Pegasus 21

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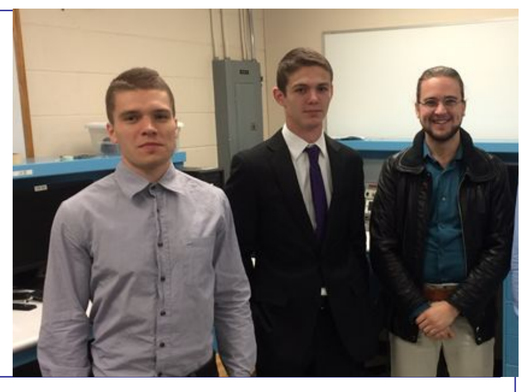


Abstract

Pegasus-21 is a directionalized acoustic tracking system that is capable of transmitting audio signals within a narrow beam and aiming that beam at a target found using facial recognition. The directionality of this device is achieved by a piezoelectric transducer array projecting modulated audio signals on an ultrasonic carrier wave which naturally demodulates as it passes through the air or hits a physical object. The array itself is mounted on a servo motor controlled turret which turns the device based upon the data it receives from a video camera. The video feed is processed on the server which communicates with the turret to control its position and trajectory.

System Overview

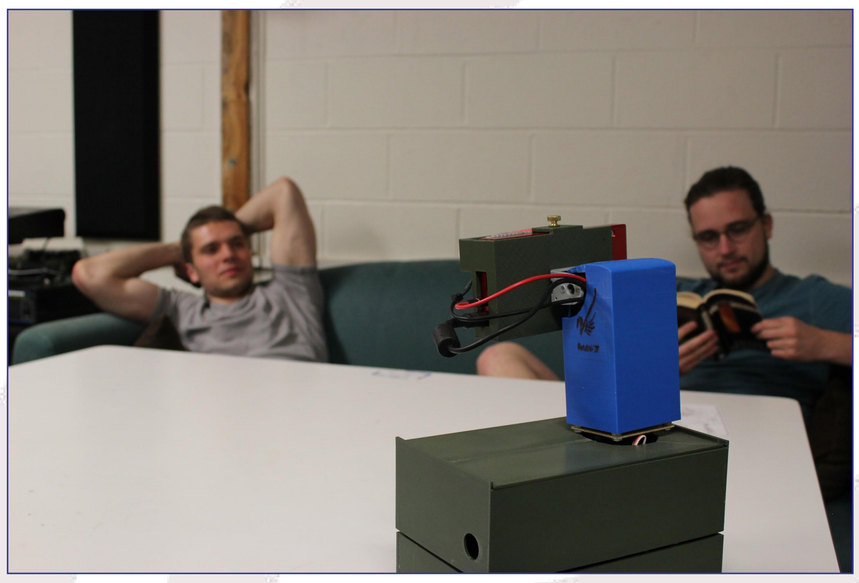
The user experience begins with the iPhone application. This app takes a short video clip of the user's face and uses the image data to train our facial recognition neural network. Once the neural network is trained on a user, the camera on the turret will start processing frames. Each frame the server processes will give the server information on the location of the target face in the frame using the MEANShift tracking algorithm. Once the user's face has been accurately trained into the system they will be given in app controls over audio and volume selection.

After the image processing and facial recognition is computed for the individual frames, the server sends the new coordinates to an Arduino Nano, which will signal the servos to turn to the new target position, thereby controlling the Soundlazer's target location. At any point during tracking mode, the user can adjust sound settings, thus delivering their personalized sound experience.

Specifications

- **Video Frame Rate (Facial Recognition): 1 fps**
- **Video Processing Frame Rate (MeanShift): 17 fps**
- **Neural Network Training Time (5 Users): < 2 minutes**
- **Neural Network Prediction Accuracy: 73% over 100 tests**
- **Rotation Speed: 1°/frame**
- **Range: 10 ft**
- **Maximum Sound Intensity (Indoors):**
  - **On Axis: 65 dB**
  - **5 ft Off-Axis: 52 dB**
- **Power Input: 2 x 120 V (Power Supply, Computer)**

Results

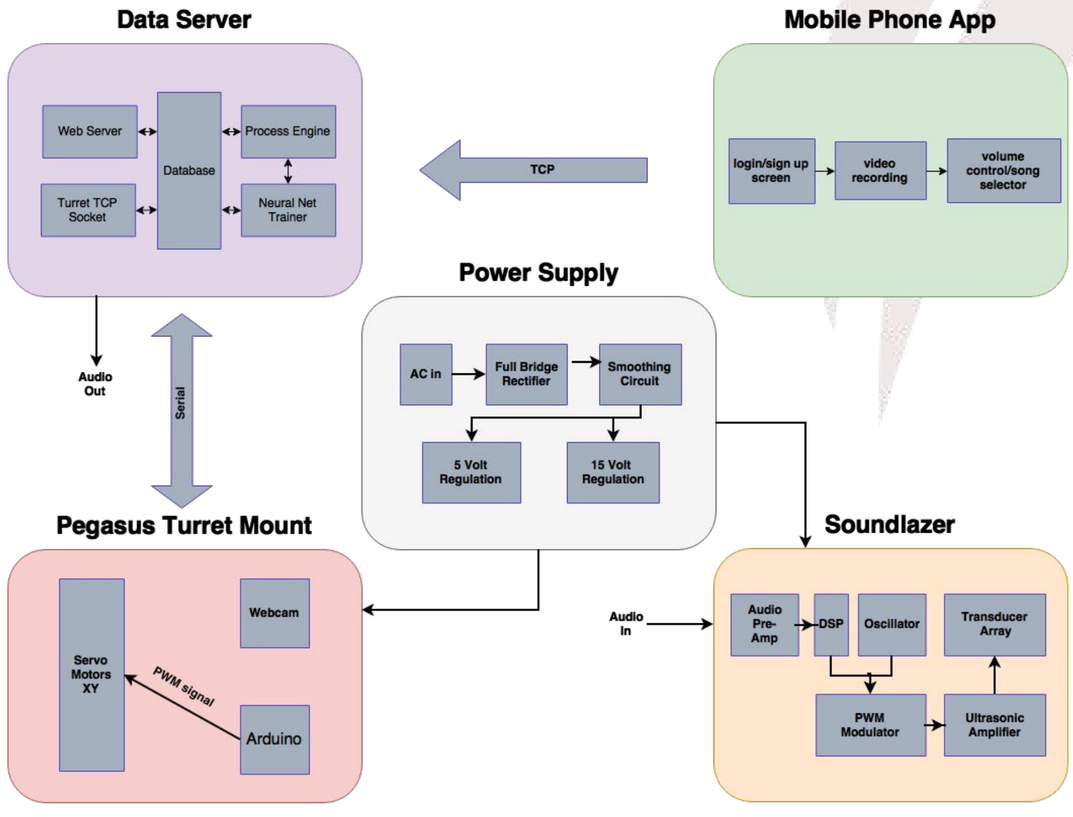


Pegasus-21 demonstrates the feasibility of directional audio turrets for consumer use. Although the concept could be used in consumer products, continuation of the project with a focus on high-end commercial systems such as theaters, stadiums, and other venues would yield increased performance due to their well defined lighting schemes and an increase in available funds to utilize higher end directional audio devices.

Constraints

- **false positive identification of users with the facial recognition as a trade off for classifier training speed**
- **poor tracking in less than ideal lighting environments**
- **loss of directionality due to acoustic reflections in small spaces**

Block Diagram



Acknowledgements

Professor Aksamija - For showing us that the truth is out there

Professor Pishro-Nik - For constructive feedback to help us improve our designs

Professor Hollot - For constructive feedback to help us improve our designs

Richard Haberkern - Soundlazer support and information

Jon Salisbury - Idea generation

Carter McCardwell - CUDA debugging and server

Soundlazer

- Uses an array of transducers to emit ultrasonic carrier waves in the direction of target
- Air, as a nonlinear medium, acts as a demodulator (no need for receiver)
- When the modulated wave reaches a person the modulated sound becomes audible

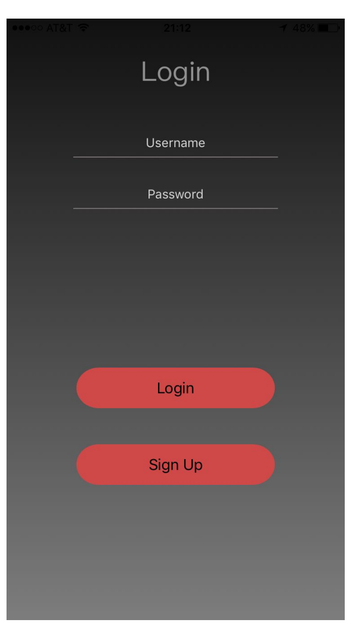
Specifications:

- 120dB ultrasonic output
- Beam size of around 3 feet
- 40 GHz Carrier Wave
- Pulse Width Modulation
- Digital Signal Processing
- 5 Watt Carrier Wave

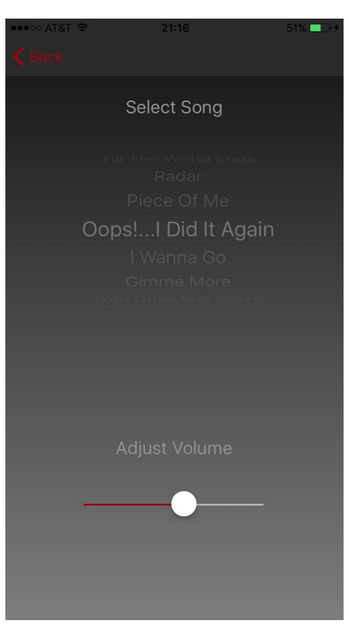
iPhone App

- Provides a user interface to interact with the system
- Supports multiple users
- Two main functionalities:
  - Allows the user to train the neural network by sending a video to the server
  - Allows the user to control the volume and genre of music

Login Screen



Song selector/ volume control

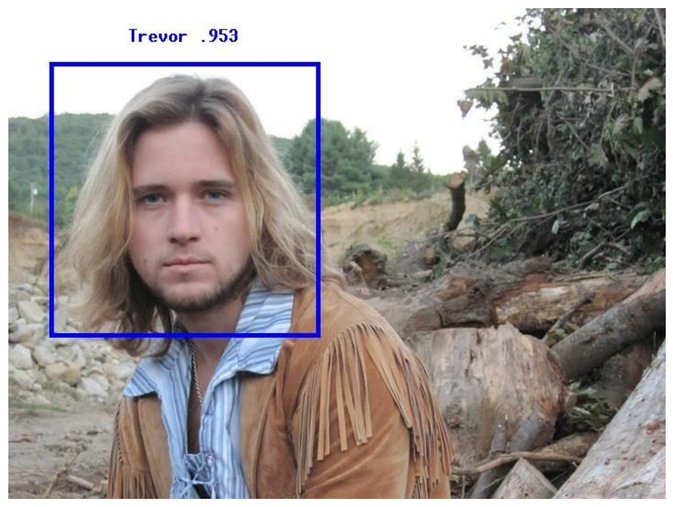


Cost

Part	# of pieces	Development cost	Production Cost
Servo	2	$18	$12
Power Supply Parts	1	$80	$12
3D Printing	1	$10	$5
Image Processing Server	1	$3000	$400
Webcam	1	$40	$9
SoundLazer	1	$250	$150
Total		$3398	$601

Data Server

- Receives data from the Arduino and Webcam over USB serial connections
- Communicates with the iPhone app over TCP
- Uses OpenFace framework for training a facial recognition neural network and computing facial recognition
- Tracks users using MeanShift algorithm



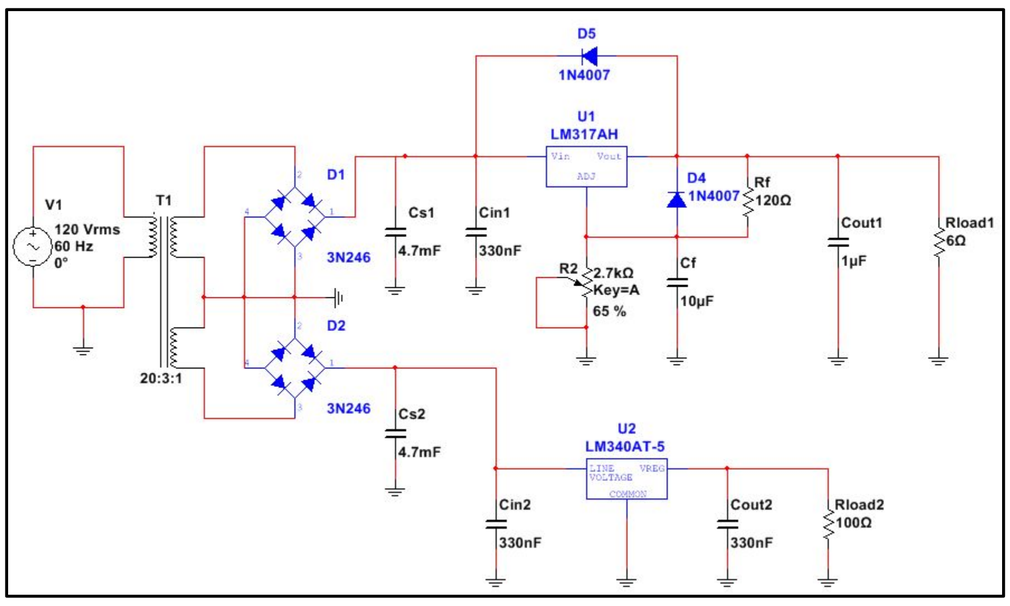
OpenCV

python™

NumPy

Power Supply

- Supplies power to servo motors and soundlazer
- Dual output linear regulator power supply
- Specifications
  - 120VAC in
  - 15VDC & 5VDC out
  - 2 Amp max



Pegasus Turret

- Controls direction of the audio beam
- Controls direction of the camera
- Locks and tracks a specific user

How does it work?

- Webcam sends live video to server
- Server sends back updated X & Y position to Arduino
- Arduino turns servos to the updated position