

HugMe: An Interpersonal Haptic Communication System

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Abstract – Traditional teleconferencing multimedia systems have been limited to audio and video information. However, human touch, in the form of handshake, encouraging pat, comforting hug, among other physical contacts, is fundamental to physical and emotional development between persons. This paper presents the motivation and design of a synchronous haptic teleconferencing system with touch interaction to convey affection and nurture. We present a preliminary prototype for an interpersonal haptic communication system called HugMe. Examples of potential applications for HugMe include the domains of physical and/or emotional therapy, understaffed hospitals, remote children caring and distant lovers' communication. This paper is submitted for demonstration.

Keywords – Haptics; Haptic communication; Remote interpersonal communication; Teleconferencing

I. INTRODUCTION

With recent advances in interactive teleconferencing multimedia systems such as high-definition (HD) video and its 3D display, the limit with what can be done with audio-video contents has been reached. Fueled by several exciting discoveries, researchers nowadays have fostered their interest to incorporate the sense of touch in teleconferencing systems [1]. For instance, haptics is crucial for interpersonal communication as a means to express affection, intention or emotion; such as a handshake, a hug or physical contact [2]. Several studies have confirmed that infants deprived of skin contact lose weight, become ill and even die [3-4]. Furthermore, studies of human infants reveal that the absence of affectionate touch can cause social problems [4]. This need for haptic communication becomes more apparent for children with disabilities such as deaf-blinded ones.

The incorporation of force feedback in synchronous teleconferencing multimedia systems has been challenged by the high haptic servo loop (typically 1 kHz), consistency assurance, access control, transparency, and stability, among others. On the other hand, asynchronous tactile playback does not provide real-time interaction. In this paper, we present a haptic audio-visual teleconferencing system to enhance the physical intimacy in the remote interaction between lovers. The HugMe system works with tolerable bandwidth (30-60Hz) for haptic data yet provides synchronous interaction.

As an application scenario, assume a child is crying (lets say in daycare) while his parent is away. What would a child need to stop crying other than a hug and a kiss from his/her parent? As shown in Figure 1, the child is wearing a haptic suite (haptic jacket) that is capable of simulating nurture

touching. The parent, on the other side of the network, uses a haptic device to communicate his feelings with his child. A 2.5D camera [5] is used to capture the image and depth information of the child and send it to the parent. The parent can touch the child captured with 2.5D camera, the touch information is calculated and sent to the child, and the child feels the touch via the haptic jacket. Whenever a collision is detected, a notification is sent from the parent host to the child host in order to activate the appropriate actuators embedded in the haptic jacket. Meanwhile, the force feedback of the child body is displayed to the parent using the haptic device.

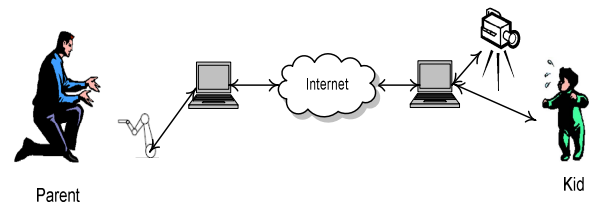


Fig. 1 Synchronous haptic teleconferencing system

The remainder of the paper is organized as follows: section 2 describes related work and highlights the scope of this paper. In section 3, we present the architecture of the HugMe system and present its implementation. Section 4 describes how the implemented HugMe system works. Finally, in section 5 we summarize the paper contents and provide our immediate future work for this project.

II. RELATED WORK

Existing researcher about interpersonal touch over a network can be categorized as synchronous and asynchronous communication systems. One of the early asynchronous systems was the TapTap prototype [6], which is a wearable haptic system that allows nurturing human touch to be recorded, broadcast and played back for emotional therapy. The tactile data is transmitted asynchronously.

Another commercially available hug shirt that enables people feel hugs over distance is proposed in [7]. The shirt embeds sensors/actuators to read/recreate the sensation of touch, skin warmth, and emotion of the hug (heartbeat rate), sent by a distant lover. The hugger sends hugs using a Java-enabled mobile phone application, in an as easy as an SMS is sent, through the mobile network to the loved one's mobile

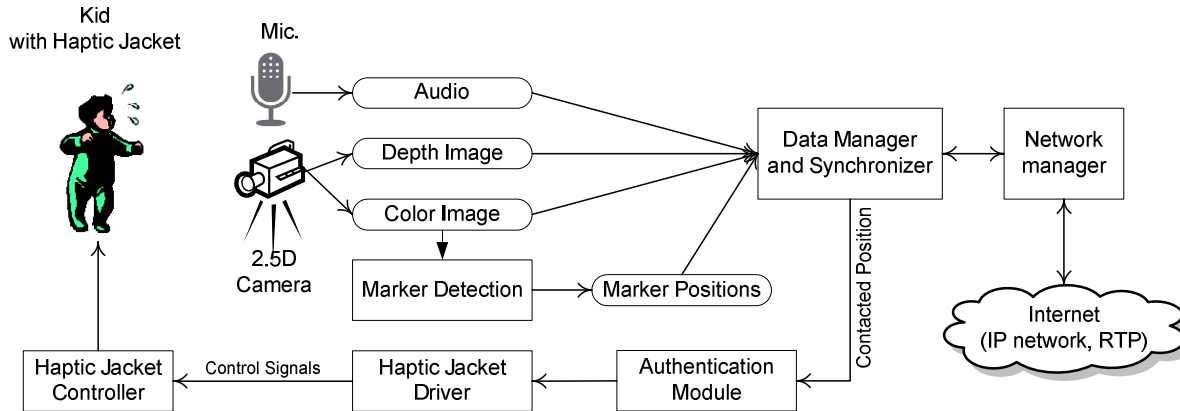


Fig. 2 System block diagram on the child side

phone, which in turn delivers the hug message to the shirt via Bluetooth.

As per synchronous interaction paradigms, a tele-haptic body touching system that enables parent/child interaction is described in [8]. An Internet pajama is envisioned to promote physical closeness between remote parent and child. The pajama reproduces hugging sensation that the parent applies to a doll or teddy bear, to the child. A similar idea is presented in [9] where a human/poultry and poultry/human interaction is made possible using a doll, which resembles the remote pet, and a tactile suit that is put on the pet body.

Unlike most of the previous works, HugMe system enables touch interaction that is synchronized with audio/visual information. It is worth mentioning here that the HugMe system is not meant to replace human-human contact, but to enhance the physical intimacy in the remote interaction between lovers whenever they cannot physically meet for some reason. It has other interesting applications in the medical field especially with children and elderly [8].

Another distinguishing feature of the HugMe system is its ability to represent the haptic properties in an image-based format, and render the haptic interaction based on these images. More details about the image-based haptic rendering algorithm can be found in [10]. Notice that there is no need to transmit the haptic device position since the rendering will be performed locally at each machine. This will save a significant bandwidth of sending data every – theoretically – 1 millisecond.

Given that there will be two major data streams (haptic and visual) the transmission of media data is another research challenge. An abstract communication protocol for haptic audio visual environments needs to be designed and developed. This protocol should be designed to be highly customizable and flexible to satisfy the varying and sometimes conflicting requirements of the application. Finally, the synchronization between the instances of the applications at the two ends of the network is one of the major challenges in our system design.

III. 3. HUGME SYSTEM IMPLEMENTATION

This section describes a one-way version of the HugMe system, where, as shown in Figure 1, the parent is trying to touch the body of his/her child. The same system can be duplicated to enable the mutual touching between the two users. Figure 2 shows the system block diagram on the child side whereas Figure 3 shows the system diagram on the parent side. In the following, we briefly describe the comprising components of the proposed system and its implementation.

A. Depth Video Camera

The depth video camera is capable of generating RGB and D (Depth) signals. The depth signal is a grey-scale bitmap image where each pixel value represents the distance between the camera and the corresponding pixel in the RGB image. The concept of operation is simple: A light beam is generated using a square laser pulse and transmitted along the Field of View (FOV) of the camera. The reflected beam carries an imprint of the objects depth information. The depth information is extracted using a fast image shutter. A commercially available camera that serves this concept is the Z-CamTM, developed and marketed by 3DV Systems [11].

B. Graphic and Haptic Rendering

The graphic rendering module renders the 3D scene using OpenGL. All the pixels of the depth image are transformed into 3-D space by using camera parameters and triangulated (with low resolution for fast rendering) and the color image is mapped on it as a texture. Since the captured scene is transformed into 3D space, we can produce the stereoscopic view. The haptic rendering module calculates 3D interaction force between the transformed depth image and the device position [11]. As a result, parent can touch the video capturing the child.

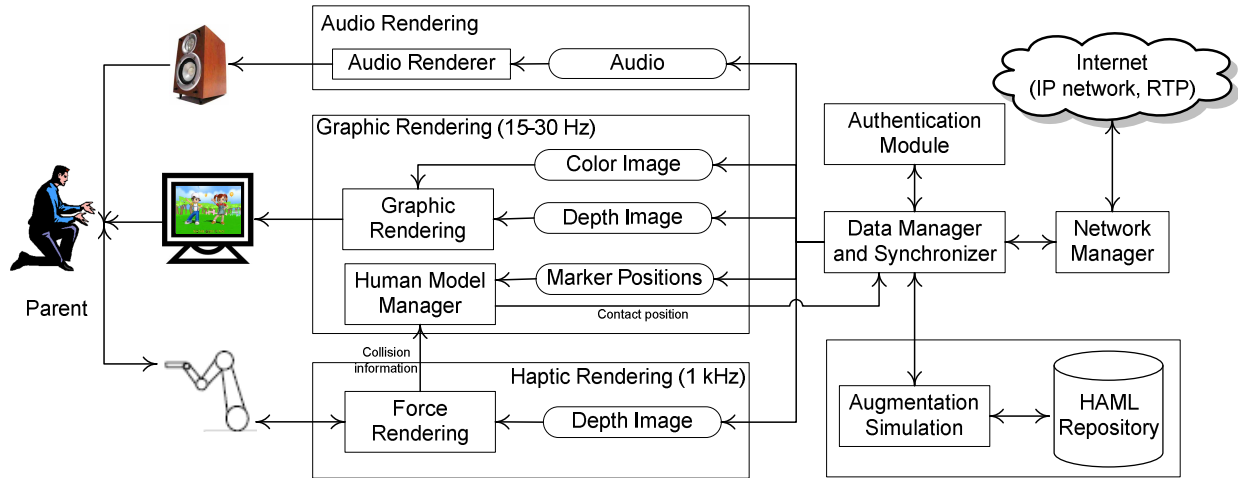


Fig. 3 System on the parent side

C. Marker Detector

In order to map the collision point in the haptic rendering and the touched point in real child, we need to track touchable part of the child. This component is responsible for tracking the movement of the remote user which can be used to construct a real-time representation (avatar). For instance, one possible tool that can be used is the Augmented Reality Tool Kit (ARToolKit) [12] that optically tracks markers, attached on touchable part of the child, in the images, and this information is mapped into the 3-D depth image space. By doing this, we can transform the collision information in the haptic rendering algorithm into the touched point on the child's body, namely the actuation point of the haptic jacket.

D. Human Model Manager

The human model manager keeps track of the user body position and calculates the touched point on the human model. This is accomplished by continuously sending the updated positions of the markers (at a rate of 30-60 Hz). The human model manager maintains a graphical representation of the remote user using a set of graphic primitives. The positions and/or orientations of these primitives are updated every time the remote user moves. The human model manager is consulted by the haptic rendering component to check for possible collision between the haptic device and the user model. Therefore, the haptic rendering is performed locally given the updated representation of the remote user. In this implementation, the torso is modeled with a rectangular parallelepiped and the right upper and lower arms with cylinders for simple calculation as a proof-of-concept.

E. Haptic Jacket

The haptic jacket is a suit that embeds vibrotactile actuators to simulate the sense of touch. One possible design

is to use a network of tiny vibrating motors distributed over a flexible layer. In order to simulate the feeling of touch, the different actuators should be controlled in a manner that best matches the real touch or touch stroke to be initiated. For example, to simulate a poke, a concentric layout of motors may be used, where a center actuator simulates the poke touch while other circularly distributed motors form the surrounding concentric circles. In addition, we plan to use heaters to simulate the warmth of touch.

Fig. 4 shows the haptic jacket that is embedded with arrays of vibrating motors. In order to measure the positions of the chest part and the upper arm, two different fiducial markers were attached on the middle of the chest and the upper arm as shown in Fig. 4(a). For easier maintenance, the arm part of

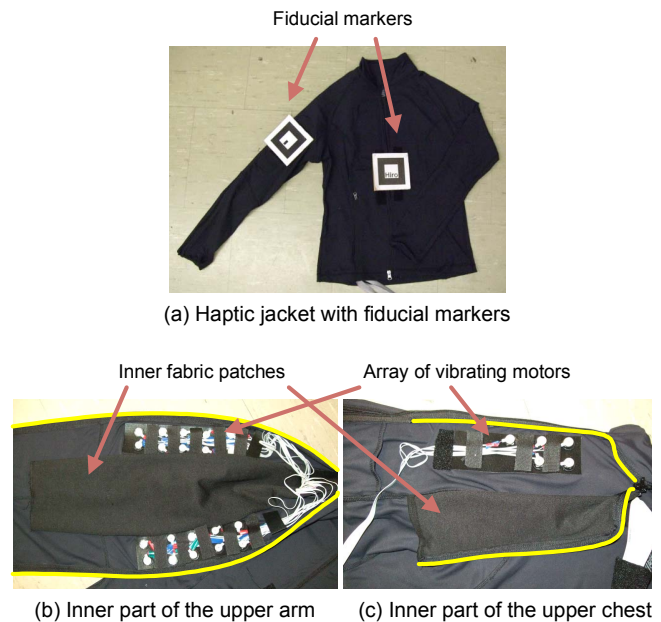


Fig. 4 Haptic jacket

the jacket was cut along and the zipper is attached along the cut line, and then the array of vibrating motors was attached on the inner part of the jacket and one layer of inner fabric arm was attached to prevent the vibrating motors and the electric lines directly touch the skin. Same approach is applied to the chest part: the array of vibrating motors was attached on the inner part and a layer of inner fabric patch was attached to zip them together. Fig. 4(b) and (c) show the embedded vibrating motors zipped open. Yellow lines show the zipper lines.

F. Network Manager

The network manager takes care of transmitting and receiving the graphic and haptic data from one end to the other. Furthermore, this component is responsible for communicating the markers positions across the network. In this implementation, the UDP was used to transmit a set of a color image, a depth image, marker positions, and a contact position. Notice that the marker and the contact position are transmitted at the same rate as with video media (30-60 Hz).

IV. DEMONSTRATION

Fig. 5 shows the implemented HugMe system with local and remote users. In the remote part, the remote person is captured with the depth camera, Zcam™, and the marker positions corresponding to the chest and the upper arm are computed through ARToolKit and these data is transmitted to the local side. The local person can 3-dimensionally see and touch the remote person through a 3 degree-of-freedom force feedback device, Novint Falcon [13]. When the sphere avatar, that represents the position of the human hand in the scene, collides with the 2.5D remote person, the local person can feel the contact force and the contact position on the human model of the remote person is computed and transmitted to the remote side. This contact position is used to stimulate the remote person on the jacket embedded with the vibrating motors. Fig. 6 shows the HugMe application window.

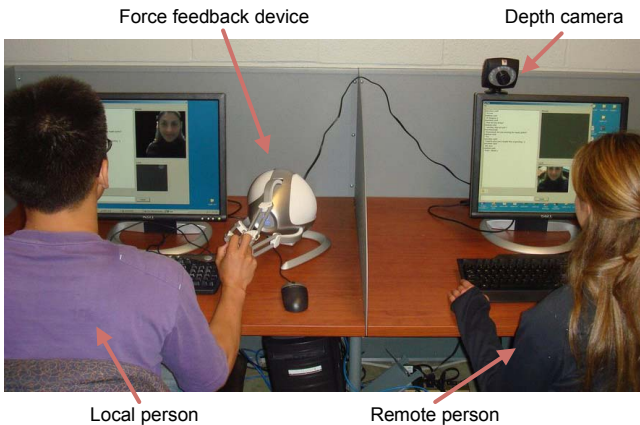


Fig. 5 HugMe system with local and remote users

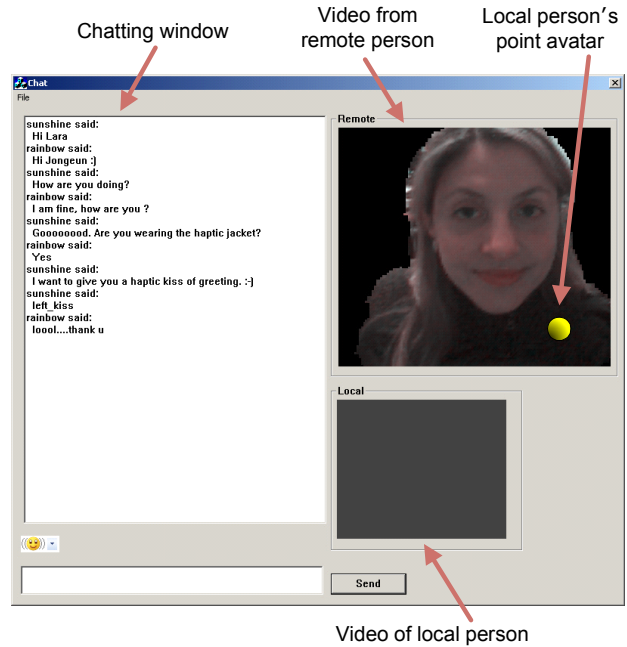


Fig. 6 HugMe system application

V. CONCLUSION

HugMe system is a synchronous haptic-audio-visual teleconferencing system that enables people to exchange physical stimuli over a network. This system can be used in the domains of physical or emotional therapy, understaffed hospitals, and absent parents/children and lovers.

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