UMassAmherst

Acoustic Battleship

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Problem Statement

Board games have failed to adapt to the technological advances of today’s market. Traditional board games have fallen out of favor. Implementing embedded systems could help to provide a jolt to the industry.

How do we plan to do this?

Problem Statement

- Provide an aesthetically pleasing, functional, scalable, and robust interface
- Applying these characteristics to Battleship

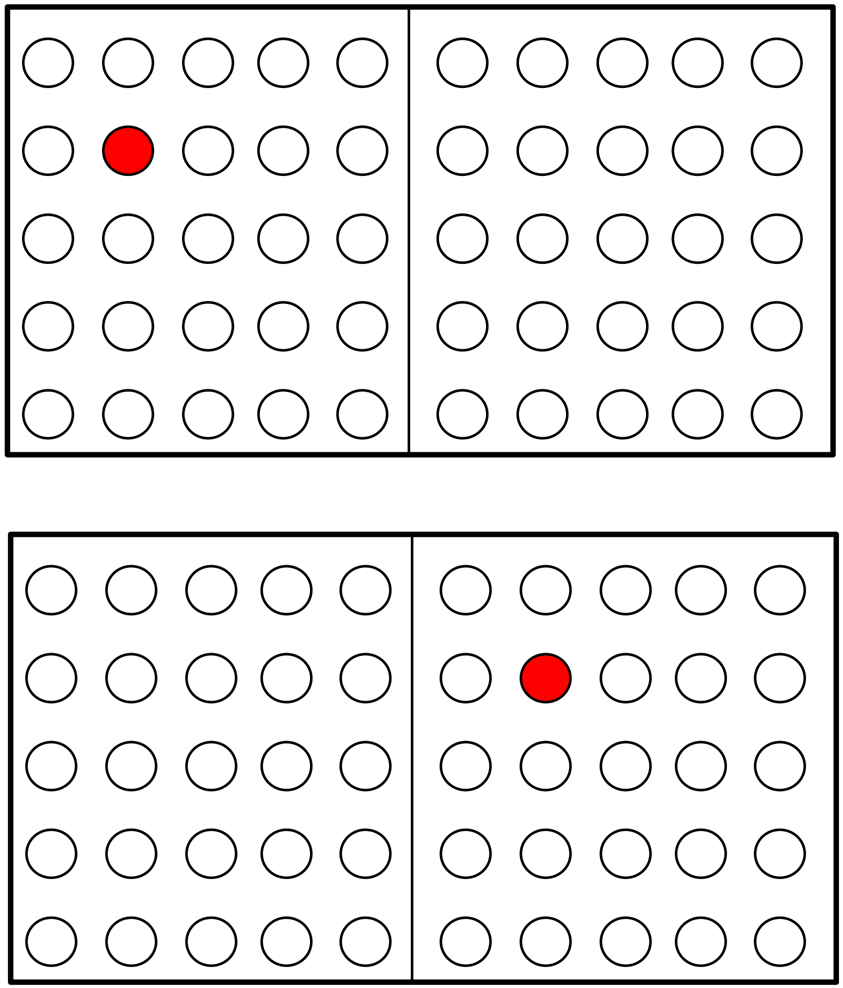
Problem Statement

- Our solution will put an interactive spin on a classic game
- Accuracy based game using a ping pong ball to provide low-latency, responsive feedback
- Will follow an adapted set of guidelines to Battleship
- Using localization from a network of microphones to detect if a target is hit

Game Demo

Player A plays, miss

Display for A



Display for B

Player A

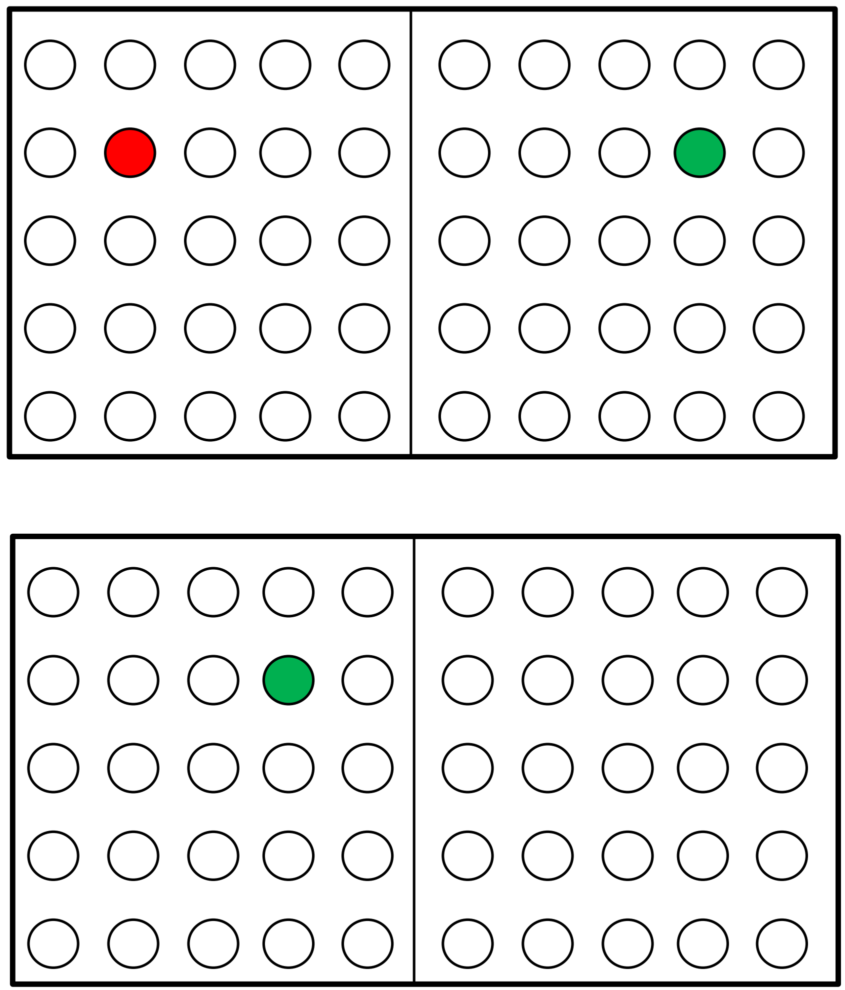
START

Player B

Game Demo

Player B plays, hits

Display for A



Display for B

Player A

Player B

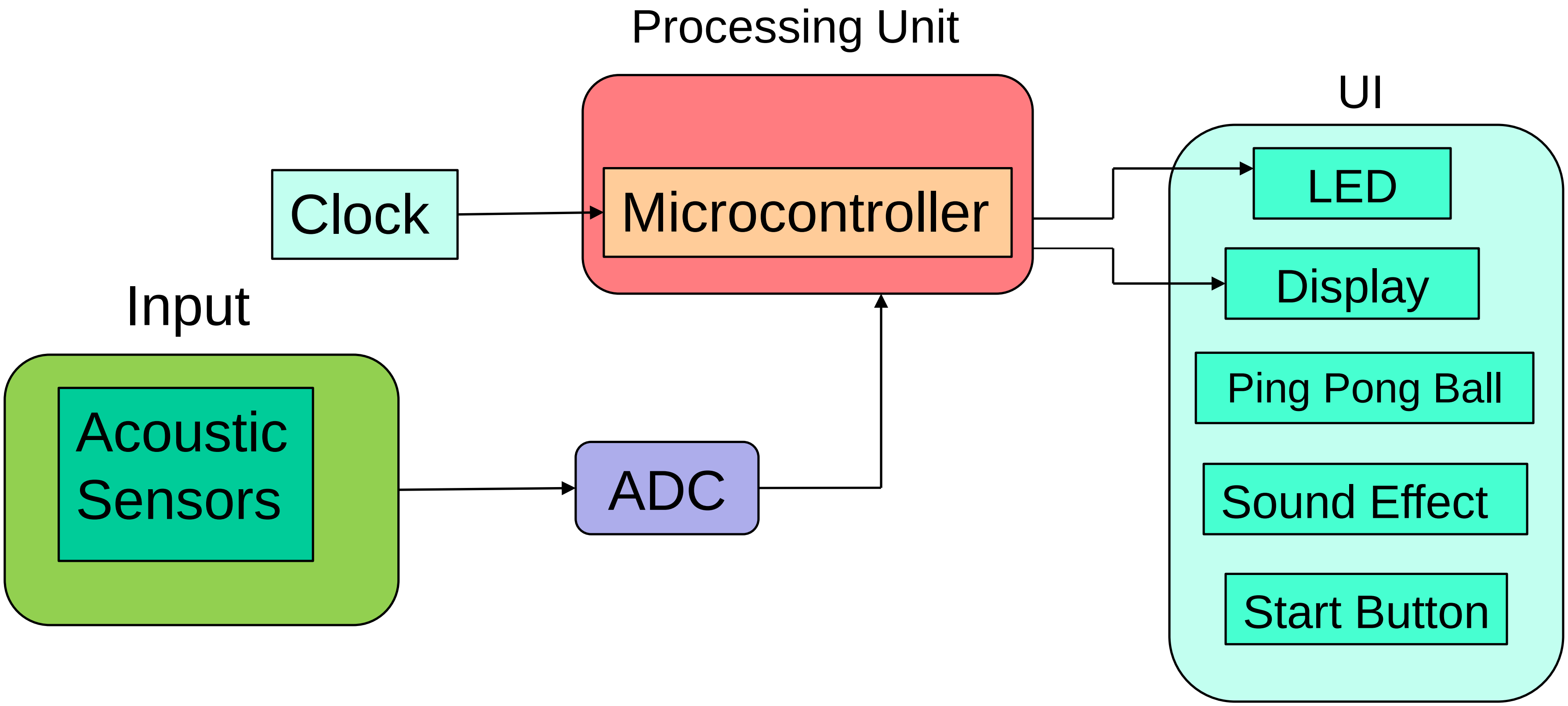
System Requirements & Specifications

Table of Requirements and Specifications

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

Components:
Microphone, LED, ADC, Microcontroller, Display, Ping-Pong Ball, transparent glass table

Block Diagram

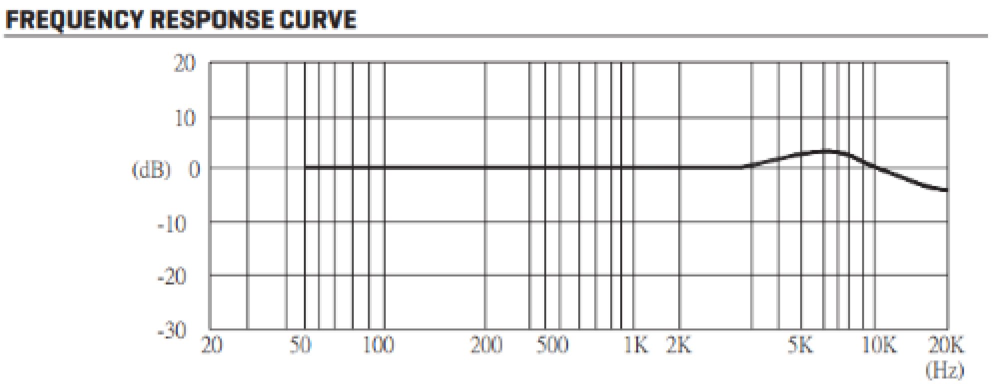


Microphone Sensors

- Implement 16 electret omnidirectional condenser microphones (CMA-4544PF) to optimize source localization in 2-Dimensional space
- Operating frequency: 20Hz – 20kHz

    Frequency of human conversation: 85Hz - 255 Hz

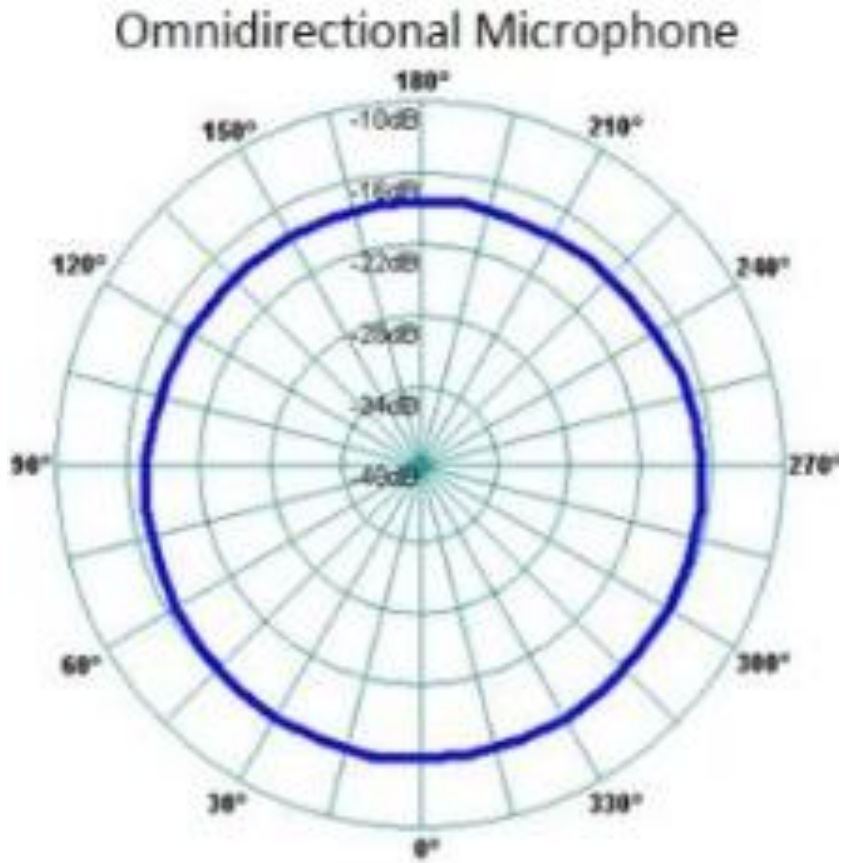
    Frequency of Ping Pong hitting a surface: 5.9kHz - 7.3kHz



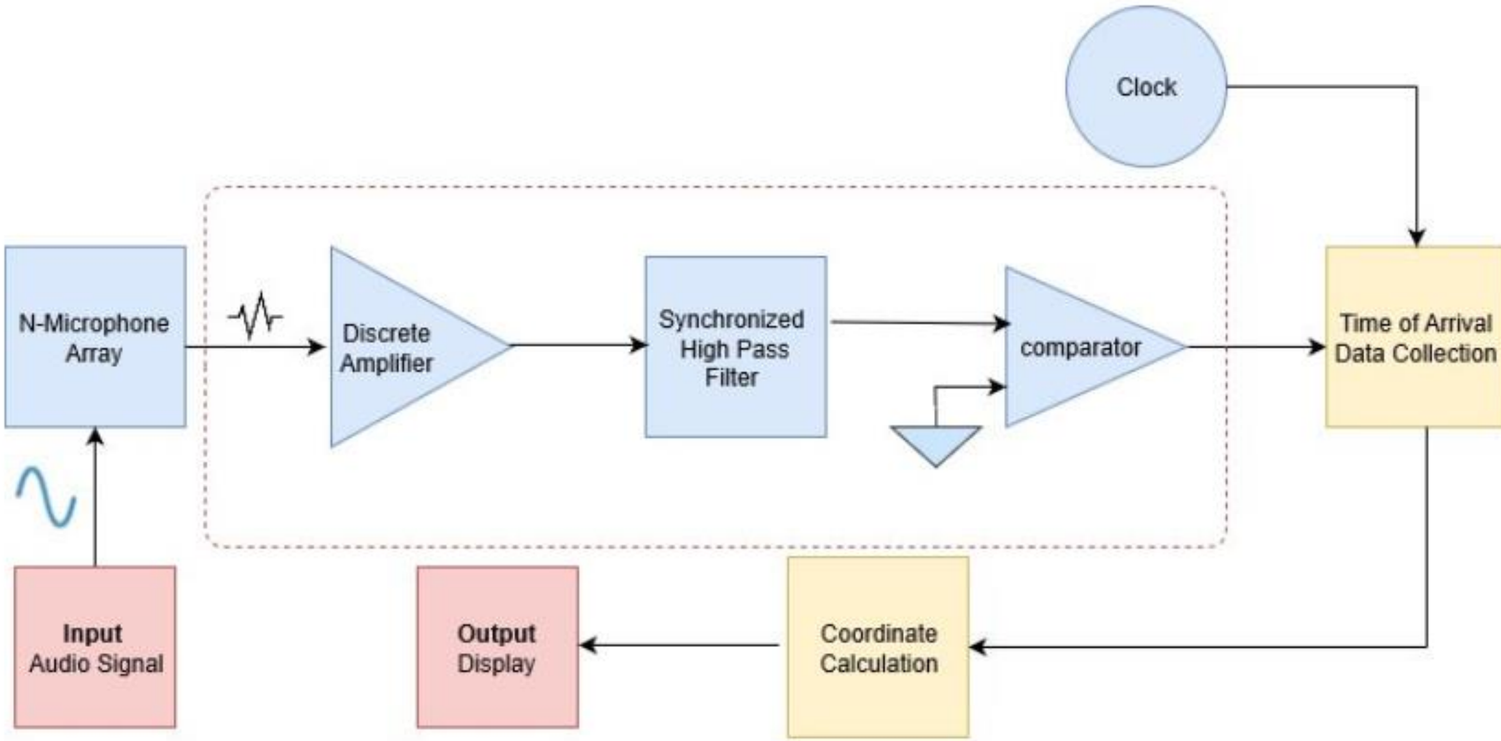
CMA-4544PF

Microphone Sensors

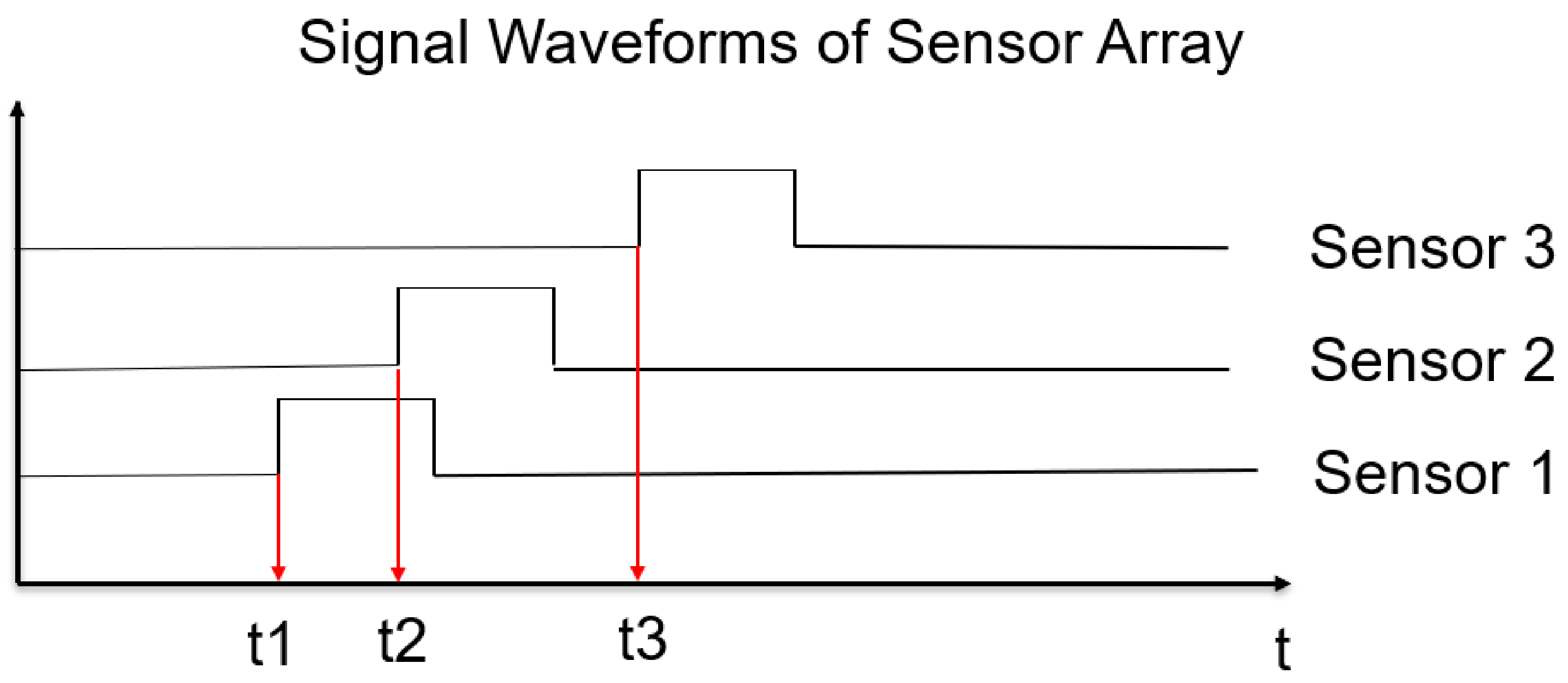
- Microphones sensors will be omnidirectional



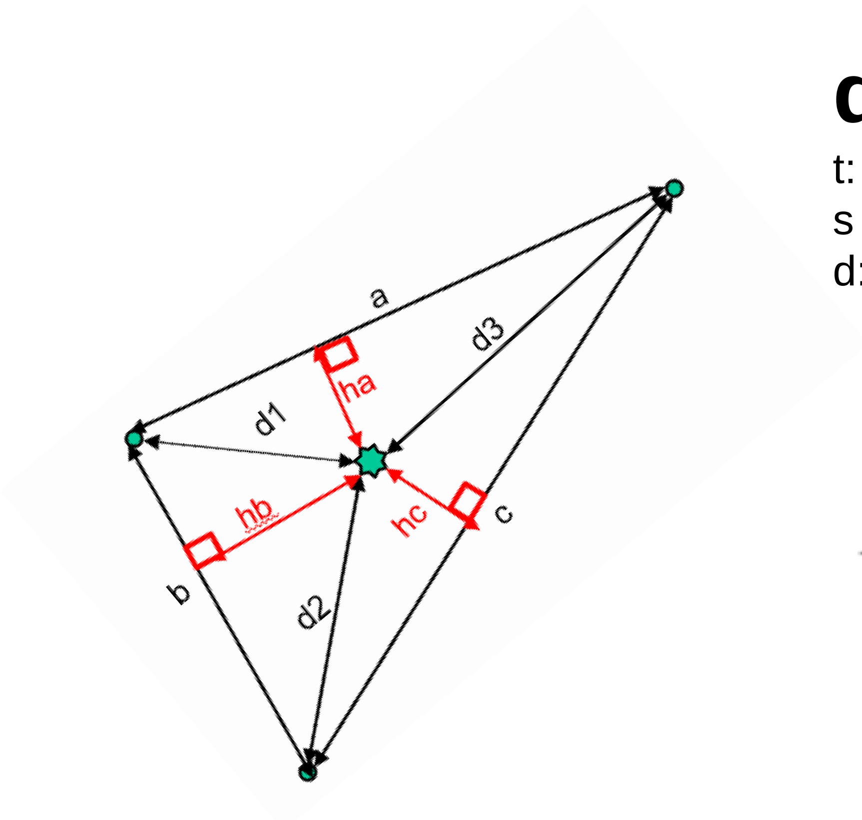
Analog Digital Converter (ADC)



Time of Arrival



Algorithms



sound source
acoustic sensor

d = t * s

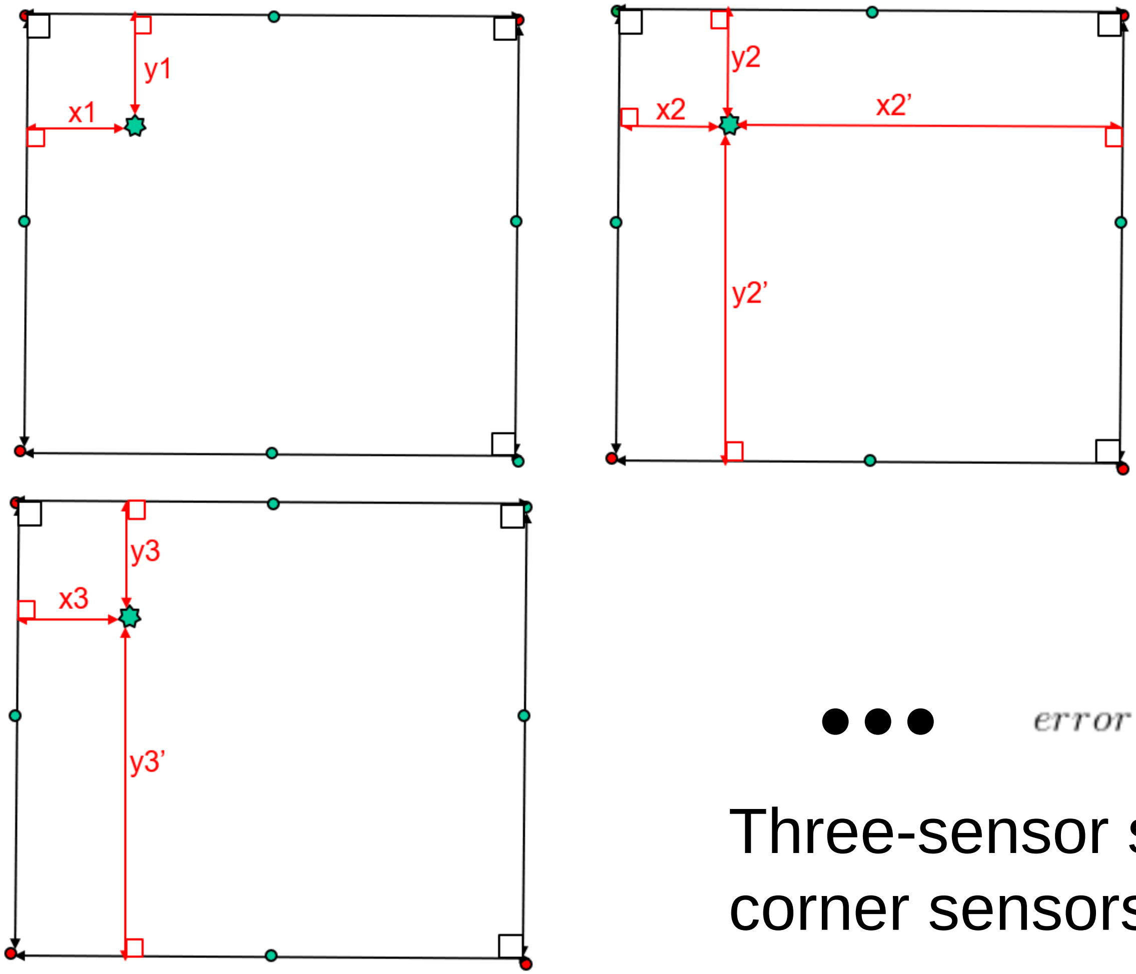
t: time duration from sound source to sensor
s = 340 m/s (sound of speed in air)
d: distance from sound source to sensor

$$p = \frac{a+b+c}{2}$$

$$A = \sqrt{p(p-a)(p-b)(p-c)}$$

$$h_a = 2\frac{A}{a} \qquad h_b = 2\frac{A}{b} \qquad h_c = 2\frac{A}{c}$$

Algorithms



sound source

acoustic sensor

calculated coordinate: (x_c, y_c)

actual coordinate: (x_a, y_a)

$$(x_c, y_c) = \left(\frac{\sum_{i=1}^{N} x_i}{N}, \frac{\sum_{i=1}^{N} y_i}{N}\right)$$

…

$$error = \sqrt{(x_a - x_c)^2 + (y_a - y_c)^2} <= 5cm$$

Three-sensor subsystem with two corner sensors

Microcontroller Function

- Takes input from the ADCs and clock
- Once the input of an ADC goes high the system time is stored
- The 16 time stamps are compared to calculate a location on the board
- The location is matched to a LED
- The relevant LED is switched through the output of a PWM signal

Technical Alternatives

FPGA (compared to microcontroller)

- Pro: flexible and reduce system components
- Con: more complex and takes more time

Camera vision (compared to microphone sensor)

- Pro: easier to track the motion, more precise
- Con: more complex and resource intensive.

Infrared sensors (compared to microphone sensor)

- Pro: more accurate, more responsive
- Con: expensive, need a lot

Non-Technical Alternatives

Ping-Pong Score Keeping (compared to Battleship)

- Pro: more interesting
- Con: not represent the precision we are looking to achieve; more edge cases

Electric Dart Game (compared to Battleship)

- Pro: straightforward; represent the precision
- Con: less technically advanced and less interesting

Prototype Budget

- (16) Microphone Sensors: $15.00
- Passive Components: $5.00
- (1) Arduino Microcontroller: $23.00
- Playing Surface: $80.00
- (200) RGB LED: $56.00

Total: $179.00

Budget Remaining: $321.00

MDR Prototype

- System on a single board for one player
- Using Arduino as microcontroller
- Calculate coordinates and light up LED accordingly
- Error distance less than 8 cm.
- Response time less than 1 s

Question?