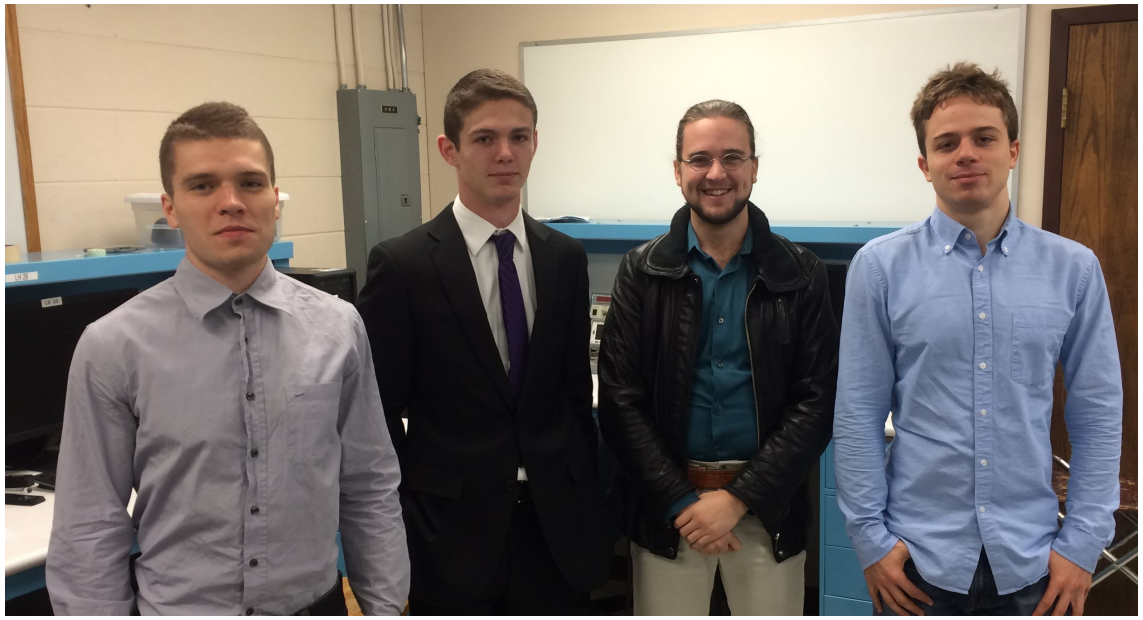
Pegasus-21

Preliminary Design Review

Senior Design Project

Fall 2016

Our Team



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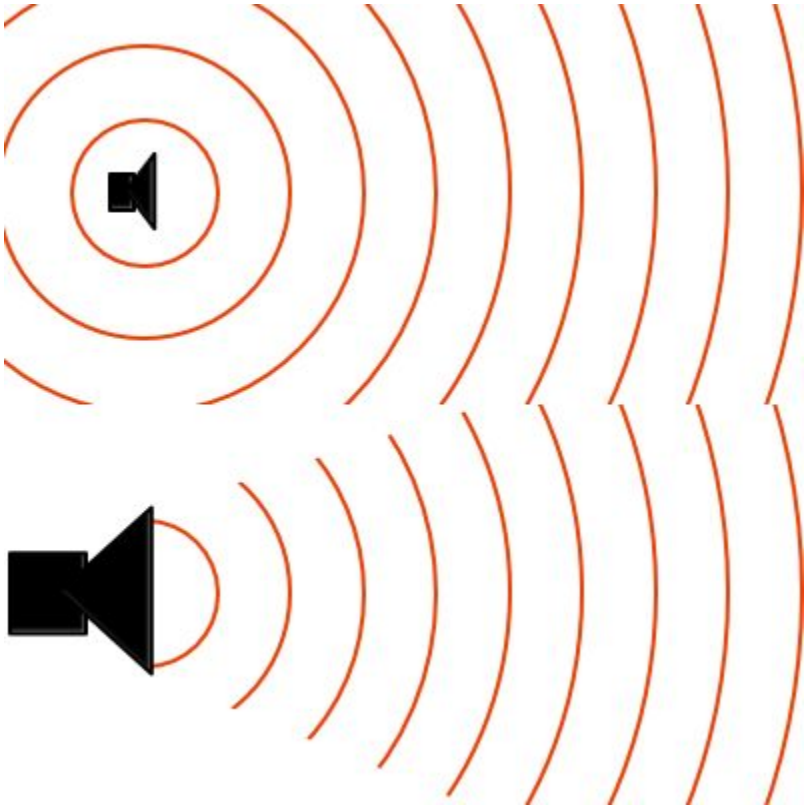
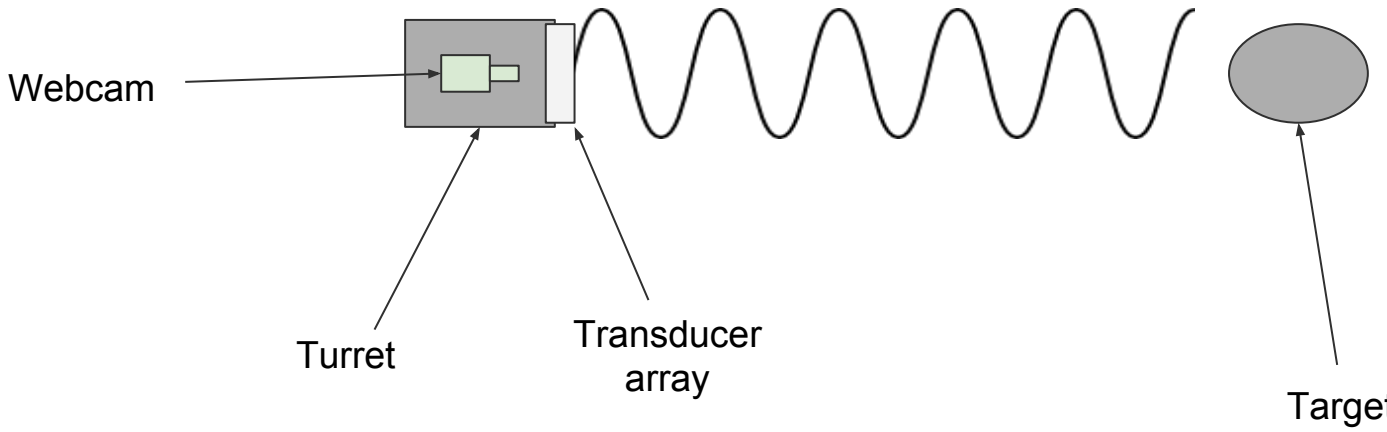
Traditional Speakers

Conventional speakers broadcast sound in all directions



Goal

Our goal is to create a system capable of transmitting audio in a focused beam which is mounted on a turret that uses facial recognition technology to track the listener.



Applications

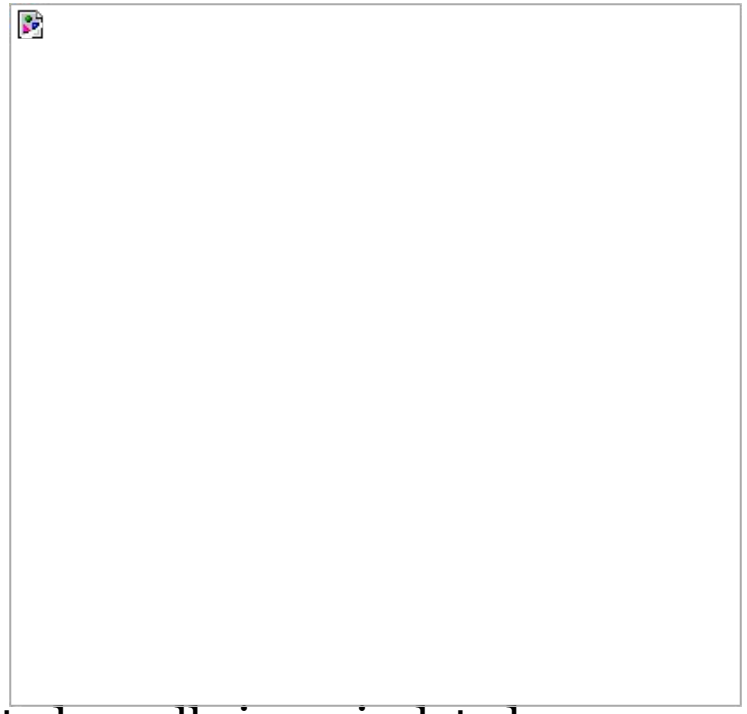
-Multi lingual audio transmission for movie theaters

-Invisible teleprompter for public speakers

-Museum exhibits

-Private Alarm clock

-Assisted listening for the hard of hearing



Any scenario where a message must be transmitted aurally in an isolated region of a public forum.

Sound From Ultrasound

$$\frac{\partial^2 p}{\partial z \partial \tau} = \frac{c_0}{2}\nabla_r^2 p + \frac{\delta}{2c_0^3}\frac{\partial^3 p}{\partial \tau^3} + \frac{\beta}{2\rho_0 c_0^3}\frac{\partial^2 p^2}{\partial \tau^2}$$

Technology to create directional, highly focused soundbeams:

-Directionality of soundbeam correlates with the size of speaker compared to wavelength

-Ultrasonic carrier wave is modulated with message signal (can be AM, FM, PWM etc.)

-An array of transducers emits ultrasound in the direction of target

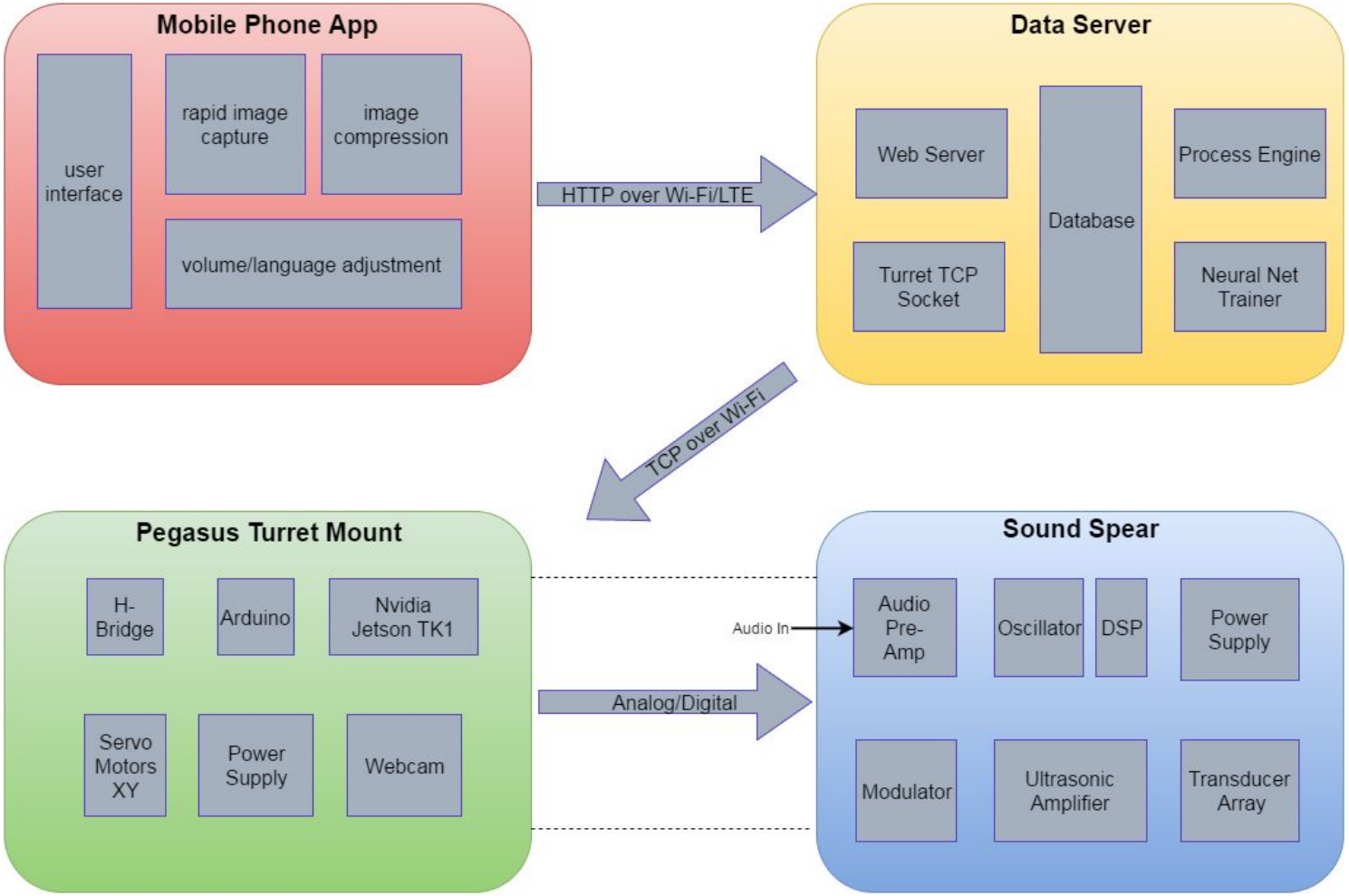
-Air, as a nonlinear medium, acts as a demodulator (no need for receiver)

-When the ultrasonic modulated wave reaches a person the modulated sound becomes audible

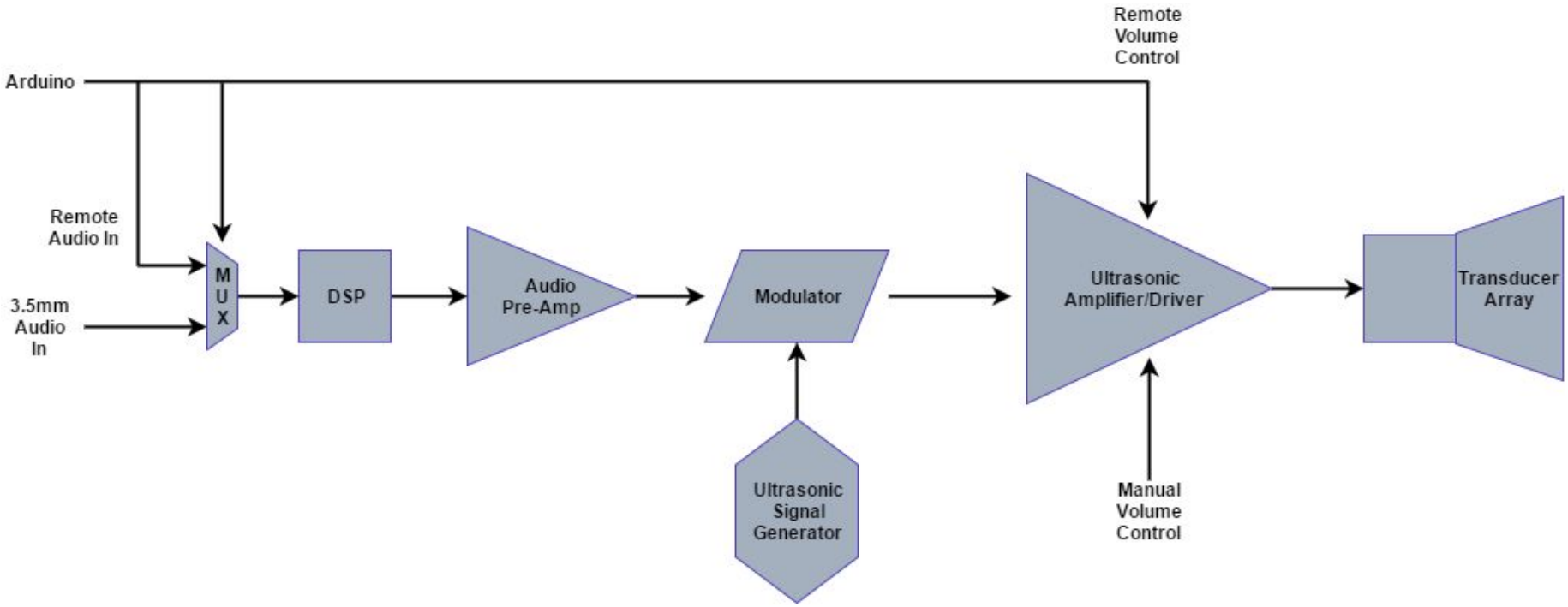
Alternatives

- Turret can have preconfigured sections of a room mapped out and selected via the iPhone application if tracking becomes a difficulty
- iPhone target selection if tracking works but facial recognition does not
- GPU cluster on AWS
- Android/Windows Apps
- Parabolic speaker instead of a parametric speaker
- One regular speaker + one directional speaker instead of having two directional speakers

System Overview



Sound Spear: Block Diagram



Sound Spear System Requirements

Ultrasonic Amplifier:
- High input impedance, load matched inductive output impedance
- Good frequency response up to 40kHz
- Total Harmonic Distortion < 5%

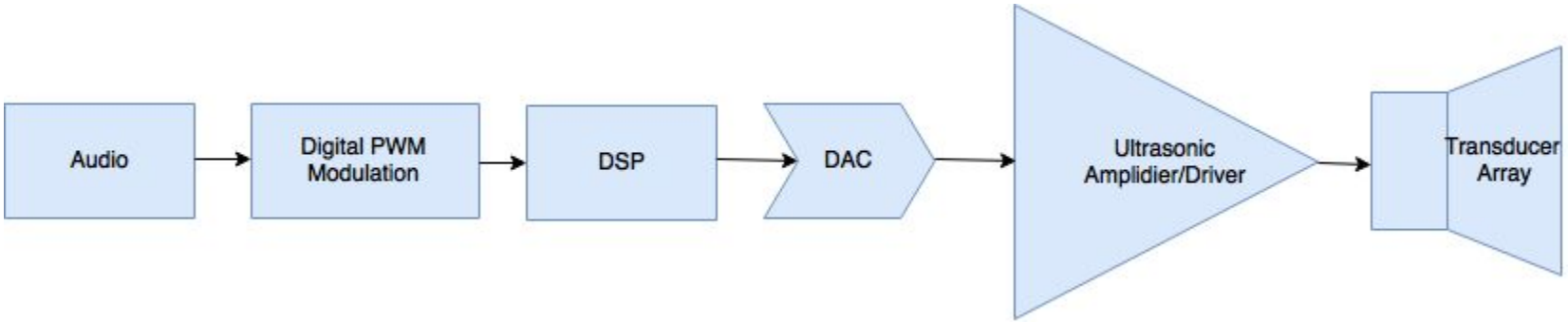
Transducer Array:
- 50 Piezoelectric transducers wired in parallel, appropriated spaced
- Resonant frequency greater than 20kHz

Modulator:
- Minimal ripple on output voltage

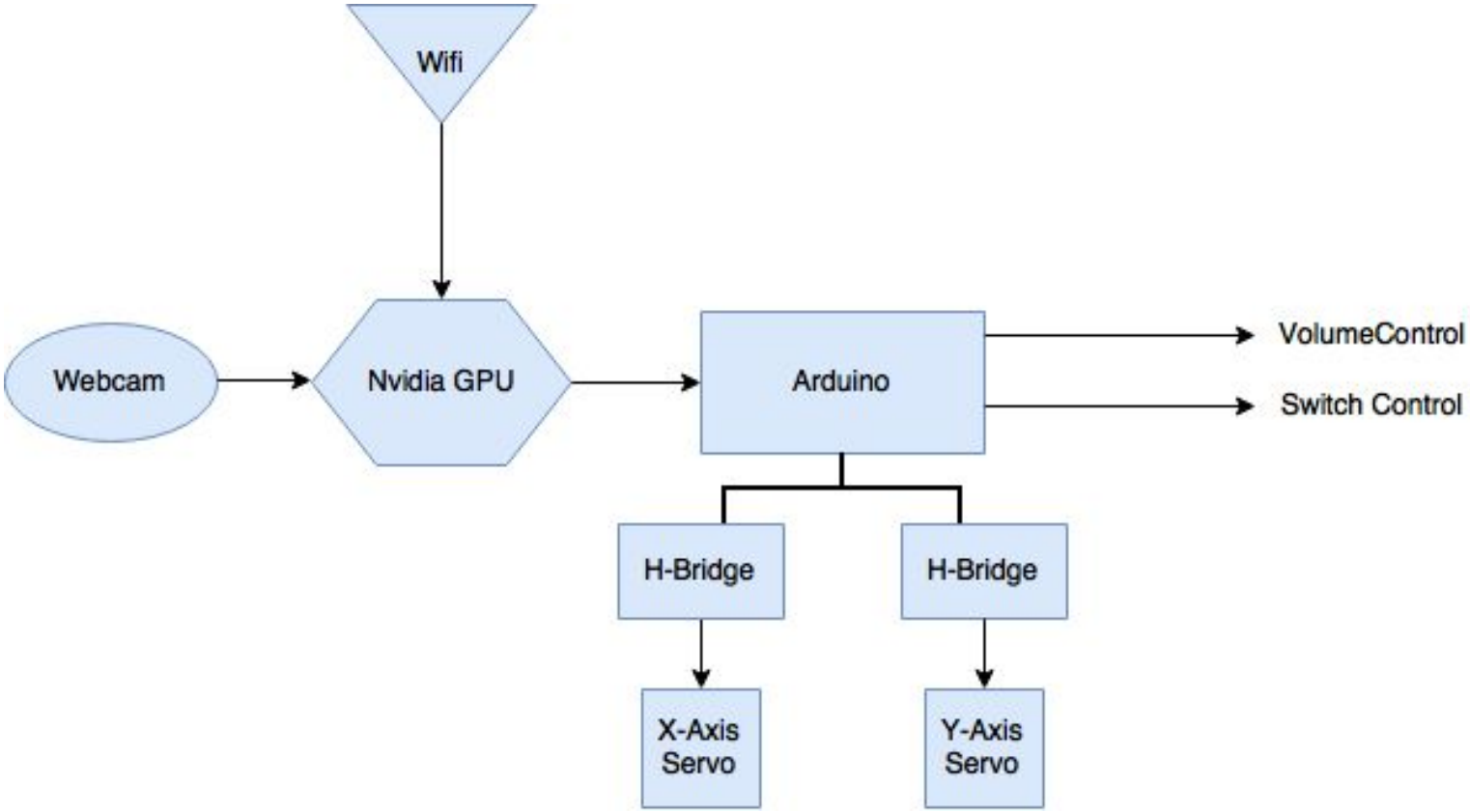
Signal Generator:
- Capable of supplying voltage waveforms between 20kHz and 40kHz

Digital Signal Processor:
- Adequate compression and equalization algorithms to fit the audio within the bandwidth limits

Sound Spear: Alternative Block Diagram



Pegasus Turret: Block Diagram



Turret System Requirements

Servo Motors:
- Bidirectionality
- X and Y axis mobility

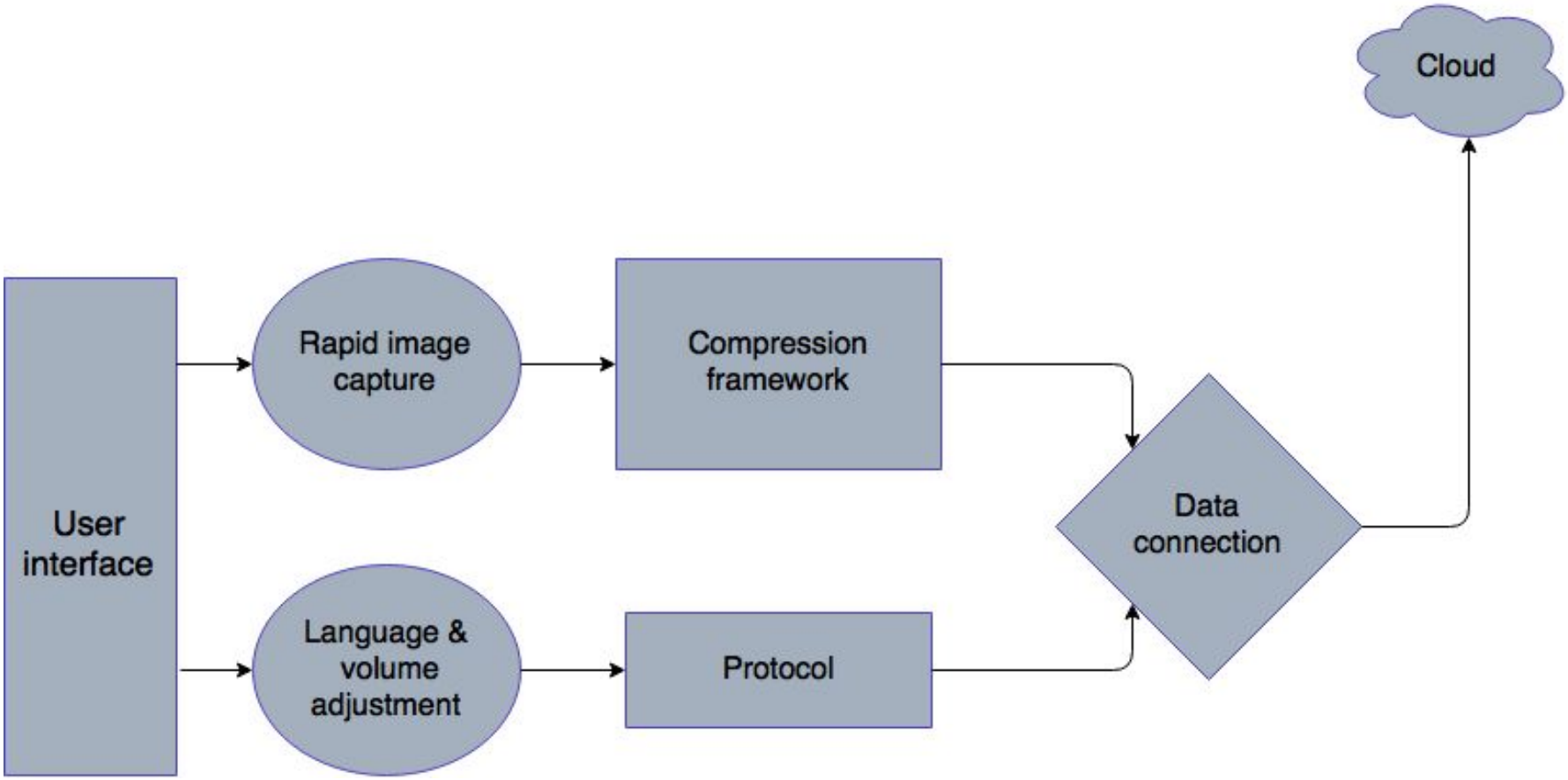
Arduino:
- Generates signal
- Serial Connection with TK1

3D Printed Housing
- Contains all electronics
- Adequate ventilation

Facial Recognition:
- Neural-net pretrained on target individuals
- Threshold that will predict the target above 80% of the time (Tracking will resolve the other 20%)

Target Tracking:
- Tracker will use feedback systems to track targets between frames

iPhone App: Block Diagram



iPhone App System Requirements

Images

- 720p image standard

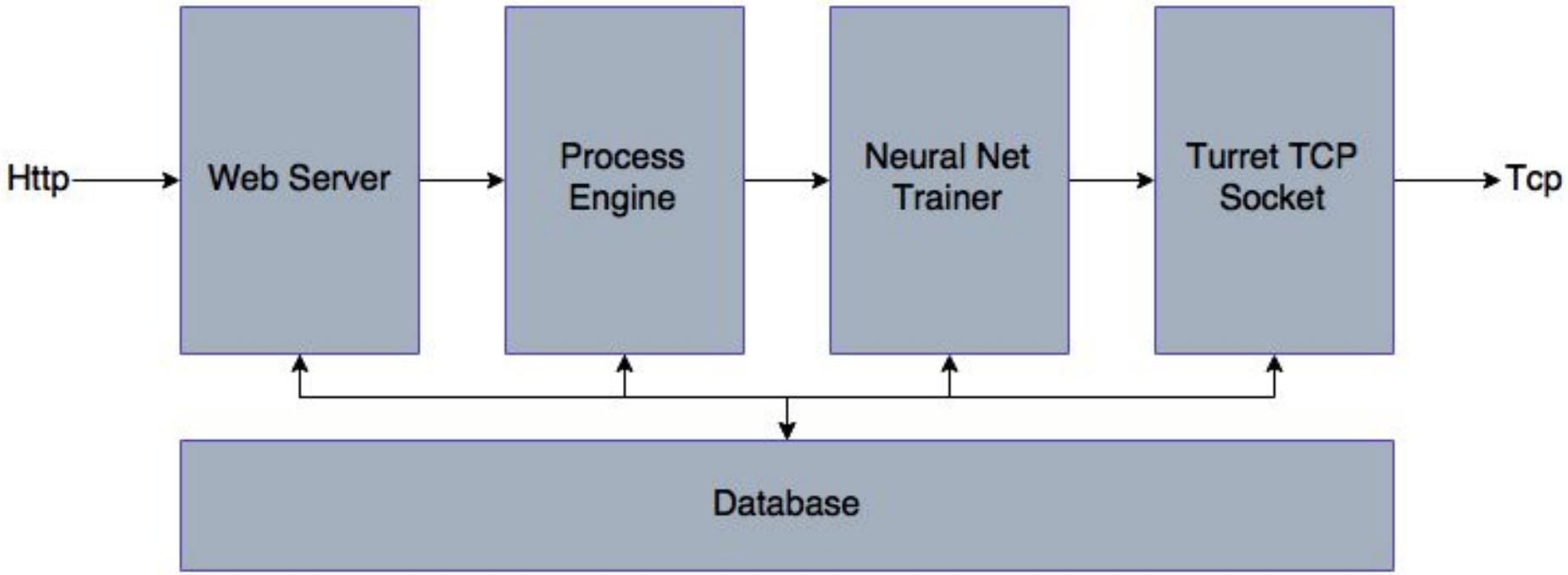
Frameworks

- RealmSwift
- .tar.gz compression
- sockets
- notifications

Targeting

- Override turret position
- Videofeed with aiming reticule

Server: Block Diagram



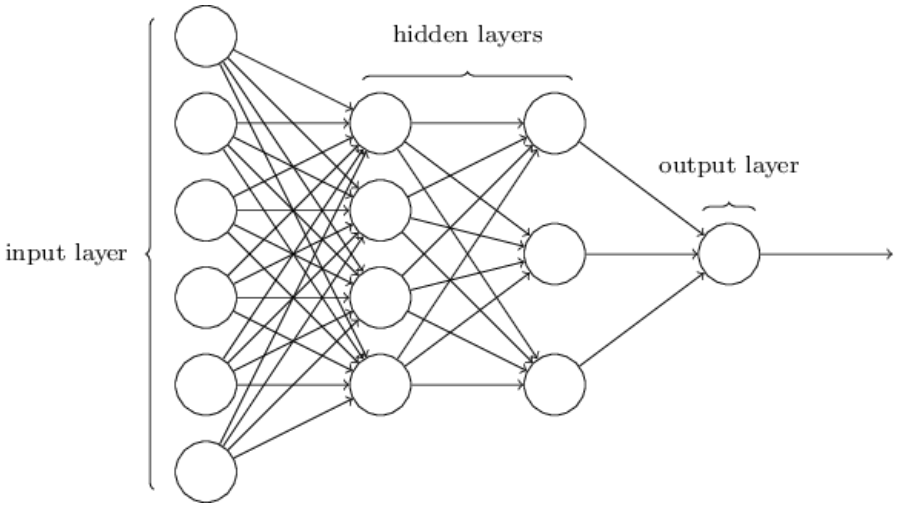
Server System Requirements

Database

- SQLite will suffice for prototyping purposes

Neural Net Training

- Train 2-person neural net in under 5 minutes for demos
- Send push notification



MDR Deliverables

Sound Spear:

- Functioning amplifier and signal generator prototype capable of driving an ultrasonic waveform through a piezoelectric transducer

Pegasus Turret:

- Functioning turret with transducer array mounted

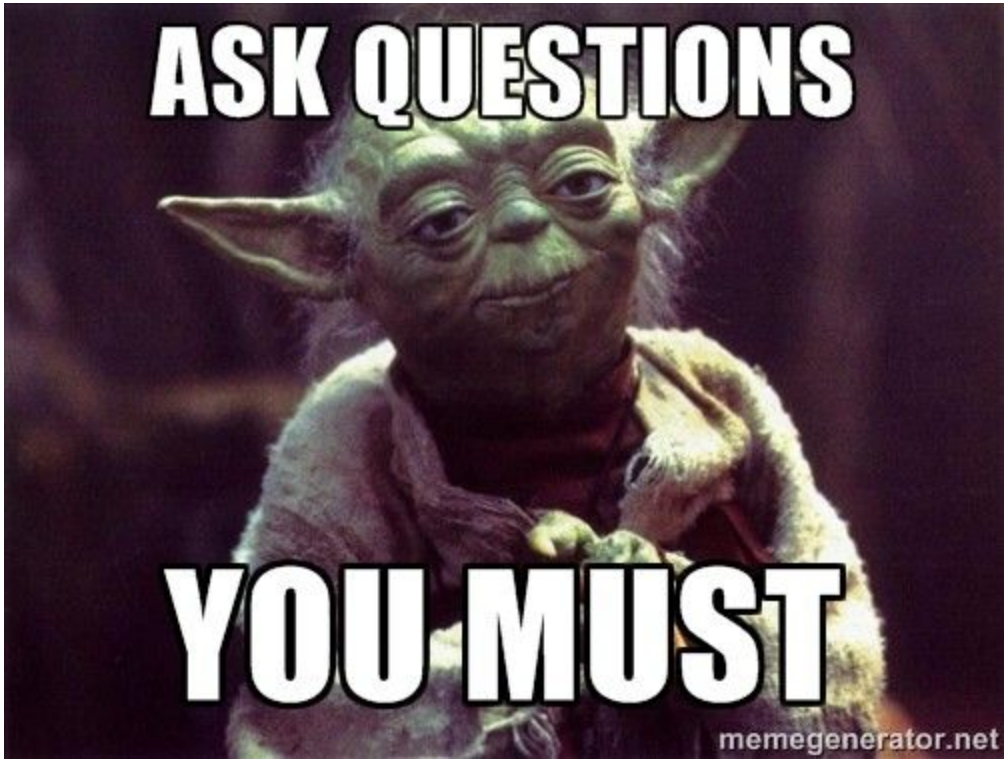
iPhone App:

- Version b.1.0
- Successfully sends pictures and preferences to the server

Server Cluster:

- Trains the neural net
- Protocols created to communicate with the app and turret

Questions?



BackUp Slides

1. P-21
2. Cost

One more thing… surrogate project

MITRE Sponsored task

use sound waves to trick auto pilot on aircraft into thinking it is at different altitude than it is

Why?

cause aircraft to change its altitude based on false reasons

potential to take down aircraft

Cost

SDP Budget			
Item	**Quantity**	**Unit Cost**	**Cost**
Transducer Array	**2**	**149.90**	**299.80**
Webcam	**2**	**30**	**60**
Digital Signal Processor	**2**	**5**	**10**
Servo Motors	**4**	**9**	**36**
Board Fabrication	**?**	**?**	**?**

Current Total: $405.80

Funds Remaining: $94.20

How can it be done?

Pegasus-21

Pro's and Con's

Pros:

- Focused sound beam can target each person individually

Cons:

- During modulation a lot of distortion can occur, thus digital signal processing is necessary to produce high quality audio output
- Modulation method can also affect sound quality, need to find the best one for this purpose
- User experience is highly dependent on facial recognition software