

Customized Intelligent  
Life-inspired Arrays

# Hairy Investigations

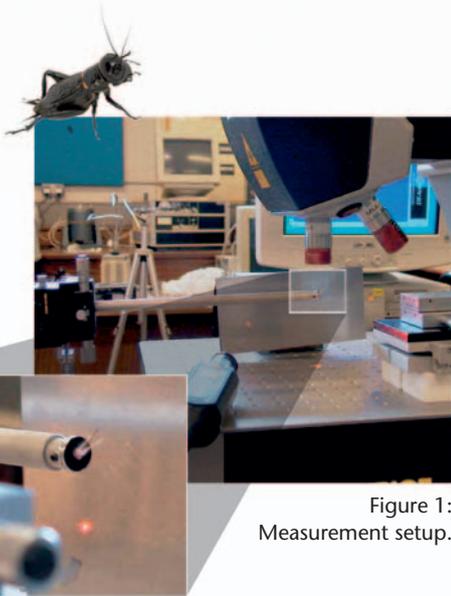


Figure 1:  
Measurement setup.

Crickets possess a hair array that can detect minute changes in air flow measuring particle velocity. It is one of the most sensitive sensory systems known to man. By understanding how this highly sensitive bio-sensor works, we open the door to engineering new sensors that substitute microelectro-mechanical systems (MEMS) technology for insect biology. The motivation for this research is the development of small, highly sensitive “sensory systems” that can extract information from operating environments via neural-type representations.

## Introduction

Researchers at the University of Reading are using a Micro System Analyzer (MSA) to investigate the mechanical response

of the hairs on a cricket’s cerci. The hair-socket arrangement functions as an auditory system, able to sense and respond to external vibrations up to 10 kHz. The mechanical receptors are sensitive to the direction, frequency, and velocity of air currents.

## Measurements

To make the measurements, the rear of the cricket’s body is mounted on a X-Y-Z adjustable probe which is positioned in the MSA’s field-of-view (Figure 1).

The hairs are excited with a “white noise” chirp produced by a vibrating membrane. The resulting vibration is measured with the MSA’s scanning laser vibrometer. The vibrometer determines the hair’s velocity and displacement along the direction of the probe laser beam, the “out-of-plane” direction when referenced to the MSA’s focal plane (Figure 2).

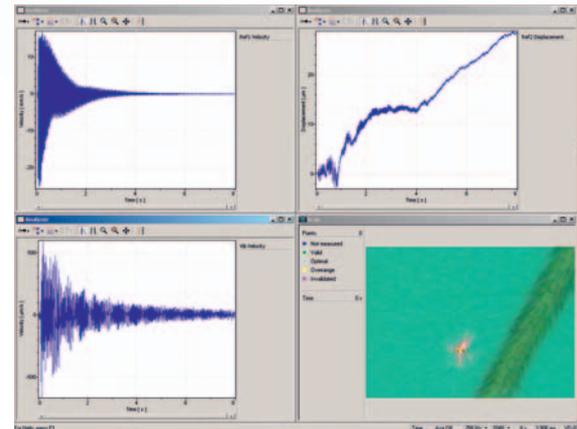
In the analysis of data, particular attention is given to the range of frequencies of biological significance (0 – 400 Hz), but also at 3 - 10 kHz, where previous investigations have indicated the presence of a rotation frequency mode for the hairs. The vibration peaks stimulated by the vibrating membrane source are clearly detected by the hairs.

## Conclusions

The mechanics and morphology of hair-based sensor arrays are being studied

in order to identify the common principles underlying the use of such systems in nature and to make these principles available for the design of engineered systems. The project is in its early stages but already shows some very promising results. Mechanically, the deflection patterns observed in the hairs are largely mixed bending and rotation, particularly at low frequencies. It is expected that future measurements will continue to focus on characterizing hair displacement, directionality and damping properties with regard to sensor performance.

Figure 2: Typical frequency response from one of several hairs measured with the scanning vibrometer.



Prof. George Jeronimidis, Dr. Emma Johnson  
Centre for Biomimetics, University of Reading,  
Berkshire, RG6 6AH, United Kingdom  
e.a.c.johnson@rdg.ac.uk