So-Lo : Sound Locator

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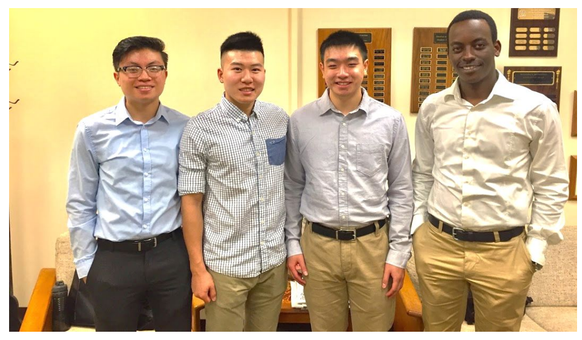
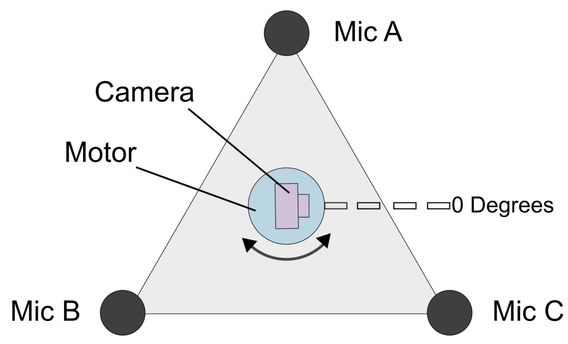


Abstract

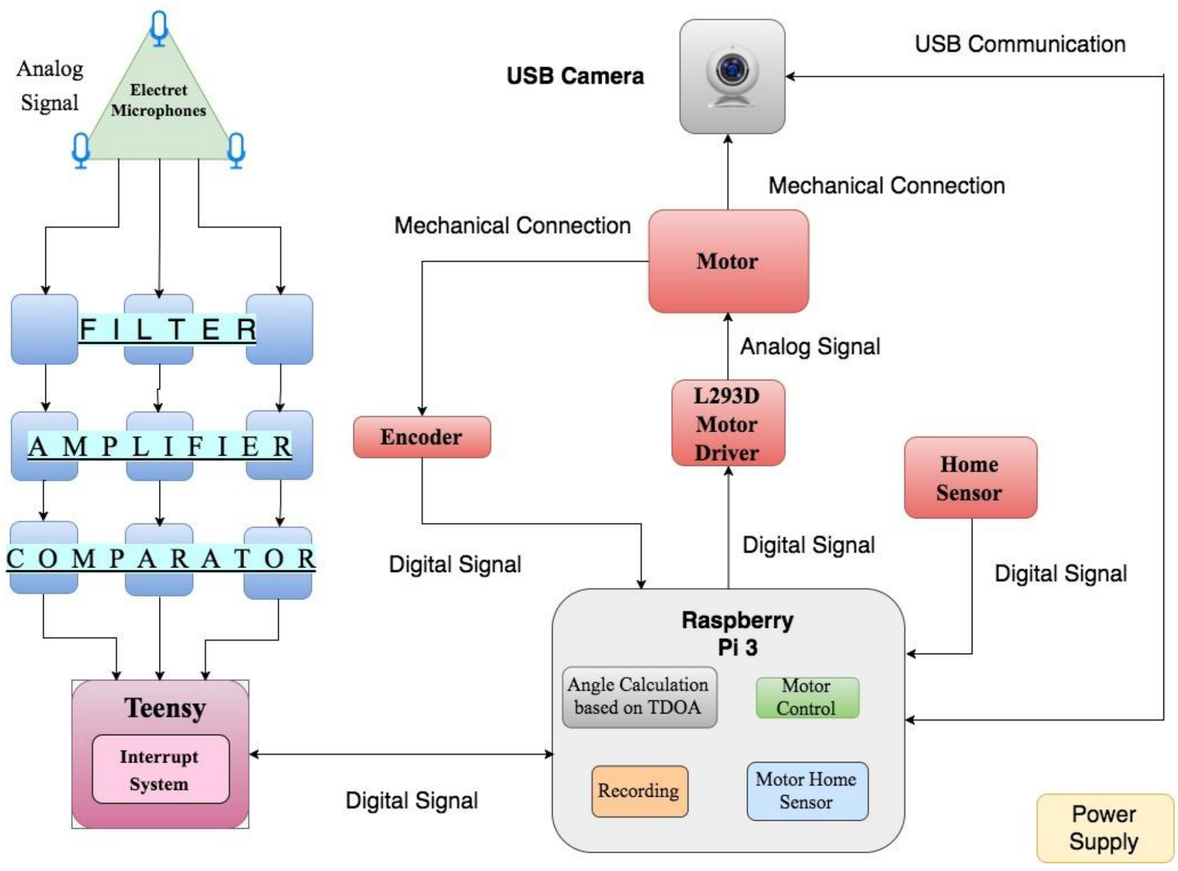
So-Lo (Sound Locator) is a real-time automated system used for recording audio and video meetings or conferences in small to medium sized rooms. The video can be easily accessed by users who want to recap the meeting or for those who missed the meeting. So-Lo uses Time Difference of Arrival (TDOA) to locate the speaker, allowing the system to focus on the former while recording the video

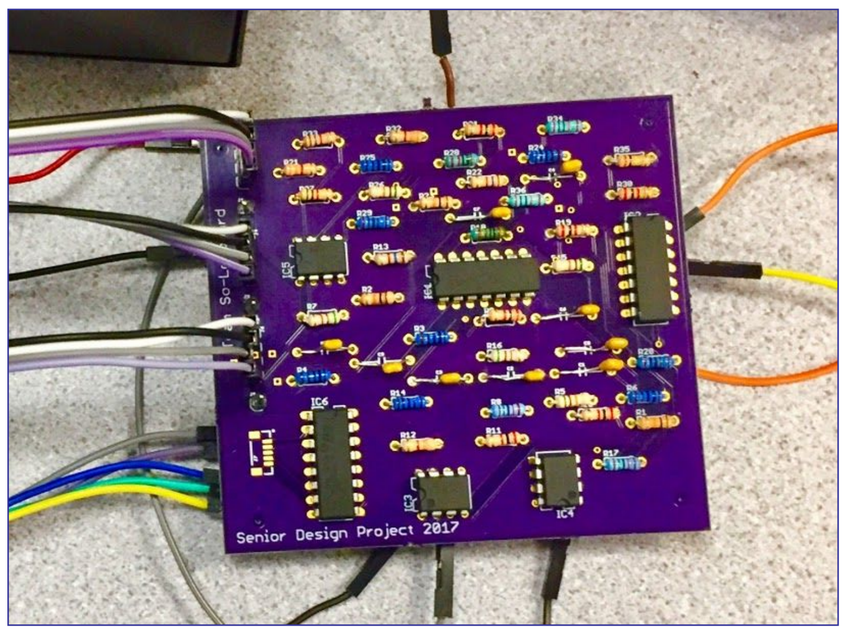
System Overview



- 3 Electret Microphones are used to detect sound
- The location of the speaker is calculated using TDOA
- A camera is mounted onto a motor that turns to the speaker

Block Diagram





Specifications

Specifications	Actual	Goal
Range	>3ft	3ft
Response Time	<1s	<1s
Cost	$100	<$200
Senitivity	Detect Voices	Detect Sharp Sounds
Frequency Range	272Hz- 3187Hz	300Hz-3000Hz
Video Resolution	720p	1080p
Video File	.mkv	.mp4

Results

Due to the sensitivity of the microphones, So-Lo works best in a quiet environment. So-Lo also has a time delay between each calculation meaning that when a person speaks and after the motor turns to them, it will wait a certain amount of time until it starts to listen again. For this project we set the time delay to be five seconds.
The camera is able to record a video while the system sound locating. 30 seconds of video is recorded while speakers talk and the system points to them. The video was set up to be automatically uploaded to Dropbox.

Acknowledgement

Special thanks to our advisor Professor Soules for his time and valuable feedback. We would like to thank Professor Hollot, Professor Polizzi and Professor Ciesielski for their feedback that helped us improve our project.
Thanks to Francis Caron for helping with parts needed for our project.

System Requirements

- Portable enclosure for the system
- Real-time Sound Location
  - Time Difference of Arrival
- Brushless DC Motor
  - RPM of 8170 RPM.
  - 360 Degree Rotation
- Optical Encoder
- Electret Microphones
  - Automatic gain, selectable max from 40dB, 50dB or 60dB
  - Frequency range after filtration: 300Hz to 3000Hz
  - Output voltage :0-15 V
  - Detection Range : 2- 3 feet
- Video Recording
  - 720p Resolution
  - 30 Minutes
  - Automated upload to Dropbox

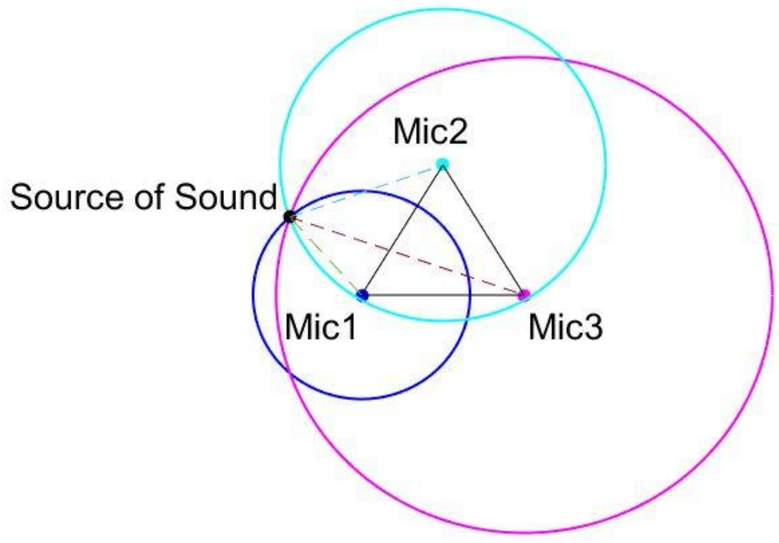
Interrupt System

When the microphones detects a voice, they each send a signal to their own comparators. The comparators produce a high when the signal received is above a threshold voltage which acts as a noise level. Those high signals are sent to three channels of the Teensy which have been programmed to detect interrupts. The program timestamps each channel upon the signals arrival. Time differences between the first and second microphones and the first and third microphones are calculated and sent to the Raspberry Pi. The accuracy of these time differences are essential in TDOA as a 10th of a millisecond is enough to produce a wrong angle. The Teensy handles interrupts well without any latency. Acceptable time differences for this system lies in the microsecond scale.

Cost

Part	Development	Production (1000)
PCB	$52.50	$6.87
Motor	$278.60 (Borrowed)	$81.60
Motor Driver	$3.90 (Borrowed)	$2.06
Electret Mic	$7.95	$6.36
USB Webcam	$14.99	$14.99
Raspberry Pi 3	$40.00	$35.00
Teensy 3.5	$24.25 (Borrowed)	$19.95
Power Supply	$20.63	$15.84
Optical Sensor	$1.87 (Borrowed)	$0.67
Optical Encoder	$51.50 (Borrowed)	$33.78
Total	$496.19	$217.12

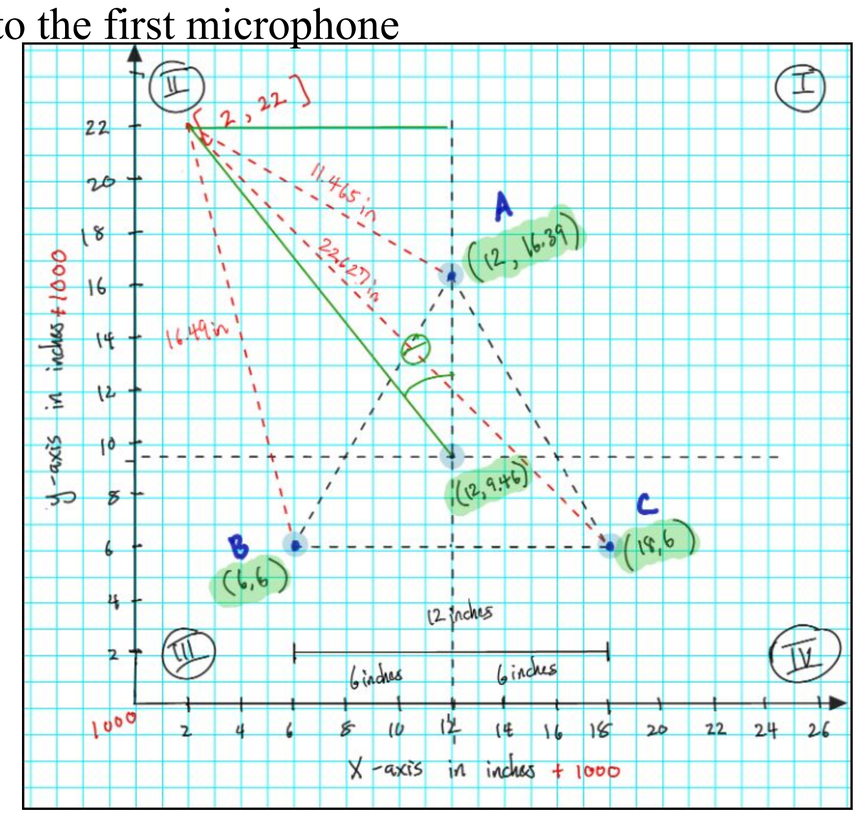
Angle calculation



- Solves a system of three non-linear equations

1. $(first\_x - x)^2 + (first\_y - y)^2 = r^2$
2. $(sec\_x - x)^2 + (sec\_y - y)^2 = (r + 13622 * \Delta Sec)^2$
3. $(third\_x - x)^2 + (third\_y - y)^2 = (r + 13622 * \Delta Third)^2$

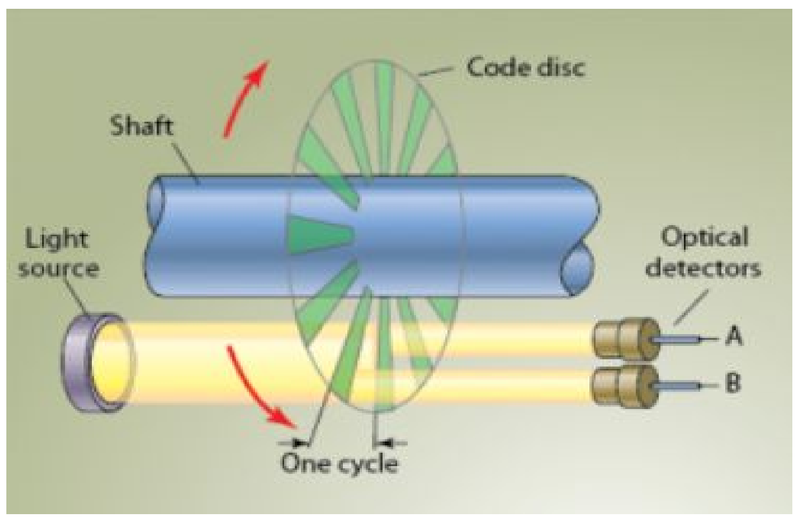
- The Coordinate (x, y) is the source of the sound
- Variable r is the distance from the source of sound to the first microphone



- The angle calculation is done based on the positions of the microphones on a graph
- System of equations used to pinpoint the source of sound
- Offset deals with negative values, origin at (1000,1000)
- An imaginary x and y axis is placed on the equilateral triangle with the origin at the center

Motor and Camera

- Motor turns to angle specified by angle calculation



- Light shines through a disc and outputs a high signal in transparent regions, creating a series of pulses.
- Determine motor position/angle based on number of pulses emitted
- USB Webcam mounted on top of motor
- Record video and audio of person speaking
- Store video in sd card and upload to Dropbox account