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3D Beamforming for Sound Field Analysis and Noise Source Localisation Employing a 2D Microphone Array

ABSTRACT - Masterthesis

Beamforming is a signal processing technique which allows spatial filtering of signals, using a sensor array. It is the combination of signals from a set of small nondirectional antennas to form a large directional antenna. The large antenna thus formed can be pointed electronically, although the antenna is not physically moved. This, when performed in real time will improve the Signal to Noise Ratio (SNR) of the signal thus reducing unwanted noise.

A beamformer uses the output of the sensors in an array to perform the required spatial filtering. So the sensors should be individually accessible. By proper signal processing we can thus steer an antenna to different directions to find the location of the signal source.

To illustrate the concept of beamforming, a simple beam pattern generated assuming a linear array with 10 elements is shown in Fig. 1 in the next page. As we can see from the figure, the array is more sensitive to signals arriving from 0 degrees to the perpendicular to the sensor array. This can be clearly understood from Fig. 2 because at this direction all the sensor outputs are in phase. By applying proper delays to the sensor outputs we can steer the array electronically to any desired direction.

This is the basic concept behind beamforming. There are different beamforming algorithms with each one having their own merits and demerits. Delay and sum beamforming is used in this thesis and it is performed in both time domain and frequency domain and its advantages and disadvantages are analyzed.

The main beamforming algorithm written is given in the Appendix. The important commands used in the algorithms are given with a short description in the Appendix section. To explain the concepts more crisply and to analyze the conclusions various figures have been generated and presented through out the report. The respective Matlab Codes are also given in the Appendix.

The chapters 2 and 3 lay the foundation and fundamental theory involved in beamforming. Chapter 4 gives a brief description of the Hardware used. Chapter 5 and 6 elaborate the idea behind the Matlab program written to perform beamforming with the help of flow Charts and examples in both frequency and time domains.

The contents of chapter 7 are the experiments and results with the corresponding explanations and inferences. While chapter 8 contains the conclusion and future works that can be done as an extension to this thesis.

Beamforming was originally researched in the area of RADAR. This was in an effort to overcome the effects of jamming and hence improving target detection and tracking. Other potential applications of beamforming include sound field diagnostics for noise source identification, hands-free telephony, hearing aids, audio conferencing etc.