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Detection of Safe Angle for Water Vehicles due to Vulnerable Swing

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*Project only

Overview

- Introduction & Problem Statement
- Methodology
- System Architecture
- Experimental Results
- Conclusion

Introduction

- Natural disasters like rapid winds and storms cause the vast quantity of waves in the river and ocean. Which inhibits the movement of water vehicles.

- During such a hostile situation the most important thing is safety.

- To remain safe we need a safe position.

Introduction cont.

- To reach to the safe position we calculate a parameter called Safe Angle.

- Safe Angle is defined as the angle between the current heading of the vehicle and the most safety position.

Introduction cont.

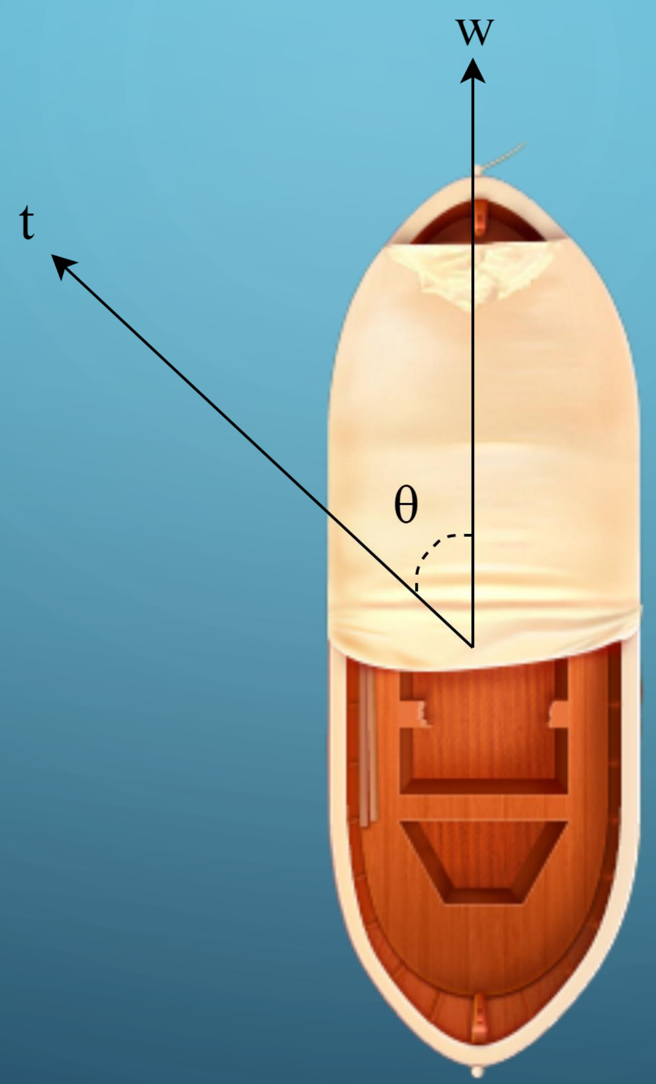

Fig. Illustration of Safe Angle

Methodology

- Measuring tilt angles
- Measuring Y-factor
- Measuring threshold values
- Measuring safe angle

Measuring Tilt Angle

- We used ADXL345 accelerometer – which gives the acceleration in x, y, and z axes as Ax, Ay, and Az.
- Using the following equations we calculated the roll (α), pitch (β), yaw (γ) angle [1].
- $\alpha = \arctan\left(\frac{A_x}{\sqrt{A_y^2+A_z^2}}\right)$
- $\beta = \arctan\left(\frac{A_y}{\sqrt{A_x^2+A_z^2}}\right)$
- $\gamma = \arctan\left(\frac{A_z}{\sqrt{A_x^2+A_y^2}}\right)$

Measuring Y-Factor

- It has been proven that "Tilt angle is proportional to the sine component of the wave force acting on a boat."[2]
- Mathematically, Tilt ∝ V sinθ
  - Where V is the acting force on boat.
- We defined Y -Factor as the ratio of rolling (*α*) and pitch angle (*β*) of the boat.
- Therefore we express as, $Y - factor = \frac{|\alpha|}{|\beta|}$

Measuring Threshold Values

- Threshold values help to determine wheatear the boat is in vulnerable position or not.
- We have used two thresholds - T_x, the threshold for x-axis and T_y , the threshold for y-axis.
- We have measured the maximum threshold angles, T_{xmax} and T_{ymax} in which angle the boat capsize.

Measuring Safe Angle

- If $|\alpha| > T_x$ or $|\beta| > T_y$, then we step to find the safe angle.
- Safe angle is calculated using the following equation:

$$\theta = \arctan\left(\frac{|\alpha|}{Y - factor \times |\beta|}\right)$$

- The safe angle is normalized between 0 to ± 90 degrees.

Safe Angle Direction

Roll angle	Pitch angle	Direction
$a \geq 0$	$\beta \geq 0$	Clockwise
$a \geq 0$	$\beta < 0$	Anti-Clockwise
$a < 0$	$\beta \geq 0$	Anti-Clockwise
$a < 0$	$\beta < 0$	Clockwise

Table. Safe angle direction

System Architecture

- Main components:
  - Arduino Uno 3
  - ADXL345 accelerometer
  - Servo Motor
  - 16x2 LCD display
  - Bazaar alarm

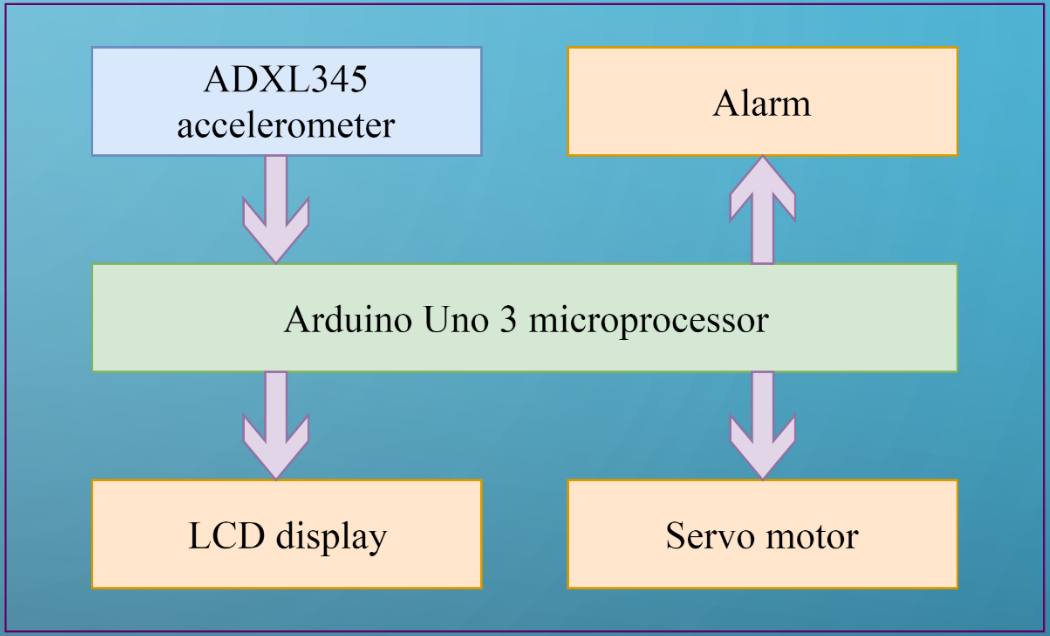

Fig. Block diagram of the system.

System Architecture cont.

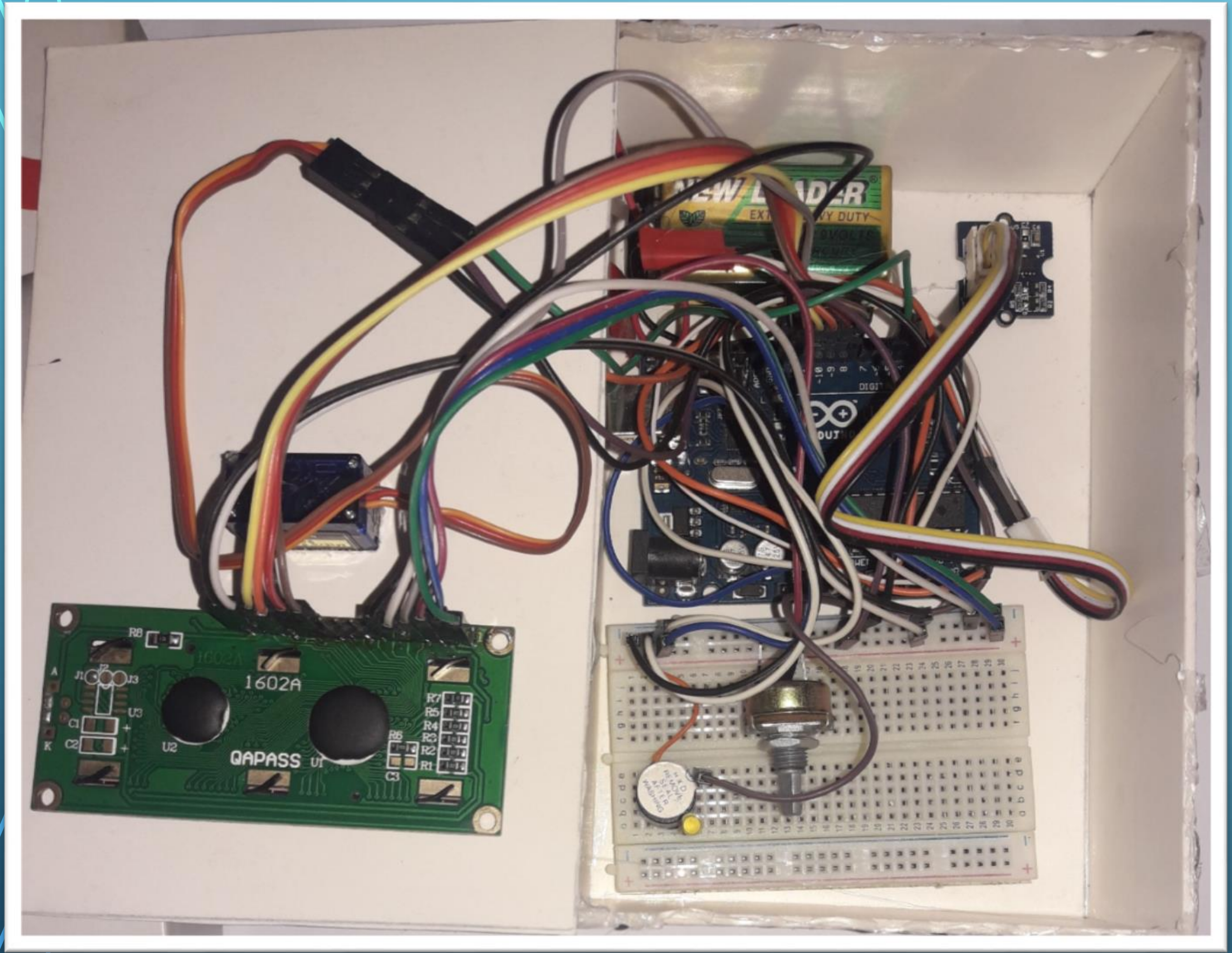

Fig. Internal circuitry and a snapshot of our device

System Architecture cont.

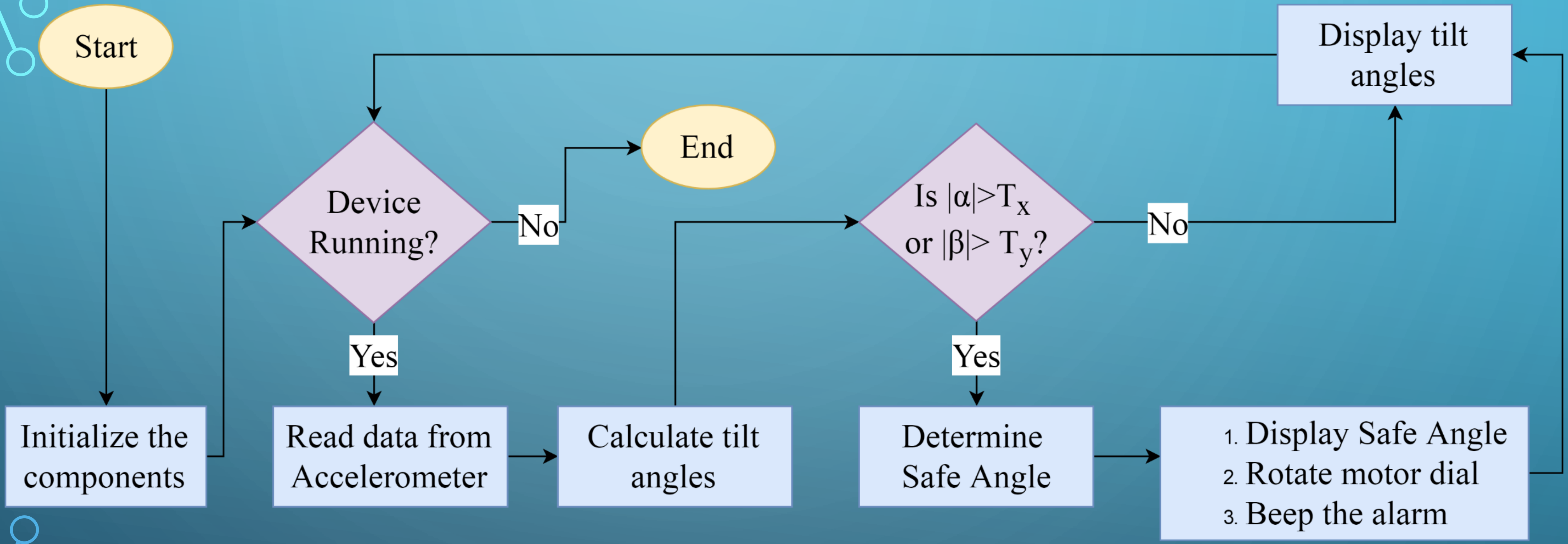

Fig. Flowchart of the system.

Experimental Results

SL	LOA (ft.)	BOC (ft.)	Y-Factor	T_{xmax} (θ°)	T_{ymax}(θ°)
1	9	2	2.35	30	44
2	12	3	2.44	34	45
3	12	3	2.49	34	46
4	5	2	7.02	35	40
5	0.66	0.66	0.99	47	47

Table. Boat geometry, Y-Factor, and maximum threshold values.

Experimental Results cont.

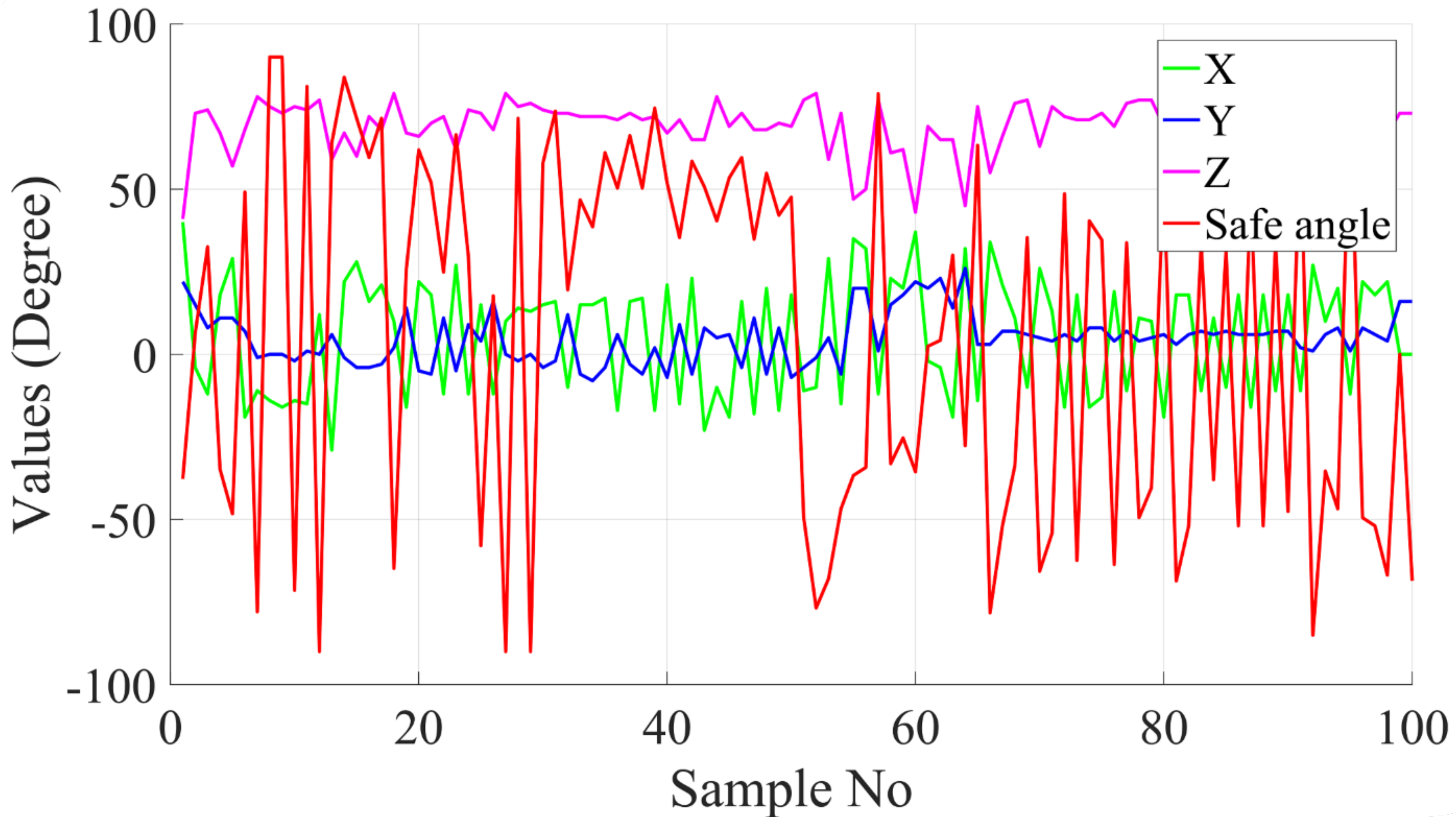

Table. Safe Angle Result for Boat 1

Experimental Results cont.

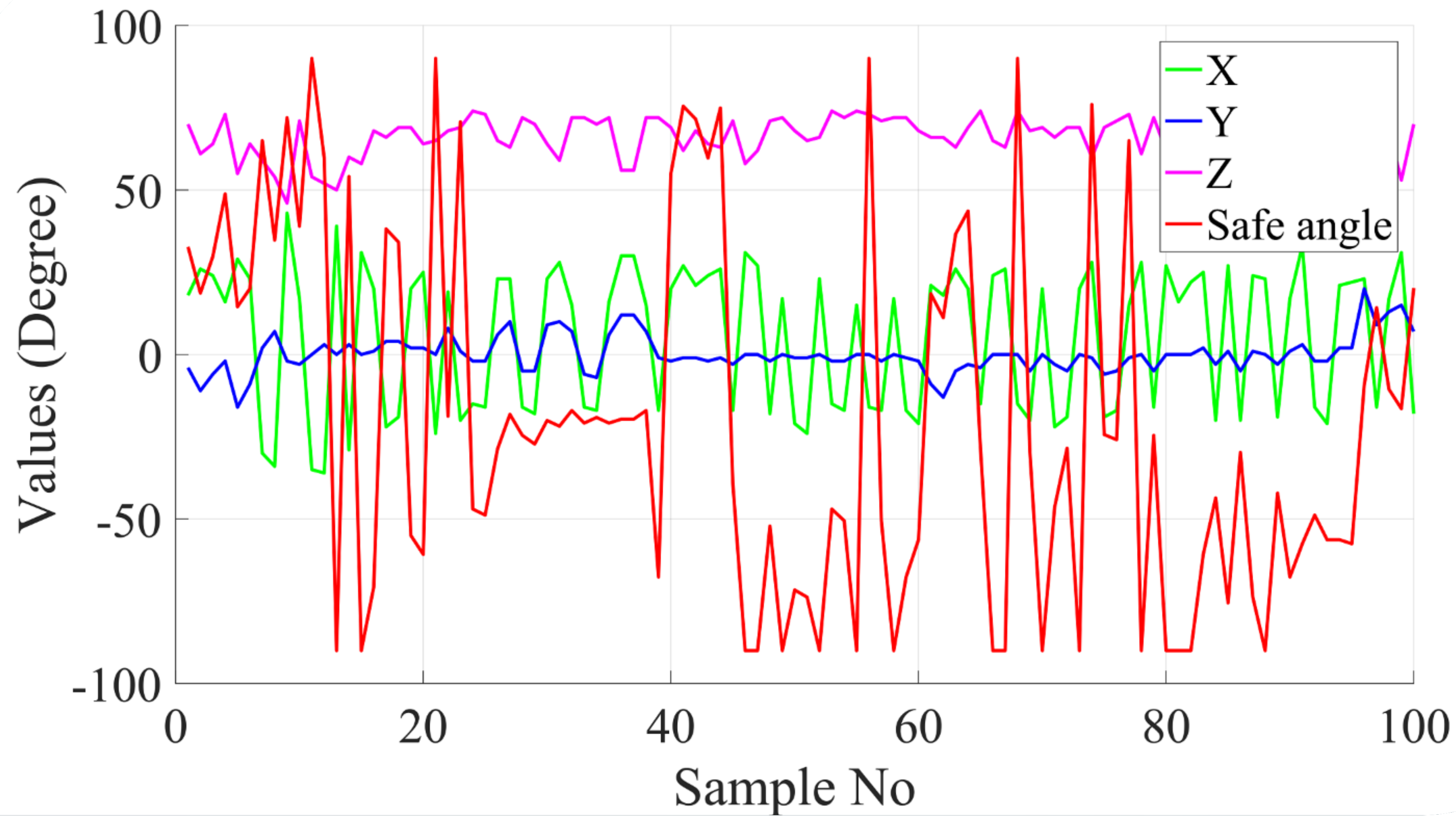

Table. Safe Angle Result for Boat 4

Experimental Results cont.

SL.	Roll	Pitch	Yaw	Safe Angle
1	-4	15	73	6
2	-12	8	74	33
3	18	11	67	-35
4	29	11	57	-48
5	-19	7	68	49
6	-11	-1	78	-78
7	-14	1	75	90
8	-16	1	73	90
9	-14	-2	75	-71
10	-15	1	74	81

Table. Safe Angle Sample Result for Boat 1

Conclusions

- Our device is suitable for on-board real-time implementation.
- It could be an ideal method for the autonomous marine vehicle also.
- The Y-factor used in this paper is not universal for all the boats with the same dimensions, before using the device, the *Y -Factor* of the boat must be calculated.

Reference

[1] C. J. Fisher, “Using an accelerometer for inclination sensing,” AN-1057, Application note, Analog Devices, 2010.

[2] Detection of Safe Angle for Water Vehicles due to Vulnerable Swing, ICASERT 2019, paper ID - 246

Thank You