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Tactile Telepresence for Isolated Patients

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Abstract

For isolated patients, for example COVID-19 patients in an intensive care unit, conventional televideo tools can provide a degree of visual telepresence, but at best approximate a "through a window" metaphor—visitors such as loved ones cannot touch the patient. We present preliminary work aimed at providing an isolated patient and remote visitors with visual interactions that are augmented by touch—a perception of being touched for the isolated patient, and a perception of touching for the visitors.

CCS Concepts

• ***Human-centered computing*** → ***Haptic devices;*** *Gestural input; Accessibility systems and tools;* • ***Applied computing*** → *Consumer health;*

1. Introduction

Human touch is a powerful component of patient care [Ver09]. There are physical impacts, psychological impacts, and spiritual impacts [DE01]. In situations where the patient is in pain, touch might be undesirable, however "being there through touch" can be very important. Even a simple "reassuring touch" has been recognized as an important intervention [FCRR91]. In the field of complementary and integrative medicine [AAB*12], the notion of "therapeutic touch" or "healing touch" is based "on a philosophy that in addition to the physical dimension, humans have an energetic dimension that must be recognized during the healing process" [AC19]. Touch is also important for those who care for or visit the patient, e.g., family members or other loved ones. Family members visiting patients in an intensive care unit (ICU) experience stress that can be reduced in several ways, including the ability to be physically close to the patient, and feeling that they are helping the patient [Plo95]. In some cases, such as the COVID-19 pandemic, patients must be isolated from visitors to avoid spreading diseases or compromising the patient. As a result, these isolated patients and their family members lose the benefits of physical contact and touch. To address these issues we have begun investigating mechanisms for mediated social touch for isolated patients.

The preliminary work we present here is aimed at bridging the visitor-patient separation with tactile technology that is integrated into, and synchronous with, traditional video. As depicted in Figure 1, our approach is designed around a *visitor side* interface, comprising touch-enabled video of the patient, with a network connection to a *patient side* interface, comprising tactile actuators on the body and video of the visitors. For the visitor side, we made the decision to initially target a smartphone or tablet interface, as these are ubiquitously available. For the patient side, discussions with ICU nurses familiar with COVID-19 circumstances informed several considerations. For example, we decided on wired actuators to avoid concerns about interference with medical equipment. We seek to minimize the actuator components on the patient, to reduce the intrusiveness of the tactile technology and to mitigate cleaning and decontamination concerns. Because patients usually have many wires and tubes attached to their body, we considered areas that are likely to be exposed, and decided to initially target the forehead. Not only is the forehead usually clear of wires and tubes, it is a place visitors would naturally touch the patient to offer reassurance [Rou99]. In addition, a headband is a familiar and relatively unobtrusive means for affixing actuators to the forehead.

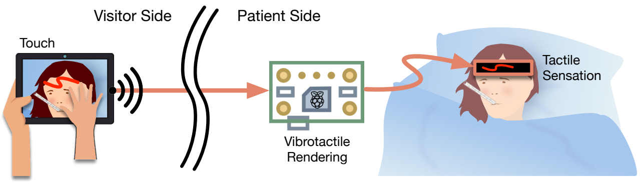

Figure 1: *Diagram of our tactile telepresence system prototype.*

Relatively few researchers have investigated mediated social touch on the forehead [Hui17]. This is possibly because people do not normally touch each others' foreheads in social situations outside of healthcare. As such, the circumstances surrounding isolated patients give rise to both a therapeutic need and a relatively new opportunity for mediated social touch research.

Our long term goal is to provide an isolated patient and remote visitors with visual interactions that are augmented by touch—a perception of *being touched* for the isolated patient, and a perception of *touching* for the visitors. Here we present a limited proof-of-concept prototype that focuses solely on touch (without video).

2. Tactile Telepresence System Prototype

Our tactile telepresence system prototype involves a visitor-side interface, a network interface for relaying mediated social touches, and a patient-side interface. The visitor-side interface provides remote family members and visitors with a touch-input interface for conveying touch patterns on the isolated patient's forehead, e.g., rubbing or other patterns that might be associated with reassurance or comfort. The network interface is responsible for transmitting touch gestures received from the visitor-side interface to the patient-side interface, which in turn, renders the gesture using a grid of tactile actuators.

2.1. Visitor-Side Interface (Touch Input)

Hardware. For our preliminary prototype, we chose to use a 10.5-inch Samsung Galaxy Tab S5e tablet for the patient-side interface.

User Interface. For the visitor-side interface, we developed an Android application using Android Studio. The current prototype displays an image of the patient, which we plan to eventually replace with a live video stream. The application currently overlays a semi-transparent yellow "region of touch" rectangle over the image of the patient's forehead. This 10.5 cm $\times$ 5.5 cm rectangle represents the valid region for performing touch input to relay to the isolated patient. Any touch points outside of the semi-transparent yellow rectangle are considered invalid touch points. The visitor-side interface supports both single-touch and multi-touch capabilities. Currently, the application can process up to ten fingers simultaneously touching the tablet within the region of touch.

2.2. Network Interface

In order to relay touch gestures, we chose to transmit touch point data through a User Datagram Protocol (UDP) connection between the visitor-side and patient-side interfaces. We chose to use the UDP protocol over the Transmission Control Protocol (TCP), in order to prioritize real-time transmission and delivery of the touch gestures and because an undelivered sets of touch points will likely be less perceptible than a delayed set of touch points.

2.3. Patient-Side Interface (Tactile Sensations)

Hardware. A Raspberry Pi 4 was used to control the patient interface through General Purpose Input/Output (GPIO) pins, that can drive the vibrotactile actuators.Because the vibrotactile actuators' operating current is greater than the maximum supply current of the GPIO pins, we used a ULN2803A Darlington Transistor Array to amplify the current from the pins to drive the actuators. An external 5 V DC battery supply was used to power the the driver and the vibrotactile actuators.

The patient-side tactile headband consists of eight 10 mm $\times$ 3 mm linear resonate actuators, with a rated speed of 12000 RPM. The far-ranging speed and compact size of the motors provided the most comfort and perceived intensity. All the actuators are arranged in a 4×2 grid with a horizontal spacing of 3 cm and vertical spacing of 2 cm. VELCRO adhesive-back squares were used to attach each motor to the headband, which was constructed out of Hook & Look tape. This allowed flexibility in the positioning of the motors.

Rendering Software. To ensure the tactile headband would produce smooth tactile sensations for the user, we implemented the Syncopated Energy Algorithm [TM19], which is a real-time vibrotactile rendering algorithm that determines the intensity that each actuator contributes to simulate the touch point.

Whenever the user lifts a finger off of the visitor-side interface, the patient-side interface recognizes it as an inactive touch point and will automatically render the actuator's contributing amplitude as 0. When the visitor uses multi-touch gestures, the Syncopated Energy algorithm computes each motor's contributing amplitude for all 10 touch points. Then, the maximum amplitude across all 10 touch points is used for rendering the actuator's amplitude value.

3. Conclusions and Future Work

In this paper we designed and implemented a prototype tactile telepresence system that detects and sends touch patterns through a UDP connection from a tablet-based visitor's interface to a tactile headband on the patient. We are continuing to evolve our prototypes, and to carry out formative experiments assessing their technical performance. We have also identified interested partners at a local hospital, where we hope to eventually carry out tests with actual patients.

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