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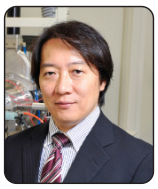
Abstract



Reproducing our Fingertip Sensation by Super High Resolution Tactile Sensing

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Abstract:

We, human has very sophisticated sense of touch on our fingertip skin. We can recognize and distinguish various and delicate difference of touch feelings obtained by sweep motion of fingertip on various kinds of materials and objects. Fingertip skin has the highest density of force and vibration receptors (Meissner's Corpuscles and Merkel Cells) under the surface skin where fine pitch patterns of fingerprint are formed on. Human's fingertip has a very high spatial resolution below 100μm and can recognize existence of 13nm-pitch patterns as reported recently.

In order to reproduce artificial sense of touch like human's fingertip, very high performances on spatial resolution and sensitivity are required to tactile sensors. In this talk, silicon based MEMS tactile sensors with a ultra-high force and spatial resolutions are introduced and demonstrated. All the mechanical structures in the tactile sensor deice are made from "pure" single crystal silicon layer of SOI wafers. No elastomer/polymer structures are used in the sensing structure. The contactor parts of the tactile sensor have curved shape which is very similar to the cross-section of a fingerprint, and its suspension springs are designed similarly to a spring constant of human's fingertip skin surface. In the latest version of our tactile sensors, six contactors with fingerprint-like shape are integrated at a pitch of 500μm to get high spatial resolution tactile images. Each fingerprint-like contactor reproduces vertical motion (by micro roughness) and horizontal motion (by frictional force) of a fingerprint closely under sweeping motion of fingertip in measurement. Spatial resolution of our tactile sensor reaches to sub-micron region, and its force resolution of friction is below 50μN. These performances are enough high to analyze surface touch feelings of "Hair surface condition", "Skin condition", and "Touch feeling of various papers and clothes" like human fingertip. Machine learning based on deep neural network has been applied to the signal from the high resolution tactile sensors. As a result, 10 kinds of "cloth" samples have been discriminated at a correct percentage of 99% successfully. Combination of high resolution tactile sensor and deep neural network is a strong approach to reproduce human fingertip sensation by state-of-the-art device electron device technology.

Biography:

Prof. Hidekuni Takao, received his BS in 1993, MS in 1995 and Ph.D. degree in 1998 all from Toyohashi University of Technology, Japan. After he worked as a research fellow (PD) with JSPS, Japan in 1998, he joined faculty of Toyohashi University of Technology in 1999 as assistant professor, and was promoted to associate professor in 2005. He moved to Kagawa University, Japan in 2009, where he has served as a full professor since 2014. He is also holding the position of director of Nano-Micro Structure Device Integrated Research Center in the same University. His research interests are high performance silicon MEMS sensors and systems and their applications to fine tactile sensing technology. Since 2015, he has been the representative of JST-CREST project on "nano-tactile sensing". He acted as a technical committee member of IEEE MEMS 2012 Paris, 2013 Taipei, 2017 Las Vegass, and 2018 Belfast.

Publication of speakers:

- Fabrication of a two-dimensional pH image sensor using a charge transfer technique, October 2006
- Highly sensitive ion sensors using charge transfer technique, March 2004
- A novel fused sensor for photo-and ion-sensing, May 2005
- A MEMS micro valve with PDMS diaphragm and two-chamber configuration of thermo-pneumatic actuator for integrated blood test system on silicon, April 2005
- Power generation circuit using electromagnetic wave, June 2011
- A sensor for blood cell counter using MEMS technology, March 2002
- Selective vapor-liquid-solid epitaxial growth of micro-Si probe electrode arrays with on-chip MOSFETs on Si (111) substrates, February 2004

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