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Functional Surfaces: Towards Sensorized Skin for Robots

FUNCTIONALIZATION OF MATERIAL SURFACES

A sensorized compliant surface with adjustable stiffness has been developed for measurement of normal and shear forces. Obvious applications are in robotics or biomedical engineering. The sensor system consists of the two layers of three-dimensional textiles, with integrated sensors, and actors for adjustment of sensor range. Implementation of the functional components in the system with mechanical distinct layers is inspired by biological inspiration concerning the components of human skin.

In a first approach, morphofunctional criteria of skin as the combination of underlying structure and boundary structure between layers, fibre orientation and sensor location can be implemented with textile materials. The basic preset stiffness can be realized by different layers via material technology, whereas the whole system stays flexible.

For a first structural model a three-dimensional textile with a thickness of 10 … 15 mm has been taken for the support, and graphite-doped silicon fibres have been chosen as sensor elements. These fibres change electrical resistance due to mechanical strain relative linearily (Fig. 1). If the substrate is strained by 1%, the change of resistance will be 3%. For the measurement of the intensity and location of the normal force, those fibres can be integrated into the textile surface in X- and Y-direction. Pressure on the surface of the textile induces deformation of the layer and therewith fibres are strained and the change of the electrical resistance can be measured [1].

During perception, stiffness adjustment of the upper layer can be achieved by activation of fluidic actuators. Textile technology allows to integrate silicone-elastomer tubes in form of loops into the layer. By application of an internal pneumatic pressure stiffness of the three-dimensional textile changes considerably. In this case stiffness of the complaint support can be changed and off-set of the signal can be varied. As a result of the decreased deformation of the textile bearing via enhancement of the internal pressure the strain of the fibres is lower. This effect enables an adaptation of the measurement range.

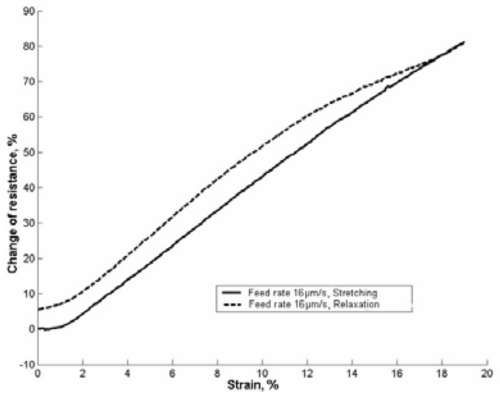

Fig. 1: Quasi-static loading curve, change of resistance in dependance of alteration of length

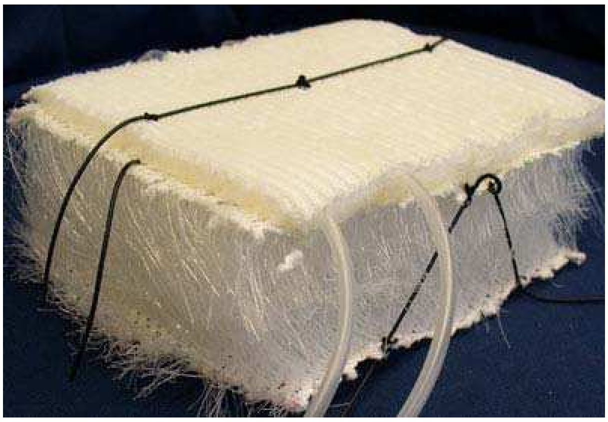

Fig. 2: Possible arrangement of the sensor fibres and the fluidic actuator tubes

Measurement of shear forces can be achieved using a second, thicker layer and sensor fibres, which are integrated on the side of the textile under an angle. Shear forces induce a displacement between both surfaces of the textile.

The combination of sensor and actuator components makes the whole system adaptive to exogenous influences and variable measuring conditions. E.g. a textile construction can be disposed tightly on a body contour or may be intentionally deformed. Compliance and adaptivity of this system allow broad application both in biomedical engineering and in robotics.

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[1] I. Gavrilova, M. Feustel, W. Scheibner, C. Schilling, H. Witte: Sensorised complaint structures with adjustable stiffness. BioMED2008, Innsbruck, ISBN 978-0-88986-721-5

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