Tuesday, November 30th, 2:30 pm

Speaker: Samiya Alkhairy

Institution: MIT

Title: Modeling the Mammalian Cochlea

Abstract:

The mammalian cochlea in the inner ear is a fascinating system that acts as a spectral analyzer and has its own power source. Such processing features motivate auditory physicists to develop an understanding of how the cochlea works through modeling the mammalian cochlea. Modeling the cochlea is also useful in designing auditory filters for machine hearing (e.g. hearing aids and cochlear implants), and applied math and signal processing applications.

To these scientific and filter design ends, we develop an analytic model of the mammalian cochlea. We use a mixed physical-phenomenological approach by utilizing existing work on the physics of classical box-representations of the cochlea, and the behavior of recent data-derived wavenumber estimates. Spatial variation is incorporated through a single independent variable that combines space and frequency. We derive closed-form expressions for response variables (velocity of the Organ of Corti and differential pressure across it) which can also be used as filter variables. We also derive closed-form expressions for mechanism variables (impedance of the Organ of Corti and wavenumber) that encode how the cochlea works. The expressions for all variables are in terms of a single set of two to five model constants and capture the variations along the length of the cochlea and as a function of frequency.

We test the model by comparison with invasive animal data and demonstrate the model's ability to process complex sounds and its ability to capture the variable of tuning. Using the model expressions, we demonstrate that the corresponding auditory filters are tunable and we may directly derive model constant values (and hence any model variable) from values of specified response characteristics such as bandwidth and group delay. We also used the model to estimate response and mechanism variables for the human cochlea, which has not been previously done due to the invasive nature of experiments.