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Sound Source Localization Using Inter-Aural Level and Time Differences

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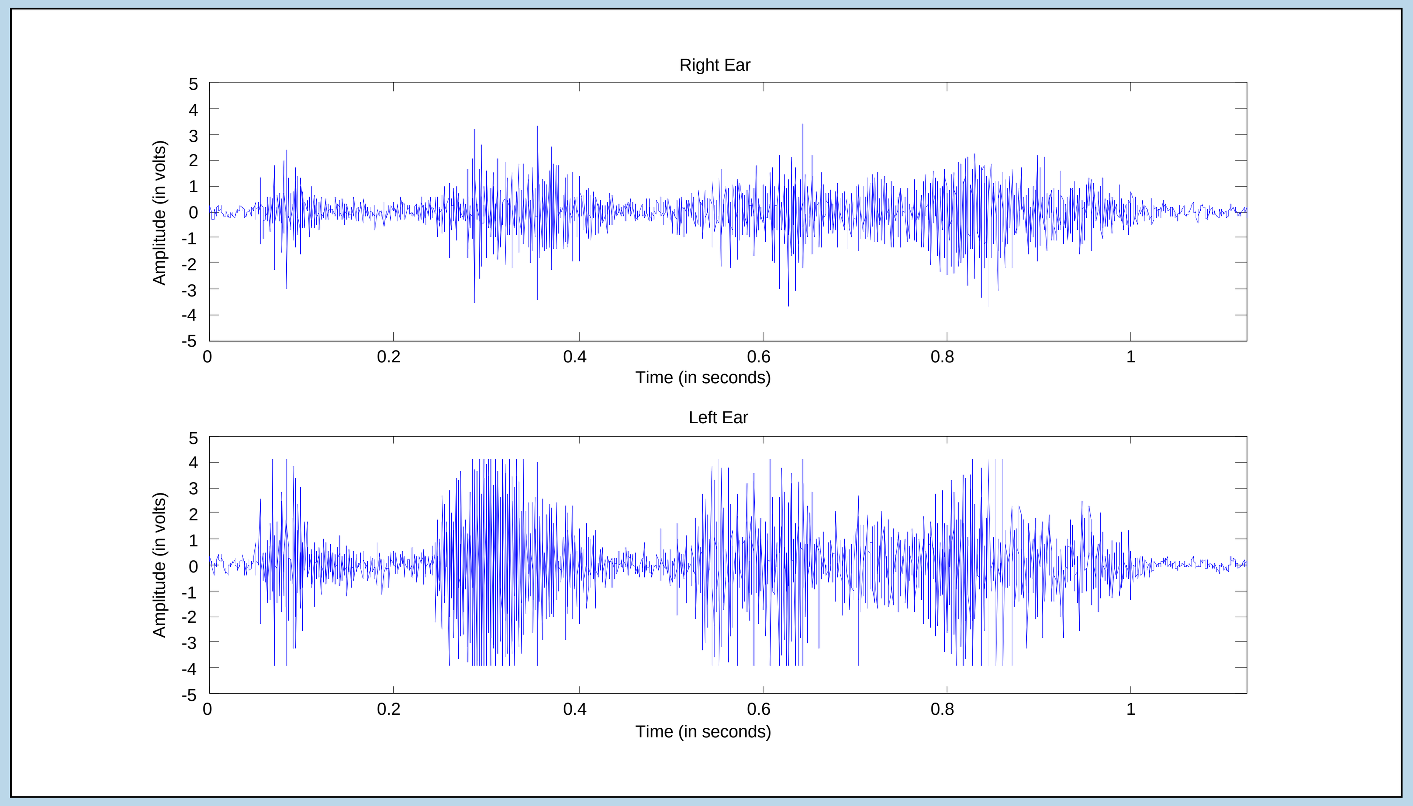
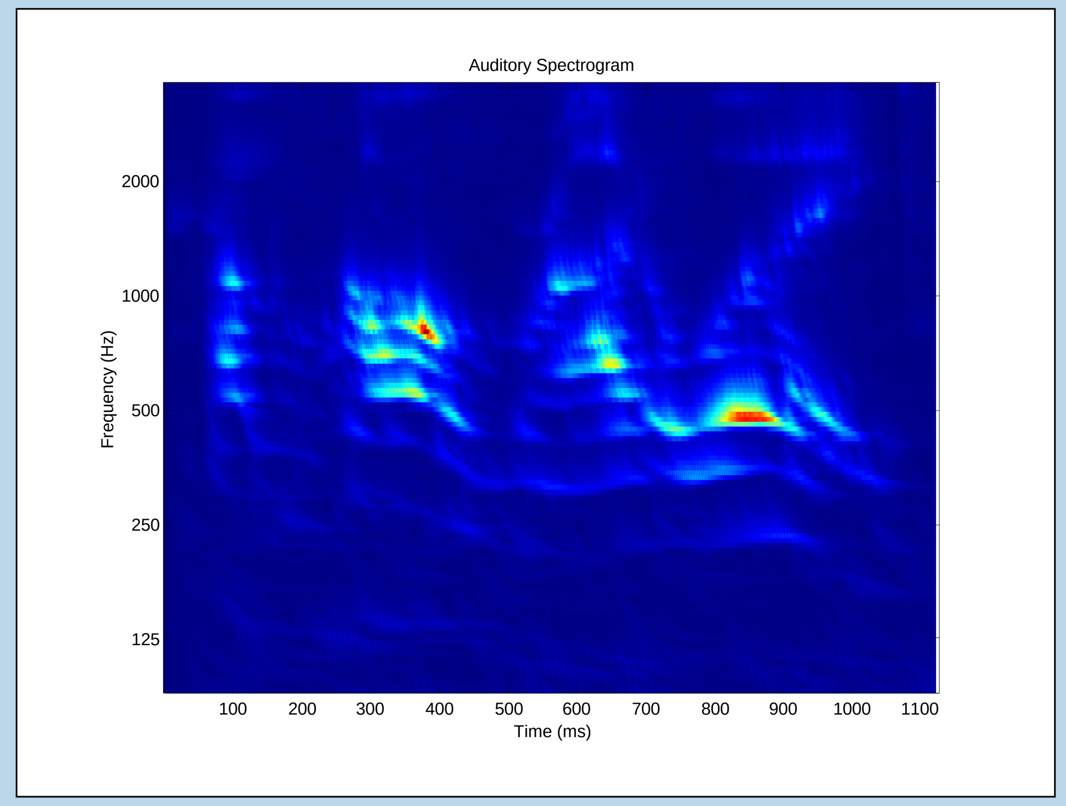
Introduction

The human auditory system is one of the least understood sensory mechanisms. Using today's technological advances in computer simulation, we can better model and thereby better understand the functioning of hearing. In addition to medical applications, this research can be used for target acquisition in military reconnaissance, as well as auditory tracking for use in security cameras or video teleconferencing. This research project focused on creating a program in Matlab which accurately localizes the horizontal position of a sound source which is heard by two microphones placed on either side of a mannequin head. This localization is based on inter-aural level and time differences between the signals recorded by the two ears. A neural network is trained to accomplish this using a series of measurements at a range of frequencies. The head then uses this localization information to rotate until it faces the source of the sound.



Time waveform of the speech signal "Come home right away."



Auditory spectrogram of the speech signal.

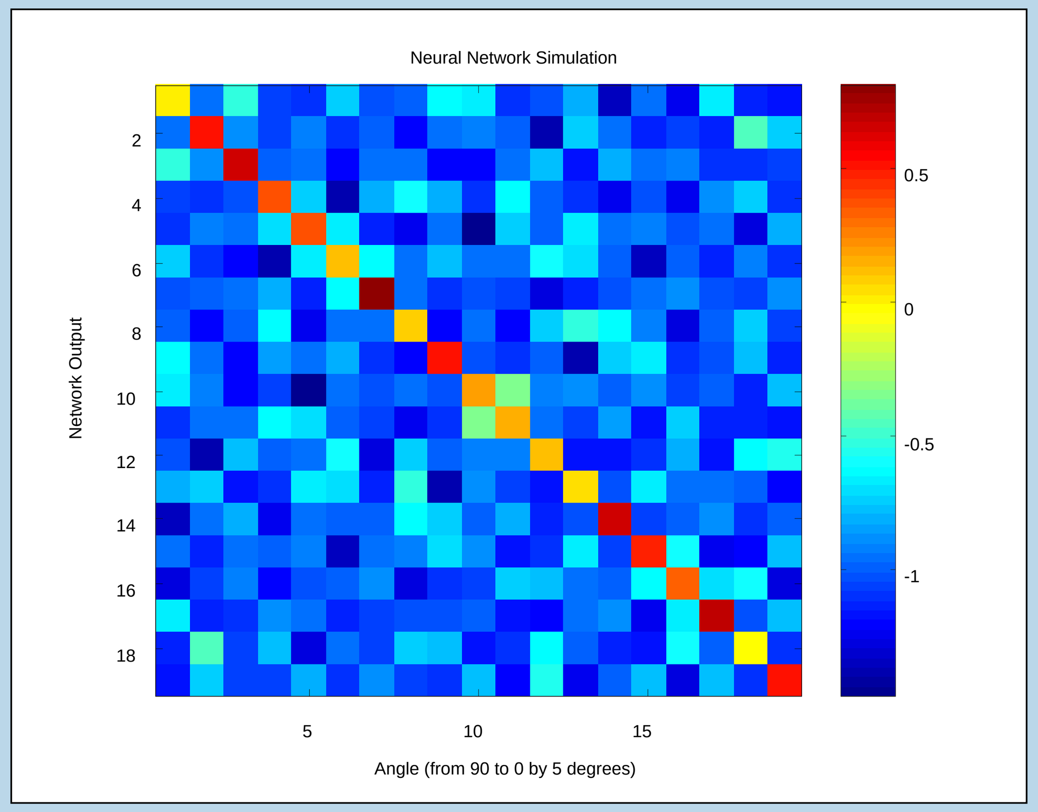
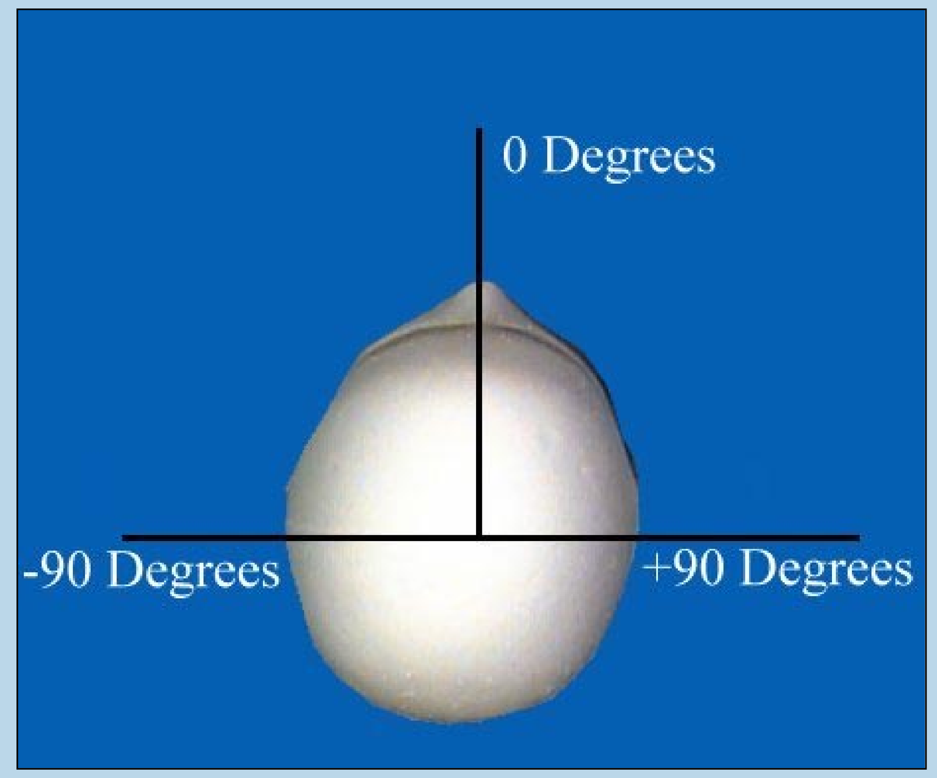
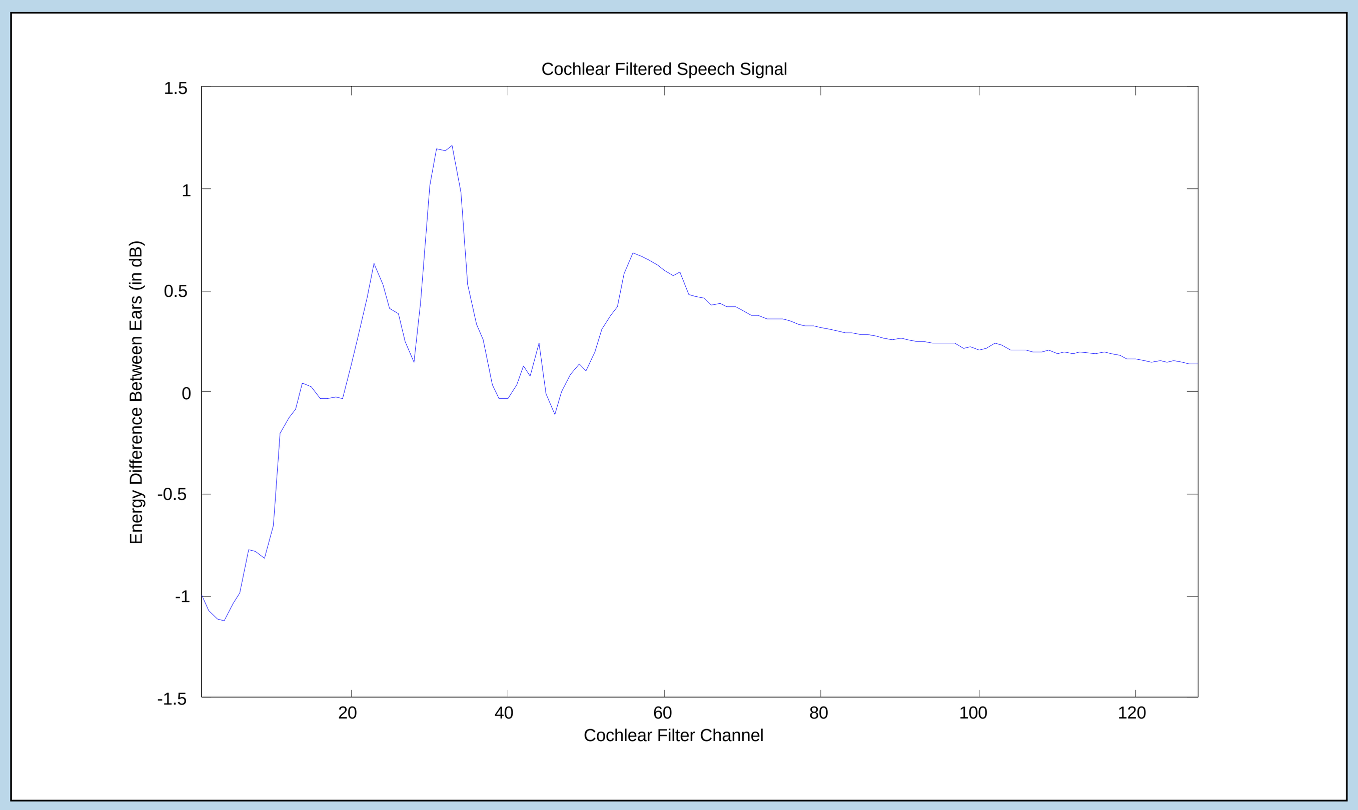


Image of neural network output after simulation using training input.

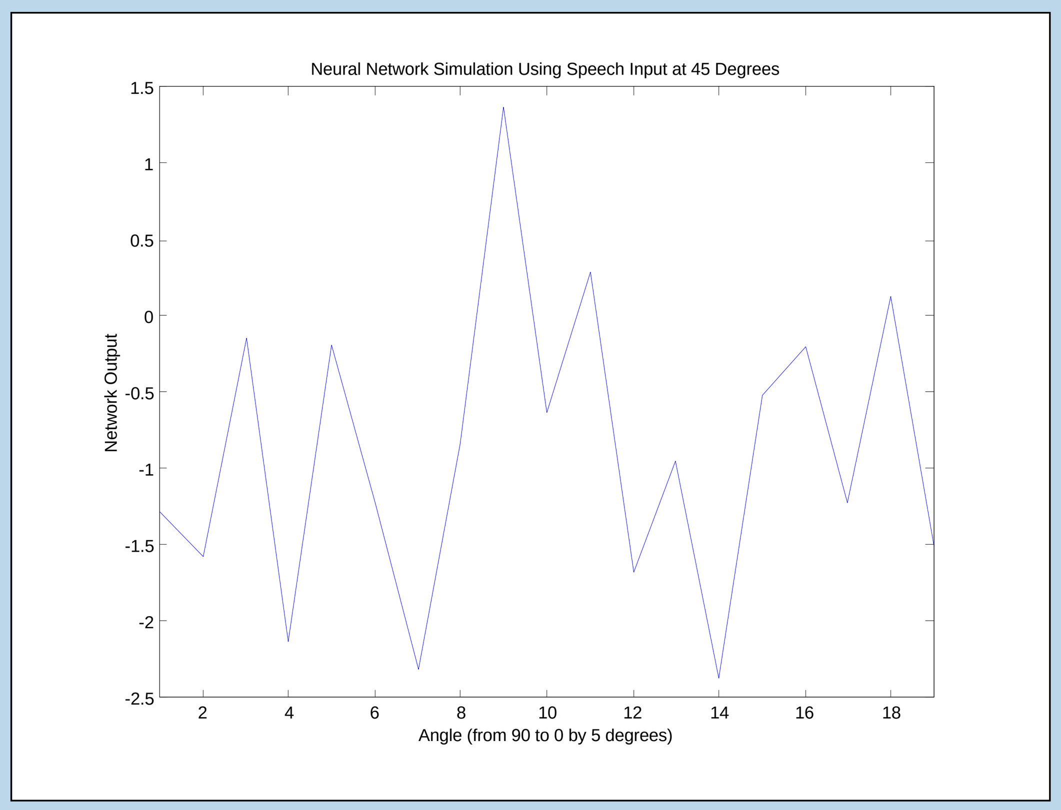
Photograph of mannequin head and base. Rotating motor located directly below neck.



Top view of head showing angling scheme for position of sound source.



Filtered speech signal "Shhhhh" used for neural network simulation input.



Neural network output of simulation at 45° using speech signal.

Conclusions

- Due to the acoustical characteristics of a head, the maximum amplitude level difference occurs when the sound source is at 70°.
- A neural network can be used to map level and time differences to locations of sound source to within a few degrees of error.
- This network uses level differences for higher frequencies and time differences for lower frequencies to determine sound location. Current research indicates that the brain also calculates position of the sound source in this manner.

Future Work

- Localize sound in vertical plane
- Recognize specific verbal commands
- Differentiate between multiple sound sources
- Integrate auditory and visual information into single system