3D printed acoustic sensor inspired by hair-like structure of insects

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Over ages insects evolved to be smaller and more efficient with several miniature sensing mechanisms reacting to the environment around them. Over the last decades, in-depth biological studies on insects have allowed a better understanding of these sensing mechanisms. The hair-like structures, called *trichobothria* or *trichoid sensilla*, are fascinating mechanisms that allow insects to react to airflow and low-frequency, near field, sound [1, 2]. Nevertheless, it is thought that from this sensing structure, other sensing mechanisms are derived by a change on the hair structure. This includes sensing of odours, acceleration, touch, temperature, as well as gyroscope-like mechanism [2].

This project proposes the use of advanced 3D printing techniques to create a sensor inspired by the trichoid sensilla of insects. Inspiration comes, in particular, from the structure of the caterpillar *Barathra Brassicae* [3], and the cerci of the crickets previously studied in the EU CILIA project [4]. The focus is on developing a mechanical structure that responds to sound; while having in mind future iterations that can sense other phenomena (odour, temperature, etc.).

3D printing allows for faster and less wasteful prototyping compared to other sensor production techniques. Moreover, 3D printed sensors do not contain rare earth minerals as they are made of polymer composites. Additionally, the use of high-resolution 3D printing provides opportunities to integrate arrays of the same sensor, as well as different sensory capabilities, within a single structure. Arrays of sensors that react at different sound frequencies allow frequency content measurement of a sound without the need for computationally expensive digital processing techniques, i.e., it would be more power efficient. Lastly, small sized, efficient sensors such as the one proposed in this project would be perfect for systems devoted to environment monitoring and other sustainable solutions.

Currently, series of sensors with different hair sizes were tested, the hair lengths were 1, 2, 3 and 4 mm long, and their diameters were 0.45 and 0.90 mm. Ideally, a good sensor for acoustic purposes should move at only, or mainly, a single sound frequency and move like a cantilever. This motion allows for better conversion of the mechanical movement to electric signal. The 4 mm long hair, in both diameter versions, showed the best response in the conducted experiments. This is because the hair had a single narrow frequency response and because its movement was cantilever-like. The 2 and 3 mm long versions also had a response to a single narrow frequency, but not with movements resembling a cantilever. Lastly, the 1 mm long hair didn't show any clear response, maybe due to the size being too short. Future work includes more advanced experiments on the hair sensors described above and a conversion of their mechanical movement into an electric signal. Furthermore, additional hair structures and hair shapes need to be tested, as this diversity already happens in nature across several insects and can be of great inspiration.

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