Development of Handshake Gadget and Exhibition in Niconico Chokaigi

Takanori Miyoshi, Yuki Ueno, Kouki Kawase, Yusaku Matsuda, Yuya Ogawa, Kento Takemori and Kazuhiko Terashima

Abstract We developed a handshake gadget that allows people in remote locations to feel mutual force and movement and exhibited it at the 2014 Niconico Chokaigi in April. The Niconico Chokaigi is a very large exhibition in Japan; 125,000 persons attended, and more than 7 million people viewed the movie via the Internet. Our handshake gadget connected individuals in Japan and Taiwan and was experienced by a number of people, including the Japanese Prime Minister and popular characters such as Funasshi and Mario. An international questionnaire administered to those trying the device found that more than 70 % expressed excitement for this gadget, while more than 65 % could feel mutual force and motion.

Keywords Tele-operation · Handshake · Bilateral tele-control · Tele-existence · Intercontinental network experiment

1 Introduction

The handshake is one of the most popular forms of nonverbal communication. There have been various proposals as to how it might be made into a communication means over a long distance. In 1997, Ouchi and Hashimoto [1] proposed a "Handshake Telephone System" to communicate both voice and force. A similar robot was developed by Handshake Interactive Technologies, Inc., in 2003 [2], using Niemeyer's algorithm [3]. These systems exercised only an arm, however. In order to achieve a more realistic sensation, both [4, 5] also proposed a method for moving a finger, although these researchers did not consider the instability dependent on communication latency. We previously reported an example that considered both finger motion and influence by communication latency [6].

T. Miyoshi (✉) · Y. Ueno · K. Kawase · Y. Matsuda · Y. Ogawa · K. Takemori · K. Terashima
Toyohashi University of Technology, 1-1 Tempk-cho, Toyohashi, Japan
e-mail: miyoshi@tut.jp
URL: http://www.syscon.tut.ac.jp/

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The purpose of this research is not to study the complicated control such as above-mentioned research, but to propose a handshake gadget that anyone can produce using simple parts, easily obtained online, and to exhibit it through an intercontinental network connection. Therefore, we used the popular haptic device Falcon [7], adding a force sensor and a sufficiently robust tele-control algorithm. That means that anyone can make the gadget and experience it anytime, anywhere. Now, tele-existence will no longer belong only to specialists.

2 Structure of System

2.1 Hardware Setup

As shown in Fig. 1, the Falcon, with the attached mannequin hands and note PCs, are set up in Taiwan and Japan. On the Taiwanese side, the 3-axis force sensor is also assembled between a Falcon and mannequin hand, and a note PC can measure the human's operating force through a USB. The Falcon and PC are connected by USB, and the PCs by the Internet. Thus, the hardware is very simple.

Subjects grasp the mannequin hand and give it a shaking motion up/down, left/right, and back/forth. The force on Taiwanese side was then transmits to the Japanese side, and the Japanese Falcon moves in accordance with Taiwanese subject's force. In the same manner, Japanese motion is transmitted to the Taiwanese side, and the Taiwan Falcon moves in accordance with Japanese motion. When each performs opposite movements, resistance can be felt. On the other hand, if subjects' movements are synchronized, attraction force can be felt. Thus, each subject experiences mutual force and movement mutually.

2.2 Software Setup

Figure 2 shows the control block diagram. T_1 and T_2 mean the communication latency of the Internet between Taiwan and Japan. Although based on wave variable control, our algorithm is more robust than [3]. That means, even if there is some packet loss and/or perturbation of communication latency, the position of the

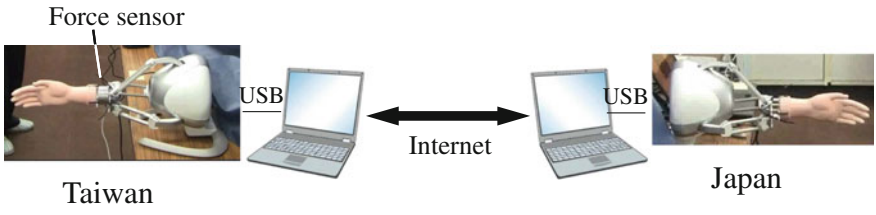

Fig. 1 Structure of whole system

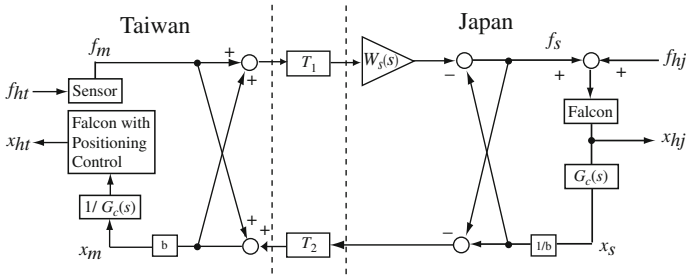

Fig. 2 Control block diagram

slave is consistent with that of the master in a steady state, because we use force-position feedback. Niemeyer's algorithm, in contrast, would drift position, because it was force-velocity feedback. It was not suitable for handshake exhibition. The details of the control algorithm are referred to in [8].

On the Taiwanese side, the detected operating force f_{ht} is transmitted to the Japanese side as force f_s through the scattering matrix and phase compensation filter $W_s(s)$. On the Japanese side, the resultant force of f_s and applied force f_{hj} by a Japanese operator move the Falcon. Accordingly, a Japanese operator can feel his/her force f_{hj}, and the response motion x_{hj} of the Falcon.

The position signal x_s, filtered by the compensation filter $G(s)$, is transmitted to the Taiwanese side as position x_m. After filtering $1/G_c(s)$, commanded position x_r was acquired. Since $G_c(s)$ and $1/G_c(s)$ are complementary, x_{hj} and x_r are almost the same. We implement the position control for the Taiwanese Falcon so that actual position x_{ht} will be consistent with x_r. Thus, the Taiwanese operator can recognize the Japanese Falcon's motion x_{hj}. The program is very simple so that the core routine, which consisted of a scattering matrix, a phase control filter, a phase compensation filter, and positioning proportional control, is only less than 15 lines.

Communication between the two handshake gadgets is performed by P2P socket communication of TCP. Although it runs every 2 ms, traffic is not busy because the data are restored to one packet.

Note that we use the Taiwanese Falcon as the positioning device, although the Falcon is usually used only as a generator of the reaction force. Moreover, the Taiwanese Falcon does not work directly by a Taiwanese operator's force, but by Japanese motion, which is exited by Taiwanese operation force.

3 Demonstration and Results of Questionnaires

3.1 Response of Subject

A Falcon was set up at the Taiwanese and Japanese locations. The gadgets were exhibited at the Niconico Chokaigi April 26–27, 2014. Subjects for the exhibition

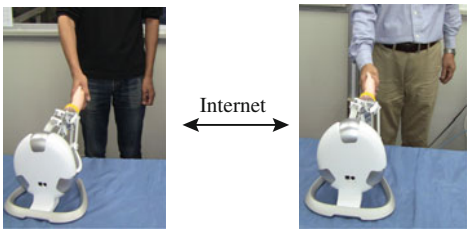

Fig. 3 Image of usage of handshake gadget

included more than 220 persons in both countries. They enjoyed not only handshakes, but also other forms of communication, such as conversation and a 5–10-min quiz, because the purposes of the event were to deepen the friendship between Taiwan and Japan. Some famous individuals and characters also enjoyed the gadget, as may be seen in Fig. 3. The handshake gadget can be seen in the bottom of the photographs.

3.2 Results of Questionnaire

During the exhibition, we asked 219 subjects in both countries to respond to a questionnaire. We included the question: "Was the experiment exciting?" to investigate participants' feelings directly. Answers were given on a 7-level scale from positive to negative. The results are shown in Fig. 4a. As to whether the experiment was "exciting," more than 96 % of subjects answered positively. We could thus see that participants had great interest in our gadget. (The number of answerers is different from the number of participants.)

Between Taiwan and Japan, the communication latency, called round trip time (RTT), was not avoided. Therefore, it was possible that operators would feel the time delay when implementing tele-control via the Internet. The percentage of those who reported feeling the time delay was only 18 % (as shown in Fig. 4b) despite the fact that the RTT was about 60 ms. More than 70 % answered that they had good operability when doing experiments with our system (Fig. 4c). As a result, despite the existing time delay, our proposed system could guarantee good performance.

The primary interest for us in this exhibition was whether or not subjects could feel the force and motion mutually between Taiwan and Japan. The results are shown in Fig. 4d. 106 persons responded that they could feel their partner's force and motion (scale 1, 2, 3), while 42 persons responded negative answer (scale 5, 6, 7). Thus, we concluded that we realized a handshake gadget, as both people mutually felt they were holding the other's arm. The reason why they could not feel partner's force would be weak generative force of Falcon. Falcon's force is less than 10 N so that the human's force overcomes it.

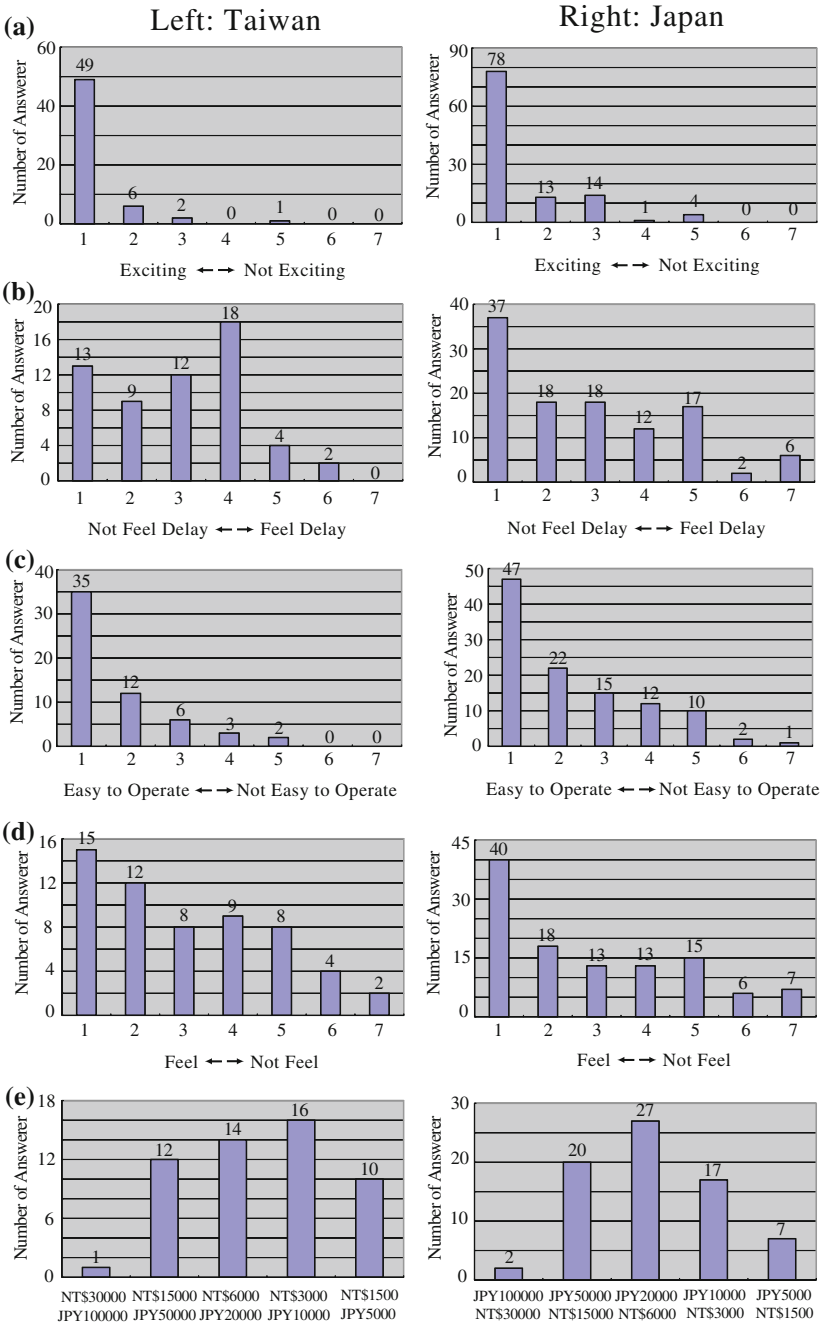

Fig. 4 Results of questionnaire

Finally, we had set the question: "How much can you buy this gadget?" so that we could estimate this gadget's value. In the evaluation of the answer in Fig. 4e, the median value was 20,000 yen (NT$6000) in both countries, although Taiwanese's trend was cheaper. Considering that the list price of Falcon is $250 in Novint HP, it would be appropriate evaluation.

4 Conclusion

We developed a handshake gadget by which people in remote locations could feel mutual force and movement and exhibited it at the international Niconico Chokaigi exhibition. The handshake gadgets were connected between Japan and Taiwan, and they were experienced by number of people including the Japanese Prime Minister and some popular characters. Our gadgets consisted of cheap haptic Falcon devices, force sensors, and our developed software; in other words, anyone could produce these gadgets using simple parts easily available online. At the exhibition, we asked subjects to complete questionnaires about their experience with the system. More than 98 % reported being excited by the exhibition, and more than 62 % could feel mutual force and motion. Now, tele-existence is no longer simply in the realm of specialists.

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