Spatial Rendering of Digital Waveguide Mesh Room Acoustic Models for Multichannel Sound

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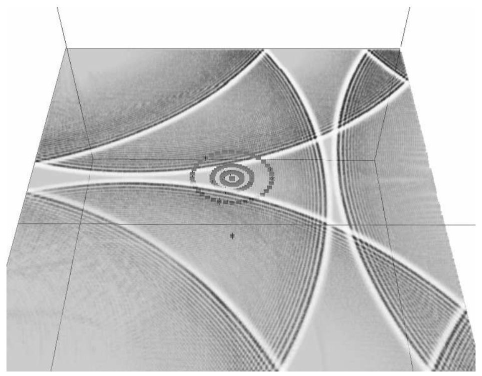
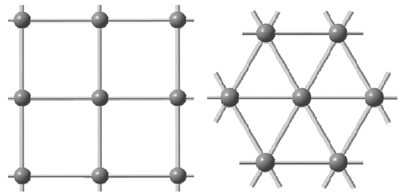
Introduction

The Digital Waveguide Mesh (DWM) is a physical model that has been previously applied to room acoustics simulations. Essentially the DWM is used here to estimate the propagation of sound through the air on either a 2D plane or 3D space. The DWM is placed inside a virtual geometric representation of a real room and may then be used to generate a Room Impulse Response (RIR).

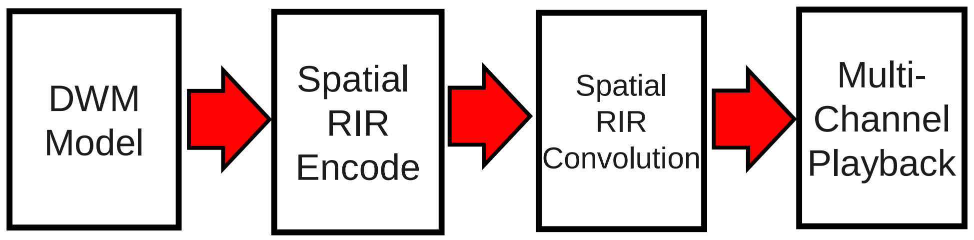


DWM application modelling the propagation of sound



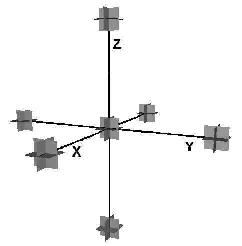
Rectilinear and Triangular DWM Topologies

Prior to the start of this research, DWM modelling was only provided RIR's for mono\stereo reverberation by convolution. Therefore the primary task of this research was to capture the directional information and then provide a means of delivering this spatial information over a suitable multichannel sound system.

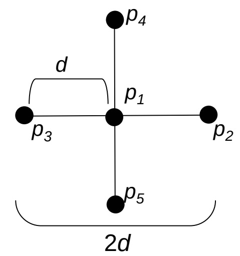


Method

The encoding method consists of multiple omni-directional pressure sensors known as receivers. These are arranged as shown for 2D and 3D soundfields.



Crux of Receivers (3D)



Crux of Receivers (2D)

B-Format was chosen as the target format for capturing the spatial information produced by the DWM as this may be later re-processed to suit multiple delivery methods.

Crux of Receivers

This technique could easily be extended to 3D soundfields however only 2D soundfields have been considered. As illustrated only 5 receivers where used for 2D. This technique is based on the principle that 2 pressure sensors can be used to calculate the velocity component of the soundfield. The X and Y velocity signals of B-Format are calculated in this manner while the W channel is taken directly as the central receiver in the crux.

Testing

In order to validate the performance of the encoding method numerous testing techniques were employed. These included:

- Ambimeter (Polar Plots)
- Ambimeter (Time vs. Angle)
- Lateral Fraction (LF) Analysis
- Informal Listening Tests

Results

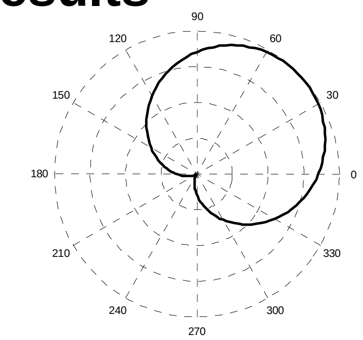


Fig 1. Ambimeter (Polar)
Source at 45°

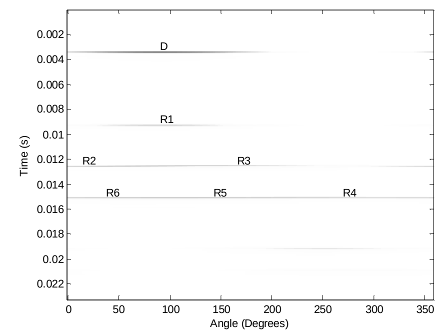
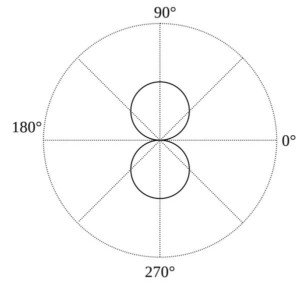
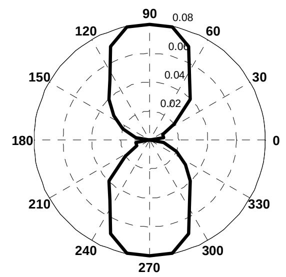


Fig 2. Ambimeter (Time vs. Angle)
Source at 90°

A source placed 1m at 45° (Fig 1) and 90° (Fig 2) fro m the crux is recorded and encoded to B-Format. Fig 1 shows the Ambimeter (Polar) result which inspects the direct sound of the RIR only. As desired this shows that at this point in time the soundfield would be loudest at 45° if decoded to a speaker array. In Fig 2, the labels D, R1...R6 represent the estimated time and angle of arrival for the direct sound and the 6 first reflections. The actual recorded wavefronts are the horizontal lines that get darker as the wavefront gets louder, hence the direct sound is darkest. It may be observed that the recorded wavefronts appear at the desired time and angle indicating that the encoding is correct.



Predicted LF Polar Plot



Actual LF Polar Plot

The LF figure is a measure of diffuseness, and it is possible to predict this characteristic as the crux is rotated. The actual LF polar plot can be seen to agree with the predicted version, hence the crux encoding method is correctly calculating the velocity component. Informal listening tests also suggest that the encoding technique is successful.

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