PUBLISHABLE EXECUTIVE SUMMARY

Background

Biological tactile sensing is a key area of sensory processing in which the brain uses frequency and intensity coded neural signals from nanoscale receptors in the skin to determine the nature of environmental surfaces. This information is important for the perception through touch of surface features, for discriminating between surfaces in terms of their microgeometry (i.e. local shape and texture) and for the efficient control of grip, in which contact surface properties, together with forces normal to the surface, determine the tangential frictional forces that limit sliding of the digit.

Project Objectives

The overall goal of Nanobiotact is to design and construct an articulated artificial finger with a biomimetic sensor based on an array of NEMS force transducers that will mimic the resolution, sensitivity and dynamics of spatial touch in the human finger. Meeting this goal requires the development of a scientific understanding of the mechanoreceptors and their neural coding of mechanical events at the skin surface. Biological tactile processing of specifically designed texture stimuli are being assessed using psychophysical and neurophysiological techniques. Psychophysical measures define the relation between experimentally manipulated variation in textures presented to the finger and behavioural responses including explicit (conscious) or implicit (automatic) effects on decision and action. Neurophysiological techniques include recording neural activity in peripheral nerves (microneurography) and the brain (EEG and functional imaging) and documenting behavioural impairments resulting from lesions in the peripheral or central nervous system. A theoretical model of the neuromechanical elements of the tactile process is being developed to enable simulation of the neurophysiological response to a tactile stimulus. The information from the psychophysical, neurophysiological, and computer simulation activities are being processed using various forms of artificial neural networks. These will lead to an improved description of the neural coding of surface texture, and lead to design strategies for NEMS arrays for spatial tactile processing based on advanced optimisation techniques.

Progress

The project is currently at the end of its first year. A Kick-off meeting was held at Birmingham followed by 6- and 12-month meetings at Pisa and Munich, with staff from all partners in attendance. Basic techniques have been agreed and experimental paradigms, together with associated tools for implementing these, are well advanced. Preliminary data on discrimination of random textures (sandpaper) have been collected following agreed protocols from healthy young and elderly adults (UCL, UB-PSY). The data from these studies included participant discrimination responses and recordings of normal and shear forces exerted by the finger during active exploration of sandpaper texture samples mounted on specially constructed state-of-art force platforms (SSSA). Initial neurophysiological studies have included microneurography recordings (GU) and these data, as well as a set of previously recorded tactile responses from hairy skin on the arm, have been conditioned and subject to using newly developed pattern recognition algorithms (TUM). Static (C3M) and dynamic (Rockwell) finite element models of the finger pad subjected to contrasting surface textures under normal and shear forces of the kind comparable to those observed in the behavioural studies have been defined using purpose developed computational methods. These finite element models reveal stress and strain patterns in the finger pad and suggest influences of the structure of finger print skin and effects of moving textured surfaces across the skin on mechanoreceptor sensory function. Various candidate skin-like materials have been tested (URDPS, SSSA) and the potential of biologically-based skin material is being evaluated (UB-CE). Principles for the design of nanoscale sensor arrays have been proposed and fabrication methods are being explored (UB-ME, SSSA). A prototype finger instrumented with a microscale sensor has been produced and initial tests of its texture discrimination capabilities have been conducted (SSSA).

Expected achievements

By the end of the project we expect to have developed an artificial finger capable of assessing complex tactile stimuli involving different textures and surface qualities such as stickiness in a way that is not possible using current approaches. This target is significantly more challenging than relatively more simple tactile indicators such as spatial acuity, geometric form, surface topography and vibration that the artificial finger will also be capable of assessing.

Dissemination

A number of publications are in preparation including papers to be submitted to Eurohaptics in June 2008 (www.eurohaptics.org). The main dissemination activities in the first twelve months have been via the Nanobiotact website and the various project partners and EU websites. There was a press release issued, which resulted in several online publications, selected references are given below:
http://www.theengineer.co.uk/Articles/296892/The+sensitive+touch.htm
http://nanoarchitecture.net/article/nanobiotact-builds-finger
http://www.admiroutes.asso.fr/larevue/2006/77/actualite.htm

The Consortium

There are 8 partners in the consortium, which is coordinated by University of Birmingham:
University of Birmingham, UK (UB-CE, UB-ME, UP-PSY; CE - Chemical Engineering, ME - Mechanical Engineering, PSY - Psychology)
Unilever R&D Port Sunlight, UK (URDPS)
Göteborg University, Sweden (GU)
Universite Catholique de Louvain, Belgium (UCL)
Rockfield Software Ltd, UK (RSL)
Technical University of Munich, Germany (TUM)
Scuola Superiore Sant'Anna, Italy (SSSA)
Centre for Computational Continuum Mechanics, Slovenia (C3M)

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