Technical, non-visual characterisation of substrate contacts modelled on the biological example of carpal vibrissae

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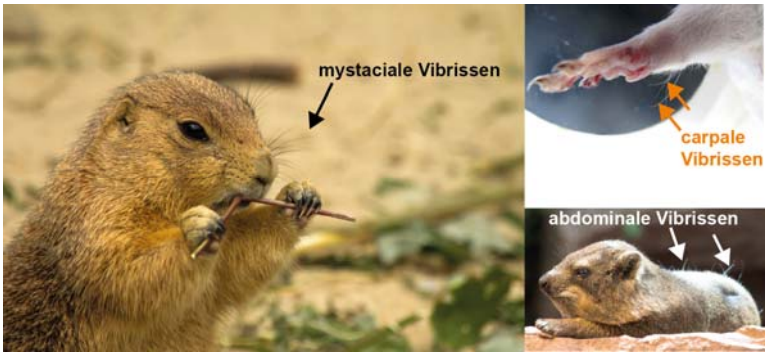
Project Description:

Living beings have adapted to their natural habitat and surrounding by evolutionarily developing specified sensing organs and systems. Thus, a great diversity of mechanical structures for biological sensors has emerged, which can be used as a source for inspiration for technical applications.



The detailed understanding of capillary tactile hairs is based on the combination of experimental research in the field of technical biology, and theoretical investigations of mathematic-mechanical models and simulation calculations. Hence, this continuation project aims to implement the previously established knowledge obtained from the fields of technical biology and mechanics into a technical, non-visual based characterisation of substrate contacts.

In the case of the technical-biological model analysis, the work focuses on the adaptor system consisting of the infector and the transmission. Just as the effector decouples the actoric energy from the system, the infector couples the sensory information in an energy- or mass-borne manner. The carpal vibrissae is understood by the project group as such a system, whose model-based description in the context of stimulus reception and transmission shall lead to technically usable tactile sensor elements.

Three main areas of technical biology, mechanics and biomechatronics are the focus of the project.

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1. The focus is on the characterization of the group of carpal sinus hairs as a functional unit and the verification of the hypothesis that these sinus hairs in their community represent an ulnar multi-point sensor with which the rotation axes of the forearm and hand can be perceived relative to the substrate surface and adapted accordingly. For this purpose, such insightful methods from the first application phase as detailed functional analysis on the rat model and structural analysis using high-resolution spatial imaging techniques will be combined to give an anatomical-mechanical characterization of the carpal multi-point sensor.

2. Having gained important insights into the geometrical, mechanical and chemical properties and parameters of the sinusoidal hair itself, the role of the follicular-sinusoidal complex in the process of signal recording, amplification and transmission is increasingly becoming the object of research. The constructive optimization and extension of the large-scale model experiment will improve the evaluation of the simulation results for the sampling process of objects. The methodology of largely analytical work on mathematical-mechanical models, which will be extended (vibrisson mounting with adjustable stiffness and damping) and made more precise (conical vibrisson shape, pre-curvature of the vibrisson), remains in focus.

3. Methodically following the model-based, mechatronic design according to VDI 2206, a proof of concept for an intelligent brush element integrated in a prototype system for the detection and cleaning of a test environment is provided. The extent to which sensor and actuator systems can be integrated is to be explored. At the same time, however, the possibilities of transferring selected transmission functions of the biological infector sinus hair to the designs of technical effectors will also be examined, an idea that is still rather visionary.

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