HugMe: Synchronous Haptic Teleconferencing

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ABSTRACT

Traditional teleconferencing systems have enabled remote communications via audiovisual modalities. However, in real life, human touch such as encouraging pat plays a fundamental role to physical and emotional communication between persons. This paper presents a synchronous haptic teleconferencing system with touch interaction to convey affection and intimacy. We present a preliminary prototype called HugMe. In this system, two remote users could see as well as touch each other.

Categories and Subject Descriptors

H.4.3 [**Communications Applications**]: Computer conferencing, teleconferencing, and videoconferencing

General Terms

Design

Keywords

Teleconferencing, haptics, interpersonal communication

1. INTRODUCTION

With recent advances in video teleconferencing systems such as high-definition (HD) and 3D video, the limit in what can be done with video contents has been reached. Fueled by several exciting discoveries, researchers nowadays have fostered their interest to incorporate the sense of touch in telecommunication systems [3]. 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 [1].

The incorporation of force feedback in synchronous teleconferencing multimedia systems has been challenged by the high haptic servo loop (typically 1 kHz) through network. On the other hand, asynchronous tactile playback does not provide real-time interaction. In this paper, we present a synchronous haptic teleconferencing system to enhance the physical intimacy in the remote interaction between users, which works with tolerable bandwidth (30-60Hz) for haptic data.

In the system, an active user can see and touch a remote passive user, who is captured in 2.5D, using a 3-dof force feedback device. The passive user could feel the touch on the contacted skin through a haptic jacket that is composed of array of vibrating motors.

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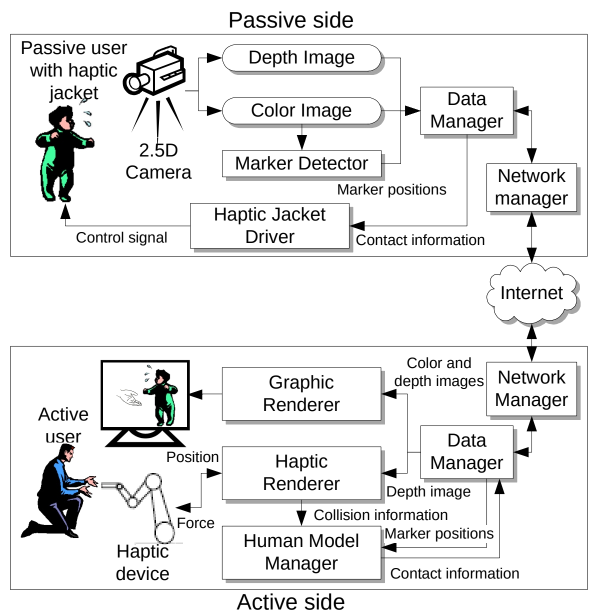


Figure 1: System block diagram

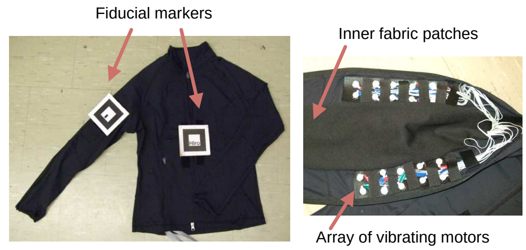
2. SYSTEM DESCRIPTION

This section describes a one-way version of the HugMe system as shown Figure 1, in which an active user touches the passive user who will then feel the touch. However, the same concept can be duplicated in the opposite way to enable the mutual touch interaction. In the following, we briefly describe the comprising components of the system and its implementation.

2.1 Depth Video Camera

In order to enable to touch the passive user in real-time, we use a depth camera, called ZCam$^{\mathrm{TM}}$[1] that captures 2.5D scene in terms of general color images and synchronized gray-scale depth images containing per-pixel depth, namely Depth Image-based Representation (DIBR). DIBR is considered a 2.5D representation in the sense that the depth

[1] http://www.3dvsystems.com



(a) Haptic jacket with fiducial markers (b) Upper arm inner part

Figure 2: Haptic jacket

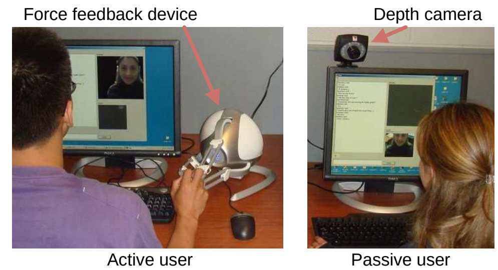


Figure 3: System configuration

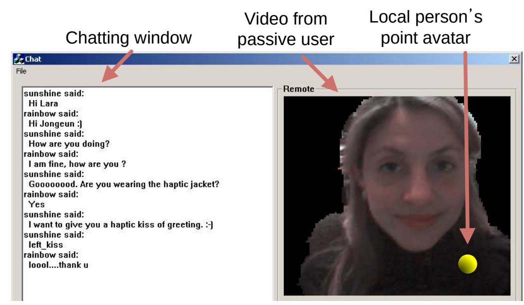


Figure 4: Active side application window

image has incomplete 3D geometrical information describing the scene from the camera view, and thus the active user can touch what they see.

2.2 Graphic and Haptic Renderers

The captured depth image is transformed into a 3D space by using camera parameters and triangulated and the color image is mapped on it as a texture. Since when triangulated there are too many triangles (152,482 triangles for 320x240 depth image), the depth image is down-sampled for fast graphic rendering. The haptic renderer calculates 3D interaction position and force between the transformed depth image and the active user's hand position that is captured by a haptic device, Novint Falcon[2][2]. The calculated force is fed back to the haptic device and then the active user can feel the interaction force.

2.3 Marker Detector and Avatar Manager

In order to map the interaction point in the depth image coordinate to the touched point in the passive user's skin coordinate, we set up an avatar that represents the passive user. Marker detector is responsible for tracking the movement of the passive user which can be used to control the avatar. For instance, one possible tool that can be used is the ARToolKit [3] that optically tracks fiducial markers, attached on touchable part of the passive user. As a result, the avatar represents the passive user and its movements. When there is a contact on the depth image, the avatar manager searches for a closest point on the avatar and if this closest point is close enough to the contact point, the contact information (the part that is touched and contact point on it) is determined. In this implementation, the torso is modeled with a rectangular parallelepiped and the right upper arm with cylinders for simple calculation as a proof-of-concept. The avatar is invisible to the active user but used for contact information calculation.

2.4 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 as shown Figure 2. 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. For comfort, the array of vibrating motors is attached on the outer part and a layer of inner fabric patch is embedded. The zipper allows of opening the jacket and checking the actuators easily.

2.5 Data Manager and Network Manager

The data manager and the network manager take care of transmitting and receiving the graphic and haptic data from one end to the other. Furthermore, this component is responsible for communicating the marker 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. Note that the marker and the contact position are transmitted at the same rate as with video media (30-60 Hz).

3. DEMONSTRATION

Figure 3 shows the implemented HugMe system with active and passive users. The active user can 3-dimensionally see and touch the remote passive user through the haptic device. When the point avatar, that represents the position of the active user's hand in the scene, collides with the 2.5D passive user, the active user can feel the contact force and the passive user feels that contact on his/her skin via vibration. Figure 4 shows the HugMe application window.

4. REFERENCES

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[2] http://home.novint.com

[3] http://www.hitl.washington.edu/artoolkit