

INVESTIGATION ON VELVET HAND ILLUSION USING PSYCHOPHYSICS AND FEM ANALYSIS

M. Ohka¹, Y. Kawabe¹, A. Chami¹, R. Nader¹, H. B. Yussof², and T. Miyaoka³

¹Graduate School of Information Science, Nagoya University,
Furo-cho, Chikusa-ku, 464-8601, Nagoya, Japan, ohka@is.nagoya-u.ac.jp

²Faculty of Mechanical Engineering, Univesiti Teknologi MARA
Shah Alam, Selangor Darul Ehsan, 40450, Malaysia

³Faculty of Comprehensive Informatics, Shizuoka Institute of Science and Technology
2200-2, Toyosawa, Fukuroi, 437-8555, Japan

Abstract-In the velvet hand illusion (VHI), a person rubs his/her hands together on either side of wires strung through a frame, producing the sensation of rubbing a very smooth and soft surface like velvet. We investigate the VHI mechanism to obtain an effective hint for a new tactile display because such tactile illusions play a good role in deceiving the brain so that operators believe that a virtual sensation is real. To elucidate the VHI mechanism, we propose two approaches: one uses psychophysics to obtain human mental models; the other is a finite element method (FEM) to evaluate the tactile stimulus that causes VHI. Based on psychophysical experiments using Thurstone's Paired Comparison, VHI strength depends on the distance between two adjacent wires, and VHI caused by wide spacing of wires is considerably stronger than that caused by narrow spacing. In FEM analysis, a mesh model of fingertips is produced to mimic an actual finger to evaluate the strain energy density (SED) because one mechanoreceptive unit is a slowly adaptive mechanoreceptive type I unit (SAI) that well responds to SED. There is a considerable difference between the SEDs of the one-finger case and the two-finger case (VHI case): the peak SED value for the VHI case is around half of that for the one-finger case. The VHI mechanism is assumed as follows: although the area bounded by two wires moves relative to the hands, tangential force does not occur on the hand surface except for the wire-passing portion, causing operators to experience the illusion of touching a smooth virtual film with a zero coefficient of friction. Since VHI decreases with a decrease of wire spacing and an increase of the peak value of SED, excessive temporal stimulus generated by wire prevents VHI from increasing.

Index terms: Tactile display and sensor, Illusion, Psychophysics, Velvet hand, Paired comparison, Finite element method, Strain energy density