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DEMO: Multimodal Sensing System for Hearing Enhancement and Research

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Introduction

Directivity in hearing aid systems is normally achieved with the use of multiple microphones in an array fashion that aims to enhance signal processing capabilities and performance. Despite the use of binaural information (hearing with two ears), natural hearing systems (e.g. human) also rely on movements of the head to retrieve directional information and the origin of sounds [1]. This kind of natural sensing technique, which combines sound with the movements and position of the body (**Fig. 1 & 2**) has previously been investigated, and showed encouraging results with improved localization performance [2]. However, the concept has not been explored or exploited yet in any standard commercial hearing aid devices. Creating a hearing aid system that can also include motion sensing would be of great benefit to the hearing impaired in order to enhance directional perception of sound with other functionalities such as frequency selectivity (**Fig. 3 & 4**) on a wearable hearing device.

Sound Intensity Mapping

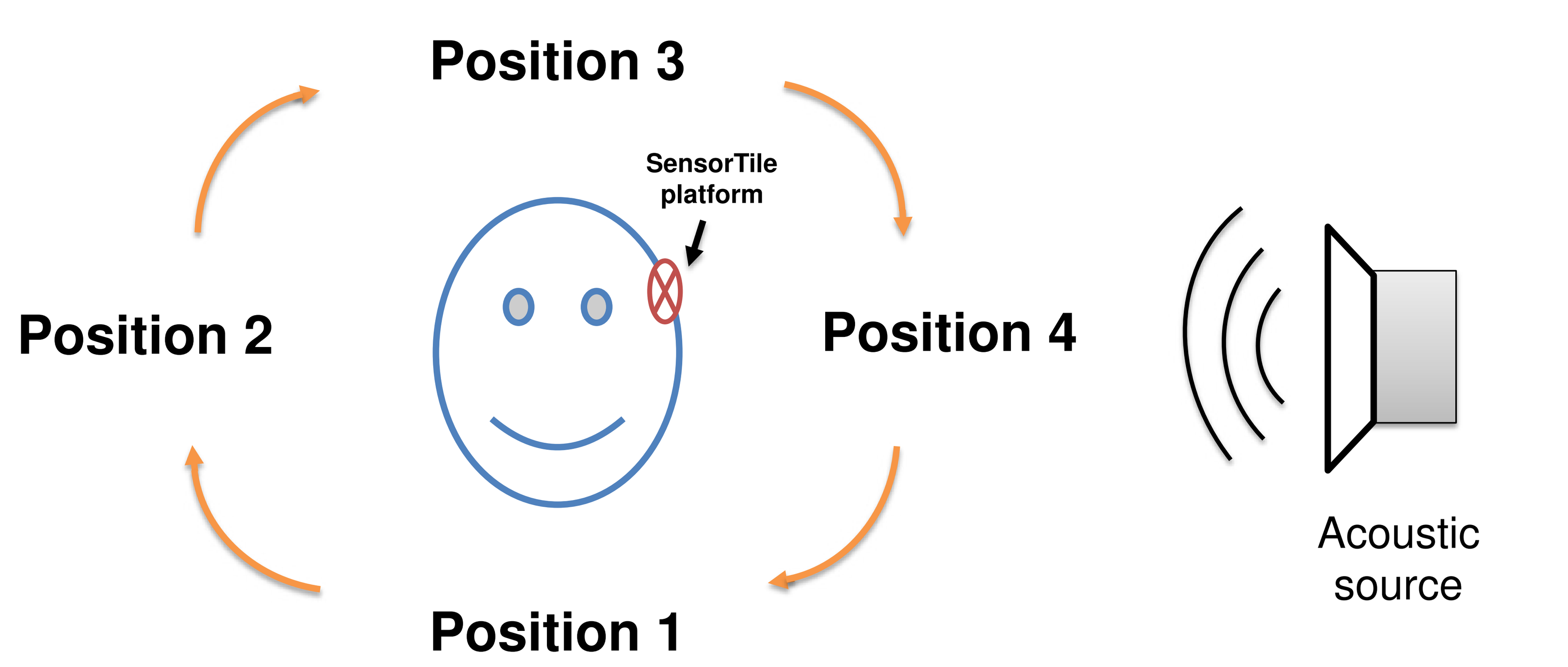

Fig. 1 – Experimental setup used to evaluate the sound intensity level while rotating at different positions.

Experimental Results

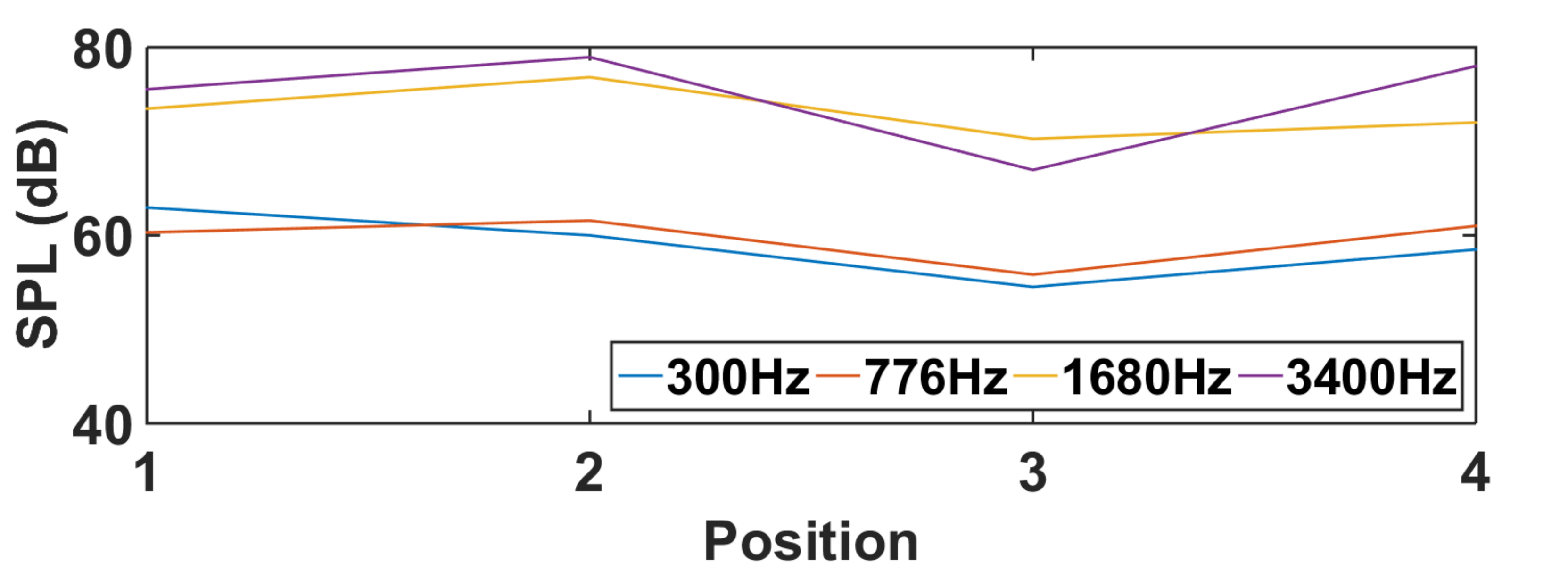

Fig. 2 – Experimental results obtained from the setup at different positions and applying different frequencies, showing that the subject's head has an effect of shadowing (when facing position 3), which results in sound intensity attenuation when the device is located at the opposite side of the acoustic source.

Auditory Signal Processing

(Frequency selectivity)

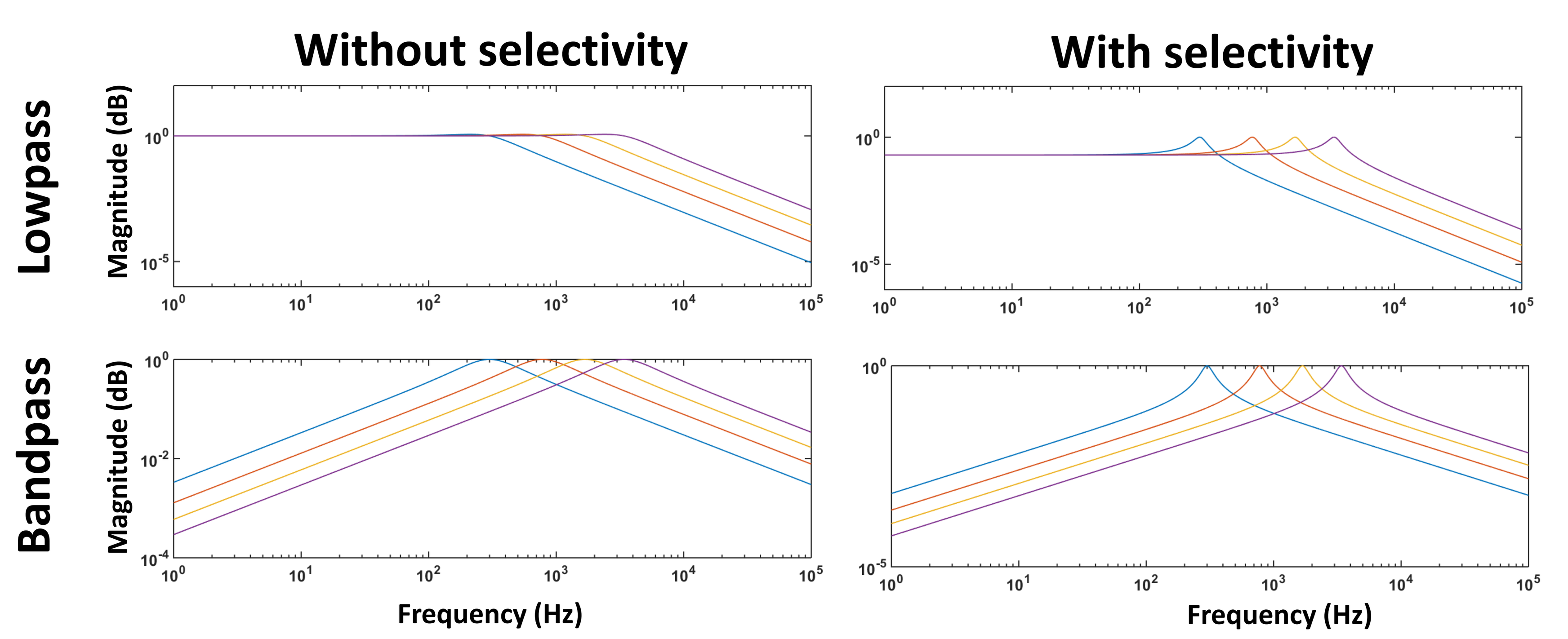

Fig. 3 – Auditory filter banks frequency response at 300, 776, 1680 and 3400Hz - (left) without tuning; (right) with tuning.

Analog filters | **Digital implementation**

Lowpass

$$H(s) = \frac{{\omega_0}^2}{K.s^2 + s\frac{\omega_0}{Q} + K.{\omega_0}^2}$$

Bandpass

$$H(s) = \frac{s\frac{\omega_0}{Q}}{K.s^2 + s\frac{\omega_0}{Q} + K.{\omega_0}^2}$$

Fig. 4 – SensorTile platform featuring multimodal sensing and processing capabilities as well as communication (e.g. MEMS microphone, magnetometer, accelerometer, gyroscope; BLE and USB) – www.st.com/sensortile.com.

Conclusions

A study with preliminary results has been conducted using the SensorTile development kit for sound directivity discrimination. Sound intensity levels with magnetometer data are acquired and sent through Bluetooth Low Energy to a mobile App. Moreover, the SensorTile platform is able to perform digital signal processing in a real-time environment. The embedded system is then tested and controlled via USB communication which allows online adaptations of the processing workflow and usability is ensured through a LabView application running on a laptop.

References:

[1] - Kato, M., Uematsu, H., Kashino, M., and Hirahara, T., "The effect of head motion on the accuracy of sound localization. Acoust. Sci. Technol.", 24: 315-317, 2003.

[2] - Boyd, A. W., Whitmer, W. M., Brimijoin, W. O., Akeroyd, M. A., "Improved estimation of direction of arrival of sound sources for hearing aids using gyroscopic information". Proceedings of Meeting on Acoustics ICA2013, 19(1):030046, 2013.

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