Recording Speech During MRI: part II

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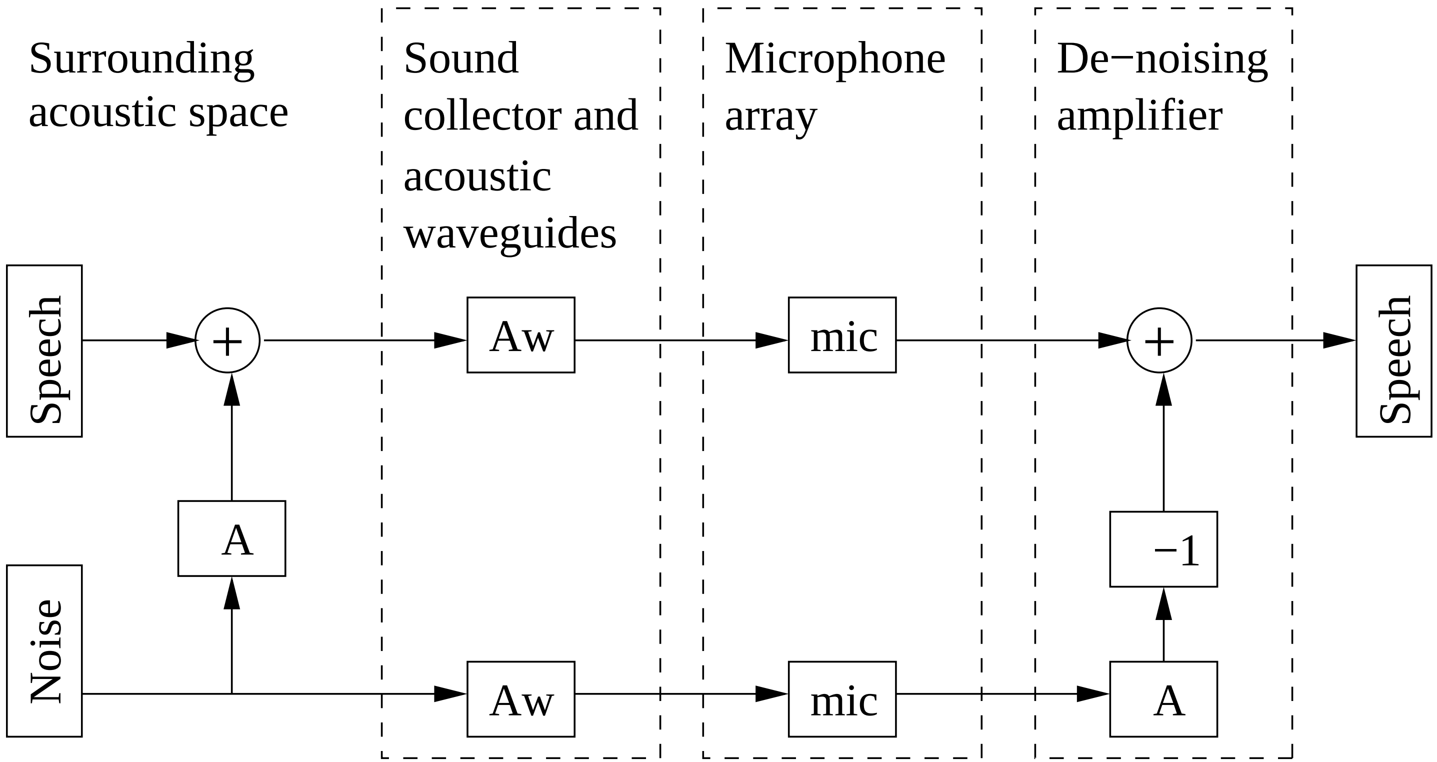
Introduction

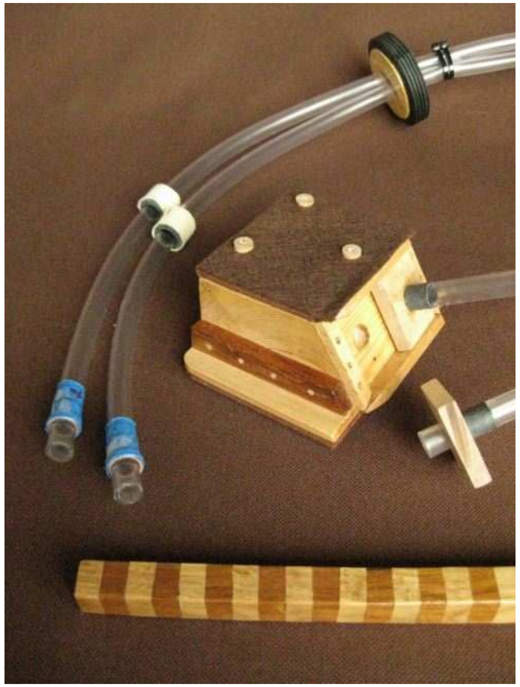
- Our main goal is to simulate vowels based on a wave equation model.
- We need accurate anatomic data for building the simulator.
- We also need simultaneously recorded sound to validate the simulation results.
- For this purpose, we have constructed a recording arrangement which will be used during MRI scans of the vocal tract.

Principle of Noise Cancellation



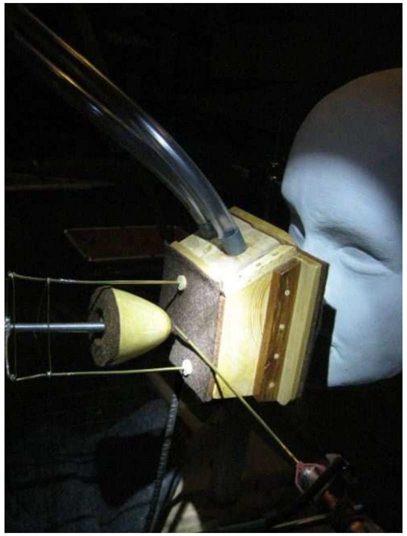
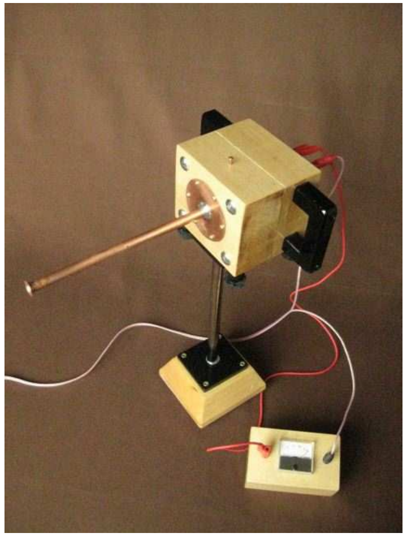
- The noise cancellation is based on the principle of a differential microphone.

Sound Collector



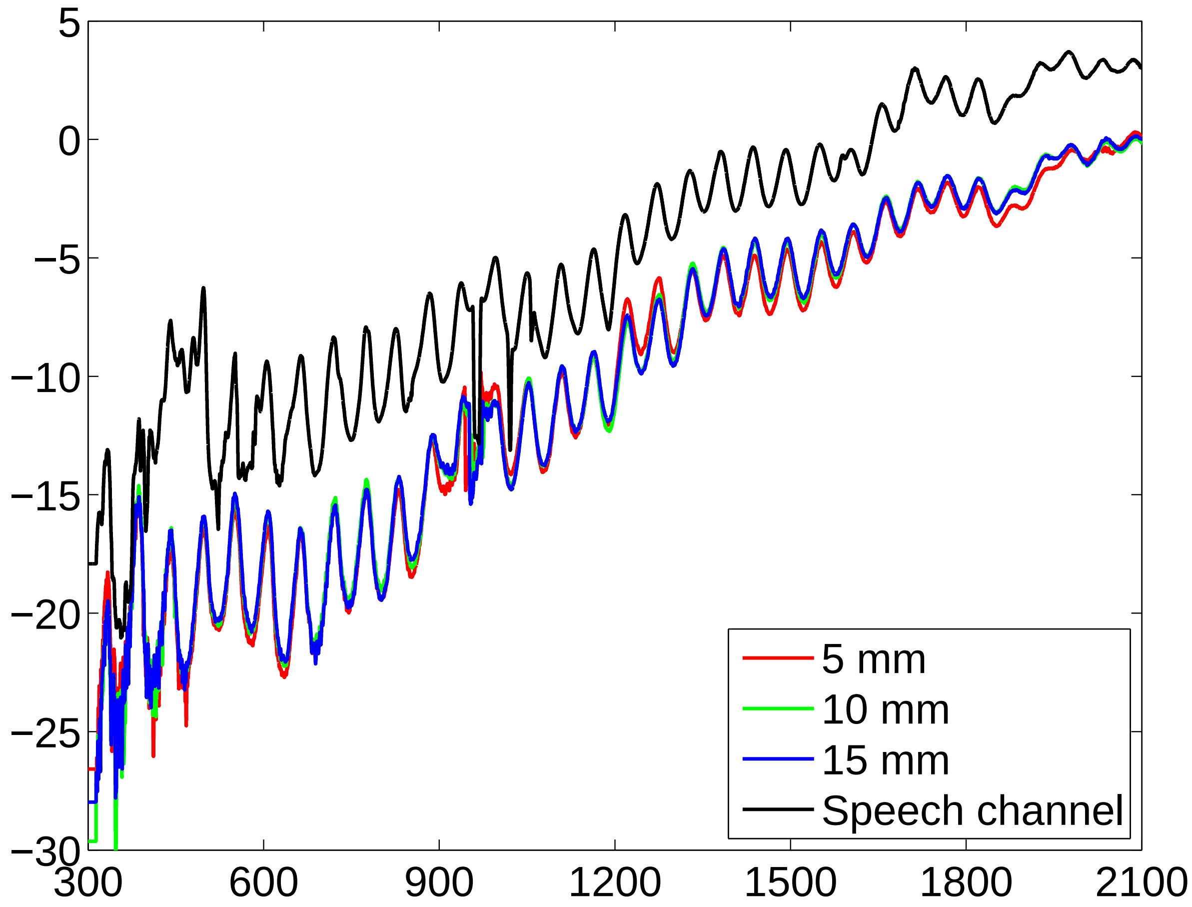

- The two channels have to be matched as closely as possible.

Frequency Response Measurements

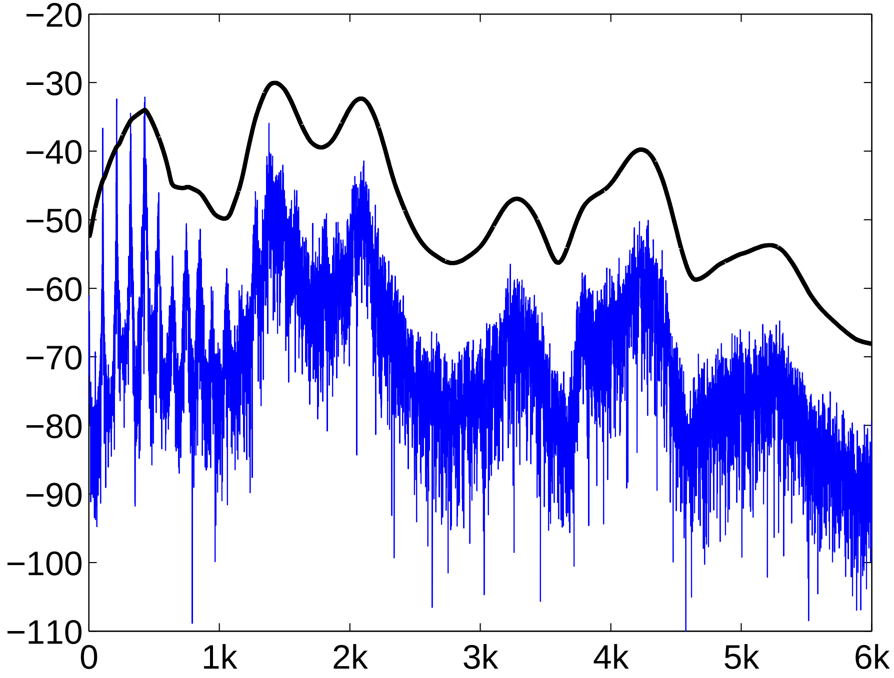
- We measured system responses in an anechoic chamber using a face model and a point wise sound source.
- The test subject's face affects the acoustic impedance of the speech channel.

Frequency Response



- On low frequencies the channels are well matched.

Vowel Response



- Formants are very clearly visible in even uncompensated spectrograms.

Vowel Post-processing

In addition to the de-noising performed with the differential microphone set up,

- we will digitally compensate the frequency response of the wave guides,
- we will build a noise model for the MRI machine and use it to remove any residual noise, and
- we will identify the formants by linear prediction from the cleaned signal.

Thank you.

Questions, please.

Wave Equation Model

$$
\begin{cases}
\Phi_{tt} = c^2 \Delta \Phi & \text{for } (\mathbf{r}, t) \in \Omega \times \mathbb{R}, \\
\Phi = 0 & \text{for } (\mathbf{r}, t) \in \Gamma_1 \times \mathbb{R}, \\
\frac{\partial \Phi}{\partial \nu} = 0 & \text{for } (\mathbf{r}, t) \in \Gamma_2 \times \mathbb{R}, \text{ and} \\
\Phi_t + c\frac{\partial \Phi}{\partial \nu} = 2\sqrt{\frac{c}{\rho_0}}u & \text{for } (\mathbf{r}, t) \in \Gamma_3 \times \mathbb{R}.
\end{cases}
$$

Faraday cage