【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Engineering)

Title of Project : Measurement of animal/cell motion using MEMS multi axis force sensor

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Research Area : Engineering
Keyword : MEMS, NEMS, Bio Mechanics

【Purpose and Background of the Research】

Living systems, from single cell to animals, can move by exerting forces to an environment and receiving reactive-forces from it. These stable locomotion of living systems provide a wealth of hints for locomotion of man-made objects. From this point, the explication of biological locomotion is a significant scientific theme. It becomes critical to measure forces acting between the interfaces of living systems and the environment surrounding them, in order to create dynamic models of biological locomotion. However, it is difficult to measure the force vector without influencing the interfacial dynamics environment. Researchers cannot create accurate dynamic models of biological locomotion.

The purpose of this research is to measure distributions of force vectors occurred at the biological locomotion without disturbing the surrounding dynamics environment of the living systems by using a MEMS (Micro Electro Mechanical Systems) multi-axial force sensor. By exploiting the MEMS sensors' miniature size, we can measure force vector distributions without disturbing an interfacial dynamics environment between the living systems and the environments.

【Research Methods】

To measure force vectors produced by locomotion of living systems, we create MEMS multi-axis force sensors whose size, shape, and sensitivity is appropriate for the target living systems. By using these sensors, we measure the forces acting on the interfaces between the living system and the environment to build an accurate dynamic model to elucidate the mechanisms of a biological locomotion. In this project, we analyze the locomotion of three living systems; cells which is a minimum unit of the living systems, micro-meter size insects, and bipedal humans. These living systems can be said to be representative examples of locomotion who utilize interactive forces between their surface and the environment. Thus, they are appropriate samples for experimental study. By analyzing the mechanisms of locomotion of various scales, from those of cells to human beings, we elucidate living systems' superior locomotive functions and their ability to control locomotion.

【Expected Research Achievements and Scientific Significance】

Our original MEMS multi-axis force sensors, the key of our research, enables to measure wide range forces; the μN-order forces applied to μm-order size single cells, the mN-order forces occur around the mm-order size insects, and the N- to kN-order forces produced by humans.

The comprehensive dynamic models of the biological locomotion can be built-up as results of this project. For example, a real-time analysis of a force distribution at an interface between a cellular membrane and its contact surface when a cell moves, a construction of a dynamic model of an insect flight's rapid transition, and an analysis of a slippage at a human walking.

【Publications Relevant to the Project】

・H. Takahashi, I. Shimoyama et al., "A triaxial tactile sensor without crosstalk using pairs of piezoresistive beams with sidewall doping," Sens. Actuator A-Phys., vol. 199, pp. 43-48, 2013.

・T. Kan, I. Shimoyama et al., "Design of a piezoresistive triaxial force sensor probe using the sidewall doping method," J. Micromech. Microeng., vol. 23, no. 3, pp. 035027, 2013.

・T. Itabashi, I Shimoyama, S. Ishiwata et al., "Mechanical impulses can control metaphase progression in a mammalian cell," PNAS, vol. 109, no. 19, pp. 7320-7325, 2012.

【Term of Project】 FY2013-2016

【Budget Allocation】 368, 900 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.leopard.t.u-tokyo.ac.jp/