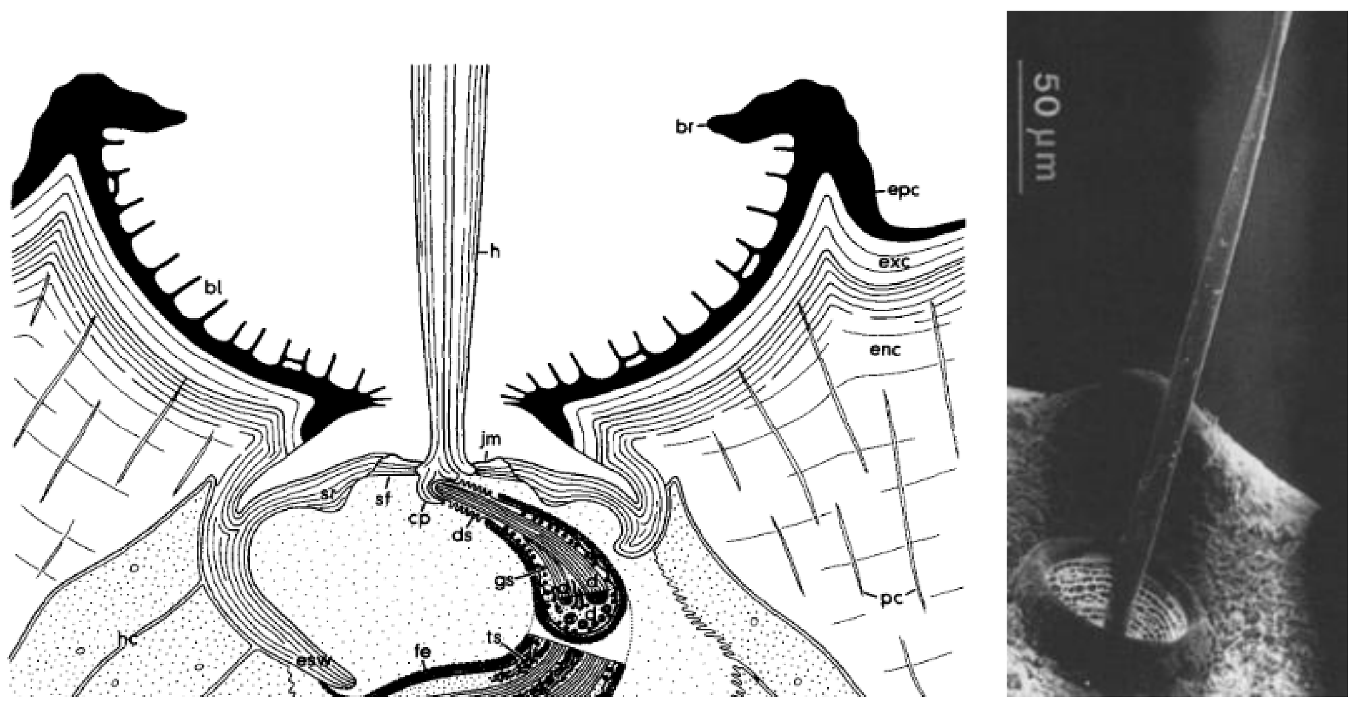
University of Strathclyde Glasgow — CUE — [dstl] — CENSIS TECH SUMMIT 2024

# DEVELOPMENT OF ACOUSTIC & AIRFLOW SENSORS INSPIRED BY THE HAIR SENSILLA OF INSECTS AND ARACHNIDS

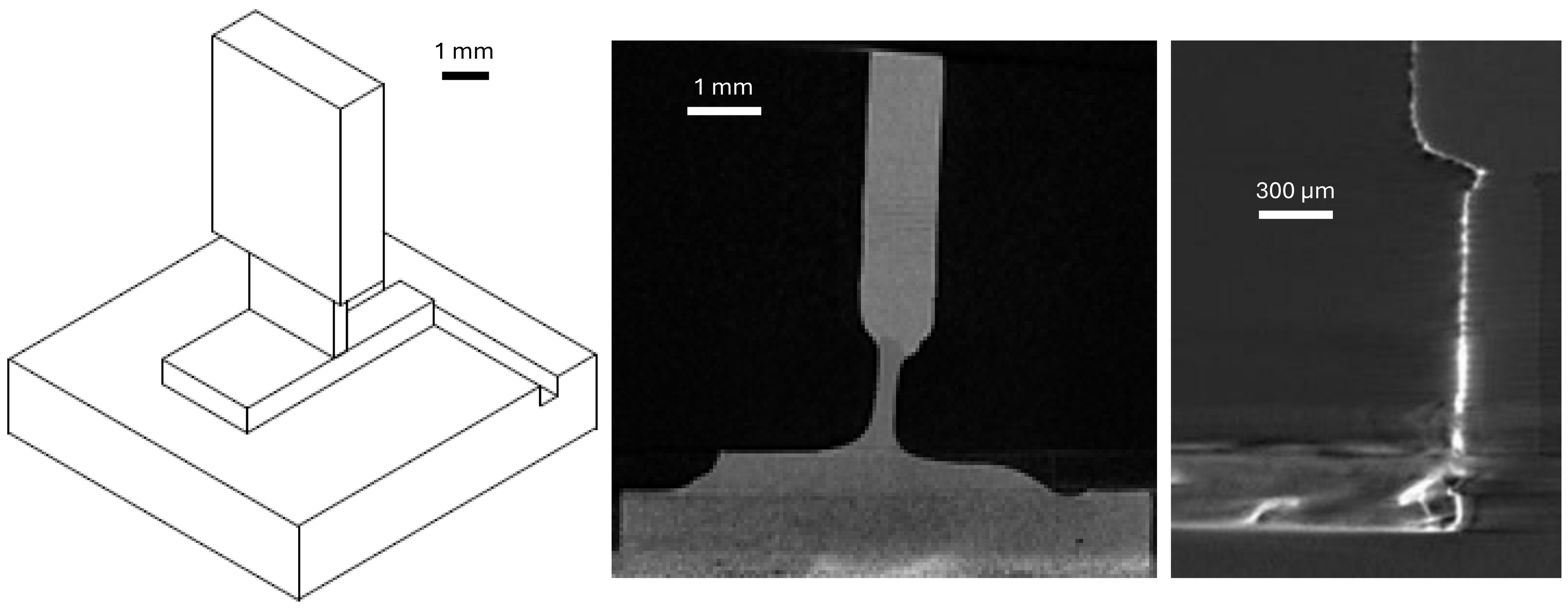
*Samuele Martinelli, Andrew Reid, James Windmill*

Nature has always inspired humans in creating innovative tools. Arachnids and insects show exceptional and functional sensory receptors at a small scale. Air flow mechanoreceptors, commonly called ***trichobothria***, are used in different shapes and sizes by several arachnid species [1]. Some trichobothria appear to be sensitive to low-frequency near-field acoustic signals [2]. Moreover, it is speculated that from this structure other sensing mechanisms (e.g., acceleration, temperature, etc.) are derived [3-5].

The goal of this work is to develop flat hair-like sensors inspired by the adult *Buthus occitanus* scorpion, that can react to either airflow or acoustic narrow frequency bands. A sensor that responds to airflow has been developed and realized using multi-material **additive manufacturing** (AM), also known as 3D-printing. Furthermore, using the same production technique, it is possible to create sensor structures that react to sound [6].

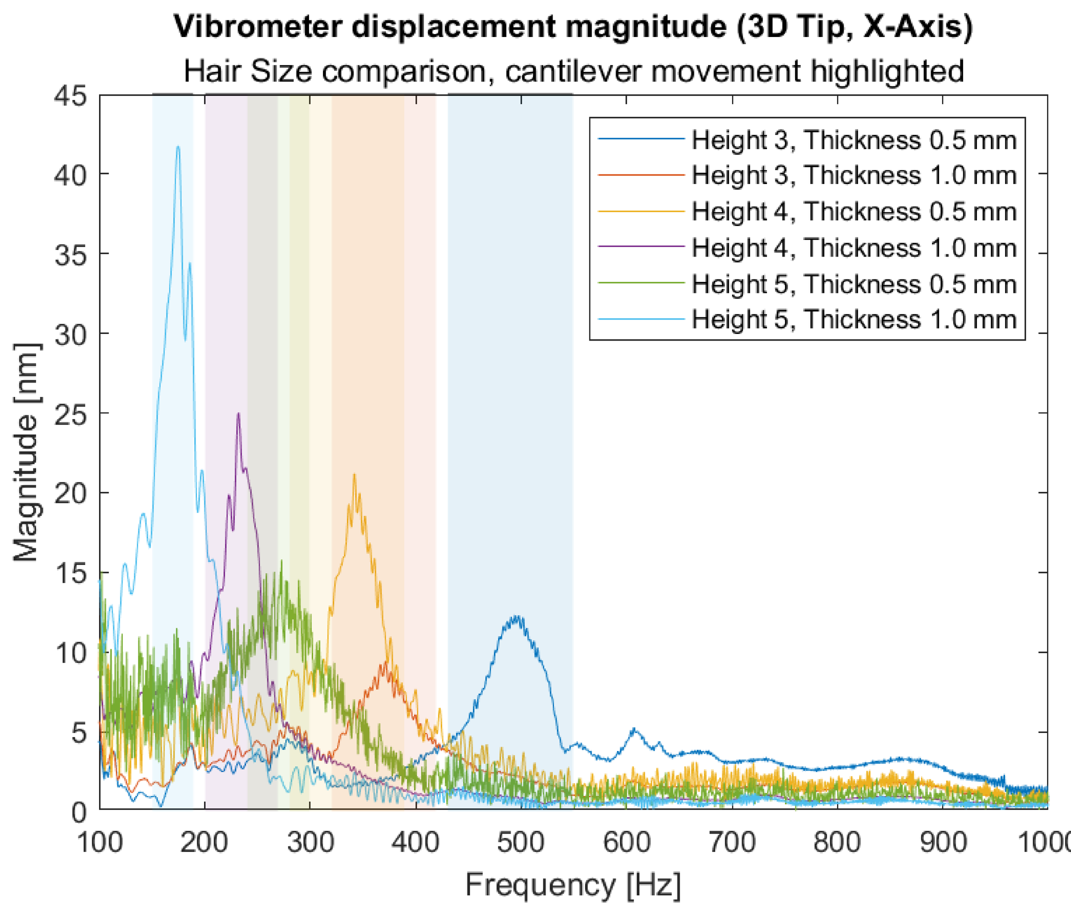



*Structure of adult Buthus occitanus's trichobothria*

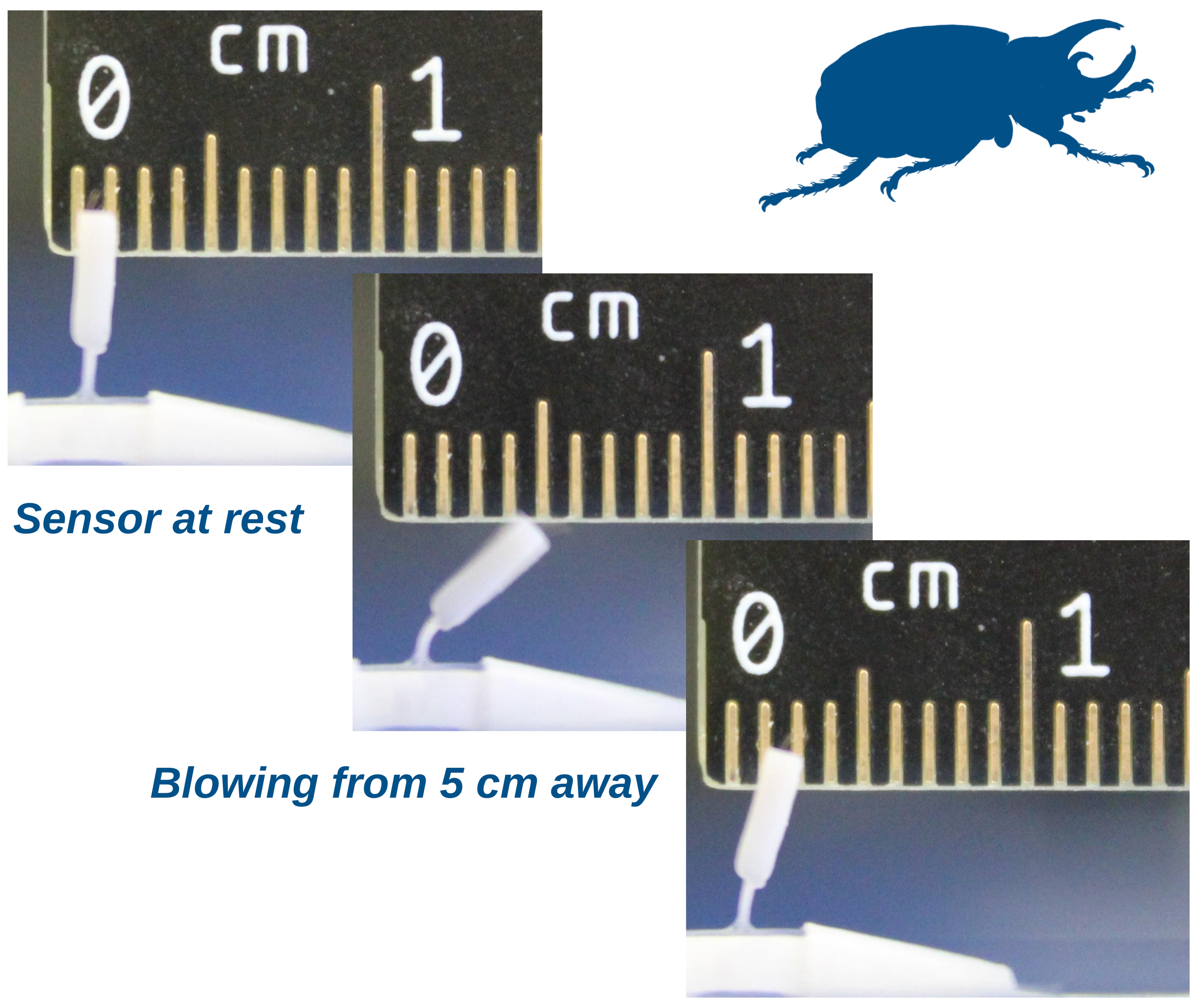



*Structure of 3D printed bio-inspired sensor*

## RESULTS



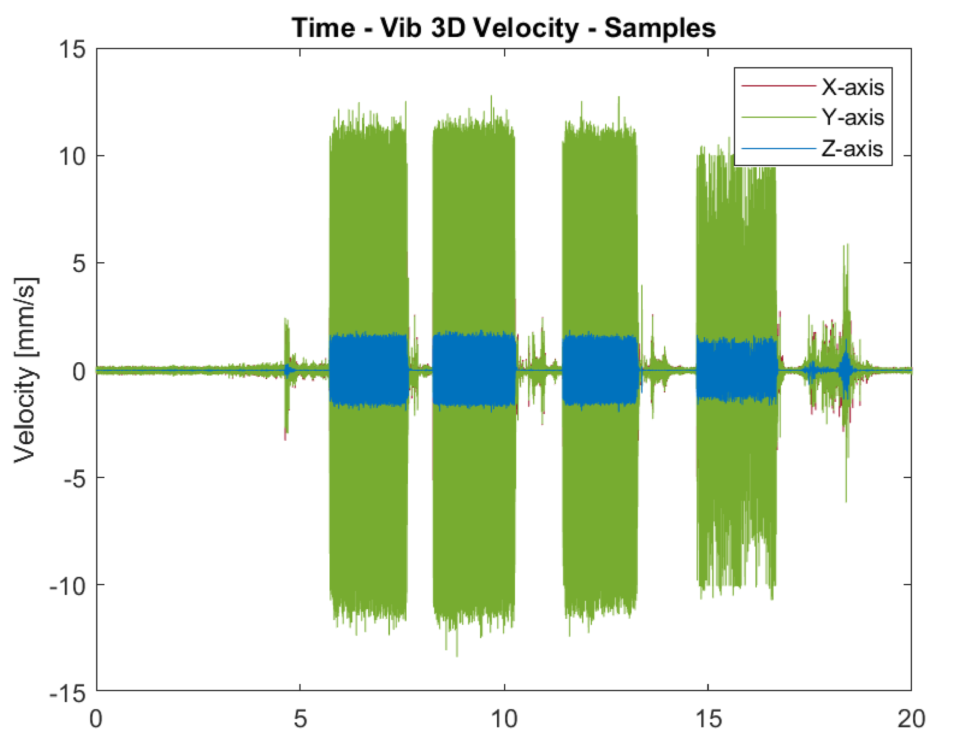

*Displacement of the hair induced by a speaker reproducing a periodic chirp (20-2000 Hz) from a 13 cm distance. Measurements taken with a 3D Laser Doppler Vibrometer (LDV).*

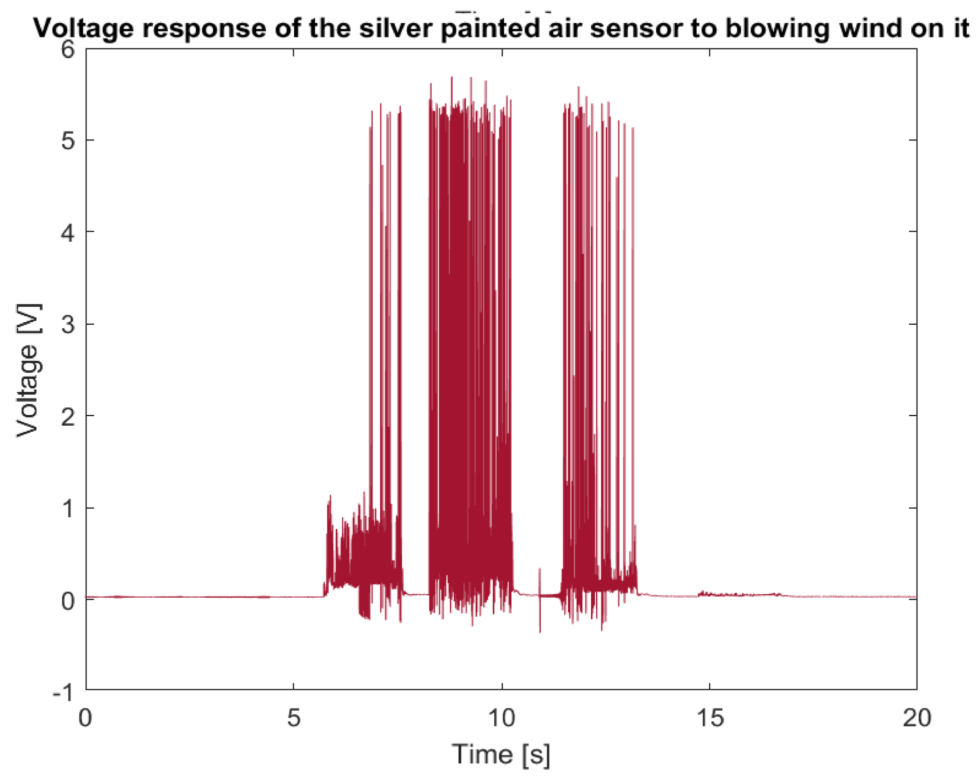



*Sensor at rest*

*Blowing from 5 cm away*

*Blowing from 30 cm away*




*Top, displacement of the hair due to blowing in the Y-axis, bottom voltage response of a metal coated sensor*

## WHY?

The 3D-printed sensors have the potential to offer low data overhead, low power consumption and decreased computational power. Ad-hoc printed arrays can also be manufactured.

The ***acoustic sensors*** can acquire audio with separate frequency bands, or for a limited set of frequencies, without the further processing normally required for this. This could prove useful in speech recognition or natural conservation.

The ***flow sensors*** can allow sensing over a wide area instead of a single point by manufacturing a large array. This is useful in drones, or pipes. Arrays can also provide a wider range of sensitivities.

Potential to sense other phenomena with similar structures, similarly to other similar arachnids or insects sensilla.

## CONCLUSIONS

The sensors show different narrow frequency bands responses based on differences in shape and size of the artificial hair. While the structure aimed at sensing airflow shows visible movement when simply blowing on it. The 3D printed structures were successfully coated with metal and the conversion of their mechanical movements into an electric signal was achieved. Further work is being conducted to improve their electric response.

**REFERENCES**

[1] D. D. Yager (1999), doi: 10.1002/(sici)1097-0029(19991215)47:6<380::Aid-jemt3>3.0.Co;2-p.
[2] T. A. Keil (1997), doi: 10.1002/(SICI)1097-0029(19971215)39:6<506::AID-JEMT5>3.0.CO;2-B.
[3] T. Vondran (1995), doi: 10.1016/S0040-8166(05)80020-5
[4] S. R. Hill (2009), doi: 10.1093/chemse/bjn080.
[5] T. A. Keil (1984), doi: 10.1007/978-1-4613-2715-8_13
[6] S. Martinelli (2023), doi: 10.1109/SENSORS56945.2023.10324858