An AR System for Haptic Communication

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Abstract

Touch is an important part of human communication. Through handshakes, hugs and a myriad of personal gestures, we convey our emotions and express our feelings. However, how such interactions can be achieved over distance remains a relatively unexplored area of research. To begin to rectify this we present the description of a system that enables one user to reach out and touch another distant user and for both to feel the resultant physical contact. In this initial exploration, we focus on the practical feasibility of this idea, and describe the technical components required.

Keywords: Haptic, Communication, Augmented Reality.

1. Introduction

Communication is a fundamental part of human life, and haptic, or touch, communication an important mechanism through which we express our emotions and convey the more ephemeral aspects of our feelings and relationships [1]. However current communication systems make little attempt to convey the experience of touch over distance, and research projects on this topic have tended to focus on communication through artificial tool-like artifacts [1, 2]. To address this absence, we propose a touch enabled interpersonal communication system with an emphasis on creating an interaction that maintains the qualities of interpersonal touch in the real world. With this system, one user can see another remote user and reach out and touch a specific part of his or her body and both users are able to physically feel the result of that touch.

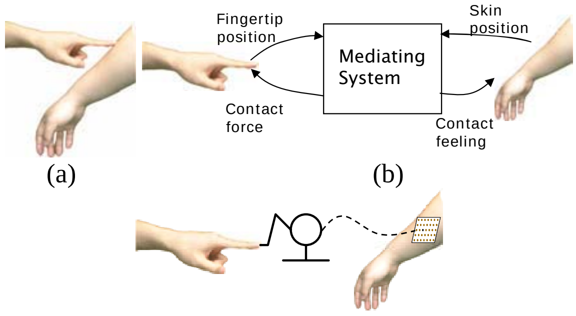

Fig. 1 (a) Touch interaction when co-located (b) When remotely located (c) Touch interfaces

2. System Concept

Fig. 1(a) shows a simple touch interaction between two co-located people. The person on the left (the active user) is using a finger to pat or rub the person on the right (the passive user), who in turn feels the presence and quality of this contact. To replicate this experience in a distributed setting, we propose a mediating system, shown in Fig. 1(b).

We can detect the presence of this touch interaction if we can monitor the fingertip position of the active user and the arm position of the passive user, and combine these two into a coherent virtual space. In order to provide feedback to support this interaction we must also be able to apply forces to the active user's fingertip and stimulate the skin of the passive user. To achieve these objectives, we used a 3-DOF haptic interface (the PHANToM) [3] to both measure the active user's fingertip position and to render forces to it. To capture

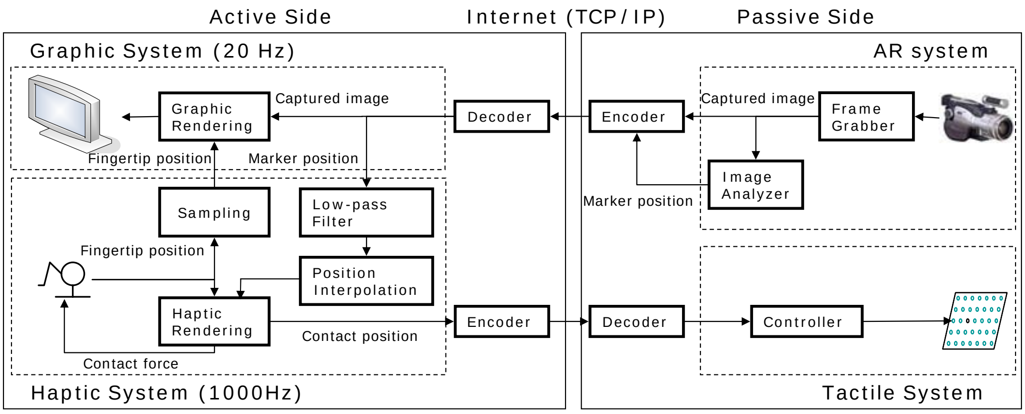

Fig. 2 System block diagram

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information about the arm position of the passive user, we used the ARToolkit API [4] and a forearm mounted fiducial marker. In order to provide touch feedback we placed an array of skin stimulating vibrotactile elements under this marker. This system is summarized in Fig. 1(c). As it takes place within an AR context, this system also benefits from the fact that it takes place in a photorealistic environment: to touch the passive user, the active user must reach out and explore a camera captured scene.

3. System Description

Fig. 2 shows the whole system structure and data flow. The two parts are physically separated. On the active side, a user can see a view of the passive side through a webcam video stream and use the PHANToM to reach into this scene and touch the passive user's arm. On the passive side, the user's figure is captured and analyzed to determine the marker's position and this information is transmitted to the active side. When the active user touches the marker, this contact position is transmitted back to the passive user and the vibrotactile array activated at a corresponding location as shown in Fig. 3. The following sections explain each subsystem.

3.1 Vision-based tracking through ARToolKit

In this proof-of-concept system, we restrict the touchable skin area to a relatively small portion of the arm as it is challenging to capture the position information for an entire human body. The passive user attaches a fiducial marker on the skin area to be touched. The AR subsystem then captures images of the user and uses these to estimate the marker's position. In this system we used ARToolkit, a freely available API that facilitates capturing fiducial markers in the form of patterned boards.

3.2 Haptic interaction through PHANToM

The haptic subsystem calculates the contact position and the contact force between the active user's fingertip and the passive user's skin. To do this, we created a simple virtual environment including a virtual hand representing the position of the haptic interface and a virtual skin representing the portion of the passive user's skin that can be touched (as derived from the position of the fiducial marker). Using CHAI3D [5], a haptic rendering API, the contact position and force between these two objects is obtained and used to drive the haptic interface to provide a sense of physical contact. This information is also transmitted to the passive user where it is used to control the tactile array described in the next section in order to provide a tactile sensation.

To achieve smooth force display, haptic rendering must take place at a high update rate, in the order of 1000 Hz. However, the update rate of ARToolkit, which determines the position of the passive user's arm, is much lower, approximately 20Hz. This discrepancy

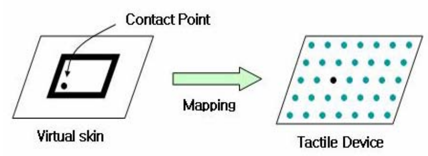

Fig. 3 Mapping the contact position to the tactile device

initially led to considerable instabilities in the forces displayed to the active user, as the object representing the passive user's skin could make substantial movements in between updates. We resolved this force discontinuity problem through interpolation [6].

3.3 Tactile feeling through vibrotactile device

In order to display the feeling of a touch to the skin to the passive user we developed an array of vibrotactile actuators (in the form widely available pager motors). Out initial prototype consisted of 25 elements, arranged in a 5 by 5 grid. It is driven by a dedicated microprocessor (the ATMega 128), and responds to commands delivered over an RS232 link from a host PC. Each tactor can be activated independently and it can display vibrations of a variety of intensities through PWM. Using this system, we can cover an area of the skin of approximately 10 by 10 cm with a reasonable density of vibrating elements, and we believe the sensations induced resemble those created by a light touch. We use the contact and force information transmitted from the active user to determined which array elements to activate, and what magnitudes of activations are appropriate.

4. Conclusion

We briefly describe the motivations for and design of a complete system that supports one user touching another across a network. While this system is currently more a proof of concept than a realistic implementation, its construction has served to highlight the technological challenges that must be overcome to successfully deliver this kind of haptic communication. Future work will focus not only on improving the technology, but also on investigation the situations where this kind of communication can be most valuable.

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