Project proposal: Simulating hearing loss

Peter van Hengel, 25 June 2014

# Introduction

Hearing loss is the second largest health problem in the developed world, costing society approximately 9% of the GBP, mostly in secondary costs (loss of productivity). Since we use our hearing – almost without being consciously aware of it – to stay in touch with the world around us, hearing loss often leads to significant social and psychological problems. These problems are aggravated by a lack of awareness in the general public of the impact of a hearing loss, amplified by the fact that the problem is invisible. Also, it is commonly believed that any hearing loss can easily be remedied by the use of a hearing aid. Unfortunately this is not the case.

# Problem description

In order to create more awareness for the problems encountered by hearing impaired, even with the use of hearing aids, several attempts have been made over the years to simulate hearing loss and give normal hearing listeners an impression of the sound experience resulting from different kinds of hearing loss.

Although it is quite easy to simulate the loss of sensitivity (elevated thresholds for certain frequencies) resulting from hearing loss, this does not give a fair impression of the problems. In most cases of inner ear or neural damage, the loss of sensitivity is accompanied by a loss of selectivity (‘smearing’ of the frequency content), a loss of temporal resolution, loss of spatial perception, higher susceptibility to noise etc. These effects can cause severe problems with speech intelligibility even with properly adjusted hearing aids. Simulating these effects, especially in real time, has not been possible until now.

# Starting point

A model of the human inner ear, developed at the RuG, has been extended with a realistic middle ear model recently (Heslinga, 2013). This allows various types of hearing loss to be simulated realistically. This model has been implemented on dedicated hardware resulting in the first real-time implementation of a realistic model of human hearing[[1]](#footnote-1). In combination with a recent publication on the simulation of the effects of neural degradation om hearing (Lopez-Poveda and Barrios, 2013), all the building blocks exist to simulate peripheral hearing damage.

# Challenge

The model parts described result in an ‘internal’ representation of sound that can be used to simulate the perception of sound, and is currently used e.g. in acoustic event detection. In order to give a normal hearing person an impression of what this ‘sounds like’ the internal representation has to be converted back into sound. Since several of the processing steps are nonlinear, and human hearing is extremely sensitive to artefacts introduced in a sound signal, this conversion is not trivial.

If a method is found that gives a realistic impression of the ‘sound sensation’ of a hearing impaired person, the question is whether this can be made to operate in real time without a significant delay.

Finally, if time permits, simulation of tinnitus (ringing of the ears) and hyperacusis (abnormal sensitivity to loud sounds) would be nice add-ons.

# Literature

Heslinga, O.: *Cochlear mechanics: Extension of the circuit model to the middle ear*, master thesis in applied mathematics RuG, December 2013

Lopez-Poveda, E.A. and Barrios, P.: *Perception of stochastically undersampled sound waveforms: a model of auditory deafferentation*, Frontiers in Neuroscience (7) July 2013, article 124, doi: 10.3389/fnins.2013.00124

1. see <http://www.incas3-solutions.com/products/esi-121-24/> for specifications [↑](#footnote-ref-1)