Communicating with Feeling

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ABSTRACT

Communication between users in shared editors takes place in a deprived environment – distributed users find it difficult to communicate. While many solutions to the problems this causes have been suggested this paper presents a novel one. It describes one possible use of haptics as a channel for communication between users. User's telepointers are considered as haptic avatars and interactions such as haptically pushing and pulling each other are afforded. The use of homing forces to locate other users is also discussed, as is a proximity sensation based on viscosity. Evaluation of this system is currently underway.

Keywords

Haptics, Collaboration, CSCW, Cursor communication

INTRODUCTION

Synchronous shared editors provide a canvas on which multiple distributed users can simultaneously create content, for instance a shared whiteboard or textual document [1, 13]. Despite the prevalence of full duplex audio and video links in implementations of these systems, communication between collaborators still occurs in a deprived environment. A person is removed from the rich multi-sensory environment of the real world and required to work in a complex, often social, setting through the primitive communicative medium of a window, or several windows, on a screen.

One of the most critical deprivations in these environments is that of the awareness [5, 15]. Gutwin *et al.* [9] define workspace awareness to include:

"…knowledge about who is in the workspace, where they are working, what they are doing and what they intend to do next."

Awareness refers to the background, low fidelity, knowledge of the positions, actions and intentions of other people. In real world interactions we gather this information through casual glances at other workers, our peripheral vision, or through the sounds others make as they work. We gather awareness information from the world around us in a host of subtle and sophisticated ways and weave this rich tapestry of information into a background picture of what, and where, work is going on.

Coupled strongly to this concept of awareness is that of observed attention [11]. This refers to the ability to know what another person is focusing on or referring to simply by observing their behaviour. This ability, typically characterised in the real world by the ability to see where someone is looking or pointing, makes talking about complex information simpler by providing a straightforward way of ensuring all participants are referring to the same object.

Information pertaining to gestures is also beneficial. Gestures in communication are of two types. Firstly gestures to aid the flow of a conversation, for instance eye contact and secondly bodily gestures, typically of the hands or arms, to illustrate, or re-enforce, the information presented in the conversation. Eye contact is important in conversation not only because it aids token passing but also because it is the medium for the transmission of a large amount of important emotional content [12]. Tang & Minneman stress the importance of bodily gestures [17]. In observational studies of several group drawing activities they concluded that hand gestures are used regularly and productively in groups to :

"…act out sequences of events, refer to a locus of attention, or mediate their interaction…."

It is clear that gestural information of both kinds is important in communication.

Many solutions to address these issues have been put forward. Typically they involve trying to enhance one of the existing communication channels. For instance video can be improved if it allows participants to maintain eye contact [11]. Non-speech audio feedback has also been shown to be effective [8]. A variety of on screen graphical widgets, such as telepointers and radar views have also been shown to help reduce these problems [9]. Telepointers are local cursors representing each remote user. They allow basic graphical gesturing and provide some measure of awareness information. Radar views provide a small map of the workspace including a small telepointer for each user.

In this paper we present a novel approach to address these issues in the form of the relatively unexplored area of haptic communication. Although there is little work on this topic, the work that does exist is promising. Brave & Dahley [2] state:

"Touch is a fundamental aspect of interpersonal communication. Whether a greeting handshake, an encouraging pat on the back, or a comforting hug, physical contact is a basic means through which people achieve a sense of connection, indicate intention, and express emotion."

The majority of work on haptic communication has reflected this statement and focused on intimate interpersonal communication.

Perhaps the first communicative haptic environment was Telephonic Arm Wrestling [18] which was an art exhibit consisting of a pair of spatially separated robot arms which allowed two remote users to arm wrestle with one another. Several devices have been developed on a similar theme. The shaker in Feather, Scent and Shaker [16] allowed users to shake a device in their hand and have this represented as vibration in another users coupled device. The Bed [4] attempted to create a distributed bed and used haptics to create a sensation of the remote partner breathing. inTouch, [2, 3] is a device consisting of three rollers. Moving a roller causes a similar movement in a connected device. This provides a richer feedback than the previous systems as each roller can be manipulated, either clockwise or anticlockwise, independently of the others. These systems are characterised by a lack of reported evaluation of any sort.

Perhaps the most sophisticated device in this area is HandJive [7], which was developed as a toy to support people's desire to fidget when listening to a group presentation such as a lecture. It consisted of a pair of cylinders, joined together at the centre. Each cylinder could rotate around this joint to lock into one of five discrete positions (including straight). A change in position of the device was reflected in other coupled devices. HandJive differs from inTouch in that a pair of users could only move the device along opposite axes, meaning that users could not fight over the position of the device. The researchers suggest that two users could co-operatively construct "dances", or perhaps play simple games using the device. This device was developed iteratively and although no formal evaluation took place the authors report that users of the various prototypes were positive about the device and the interactions that it afforded.

It is possible that haptics can have more impact than simply acting as a conduit for interpersonal communication. Durlach & Slater [6] speculate that the sense of touch may be vital to the sense of presence that users perceive in Collaborative Virtual Environments (CVEs). They reason that the ability to feel objects or other users would enhance feelings of interaction and direct manipulation which have been linked with an increased sense of presence. They also refer to touch not being a "distance sense" – if we are to feel something it must be close to us, making a simulation more compelling. Finally, they suggest that users are unused to receiving illusions of touch and are continually bombarded with artificial visual and auditory stimuli, and therefore haptic simulations are more likely to draw users in and increase their subjective experiences of presence. This last effect would obviously hold only while haptic simulations are a rarity.

In a companion paper to the one described above Ho *et al.* [10] discuss how both performance and a sense of "togetherness" are increased with the addition of haptics to a simulation of the physical task of co-operatively steering a ring along a wire. While these results were statistically significant, they were over a small sample of users and were based on an unvalidated questionnaire. Furthermore the ecological validity of testing user performance with and without haptics in a physical task is questionable. The authors admit that this work is non-conclusive and ongoing.

The sum total of this research is that, while little of it is formal, it does seem that haptics can be advantageous to communication. Observational reports in a number of papers suggest that touch does enhance a users sense of interaction and presence. Users enjoy the experience of communicating through touch in a variety of situations and feel confident interacting with one another through this modality.

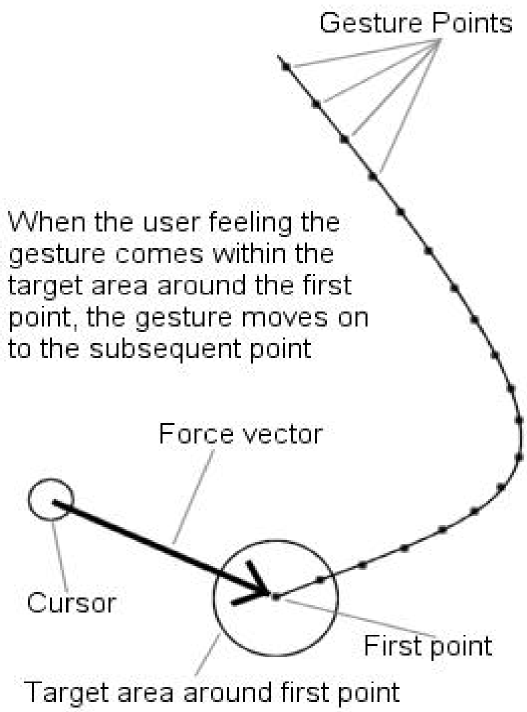
HAPTICS IN SHARED EDITORS

Given the discussion of some of the problems of shared editors – awareness, attention and gesturing – the question arises as to how haptics be applied to solve these problems. This paper presents the idea of enabling haptic cursor interactions between collaborators. Telepointers are transformed from being a simple graphical representation of position to physical avatars in the virtual space that can haptically influence one another. Five types of interaction between these avatars have been implemented.

Firstly, the telepointers can push one another around the workspace. As one cursor encroaches on another both can feel a force pushing them apart, or if one cursor intersects another at speed then the other cursor will be pushed away. We hypothesise this would be used as a warning, for instance if a user was about to perform some disastrous action another user might attempt to push the first user aside in order to prevent this. Another potential use would be to catch another user's attention, the remote equivalent of a tap to the shoulder. This interaction is reminiscent of others in the literature – for instance both the arm wrestling simulation [18] and inTouch [2] are basically mechanisms that allow distributed users to push against one another. In this instance, however, the pushing simulation is much more complex, as it is embedded within the context of a spatial workspace – to push a user you must first locate that user, and as you push them they can retreat away from you. Currently the push effect is implemented with each cursor being represented by a frictionless sphere. A consequence of this is that it is difficult for cursors to push each other uniformly; they tend to slip and slide off each other. A more complex haptic simulation, including friction, or possibly even an attractive force between cursors involved in a push interaction might prove more useful.

Secondly, to extend the technique of gesturing with telepointers, a telepointer can haptically take hold of another by moving over it and depressing a button. Once held subsequent movements are played back haptically to the other cursor until the button is released. This operation has the effect of grabbing a pointer and then making it follow your path. While this is far from directly analogous to how gestures are perceived in reality, it does considerably extend and make concrete the basic gesturing function of telepointers. You can firmly and interactively transmit a complex spatial pattern to a remote user, without words.

Figure 1 - Haptic Gesture.



There were some problems in implementing the gesture. The basic algorithm involved storing key points along the path of the gesture, based upon the distance of the current point to the previous key point. This distance was small, typically within 5 mm, to maintain the fidelity of the gesture. When the gesture begins an attractive force towards the first point in the gesture is applied to the user. The magnitude of this force increases with the range from the user to the point. When the user comes within a certain target range of the point the focus of the gesture moves on to the subsequent key point. Again to maintain the fidelity of the gesture this target range was kept small: 1 cm. This procedure iterates for all the points in the gesture. This is summed up in Figure 1.

However, we noticed that using this system users experienced difficulties – they became lost and unable to follow the gesture. We attributed this to the fact that forces of attraction used are relatively weak and become weaker as a user approaches a target area, making it difficult to locate these areas. There were several solutions to this problem. As we had mapped larger forces to greater distances we did not want to simply increase the magnitude of the forces when users became close to a point. Nor did we want to increase the size of the range at which a user is said to have reached a point as doing this would reduce the fidelity of the gesture – small perturbations would not be recorded. We also felt that it would be easier for users to detect changes in the direction of a force rather than just its magnitude.

To achieve these goals we smoothed the gestures. As time went by without the user reaching the currently active key point in the gesture the target area around that point would increase. Eventually it would encompass the user, at which stage the simulation would turn it's attention to the subsequent point in the gesture, with a small active range once more. Moving the simulation along the path of the gesture even while the user remains stationary means that the magnitude and direction of the force applied to the user will continually change. A further consequence of this is that if a person ignores the forces from a gesture then eventually all they will feel is a force to the last point of the gesture – the details would have been smoothed away. This algorithm has the benefits of initially presenting the user with an accurate representation of the gesture and then gradually reducing its resolution. In this reduction of resolution it also ensures that a user is presented with vectors of varying magnitude and direction while remaining on the gesture's path. The algorithm also only reduces resolution as it needs to – if a person begins to follow the gesture closely after losing it for a short time, the resolution will increase once more. A temporal aspect to the gesture is also added. If you ignore the gesture for long, it will slowly lose detail and eventually vanish.

Finally, this gesture effect was further enhanced to factor in the speed of the user recording the gesture. The force applied to the user receiving the gesture was varied according to the speed at which the person recording the gesture was moving, above a certain minimum. This allows users to highlight or emphasise certain parts of a gesture by varying their speed.

The third interaction between the telepointers is designed to provide some simple awareness information. The resistance to movement of the workspace is made to change when another user draws near to your position. Or alternatively, if you are stationary when another approaches, a small vibration is applied. This provides a haptic proximity sense and is analogous to the physical sensation of presence perceived when close to another. While the information content of this effect is low, for instance it will not help determine who is approaching, nor from what direction they hail, it is hoped to have the advantage of being obvious while remaining unintrusive.

The remaining two communicative interactions are focused towards the awareness problem of being unable to locate other users in the workspace. Previous work on haptics has shown that it can be useful in targeting tasks [14]. Finding other users in a canvas is fundamentally a targeting task. In accordance with this a locate effect was implemented which allowed users to activate a homing force on their cursor which would tug them towards another user. This force is applied at two levels. Initially a small force is applied, which allows a user to determine in what direction another user is located. After a brief time this force is increased to actually guide the user towards the other's position. The final interaction is an inverse version of the locate effect. This grab interaction allows users to turn on a homing force which pulls all other users in the workspace towards their position. This allows a user to request other users to come to some location in the document without being burdened by having to describe that location. It was hoped that these two effects would facilitate easier navigation and co-ordination between users in the workspace.

A final consideration in the design of this haptic communication was how intrusive it could be. A user working on a diagram, for instance, would probably not appreciate the application of arbitrary forces by other users. The push, gesture, and grab interactions allow a user to haptically influence another user with intrusive forces and the grab interaction in particular does this without any associated visual feedback. Modes are a potential solution to this problem. Three modes are suggested – working, communication and observation. In the working mode a user can interact with the canvas and can create content, but cannot be haptically influenced by another user. In the communication mode, users cannot interact with the canvas but have access to the haptic communication. In the observation mode, users can neither communicate haptically nor access the canvas. In our current use of a two-dimensional canvas and three-dimensional haptic device (the PHANToM from SensAble Technologies), these three modes are mapped to the z-axis of the device. Closest to the canvas is the working mode, beyond that the communication mode and, furthest away, is the observation mode. We feel that this mapping supports the physical metaphor of the canvas. You must be on the canvas to work, near the canvas to interact with other workers and when far from the canvas, you can simply watch.

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