Anupam Mohanti
Mark Allen-Piccolo

Final Project Interim Report

1) Description of the project objectives

The purpose of this project is to apply DSP design principles towards a practical objective. We will use the fundamental concepts we have learned in class, such as frequency domain analysis and processing, to synthesize a human voice. By the end of this project, we will have implemented a LPC vocoder along with a graphic user interface. The working design will be demonstrated to the class.

2) Clearly itemizes the tasks to be completed

There are two main components to the design:

1) The Vocoder
2) The GUI

1) The Vocoder
    a) Analyzer
        i) Pitch analyzer
            (1) Pitch
            (2) Voice/Unvoiced decision
        ii) LPC analyzer
            (1) LPC coefficients and gain
    b) Quantizer
    c) Parameter Recovery
        i) Gain and filter coefficients
        ii) voiced/unvoiced
        iii) Pitch
    d) Synthesizer
        i) White noise generator
        ii) Periodic impulse generator
        iii) Gain control
2) The GUI
    a) Import audio (select audio from disk)
    b) Record audio
    c) Choose time window
    d) Display spectrogram
    e) Display time window

The programming tasks that must be completed to meet the design criteria of the project are as follows (from the project description):

(a) Retrieve a segment of voice recorded; Generate a spectrogram.

(b) Pass the voice through LPC vocoder to generate a low rate output bits into a file (<16k bit/s).

(c) Save the bits in a local file and let the synthesizer to recover the voice.

(d) Play back the synthesizer output and generate its spectrogram for comparison with (a).

(e) Provide at least two ways of estimating the pitch of the voice signal. Compare the result of the two different pitch estimation.

3) References and important information that you have read thus far and found to be very helpful this project: Provide the reference source and describe the specific methodology

---

Cepstrum Pitch Determination, (1967). A Michael Noll
Citation: The Journal of the Acoustical Society of America 41, 293 (1967); doi: 10.1121/1.1910339 View online: https://doi.org/10.1121/1.1910339 View Table of Contents: https://asa.scitation.org/toc/jas/41/2 Published by the Acoustical Society of America

A paper with fundamental design concepts and techniques about Cepstrum Pitch Detection. Also contains links to several other papers regarding pitch detection.

Pitch Detection Algorithm: Autocorrelation Method and AMDF, (2003), Li Tan and Montri Karnjanadecha, Department of Computer Engineering, Faculty of Engineering, Prince of Songkhla University, Hat Yai, Songkhla, Thailand

A paper about pitch tracking techniques using autocorrelation method and Average Magnitude Detection Function to extract the pitch pattern.

On the Use of Autocorrelation Analysis for Pitch Detection, (1977), Lawrence R. Rabiner, IEEE TRANSACTIONS ON ACOUSTICS, SPEECH, AND SIGNAL PROCESSING, VOL. ASSP-25, NO. 1, FEBRUARY 1977

Another paper describing types of autocorrelation to determine the pitch of a speech signal

---

Wideband Speech Coding with Linear Predictive Coding (LPC), 2002. Abeer Alwan, Ozgu Ozun, Philipp Steurer, Daniel Thell.
University of California at Los Angeles, Department of Electrical Engineering,
EE 214A: Digital Speech Processing, Winter 2002

A project carried out at University of California, Los Angeles for the department of Electrical Engineering. Interesting in that it gives a sense of how another group approached this same design and can offer insights into our own design. They also have some examples of MATLAB script. While we will write our own, it can be helpful to see how another group approached the same problems that may come up.

An Introduction to the Phase Vocoder, 1975. Gordon, J. W., and J. Strawn
URL: https://ccrma.stanford.edu/files/papers/stanm55.pdf

Although not directly related to LPC-vocoders, reading about phase vocoders gives an alternate approach, providing insights into how speech can be synthesized.

Efficient codebook search for CELP vocoders, 1991 (US Patent). William C. Yip, David L. Barron. https://patents.google.com/patent/US5187745A/en

We won't implement this vocoder, but it is a design that improves the fidelity as compared to the LPC that we are designing.

---

4) Methods you plan to adopt

- Pass the signal through a Kaiser window and then generate Spectrogram
- Design a pitch detector using 2 different methods - Autocorrelation and Cepstrum Analysis
- Design the LPC analyser.
- Change the pitch - for male to female conversion
- Design the Quantizer
- Build the GUI using App Designer in Matlab

5) Your plans, specific tasks, and date-specific milestones

- Generate a spectrogram - by 28 Feb, 2019 (completed)
- Determine the Pitch using Autocorrelation - by 1 March, 2019 (Completed)
- Determine the pitch using Cepstrum Analysis -
- Design the LPC Analyser - by 3 March, 2019
- Design the Quantizer - by 6 March. 2019
- Design the Synthesizer - by 8 March, 2019
- Build a GUI for all the functions - by 10 March, 2019
- Test out if everything works in conjunction to each other - by 12 March,2019
- Correct if something is not working properly - by 15 March, 2019 (Optional)
- Final tests - 14 and 15 March, 2019

6) Members in charge of each task.

Anupam Mohanti - Spectrogram, Pitch detection using Autocorrelation function, LPC Analyser, Synthesizer, GUI

Mark Allen-Piccolo - Spectrogram, Pitch detection using Autocorrelation function, LPC Analyser, Synthesizer, GUI, updating website

We will share the tasks and delineate depending on what is needed.

7) Any preliminary findings and results.

- We have generated a spectrogram for a speech signal where two men are talking.
- We have also determined the pitch using autocorrelation but it seems to be off by some Hz. We are working on fine tuning the algorithm and use Cepstrum Analysis to determine the pitch and compare the two.