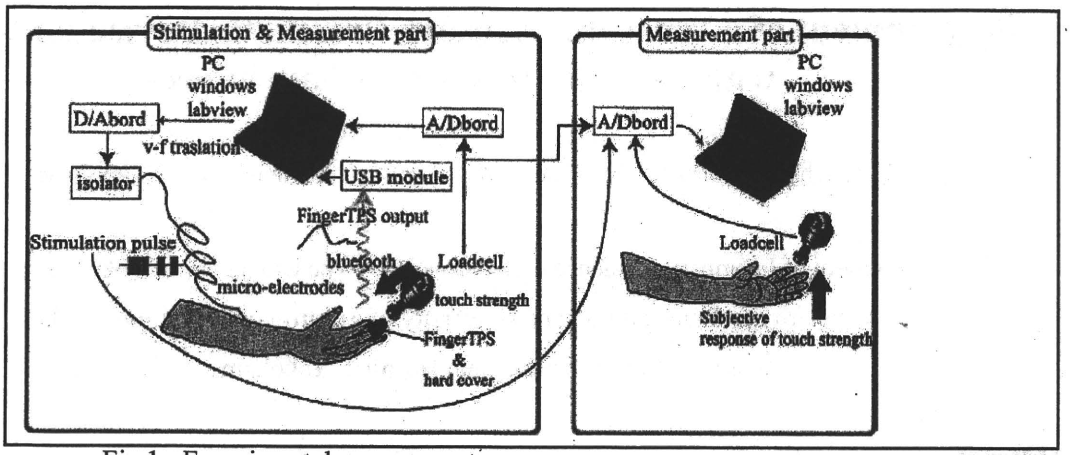


Fig.1 Experimental arrangement

frequency of the stimulus but not by the amplitude of the stimulus [3].

First, we inserted a microneurographic electrode into the median nerve of the subject and fixed the electrode where the nerve signals from a single SA-I mechanoreceptor unit can be measured. We then switched the electrical circuit to stimulation mode and gave electrical stimulation to the nerve fiber using the same microelectrode.

As a single electrical input pulse for the stimulation, we used a biphasic square-wave pulse for 250 micro-seconds. The amplitude of the electrical stimulation (electrical current) was fixed at around 1.2 times the level of the threshold value (the current at which the subject first felt a sensation when the frequency was fixed at 50 Hz). The amplitude was then gradually raised from 0.

*System for Sensing Mechanical Stimuli*

A commercially available pressure sensing system (Finger TPS system) was used in this study. The sensor probe has a flexible fingerstall shape and is equipped with a pressure sensor of the electrostatic volume (Fig.2).

The subject first put a hard plastic fingerstall on the finger and then put the Finger TPS system on the fingerstall.

Fig.2 Sensor probes of the Finger TPS system

With this arrangement, the hard fingerstall protects the skin from mechanical stimuli, so that the mechanical stimuli given to the finger do not affect the mechanoreceptors of the skin and the subject can feel only the pressure sensation evoked by the microstimulation of the SA-I sensory nerve fiber.

When pressure stimuli were given to the subject's finger covered with the sensor probe, the intensity of the pressure detected by the Finger TPS system was transferred to a personal computer, and the value of repetition frequency of the electrical stimulation was determined and output to the microstimulation system.

(The pressure stimuli were given using a bar-shaped force sensor and the pressure applied to the Finger TPS system was measured by the sensor.)

The repetition frequency of the output electrical pulse train was determined in accordance with the strength of the pressure by the following equation.

$$f = 50 \times P$$

where f is repetition frequency of the electrical pulse train used for stimulation (Hz) and P is the pressure measured by the Finger TPS system (N).

*Evaluation of the Intensity of the Evoked Pressure Sensation*

The intensity of the pressure sensation that was evoked by the microstimulation of the SA-I sensory nerve fiber and subjectively perceived by the subject was evaluated as follows.

When the pressure sensation was evoked to the subject by the microstimulation of the SA-I sensory nerve fiber, the subject indicated the intensities of the evoked pressure sensation by pushing a bar-shaped force sensor (load cell) with the contralateral hand so that the pressure he felt from the bar became the same intensity as that evoked by the electrical stimulation of the sensory nerve fiber. We defined the intensity of the evoked pressure sensation as the pressure value he indicated with the load cell.

## Results and Discussion

Stimuli (pressure) were successfully conveyed to the subjects via the developed system, which produced the same somatic sensation (pressure sensation) as the original stimuli, and did so with the corresponding magnitude.

Figure 3 shows an example of the results. The upper graph shows the changes with respect to time in the force with which the Finger TPS sensor system is pressed (green line), force measured by the Finger TPS sensor system (red line), and the intensities of the subjective pressure sensation that the subject expressed by pushing a load cell using the contra-lateral hand in the manner written in the "method" item (blue line). The middle figure shows changes with respect to time in the repetition frequency of the electrical stimulation to the sensory nerve. In this case, as the frequency for electrical stimulation was determined as 50 times the value of pressure detected by the finger TPS system, the shape of the waveform basically becomes similar to the red line (of the upper graph). The lower graph shows the train of the electrical pulses used to stimulate the nerve fiber of interest.

As can be seen in the upper figure, the changes in the pressure sensation generated by the electrical stimulation of the SA-I sensory unit in accordance with the pressure value measured by the Finger TPS system and the changes in the pressure applied to the Finger TPS system showed a very similar tendency. The correlation coefficient between these two factors was 0.91, indicating that the system transfers mechanical stimuli to the subject so that the subject can experiences the stimuli as the corresponding somatic sensations and can do so with the same intensity.

The correlation coefficient between the pressure applied to the Finger TPS system and the value of the pressure measured by it was 0.97, showing that the Finger TPS system can measure the applied pressure with high reliability.

These results indicate that the system will be able to not only compensate the sensory function that has been lost due to peripheral neuropathy but also even enhance the natural sensory functions of the living body when high-performance sensors are adopted for the system.

## Conclusion

In this study, we developed a prototype of a sensory prosthetic system capable of substituting for sensory functions that have been lost due to injury or diseases of peripheral nerve system.

In trials, stimuli were successfully conveyed to the subjects via the system, and the system produced the same somatic sensation as the original stimuli, with the corresponding magnitude. The results indicate the possibility that the system could substitute for sensory functions that has been lost in people with peripheral neural disorders.

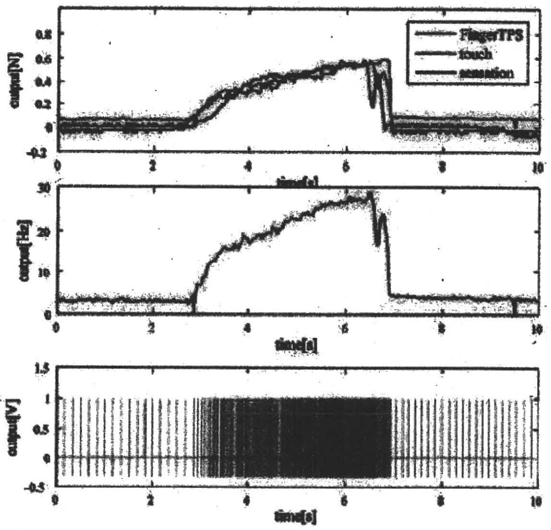

Fig.3 An example of the results. (please refer the text.)

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## Author's Address


Name: Kunihiko Mabuchi
Affiliation: Graduate school of Information Science and Technology, The University of Tokyo
7-3-1, Hongo, Bunkyo-ku, Tokyo, 113-8656, Japan
e-Mail: Kunihiko_Mabuchi@ipc.i.u-tokyo.ac.jp
Homepage: http://www.mels.ipc.i.u-tokyo.ac.jp/