots of capsizing to overloading through on-model indication of real-time data, this can be extended to online data access with greater accuracy and efficiency with some visual, analytical, and graphical presentations acknowledged by programmed modelling and optimization of boat for achieving heavenly and streamlined water experience.

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REFERENCES

[1] Kamakshi Kaul, Naman Shukla, Mrugesh Shah, Het Gandhi, Tirthraj Gandhakwala "Implementation of Monitoring Feature for Prevention of Inland Boat". *Journal of Emerging Technologies and Innovative Research*, November 2018, Volume 5, Issue 11.

[2] Prakhar Shrivastava, Praveen Kumar, Ankit Tiwari "Project Review on Ultrasonic Distance Measurement". *International Journal of Engineering and Technical Research* , 2014.

[3] Anderson Langone Silva, Marcus Varanis, Arthur Guilherme Mereles, Clivaldo Oliveira, José Manoel Balthazar "A study of strain and deformation measurement using the Arduino microcontroller and strain gauges devices". *Scientific Electronic Library Online,* November 2018.

[4] Arun K Ghosh, "Introduction to Measurements and Instrumentation", Prentice Hall India Learning Private Limited,4th Edition,2012.

[5] S K Singh, "Industrial Instrumentation and Control", McGraw Hill Education, 3rd Edition ,2017.

[6] A.K. Sawhney, Puneet Sawhney, "A Course in Electrical and Electronic Measurements and Instrumentation", Dhanat Rai and Co., 2012 edition.

[7] Anuradha Srinivasaraghavan, Vincy Joseph, "Machine Learning", Wiley India Private Limited,1st Edition,2019.

[8] Bela Liptak, "Instrument Engineer's Handbook", CRC Press, Third edition,2003

[9] Precise boat waterline length calculation. [Internet].Available from:https://blog.theboatdb.com/precise-boat-waterline-length-calculation/