

# Pegasus-21

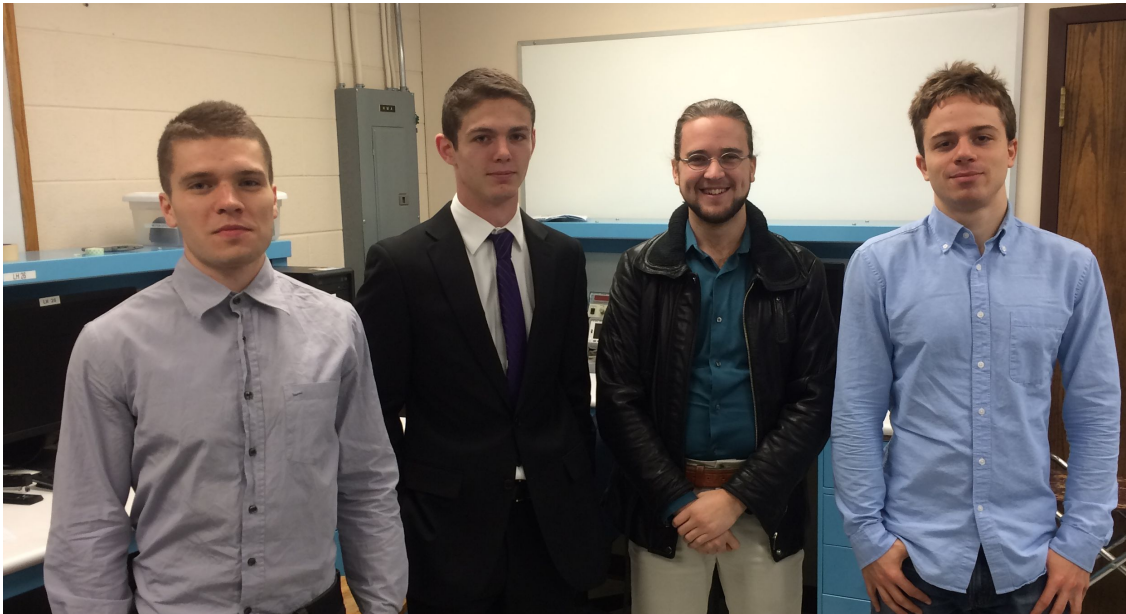
Preliminary Design Review

Senior Design Project

Fall 2016



## Our Team



**Istvan Kreis**  
EE

**Keith Miller**  
CSE

**Trevor Berry**  
EE

**Corey Smith**  
CSE

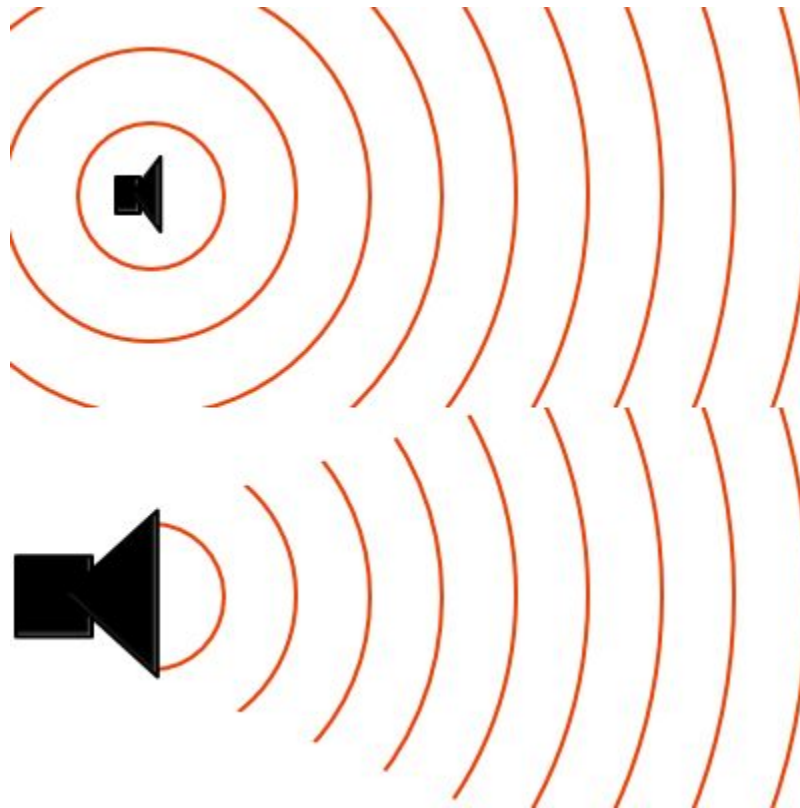
**Advisor:**

**Zlatan  
Aksamija**



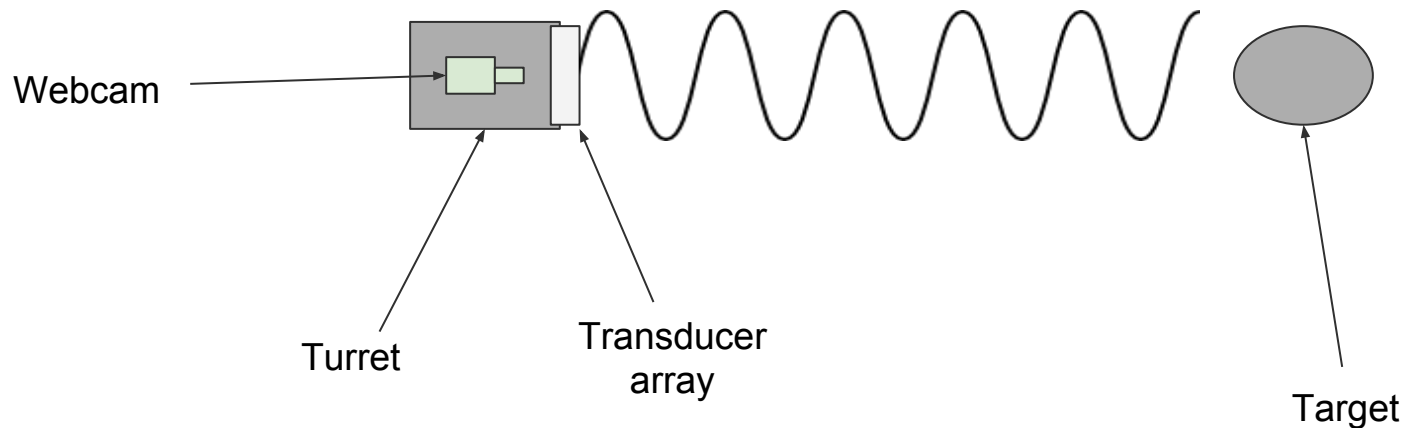
## Traditional Speakers

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:

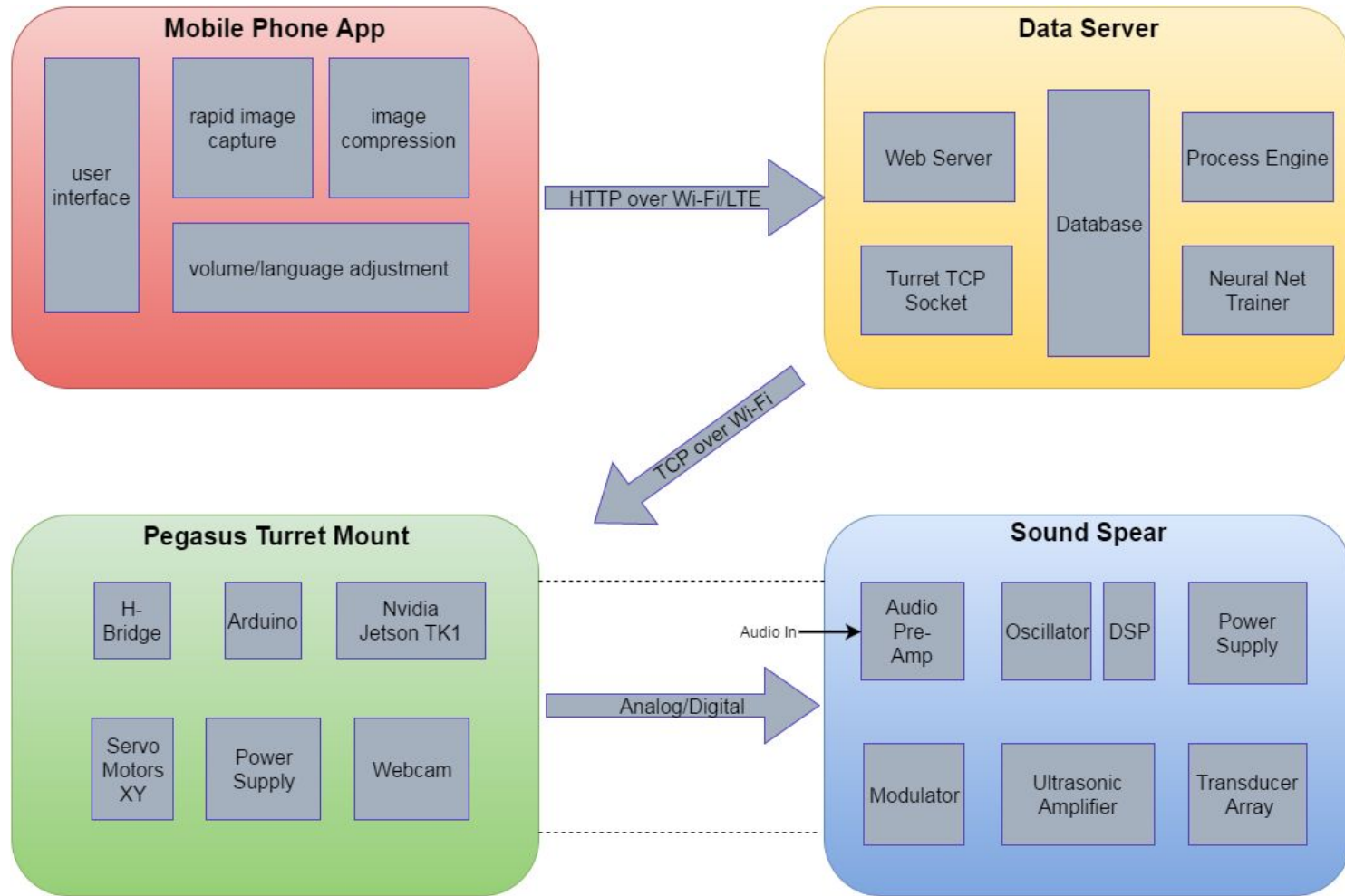
- Directionality of soundbeam correlates with the size of speaker compared to wavelength
- Ultrasonic carrier wave is modulated with message signal (can be AM, FM, PWM etc.)
- An array of transducers emits ultrasound in the direction of target
- Air, as a nonlinear medium, acts as a demodulator (no need for receiver)
- When the ultrasonic modulated wave reaches a person the modulated sound becomes audible

## Alternatives

---

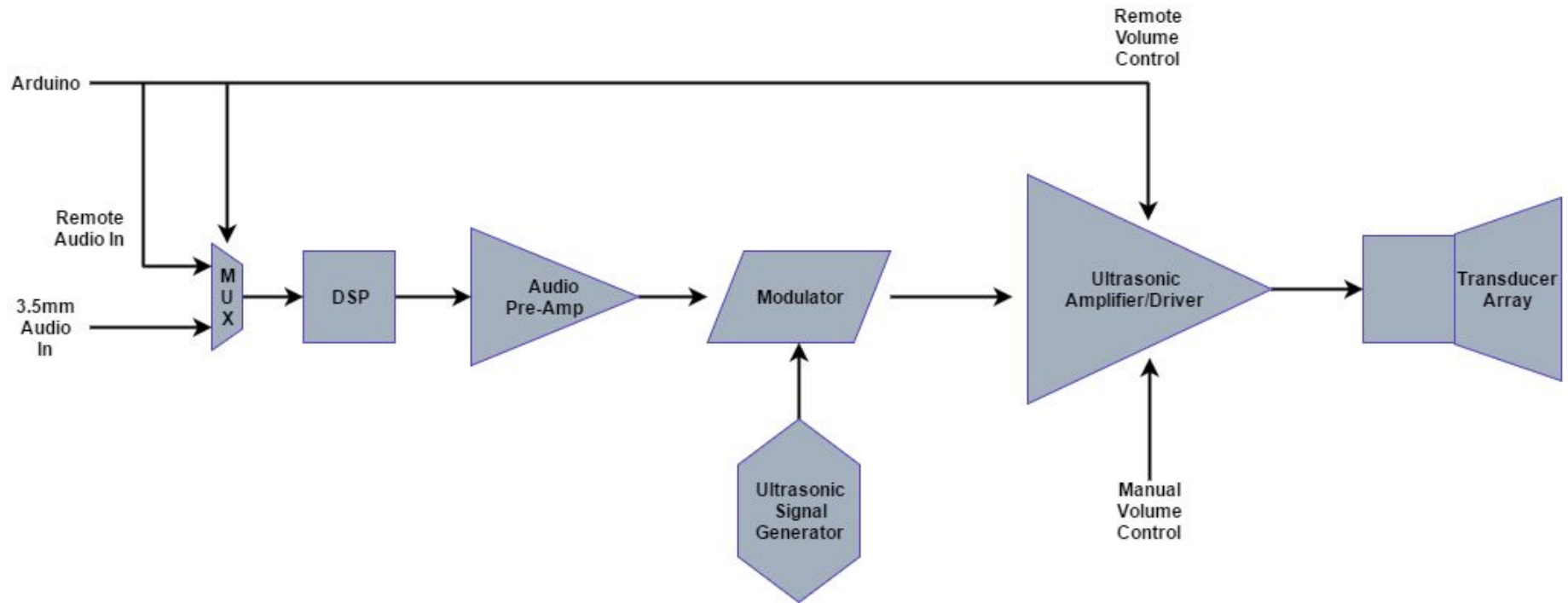
- Turret can have preconfigured sections of a room mapped out and selected via the iPhone application if tracking becomes a difficulty
- iPhone target selection if tracking works but facial recognition does not
- GPU cluster on AWS
- Android/Windows Apps
- Parabolic speaker instead of a parametric speaker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

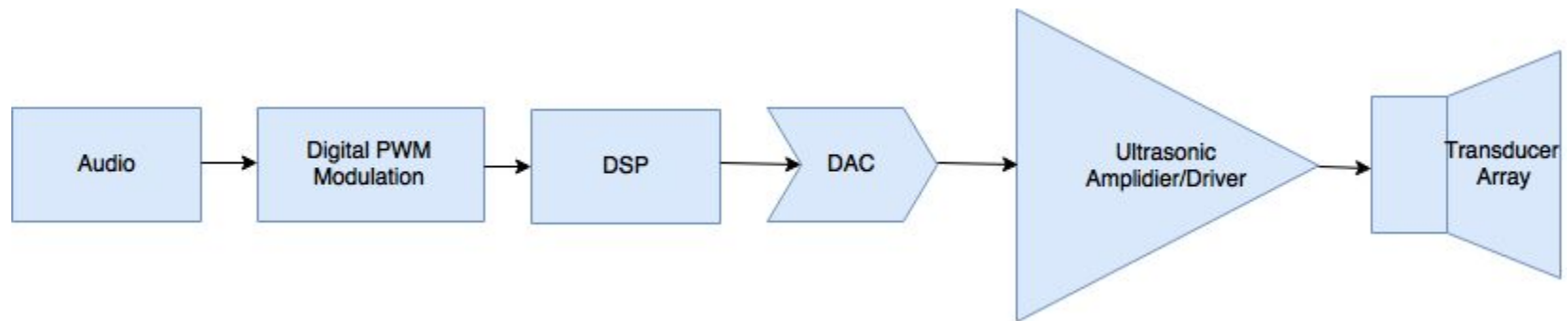
## Signal Generator:

- Capable of supplying voltage waveforms between 20kHz and 40kHz

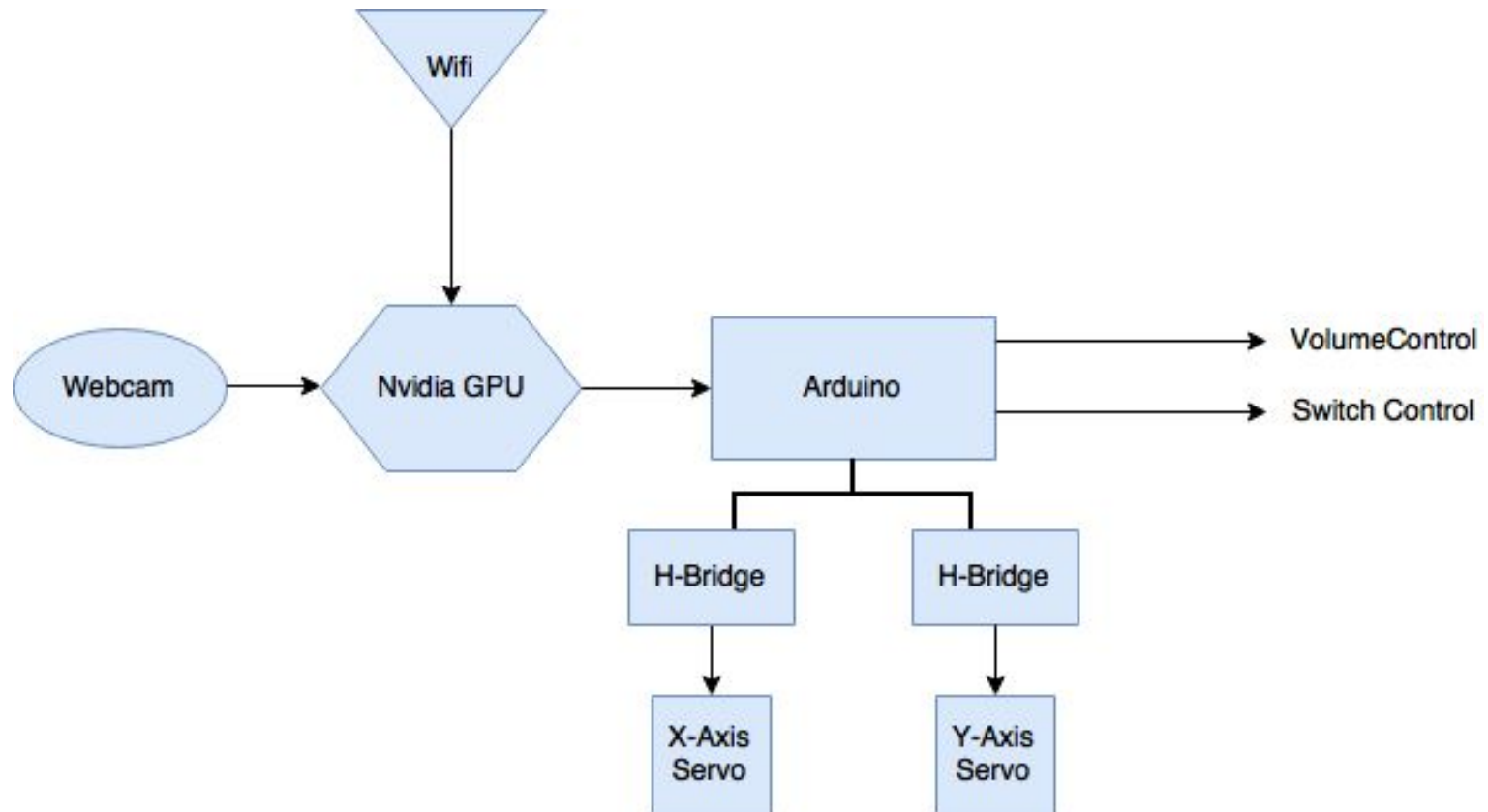
## Digital Signal Processor:

- 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

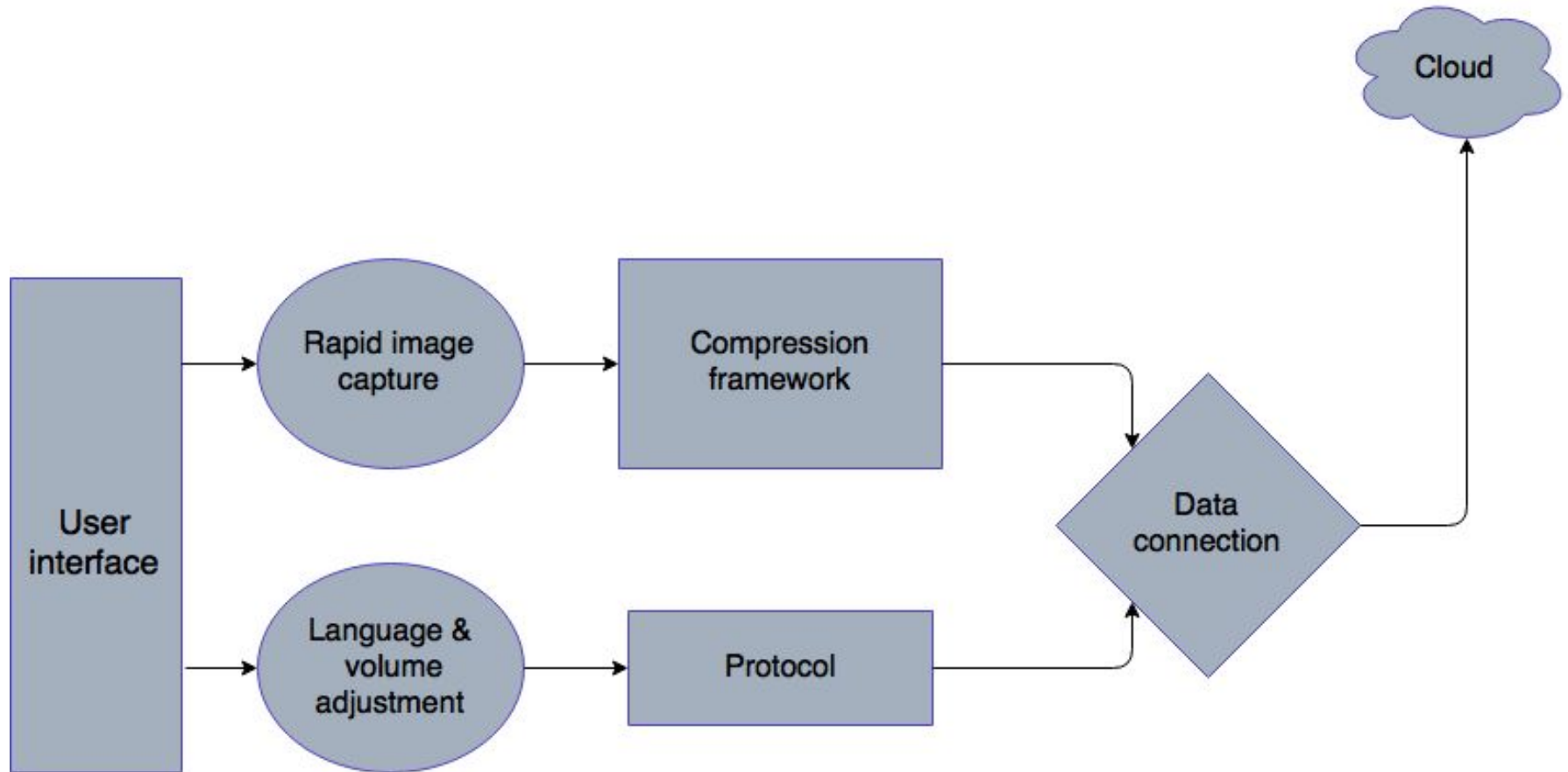
## **Facial Recognition:**

- 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

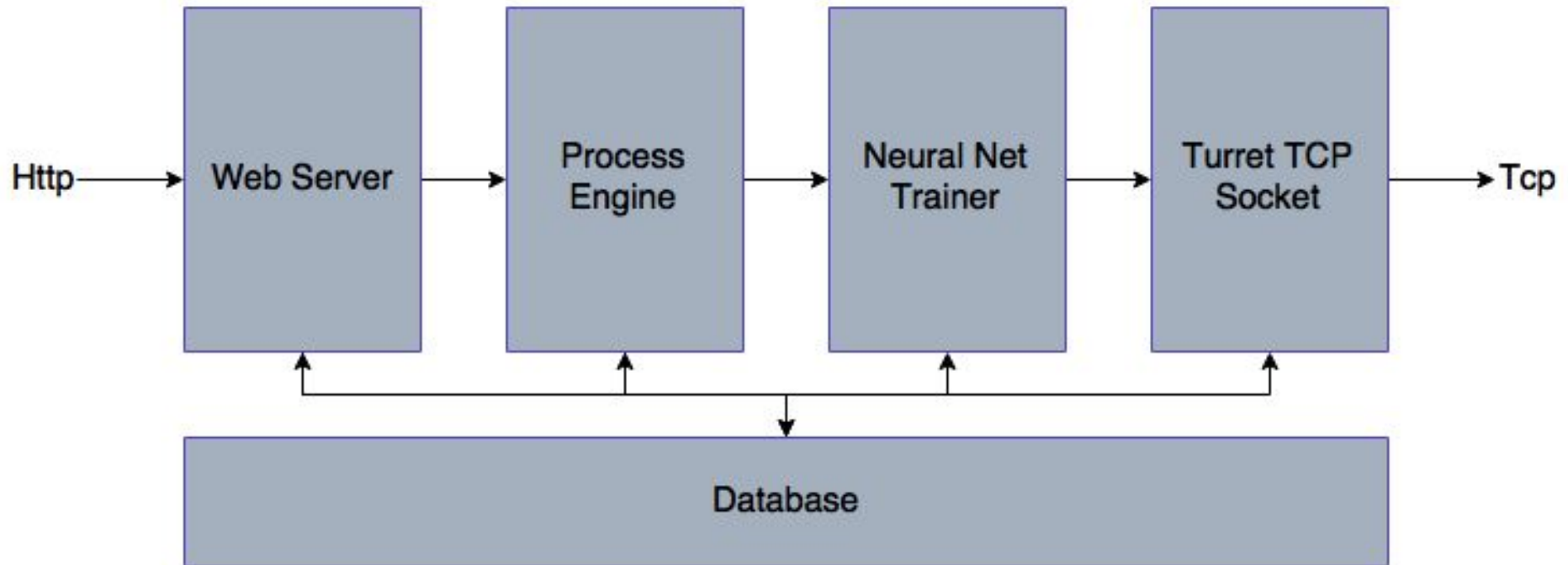
### **Frameworks**

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

### **Targeting**

- Override turret position
- Videofeed with aiming reticule

## Server: Block Diagram





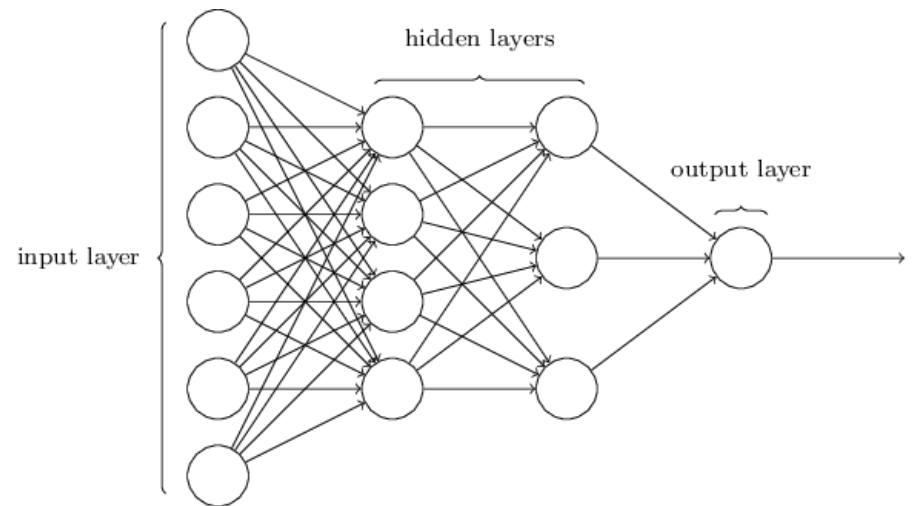
# Server System Requirements

## 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

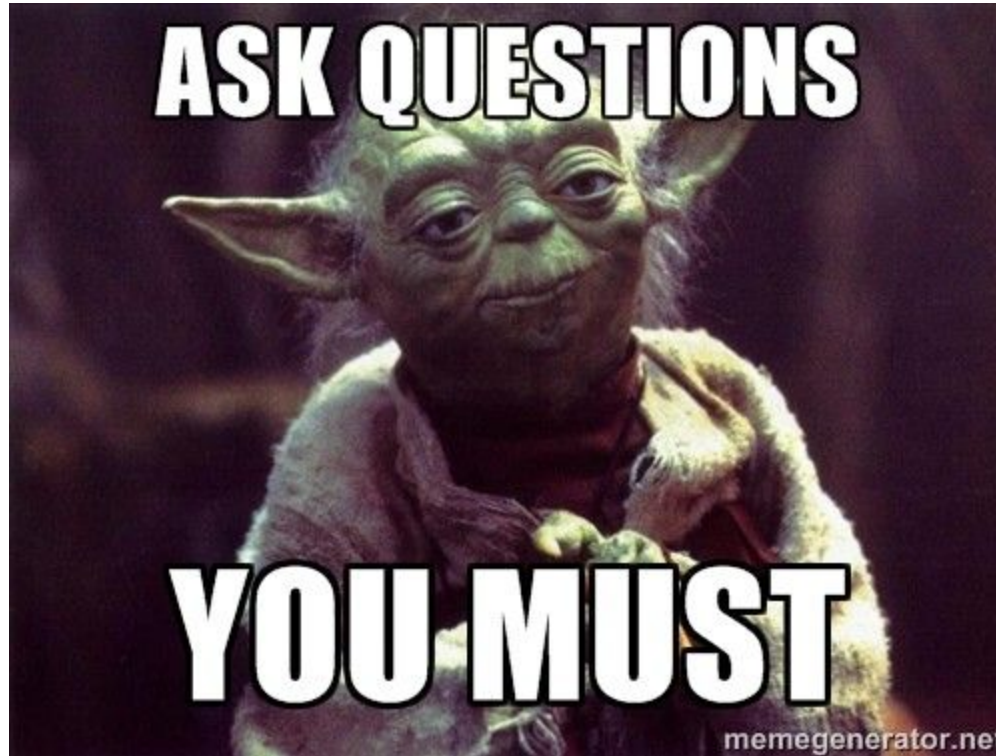
### **iPhone App:**

- 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