Aqua Navigators: Empowering Visually Impaired Swimmers

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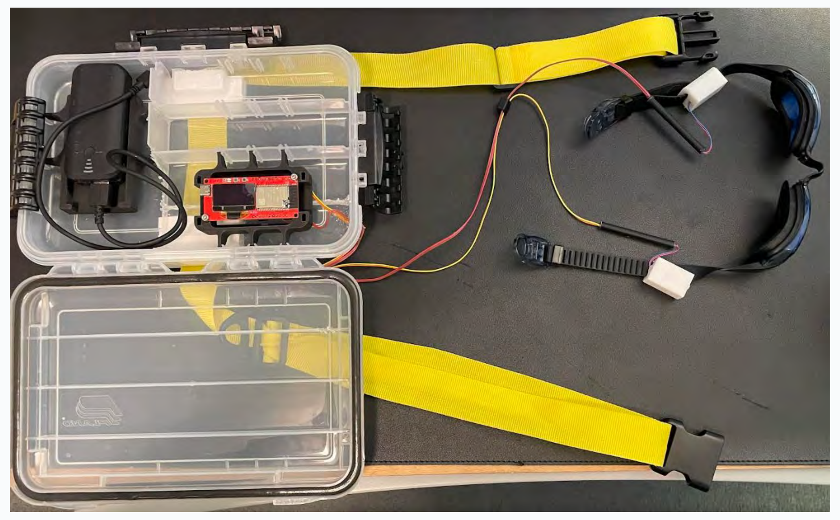
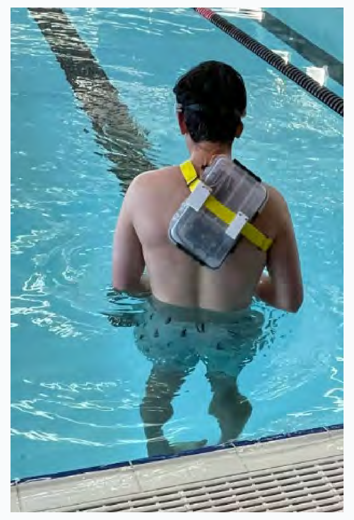
INTRODUCTION

Our project endeavors to innovate the swimming experience for visually impaired individuals. Our objective is to design a device that facilitates autonomous swimming, empowering visually impaired swimmers to navigate independently. Utilizing either tactile, audio, or visual feedback, our device will alert the swimmer of any deviations from a straight path and provide warnings as they approach the pool wall, enhancing their safety and confidence in the water.





USER NEEDS

To create a successful device it is essential we meet the user needs to the right. The most important factors are the positional accuracy and the operating range since these are the drivers for the device's purpose. Through iterative development and user feedback, we ensured our product exceeds expectations.

User Needs	Units	Values	Fulfilled
Volume	cm^3	<35	✓
Weight	kg	0.1	✓
Dimensions	cm	3x5x2	✓
Positional Accuracy	m	0.5	✓
Operating range	m	55	✓
Feedback Strength	dB	70	✓

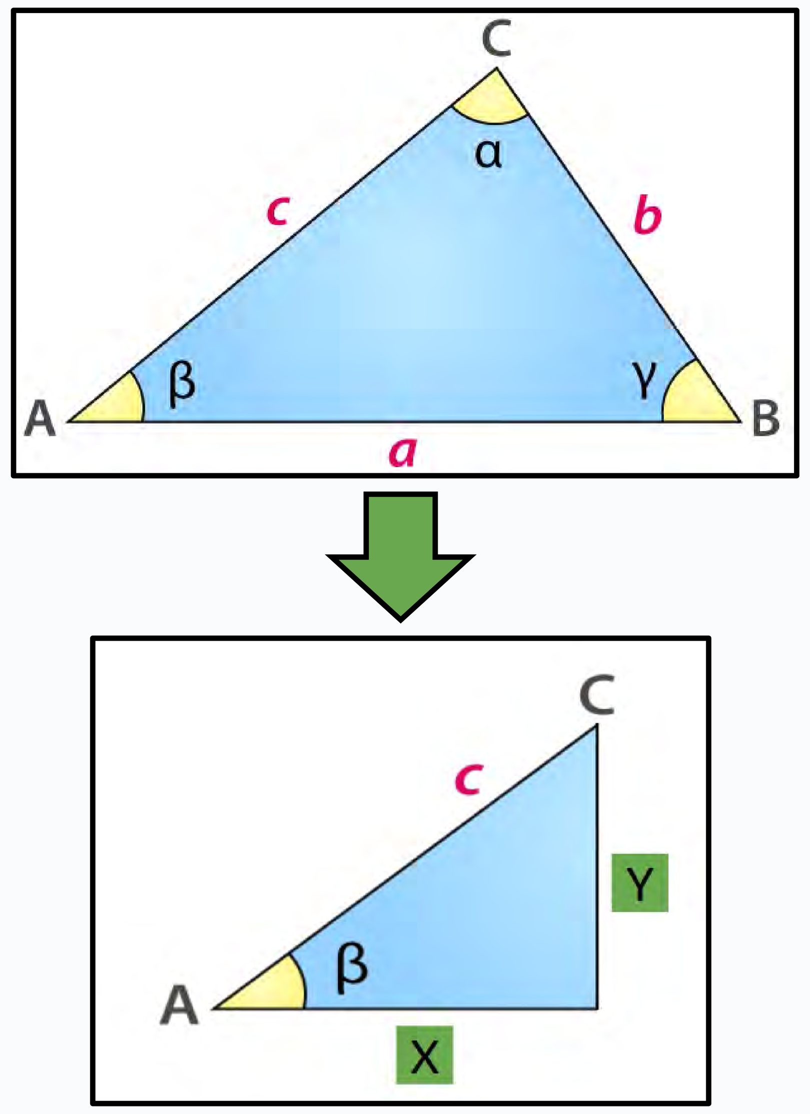
METHODS

To precisely track the swimmer in the water, triangulation will be employed. This method involves two anchors (point A and B) and a tag attached to the swimmer (point C). By accurately measuring the distances between these points, we can utilize the law of cosines to determine the angles.

$$\cos(\beta) = (c^2 + a^2 - b^2) / (2ab)$$

Next, the triangle can be transformed into a right triangle which allows the use of trigonometric principles (such as sine, cosine, and tangent) allowing the the swimmer's x and y coordinates to be calculated.

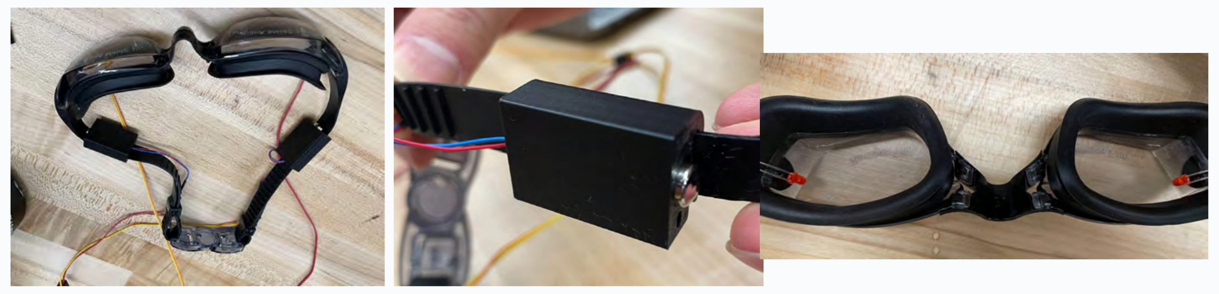
$$X = \cos(\beta) * c$$
$$Y = \sin(\beta) * c$$



PROTOTYPES

Tactile & Visual

Tactile and visual prototypes attach to the swim goggles and use led lights and vibration motors. The swimmer will then go away from the flashing light or the vibration on either side.



Audio

The audio prototype utilizes waterproof bone conduction headphones for sound transmission. Arduino communicates with the phone via HC-05 Bluetooth. A custom app connects the Arduino to the phone, which is then linked to the transceiver using an aux cord.

USER TESTING DATA

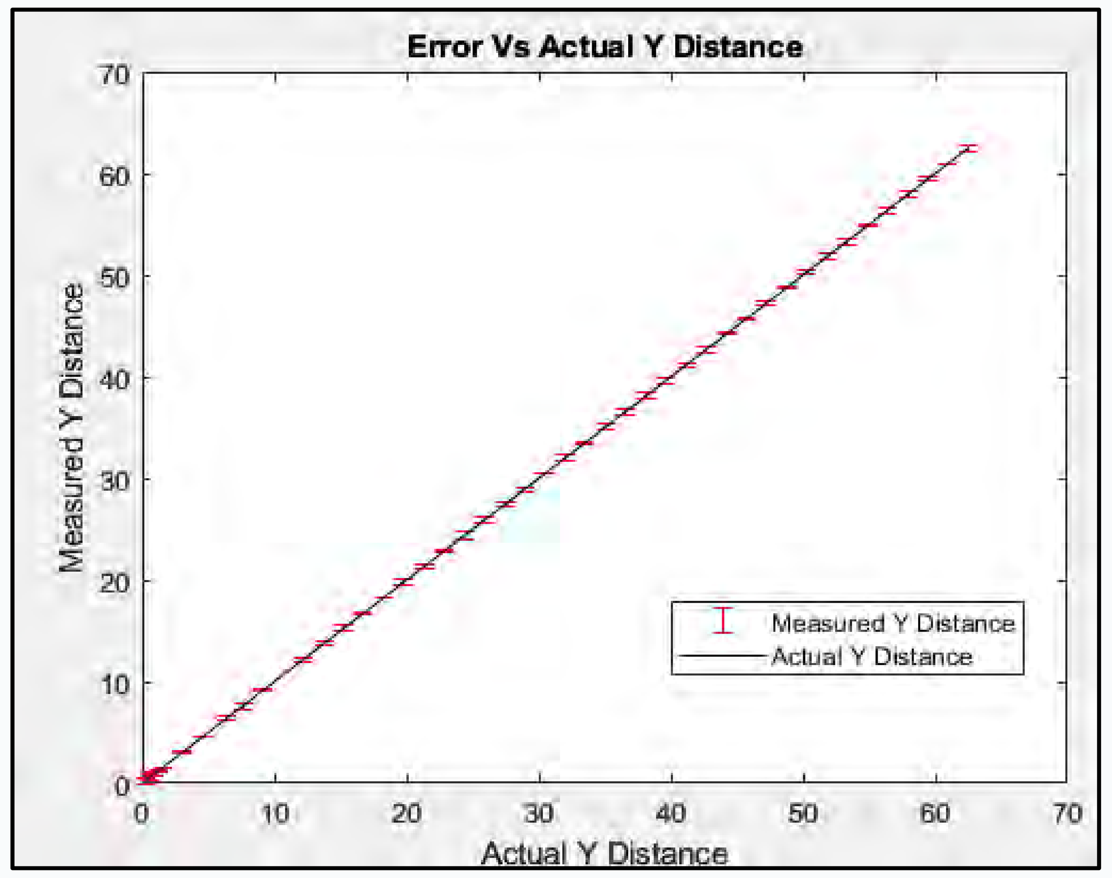
Before conducting water testing, thorough evaluation was carried out on land. Blindfolded participants were engaged in user testing, where they navigated 15 meters with each prototype—audio, tactile, and audio-tactile. They were prompted to maintain a close proximity to a straight line, receiving necessary notifications. The prototypes were evaluated based on the scoring system below.

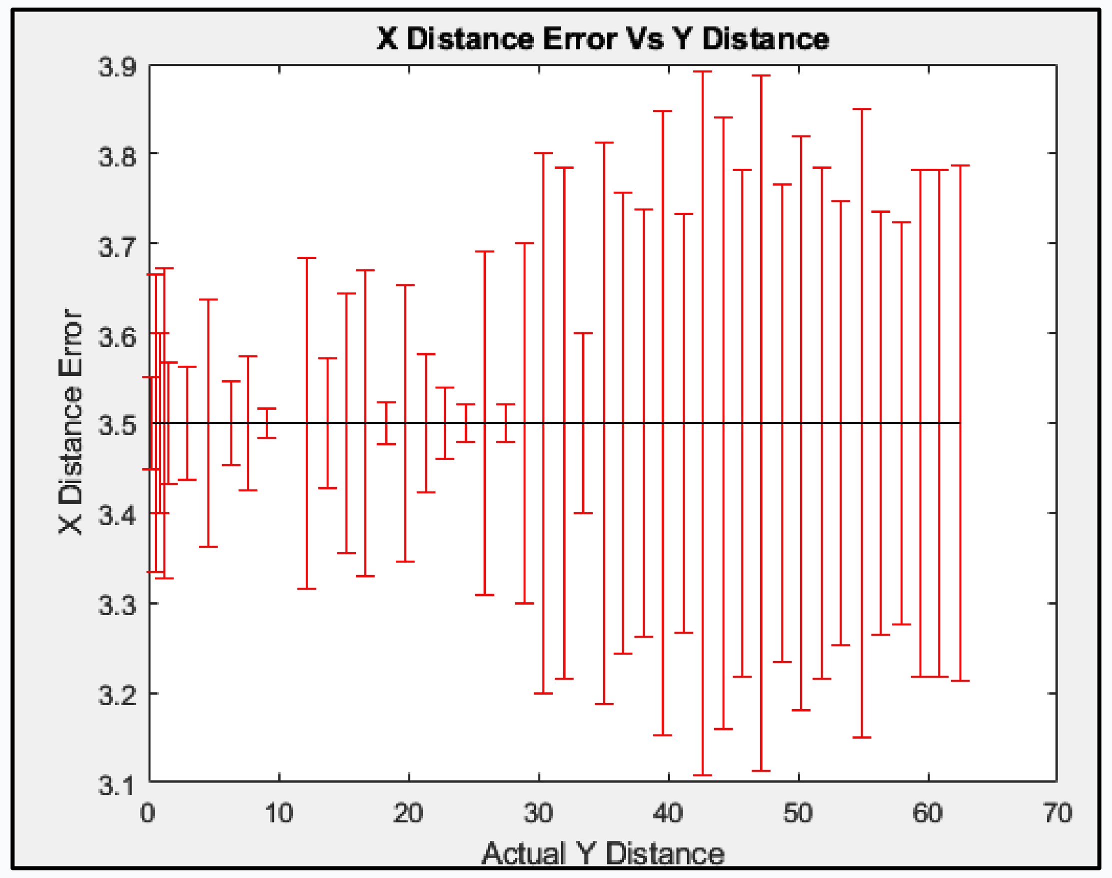
	User 1			User 2			User 3			User 4			User 5			User 6		
Data	**Audio**	**Visual**	**Tactile**	**Audio**	**Visual**	**Tactile**	**Audio**	**Visual**	**Tactile**	**Audio**	**Visual**	**Tactile**	**Audio**	**Visual**	**Tactile**	**Audio**	**Visual**	**Tactile**
Average Distance Before Turning Desired Distance: 15 Meters	15.6	15.3	14.3	15.8	15.4	15.2	15.4	15.2	15.2	15.3	15.2	14.9	15.2	15.5	15	15.6	15.3	14.9
Time Spent For Testing (Seconds)	15	15	14	16	16	15	17	14	13	16	14	14	18	19	15	15	16	15
Average User Speed (Meters/Second)	1.04	1.02	1.02	0.99	0.96	1.01	0.91	1.09	1.17	0.96	1.09	1.06	0.84	0.82	1.00	1.04	0.96	0.99
Overall Satisfaction	6	4	8	8	3	6	6	5	8	8	2	9	8	2	5	5	5	8
Favorite Communication Method	Tactile			Audio			Tactile			Tactile			Audio			Tactile		

Based on the scoring system, the tactile system was the favorite. Subsequent underwater testing revealed that while the device performed well overall, there were issues with positional accuracy beyond 20 meters for right-to-left adjustment. However, the end-of-lane sensing function worked great. Regarding specifications, the device successfully met the following criteria below.

DEVICE PERFORMANCE

Accuracy for both the x and y distance were within the .5 meter positional accuracy specification. The y distance had an average error within .1 meters which allowed users to have dependable end of lane sensing. The x distance is reliable up to a y distance of 30 meters. After 30 meters, the distance difference between the anchors and tag become minimal and cause the angle calculated to be inaccurate. Overall, the system demonstrates robust performance within its specified parameters, providing reliable positioning within the designated range.





CONCLUSION

In conclusion, our adaptive swim sensor project is a significant success, considering the budget constraints, the device is commendable. The current outcomes are encouraging and our device is promising for the future iterations. The device successfully achieves the baseline goal of end of lane sensing. Although centering the swimmer within the lane needs improvement, the current outcomes are encouraging, demonstrating that the methods of localization holds promise.
For future work, we aim to further enhance our adaptive swim sensor by incorporating the following improvements: adding cord grips with NPT threads to enhance waterproofing, implementing thinner walls in the housing to improve communication capabilities, integrating a more secure strap for enhanced stability, and incorporating a heat sink/water cooling system. With an increased budget allocation, these advancements hold promise for broader implementation within the visually impaired community, ensuring even greater effectiveness and accessibility for all users.