world HAPTICS conference
Pisa, Italy March 18-20, 2005

Remote haptic sharing of elastic soft objects
-Real-time estimation and display by contact area control –

Kinya Fujita* and Yoshiaki Ikeda*

(*)Tokyo Univ. of Agri. & Tech., Japan
E-mail: kfujita@ cc.tuat.ac.jp

• Introduction

Force display devices enabled to display the sense of elastic objects by representing the reaction force from the objects. The tactile display device, which represents the fingertip contact area change caused by the fingertip sinking into the objects, added more realistic sensation about the elastic soft objects[1,2]. Estimation, transfer and display of the physical properties of soft objects over the computer network is expected to provide us the function to touch and feel the distant objects. Especially, the sharing between users has potential applications such as remote palpation or haptic broadcast. This study is focused on to develop a prototype remote haptic sharing system based on the fingertip contact area control device and to examine the feasibility of the system.

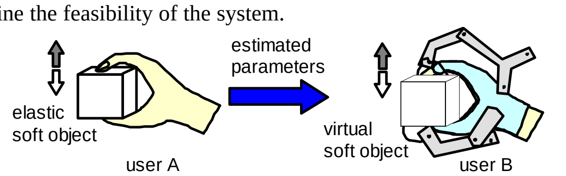

Fig.1: Concept of remote haptic sharing

• System Design
- Real-time estimation of stiffness and size

The difficulties in the real-time stiffness estimation from the human pinch are the unknown object size and the deformation of the fingertip. In order to overcome these difficulties, 1) the stiffness and the size was estimated at the same time using the regression line, and the data below 0.15N was omitted. 2) the fingertip deformation property was measured in advance and subtracted.

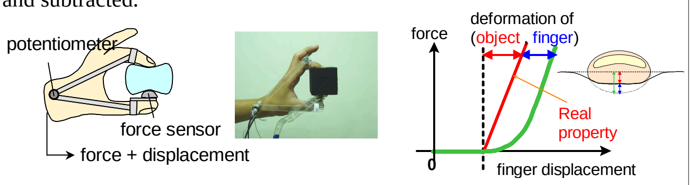

Fig.2: Estimation of the object stiffness

- Fingertip contact area and force control

The pinch of a soft deformable object causes the sinking of the fingertip and it increases the contact area. The role of this information was greater than the reaction force in our former experiment [3]. A contact area control device with force feedback function was developed [2]. The device consists of the pneumatic contact area control device and the wire-driven force feedback device. The contact area was calculated using Hertzian contact theory using the Young's modulus, which is converted from the transferred stiffness. The Poisson's Ratio was assume to 0.5. The air pressure to drive the pneumatic contact area control device was controlled using the pre-measured device property. The reaction force was calculated based on the stiffness using Hook's law.

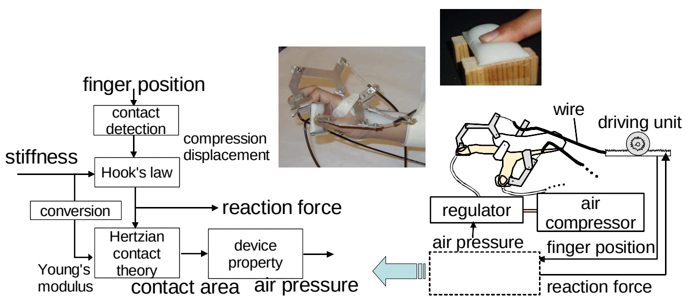

Fig.3: Fingertip contact area control system

• Stiffness and Size Estimation Experiments

The results of the real-time estimation of the stiffness and the size of the objects are shown in figure 4. The objects were 50mm cubes with 0.012, 0.035, 0.14 (rubber foam) and 0.7 (silicon rubber) N/mm^2 Young's modulus. The stiffness estimation errors in steady state were less than 10%. The steady state size errors were less than 5% (not shown). It was demonstrated that the correct estimation is possible after the first pinch has completed.

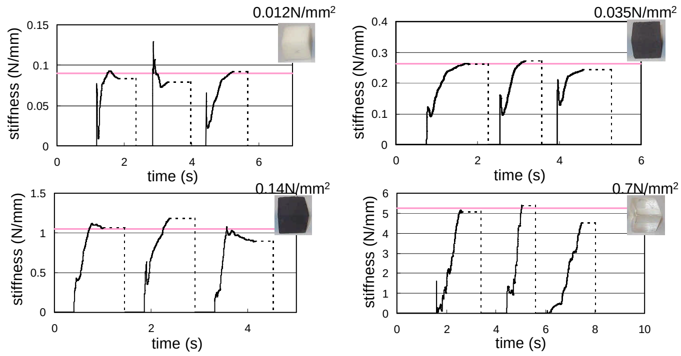

Fig.4: Estimated stiffness in real-time

• Display and Recognition Experiments

The paired-comparison experiment was carried out in five adult volunteers. The displayed Young's modulus was calculated from the estimated stiffness. The average cognitive rate of the difference was 90% as seen in figure 4. It is concluded that the feasibility of the remote haptic sharing was experimentally demonstrated.

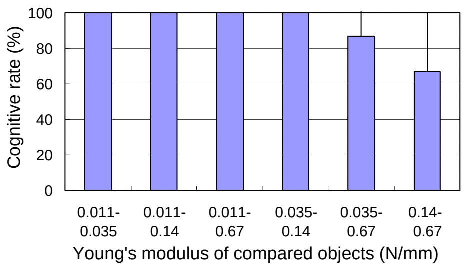

Fig.5: Cognitive rate of the objects

• Conclusions

A haptic remote sharing system was proposed, which consists of the fingertip force and contact area display device and sensors to real-time stiffness estimation. Real-time estimation of the elastic soft objects and the recognition of the transferred and displayed virtual object was experimentally demonstrated.

• Acknowledgements

This study was partially supported by a Grant-in-Aid for Scientific Research from The Ministry of Education, Culture, Sports, Science and Technology.

• References

[1] K.Fujita and H.Ohmori, A New Softness Display Interface by Dynamic Fingertip Contact Area Control, in Proc. 5th World Multiconference on Systemics, Cybernetics and Informatics, pp.78-82, Jul. 2001
[2] Y.Ikeda and K.Fujita, Display of soft elastic object by simultaneous control of fingertip contact area and reaction force, Trans. VRSJ, Vol.9, No.2, pp.187-194, 2004 (in Japanese)
[3] H.Sasaki and K.Fujita, Experimental analysis of role of visual information in hardness cognition displayed by a force display system and effect of altered visual information, Trans. VRSJ, Vol.5, No.1, pp.795-8202, 2000 (in Japanese)