HaptiHug: A Novel Haptic Display for Communication of Hug over a Distance

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Abstract. The motivation behind our work is to enrich social interaction and emotional involvement of the users of online communication media. The paper focuses on a novel haptic display HaptiHug for the representation of hug over a distance by means of online communication system supporting haptic feedback. The system integrates 3D virtual world Second Life, intelligent component for automatic recognition of hug cue from text messages, and innovative affective haptic interface providing additional nonverbal communication channel through simulation of social touch. Based on the real data (the pressure and duration of the interpersonal hug), the control system generates a signal that produces the feelings similar to the real hugging sensations. User study revealed that social pseudo-touch was successful in increasing the hugging immersion as well as hugging sensation.

Keywords: Affective haptics, computer-mediated communication, haptic display, sense of touch, 3D world.

1 Introduction

In a real world, whenever one person interacts with another, both observe, perceive and interpret each other's emotional expressions communicated through a variety of signals. Valuable information is also transferred by non-verbal communication (e.g., social touch). It is well known that touching is one of the most powerful means for establishing and maintaining social contact. The fact that two people are willing to touch implies an element of trust [1]. Expressive potential of touch is the ability to convey and elicit strong emotions.

Computer-mediated on-line interactions heavily rely on senses of vision and hearing, and there is a substantial need in mediated social touch [2]. Among many forms of physical contact, hug is the most emotionally charged one. It conveys warmth, love, and affiliation. DiSalvo et al. [3] introduced "The Hug" interface. When person desires to communicate hug, he/she can squeeze the pillow, so that such action results in the vibration and temperature changes in the partner's device. The Hug Shirt allows people who are missing each other to send physical sensation of the hug over distance [4]. User can wear this shirt, embedded with actuators and sensors, in everyday life.

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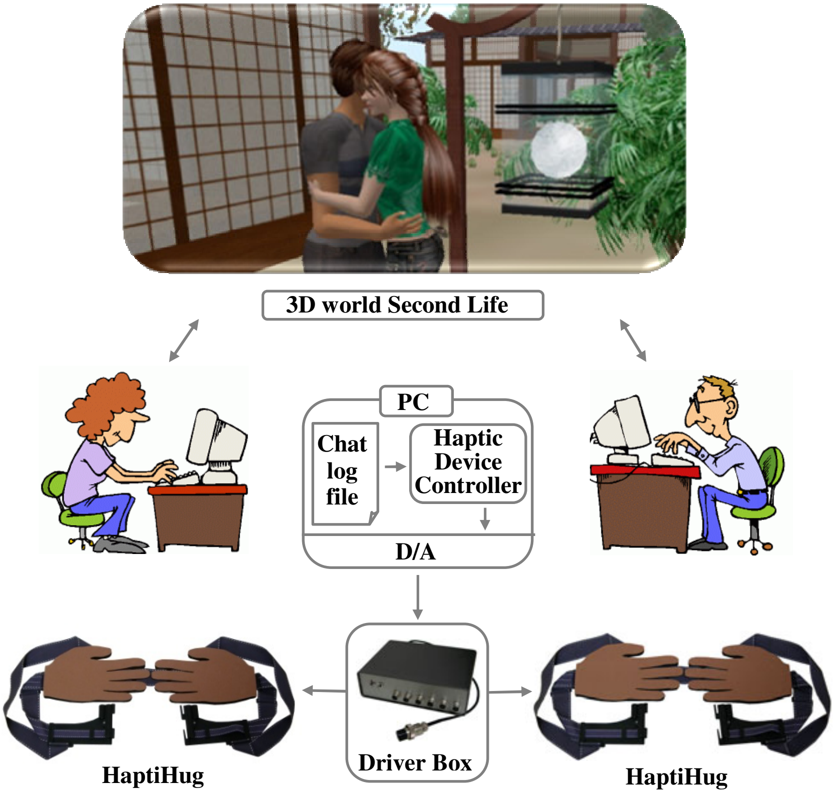

Fig. 1. Architecture of computer-mediated communication system with hug display HaptiHug

However, these interfaces suffer from inability to resemble natural hug sensation and, hence, to elicit strong affective experience (only slight pressure is generated by vibration actuators) [5]; lack the visual representation of the partner, which adds ambiguity (hugging in a real life involves both visual and physical experience), and do not consider the power of social pseudo-haptic illusion (i.e., hugging animation is not integrated). Moreover, real-time online application, open to public and supporting hug feedback, has not been developed.

Driven by the motivation to enhance social interactivity and emotionally immersive experience of real-time messaging, we developed a novel haptic hug display producing realistic force feedback through online communication system. The interpersonal relationships and the ability to express empathy grow strongly when people become emotionally closer through disclosing thoughts, feelings, and emotions for the sake of understanding.

2 Architecture of the System

We placed great importance on the automatic sensing of keywords through textual messages in 3D virtual world Second Life, the visualization of the hugging animation by avatars in virtual environment, and reproduction of feeling of social touch by means of haptic stimulation in a real world. The architecture of the developed system is presented in Fig. 1.

As a media for communication, we employ Second Life, which allows users to flexibly create their online identities (avatars) and to play various animations (e.g., facial expressions and gestures) of avatars by typing special abbreviations in a chat window.

The control of the conversation is implemented through the Second Life object called EmoHeart (invisible in case of 'neutral' state) attached to the avatar's chest. EmoHeart is responsible for sensing symbolic cues or keywords of 'hug' communicative function conveyed by text, and for visualization (triggering related animation) of 'hugging' in Second Life. The results from and EmoHeart ('hug' communicative function) are stored along with chat messages in a file on local computer of each user.

Haptic Devices Controller analyses these data in a real time and generates control signals for Digital/Analog converter (D/A), which then feeds Driver Box for haptic device with control cues (Hug intensity and duration).

3 Development of Haptic Hug Display

Recently, there have been several attempts to improve the force feeling by haptic display. Mueller et al. [6] proposed air-inflatable vest with integrated compressor for presentation of hug over a distance. Air pump inflates the vest and thus generates light pressure around the upper body torso.

Hug display Huggy Pajama is also actuated by the air inflation [7]. The air compressor is placed outside of the vest allowing the usage of more powerful actuator. However, pneumatic actuators possess strong nonlinearity, load dependency, time lag in response (1-2 sec.), and they produce loud noise [6].

Our goal is to develop a wearable haptic display generating the pressure and patterns that are similar to those of a human-human hug. Such device should be lightweight, compact, with low power consumption, comfortable to wear, and aesthetically pleasing.

When people are hugging, they generate pressure on the chest area and on the back of each other by the hands, simultaneously (upper back side of the torso is more frequently touched by the partners). The key feature of the developed HaptiHug is that it physically reproduces the hug pattern similar to that of human-human interaction. The hands for a HaptiHug are sketched from a real human (partner) and made from a soft material so that hugging persons can feel affinity and social presence of each other.

The couple of oppositely rotating motors (Maxon RE 10 1.5 W with gearhead GP 10 A 64:1) are incorporated into the holder placed on the user chest area. The Soft Hands, which are aligned horizontally, contact back of the user. Once 'hug' command is received, couple of motors tense the belt, pressing thus Soft Hands and chest part of the HaptiHug in the direction of human body (Fig. 2). When the movement of the motors stops, the belt rests around the chest snugly. Shoulder straps support the weight of the HaptiHug, so that the user naturally perceives this device as the part of the garment.

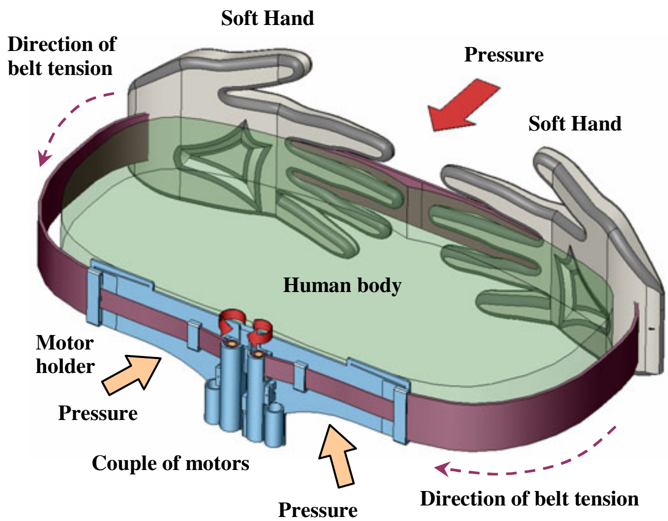

Fig. 2. Structure of the wearable HaptiHug device

The duration and intensity of the hug are controlled by the software in accordance with the emoticon or a keyword, detected from text. For the presentation of a plain hug level (e.g., '(>^_^)>', '{}', '<h>'), a big hug level (e.g., '>:D<', '{{}}'), and a great big hug level (e.g., 'gbh', '{{{}}}'), the different levels of pressure with different durations were applied on the user's back and chest.

The Soft Hands are made from the compliant rubber-sponge material. The contour profile of a Soft Hand is sketched from the male human and has front-face area of 155.6 cm^2. Two identical pieces of Soft Hand of 5 mm thickness were sandwiched by narrow belt slots and connected by plastic screws. Such structure provides enough flexibility to tightly fit to the human back surface, while being pressed by belt. Moreover, belt can loosely move inside the Soft Hands during tension. The dimensions and structure of Soft Hands are presented in Fig. 3.

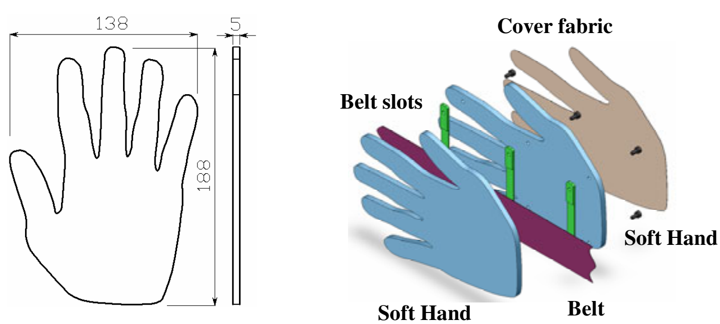

Fig. 3. Left: Soft Hand dimensions. Right: sandwiched structure of Soft Hands.

4 Emotional Haptic Design

Aesthetically pleasing objects appear to the user to be more effective by virtue of their sensual appeal [8]. The designed device is pleasurable to look at and to touch (colorful velvet material was used to decorate the device) and have personalized features (in particular, the Soft Hands in HaptiHug can be sketched from the hands of the real communication partner). We placed great attention on the comfortable wearing of garment. HaptiHug has flexible and intuitive in use system of bucklers and fasteners to enable user to easily adjust the devices to the body shape. Moreover all components of the haptic display are made from compliant and soft materials: rubber-sponge, textile, flexible plastic that makes it comfortable, safe and fun to wear.

5 Social Pseudo-haptic Touch

We developed animation of hug and integrated it into Second Life (Fig. 4).

Fig. 4. Snapshots of hugging animation in Second Life

During the animation the avatars approach and embrace each other by hands. The significance of our idea to realistically reproduce hugging is in integration of active-haptic device HaptiHug and pseudo-haptic touch simulated by hugging animation. Thus, high immersion into the physical contact of partners while hugging is achieved. In [9], the effect of pseudo-haptic feedback on the experiencing force was proved. We expect that hugging animation will also increase the force sensation.

6 Hug Measurement

Since so far there were no attempts to measure the pressure and duration of the hug, we conducted the experiments. A total of 3 pair of subjects (3 males and 3 females) with no previous knowledge about experiment was examined. Their age varied from 24 to 32. They were asked to hug each other three times with three different intensities (plain hug, big hug and great big hug levels). The subject's chest and upper back side were covered with Kinotex tactile sensor measuring the pressure intensity through amount of backscattered light falling on photodetector [10]. The taxels (sensing elements) displaced with 21.5 mm in *X* and 22 mm in *Y* direction make up 6x10 array. The Kinotex sensitivity range is from 500 N/m^2 to 8 000 N/m^2. The experimental results (average value of pressure and duration) are listed in Table 1.

Table 1. Experimental findings

	Plain Hug	Big Hug	Great big hug
Pressure on male back side, [kN/m^2]	1.4	2.5	5.05
Pressure on female back side, [kN/m^2]	1.7	2.9	6.4
Pressure on chest, [kN/m^2]	2.3	3.5	5.9
Average duration, sec.	1.98	2.6	3.4

Experimental results shows that males produce more force on the partner back than females. What it is interesting, is that the pressure on the chest changes nonlineary. The probable cause of this is that while experiencing great big hug level humans protect the vitally important part of our body, heart, from overloading. The example of pressure patterns on the back of the user and on the chest area are given in Fig. 5.

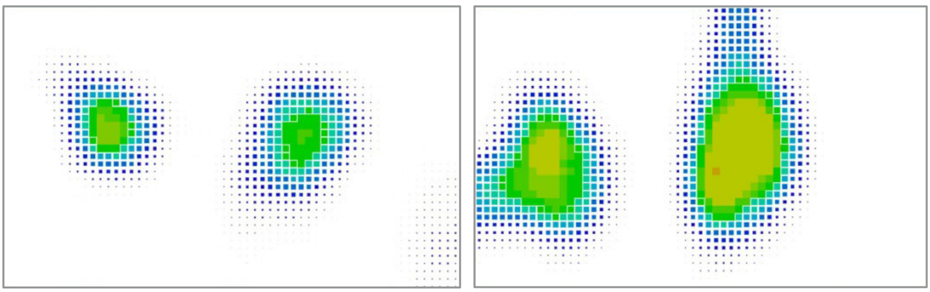

Fig. 5. Left: example of pressure distribution on the back of the user. The highest pressure corresponds to 4800 N/m^2. Right: example of pressure distribution on the chest of the user. The highest pressure corresponds to 5900 N/m^2.

While hugging, three phases can be distinguished, i.e., initiation (pressure increases rapidly), steady-state (pressure level is stabilized), and retrieval (pressure decreases rapidly) (Fig. 6). The developed HuptiHug device can achieve the force level of plain hug (generated pressure is bigger comparing with other hug displays). We consider that there is no reason to produce very strong forces (that requires more powerful motors) resulting sometimes in unpleasant sensations. Based on the experimental results we designed the control signals in such a way that the resulting pressure intensity, pattern, and duration are similar to those of human-human hug characteristics. We summarized the technical specifications of the hug displays in Table 2 (**O** means this characteristic is present, **–** is absent).

Developed HuptiHug is capable of generating strong pressure while being lightweight, and compact. Such features of haptic hug display as visual representation of the partner, social pseudo-haptic touch, and pressure patterns similar to that of human-human interaction, increase the immersion into the physical contact of partners while hugging greatly.

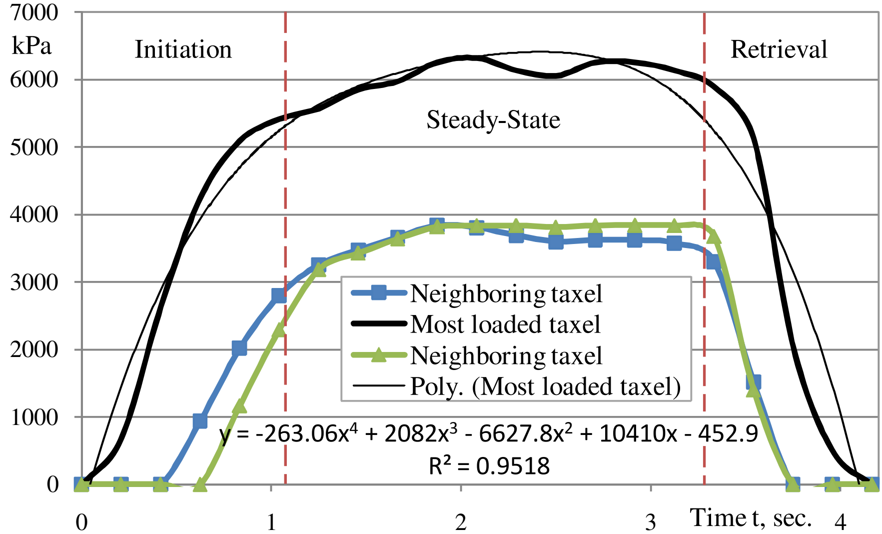

Fig. 6. Example of the pressure plot while people hugging with a big hug level

Table 2. Specifications of the hug displays

	HaptiHug	The Hug	Hug Shirt	Hug vest	Huggy Pajama
Weight	0.146 kg	>1.0 kg	0.160 kg	>2.0 kg	>1.2 kg
Overall sizes Height, m × Width, m	0.1 × 0.4	0.5 × 0.6	0.4 × 0.5	0.4 × 0.55	0.3 × 0.45
Wearable design	O	–	O	O	O
Generated Pressure	2.0 kPa	–	–	0.5 kPa	2.7 kPa
Actuators	DC motors	Vibro-motors	Vibro-motors	Air pump	Air pump
Visual representation of the partner	O	–	–	–	–
Social pseudo-touch	O	–	–	–	–
Based on human-human hug	O	–	–	–	–

7 Conclusions

We demonstrated the HaptiHug (Fig. 7) as the part of the iFeel_IM! system at such conferences as INTETAIN 2009, ACII 2009, ASIAGRAPH 2009, and CHI 2010.

In total more than 300 persons had experienced our system. Subjects enjoyed wearing the HaptiHug. The majority of users reported that this device presented pressure and haptic stimuli in a very realistic manner. The simultaneous observation of hugging animation and experiencing hugging sensation evoked surprise and joy in many

Fig. 7. Demonstration at ASIAGRAPH 2009

participants. The atmosphere between the participants and exhibitors became more relaxing and joyful during HaptiHug demonstration. That proves that HaptiHug was successful at emotion elicitation as well. Also, in spite of users varied greatly in size the device was capable of fitting everyone. In future we will conduct more thorough user study to determine average hug levels, emotional feedback, levels of hugging immersion with and without animation.

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