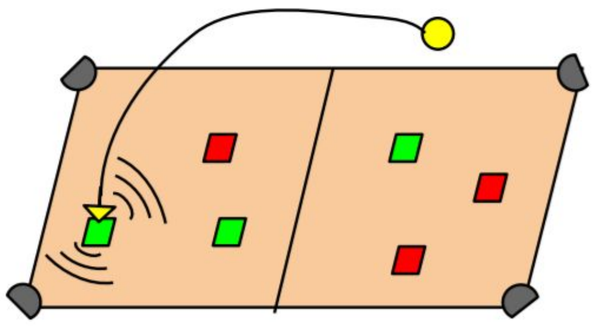

Acoustic Battleship

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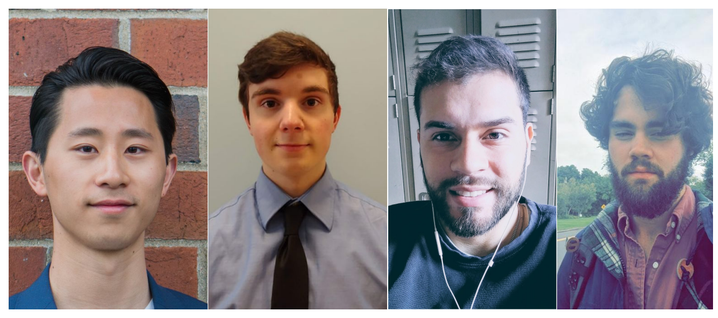
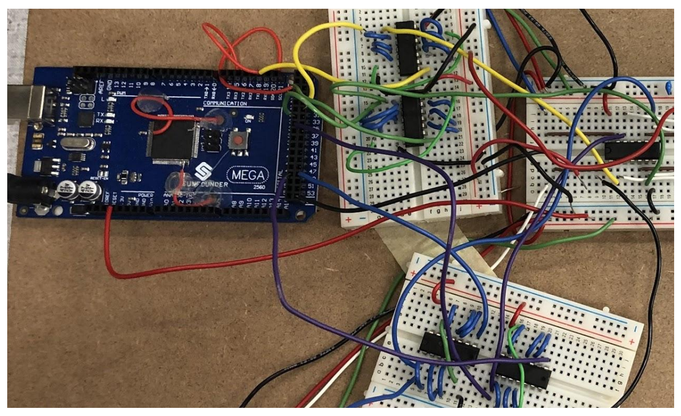
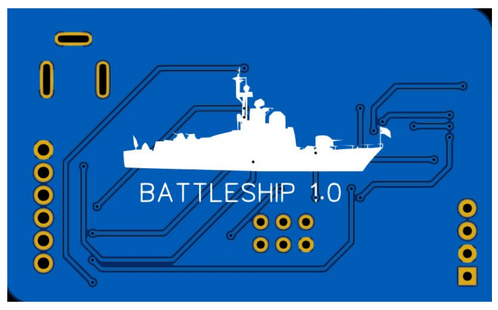


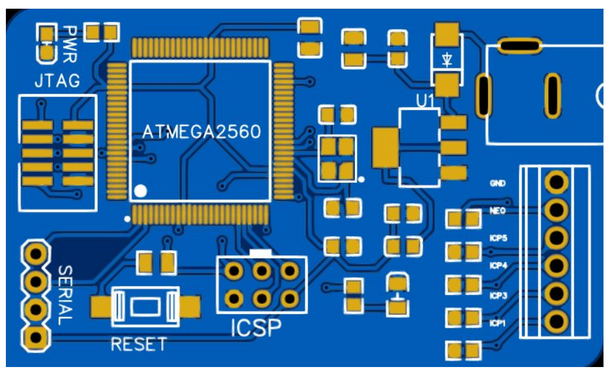
Abstract

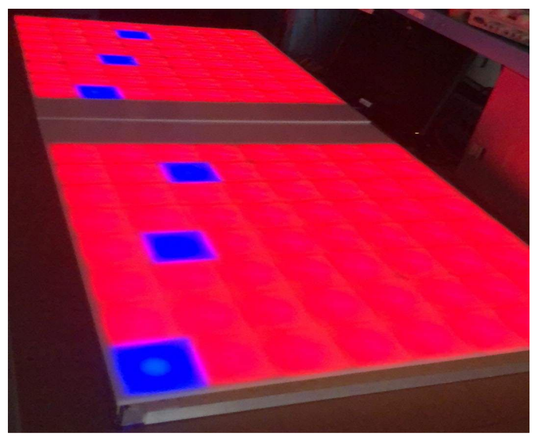
The traditional battleship game is an easy and fun two-player game. As engineers, we seek to innovate upon this game by adding our own technology. We designed a sound localization system that converts the traditional battleship game to a precision-based game. We call this new game “Acoustic Battleship”. Players take turns to attack by throwing a ping pong ball at their opponent’s side of the board. The system then calculates the location the ball hit based on the difference in the time it takes the ball’s sound to reach four microphones, one at each corner of the board. A hit or miss is determined by comparing the calculated location to known ships' locations and is then indicated by the LEDs in the board.

Functional Prototype

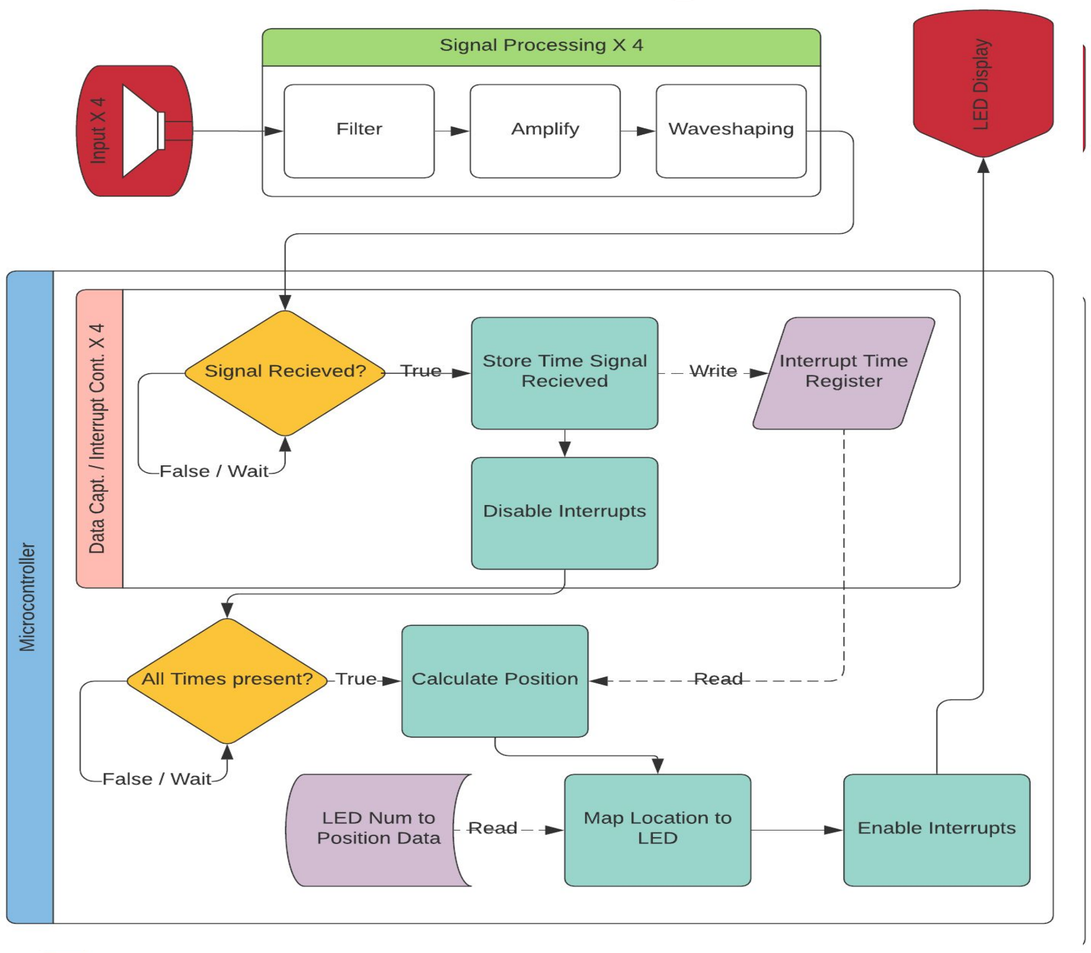








Block Diagram



System Overview

There are four mics, one at each corner of the board. Each mic has a custom-designed comparator circuit that filters out noise and shapes the signal. There are four 16-bit timers with interrupts. Each timer interrupt is triggered by a rising edge on the input pin of its mic. When the interrupt is triggered it writes the time that it occurred to a dedicated register. This gives us four different, high-resolution time of arrivals that we then use to determine position. These circuits run on custom PCBs and are powered by an ATmega2560.

Localization Algorithm

a = SOUND_SPEED * (t1 - t0)

b = SOUND_SPEED * (t2 - t0)

c = SOUND_SPEED * (t3 - t0)

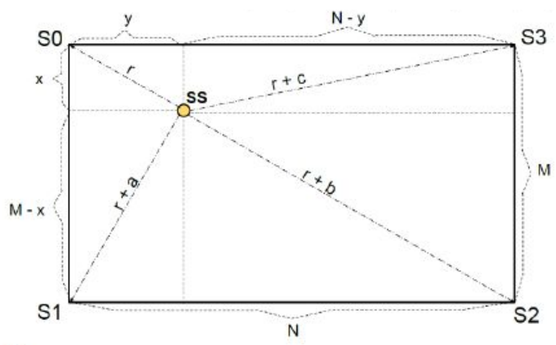
$$Ar^2 + Br + C = 0$$

$$A = \frac{a^2}{M^2} + \frac{c^2}{N^2} - 1$$

$$B = -\left(\frac{aM^2 - a^3}{M^2} + \frac{cN^2 - N^3}{N^2}\right)$$

$$C = \left(\frac{M^2 - a^2}{2M}\right)^2 + \left(\frac{N^2 - c^2}{2N}\right)^2$$

$$discriminant = B^2 - 4AC$$



$$\begin{cases} r_1 = \frac{-B + \sqrt{discriminant}}{2A} \\ r_2 = \frac{-B - \sqrt{discriminant}}{2A} \end{cases}$$

Specifications

Requirement	Specification	Value
Accuracy	Distance Error	<= 5 cm
Responsiveness	Response Time	<= 500 cm

Results

Our team was able to achieve 5cm accuracy on a 1:4 scale surface with less than 500 ms latency. Our project was reaching maturity before the SDP was suspended. We produced our final game environment and reduced the number of microphones necessary to play the game by a factor of 2. We had rigorously tested the game environment and were in the process of fine-tuning our software, hardware, and interfaces for the end user. By FPR, we hoped to test and verify that our custom PCBs function as intended and ensure our software output location consistently.

Acknowledgement

Our group would like to thank Professor T. Baird Soules, for keeping us on track with his helpful guidance and advice. We would also like to thank the staff in M5 and the All-Campus Makerspaces for supplies, assistance, and advice. Lastly, we would like to thank Francis Caron for assisting us in the lab.