Recording Speech During MRI II

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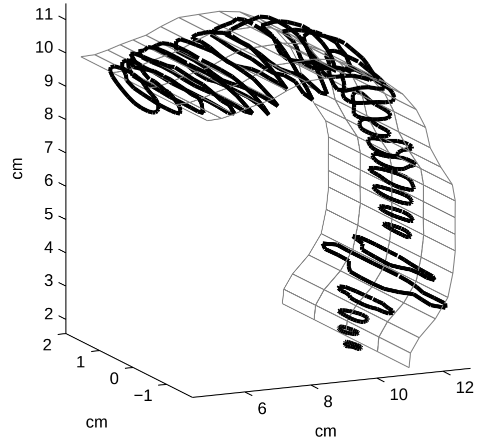
Background

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

(a)



(b)

Figure 1: (a) The wave equation model and (b) a sample vowel geometry

- The main goal is to simulate vowels based on a wave equation model.
- We need accurate anatomic data and simultaneously recorded sound to validate the simulation results.

Resonance Calculations of the Vocal Tract I

Table 1: Formants for [øː] in kHz obtained by various means.

	F1	F2	F3	F4
Webster, uncurved	0.66	1.35	2.68	3.76
Webster, curved	0.64	1.32	2.64	3.71
Wave equation	0.68	1.35	2.71	3.79
Measured (EB99)	0.50	1.06	2.48	3.24

Comparison of these results is not a straight forward task.

Resonance Calculations of the Vocal Tract II

- Defining acoustical length of a resonator is a work in progress.

Figure 2: A simple reference resonator

If you can't do this, you can't do anything.

System Measurements

- Design can not be done while blind.
- Geometric scales, damping and reflection effects, as well as the patient's acoustic qualities have to be taken in to consideration.
- We need physical measurements in addition to theoretical thinking.

Figure 3: The setup for acoustic field measurements

Fant I

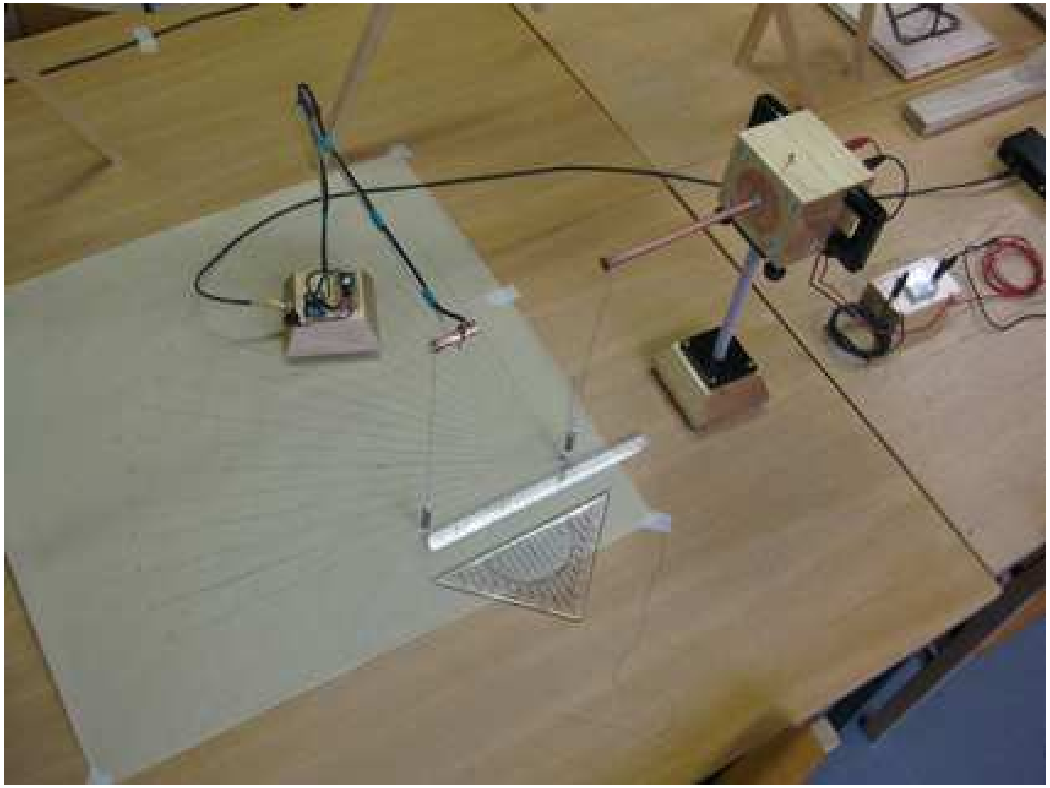


Figure 4: Fant and reference microphone

Fant is a point wise sound source. Its operation area is a hemisphere with a radius of 30cm.

Fant II

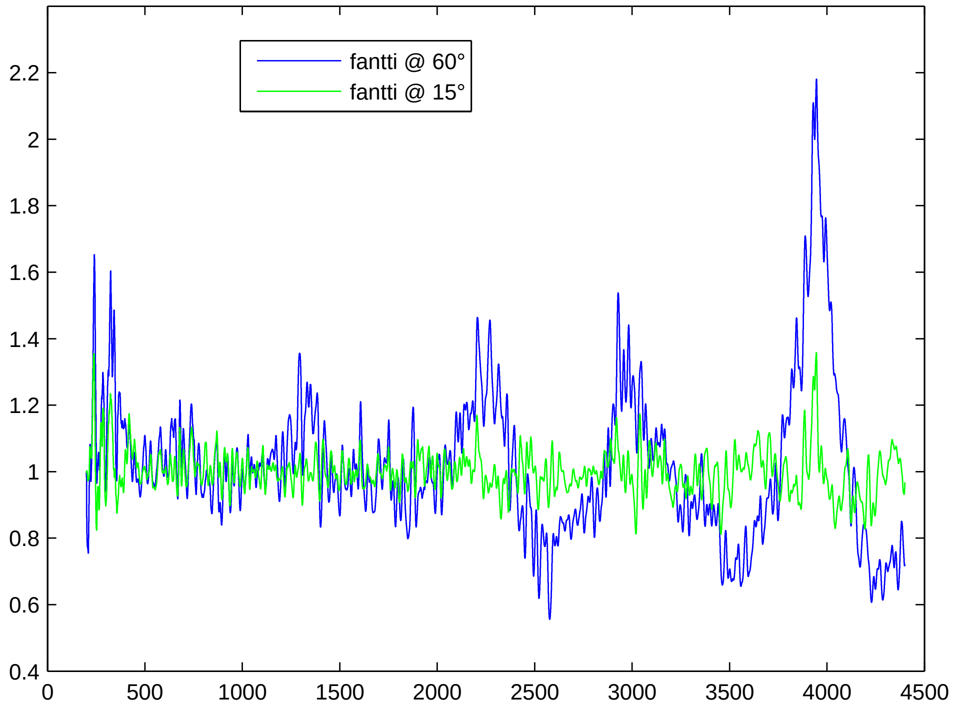


Figure 5: Fant's frequency response at 15 and 60 degrees (normalised with respect to 0 degrees)

Fant III

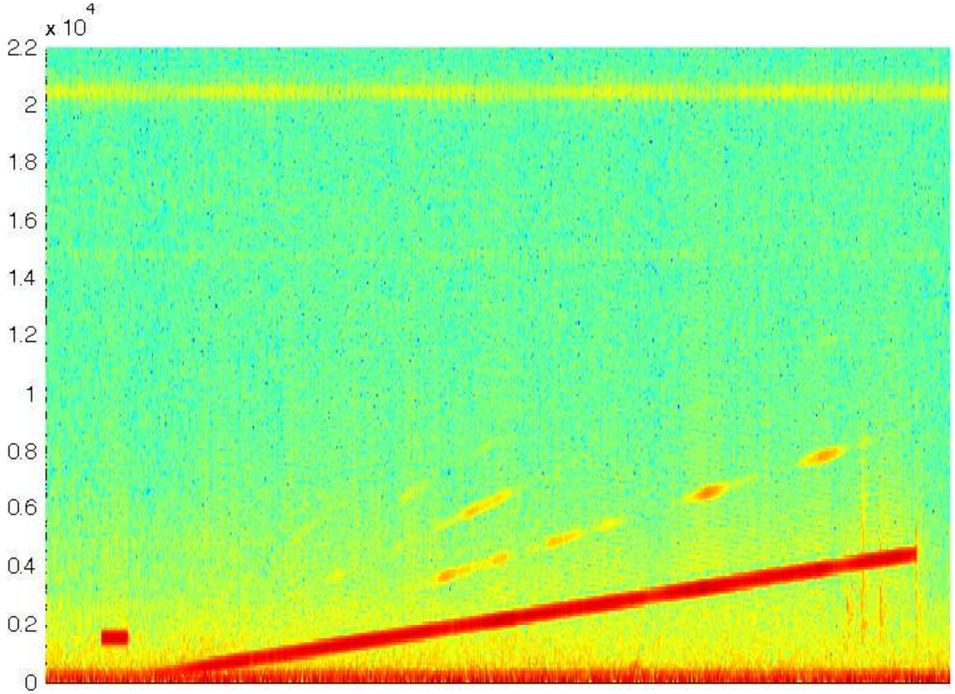


Figure 6: Spectrogram of the sweep at 90 degrees

Luciano

(a) (b)

Figure 7: (a) Luciano models the acoustic impedance of a human face. (b) Sample paraboloid reflectors for the noise channel.

Luciano's Snake in the Garden

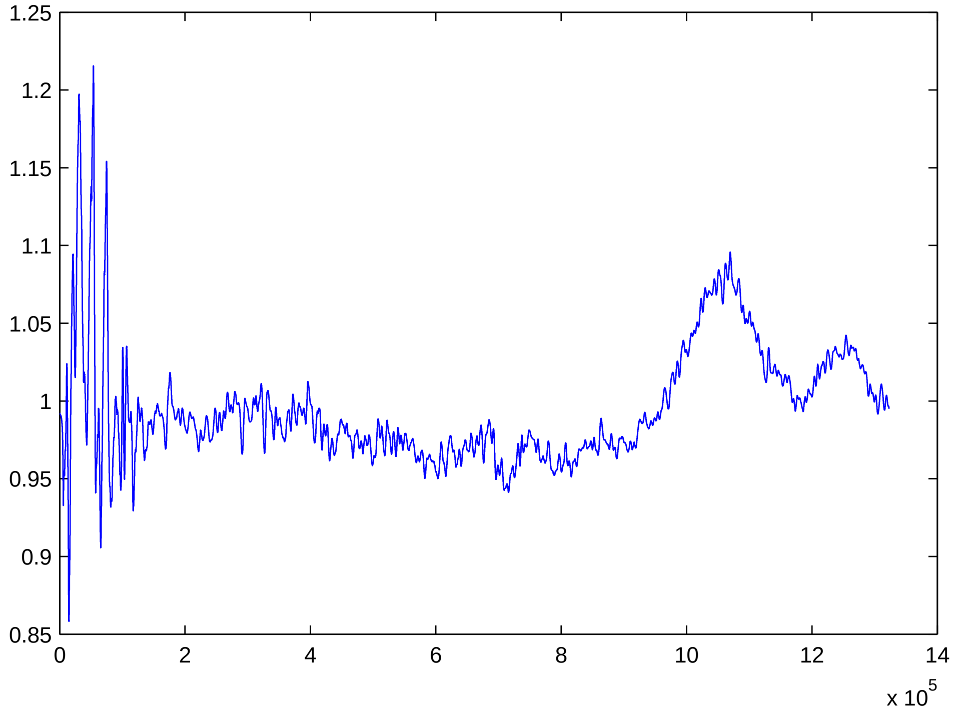
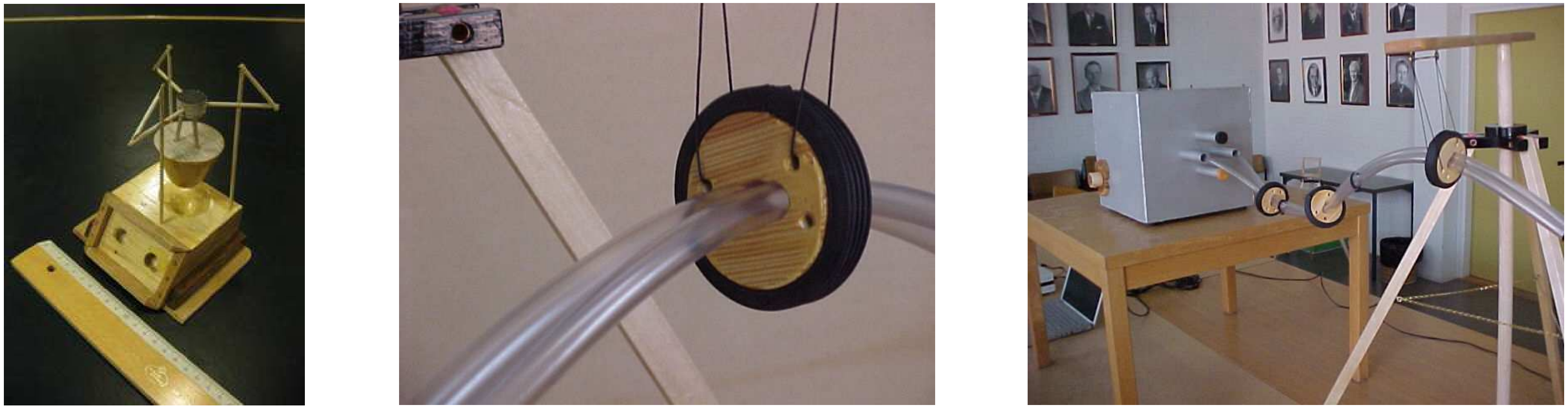


Figure 8: The microphone's effect on Luciano's response

The Actual Equipment



(a) (b) (c)

Figure 9: (a) Sound collector with a paraboloid adapter (b) Acoustic waveguides (c) The Faraday cage a.k.a. Mike

System Response

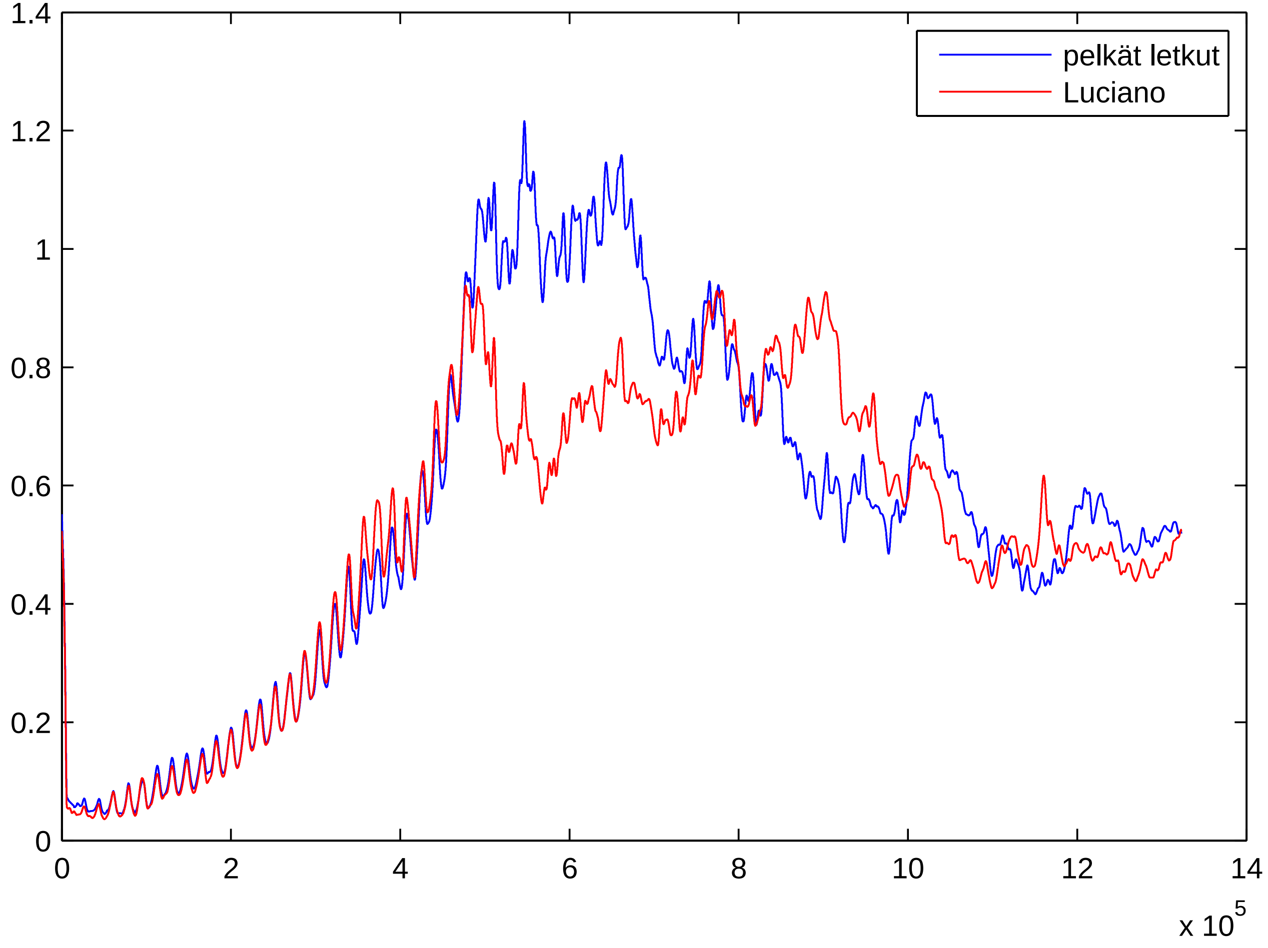


Figure 10: System response with (red) and without (blue) Luciano

Kirahvikin uskoo konvoluutioon!