Distinct Sound

iOS-based Intelligent Sound Processing System

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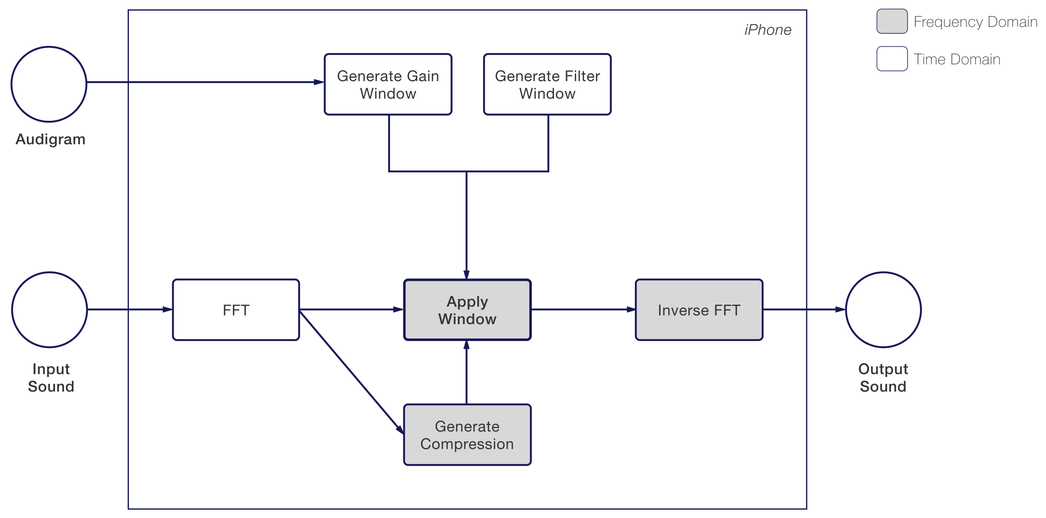
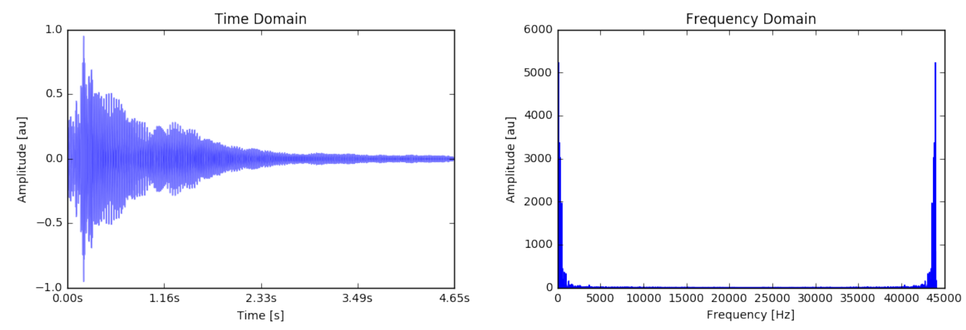
System Design

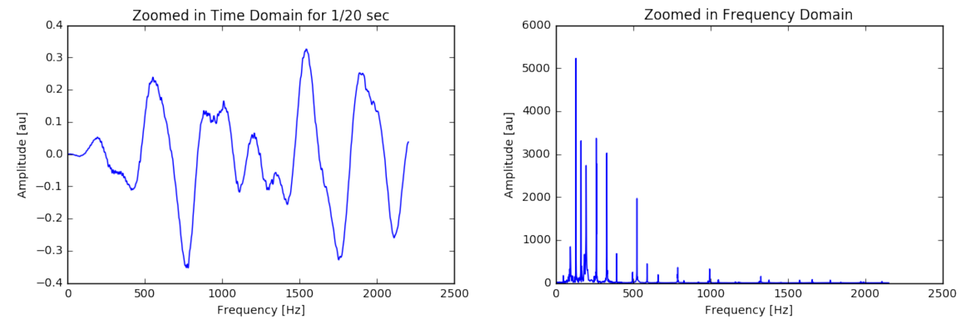
- Take two inputs: sound and audiogram
- Convert audiogram to a vector of coefficients
- Convert sound from time domain to frequency domain with Fast Fourier Transformation (FFT)
- Amplify certain frequency and filter out noise
- Generate a vector to compress the dynamic range in real time when necessary
- Convert sound back to time domain with inversed FFT and play back the audio to the user



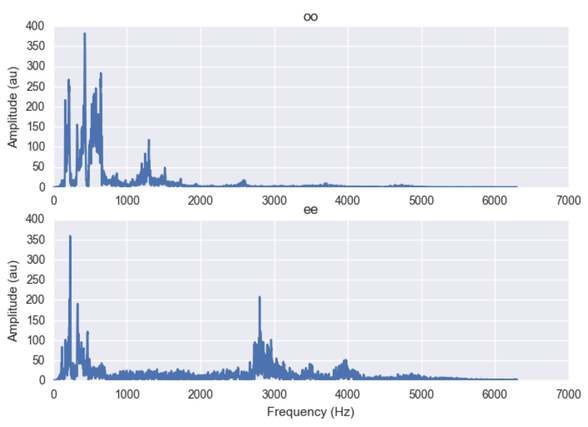
Audio Representation

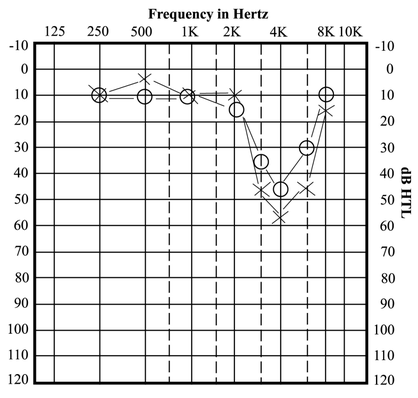
- Sound is air vibrating and we are able to hear sound by separating them into different frequencies
- Smart phones perceive sound as air pressure (e.g., an array of real numbers) and can only capture the pressure at discrete moments in time (e.g., 48,000 samples per second on the iPhone 7)
- There is a limited manipulation capability room in time domain





Decreased Audibility





Problem

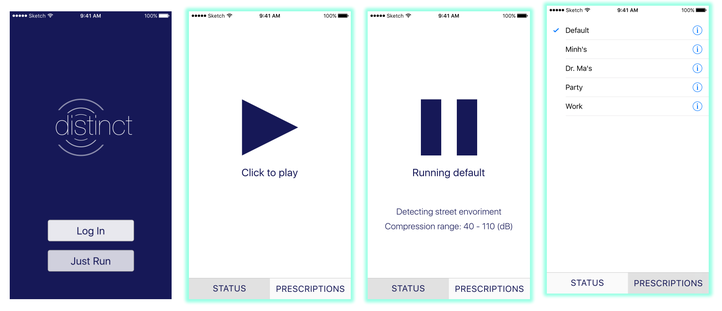
- Original sound maybe loud, but it may not be sufficiently clear for a hearing impaired individual
- Due to hearing impairments, the sound above certain frequency becomes indifferentiable
- For example, if all frequencies above 700 Hz to be inaudible, then the two sounds, “ee” and “oo”, are indifferentiable

Solution

- Dynamically amplify the sound at different frequencies as necessary
- Take input from an audiogram and adjust the amount of gains for each frequency

Distinct Sound Interface and Features

Because hearing impairment appears most often in aged individuals, the interface has to be as simple as possible. Thus, the patients need only to open the application and press one button. In the future, we want the application to be highly customizable if needed. Users can either modify theirs prescriptions themselves or log in and get help from their doctors remotely. Furthermore, if Distinct Sound offers real-time statistics such as the current environment, the users can help validating, making the application smarter.



Abstract

There are two types of hearing loss, conductive and sensorineural. The former simply reduces the sound level as it passes through the external ear canal to the middle ear, so amplifying comes close to restore hearing to normal. On the other hand, sensorineural hearing impairment results from a defect in the inner ear or the cochlea nerve. Most of the time, this condition cannot be medically or surgically corrected. This is also the most common form of hearing loss and amplification of sound alone is not sufficient. Thus, we create Distinct Sound to help patients with sensorineural hearing loss, using many other sound manipulation techniques.

Filter Processing

- Reduce background noise with a filter window

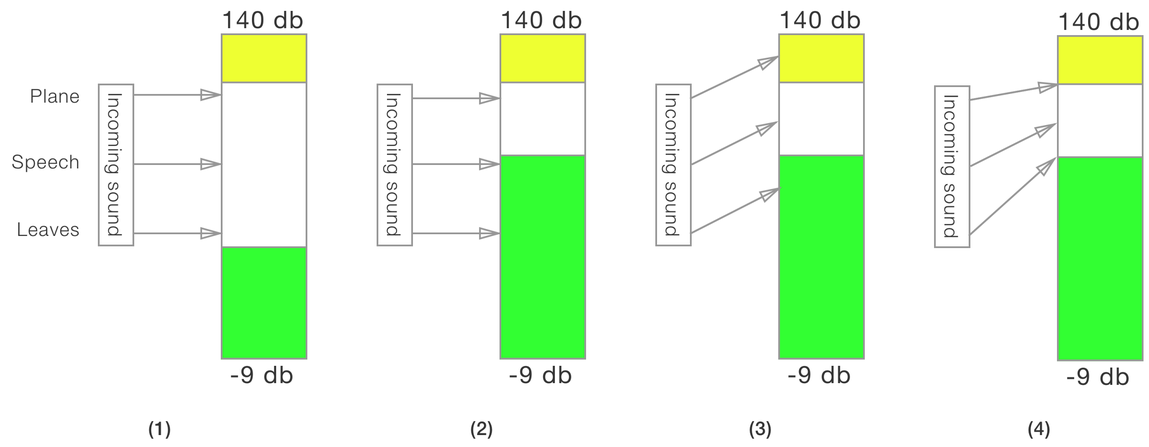
Gain Processing

$$\theta = (X^T X)^{-1} X^T y$$

For Theta be a vector of coefficients, X be a matrix of different magnitudes of the same frequency for all frequencies from 250 Hz to 8000 Hz, and y be the a vector of amplification needed for each frequency according to the audiogram

- Formulate a curve from the audiogram with the normal equation
- Boost a certain frequency by a specific loudness level calculated with the equation

Decreased Dynamic Range



(1) Normal hearing range
(2) Decreased hearing range
(3) Universal amplification
(4) Adaptive amplification

Problem

- For the hearing impaired, the dynamic range gets smaller
- Sound amplification will produce a bigger loudness increase for a hearing-impaired person than for a normal one

Solution

- Track the environment for a change in average loudness
- Automatically turn itself down or up as the sound gets stronger or weaker correspondingly

Future Work

Future work for Distinct Sound will focus on location sensing using GPS and a neural network to predict the environment based on sound. This feature would greatly enhance our capability to compress sound in real time. Furthermore, we would like to test our application in a setting where human trials are possible.

Acknowledgements

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About the Author and Technologies Used

Minh is current a junior majoring in Computer Science. Due to unexpected changes from Apple, he is building the application from scratch with Swift for iOS, Django for data collection, Numpy/SciPy/Pandas for visualization and machine learning, and Sketch for design.

References

Audiogram Reference - http://hearinghealthmatters.org/hearthemusic/2011/music-and-audiometric-asymmetries/