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Acoustic MEMS Sensor System to emulate properties of the human hearing

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Introduction

The human hearing is one of the most astonishing senses, allowing us to receive and recognize sounds in various conditions, including noisy environments and multiple sound sources. A system which emulates the frequency decomposition in the basilar membrane, transduction of the sound wave and nonlinear amplification as well as the encoding in the hair cells provides an environment to study improvements for nowadays technological systems. The results can be used to improve systems like hearing aids and natural language processing systems, such as Alexa, Cortana, and Siri.

Methods

The acoustic sensor is a MEMS beam consisting of a piezo-resistive readout bridge to detect the bending and an aluminium heater for actuation. An additional circuit takes the signal from the piezo-resistive readout bridge and tunes the actuation signal depending on sound intensity and sound intensity changes. The completely in hardware realised setup allows further optimization for power consumption and scaling.

Results

The build setup with sensor and circuit implements adaption to constant sounds and therefore enhances sound changes like sound on- and offsets and encodes features like sound frequency and intensity. The sound can be encoded with an envelope signal and/or in spikes. Furthermore, the spike generation is based on a signal integration and therefore sound intensity dependent spike encoding, like time to first spike, rate coding, and rate coding with offset, is achieved. The different coding regimes and the ability to change the minimal input signal for spiking as well as the time constants in the circuit, leads to an encoding of various sound ranges for different acoustic sensors.

Conclusion

The implemented system with a tuneable acoustic MEMS sensor and a control circuit can be used to emulate properties of the human hearing like adaptation, feature extraction and encoding of sound. Different encoding techniques and adjustable circuit parameters allow a broad range of applications. Furthermore, sensing and encoding dependent on the environment can enhance important sounds, which can yield a better sound perception and analysis especially in hard-to-hear situations, and reduces data streaming and power consumption.