Interaction in motion:

Augmented Telepresence as a Tool for Immersive Dance Experience

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ABSTRACT

The paper explores the use of interaction technologies in the domain of dance and attempts to visualize a future tool to complement current applications. We begin with a review of various tools and technologies that have been used within the domain in the past and make a projection for how interaction technologies could develop in the coming decade. We then present a concept of a tool for social dance, '*disDans*', that utilizes the modalities of touch, vision and hearing to provide an immersive experience. It allows users who are not physically present in a given space to dance together, and be able to touch and feel the other, as if present there. In the end we also discuss challenges and limitations to the proposal.

Author Keywords

Telepresence; Dance technology; Augmented Reality; Interactive Skin; Smart Glasses; Smart Fabric;

INTRODUCTION

Dance, or the act of moving your body to music, is one of the most spontaneous and natural reactions of the human body. It is also a way to express your emotions and communicate. Primarily, dancing is a social activity and thus requires two or more people to interact, and in that process their bodies also come in contact. But what if your partner isn't physically present in the same space? The paper explores this scenario to visualize how one can see, hear, touch, feel and interact with a partner who isn't physically present in the same room. How does one feel the connection and the intimacy, especially in the context of social dancing? Today, technologies exist which allow us to capture, reproduce and communicate motion, in ways which were previously not possible. Inexpensive sensor suites such as the Microsoft Kinect have already been adapted and used for dance performances and research, and new innovative applications continue to emerge. At the same time and as predicted by Azuma[1], augmented reality and telepresence technologies are maturing to the point that it is becoming feasible to interact with these virtual representations in real-time over vast distances.

Paper submitted to SIDER '14
Royal Institute of Technology, KTH, Stockholm, Sweden

The question that this article will examine is how interactive technologies for dance could continue to develop in the coming 10 years. We will present a sketch of one concept for a future telepresence system for teaching dance remotely that uses the modalities of vision, touch and hearing to increase immersion for its users.

RELATED WORK

Dance technology

Before the advent of information technology, choreographers were using self-developed written notation systems to communicate and document their work. The Labanotation system[4] that was developed by Rudolf Laban in the 1920s eventually became the most commonly used notation system for dance and human movement. Common to these written systems was that they assigned symbols to different body parts, and documented how they changed their position, or moved, over time. More recently, attempts have been made to create digital representations of the same thing. For instance, Kojima et al. created LabanEditor[3], an application for creating and editing Labanotation choreographies that could also translate the same movements to computer-generated 3D scenes.

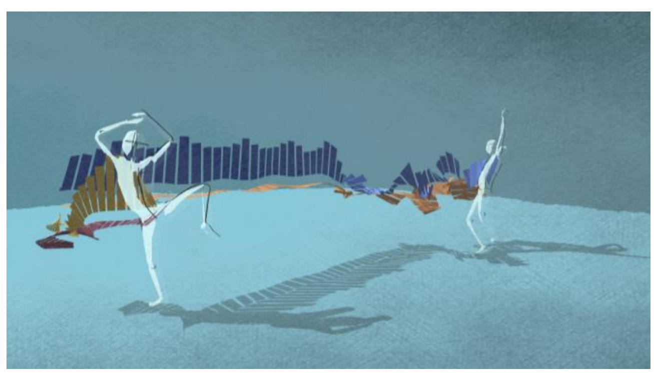

Figure 1. 3D visualization from the Motion Bank project[7]

Another approach has been to utilize motion capture technology to directly record the movements of the dancer and reproduce them digitally. Yang et al.[10], explored how such a system could be combined with virtual reality (VR) technology to teach dance and sports, using what they termed the "ghost" metaphor. A student with a head-mounted display (HMD) would be able to view the teacher's pre-recorded performance of the steps from different viewing angles, in order to replicate and learn them. The authors found this method to be as effective as conventional methods for teaching motor skills. Further developments were made by Hachimura et al.[2], who used Mixed Reality technology (MR) to overlay computer-generated images onto a live camera feed, thus merging representation and reality.

In the last few years, sensors have improved drastically to the degree that it has become possible to accurately capture motion in 3D using relatively cheap infrared depth cameras. A good example of this new technology in use is the Motion Bank project[7], which a collaboration between professional choreographers and researchers, aiming to document dance movements and visualize them in digital patterns that can be easily reproduced or analyzed later. Using a studio setup with Kinect sensors and cameras, the Motion Bank team records the detailed body movements of the dancers on a stage. Here, no special suits or equipment is required on the part of the dancers, which drastically increases the usefulness of the technique, if compared to the previous, more intrusive motion capture technologies.

Telepresence

The concept of telepresence has been an active field of study within HCI since the early 1980s. Long before the technologies themselves were available, researchers such as Minsky[6] and Steuer[8] imagined future humans using technology to experience and influence environments physically remote from themselves in intuitive ways. Most important for this was the concept of presence, which Steuer defined as the "sense of being in an environment". Telepresence is thus the "experience of presence by means of a communicated medium".[8] Subsequent research in the field has focused on cognition, mental processes and other factors affecting the user's sense of presence in technology-mediated systems.

Recently, researchers have explored the feasibility of real-time 3D telepresence applications using commercially available depth sensors like the Microsoft Kinect. For instance, the Microsoft research project *Immersive Telepresence* developed an application that allowed users to take part in virtual meetings where all participants were captured separately and displayed as if they were in the same room, even maintaining mutual gaze. Maimone & Fuchs[5] successfully implemented a real-time 3D teleconference system that used several connected Kinect devices to capture an entire room. The remote participants were shown on a display wall that tracked the position of the viewer and adjusted the angle of view accordingly. This gave the users the impression of being separated only by a window or "hole in the wall", increasing their sense of presence.

FUTURE PREDICTIONS

Based on the current state-of-the-art of research within this area, we see a number of trends that may develop further in the coming 10 years. For one, motion sensors are becoming smaller, less noticeable and more precise and ubiquitous. Even today, it is no longer necessary to use cumbersome motion capture suits for capturing complex dance motion.[7]

Secondly, technologies for Augmented Reality and immersive 3D are quickly maturing, with commercial products already being released to the public (see *Occulus Rift*, *Meta SpaceGlasses* and *Google Glass*). These could be employed for the next generation of telepresence applications.

Adding a tangible element to this, is the concept of wearable computing and smart clothing. New technologies such as electro-active polymers (EAP), i.e. synthetic polymer sheets which exhibit a change in shape when stimulated by an electric current, make it possible to simulate how muscles contract and expand. Attempts are being made today to make fabrics with these properties, which could give the wearer the sensation of pressure and contact.[9]

Combining these trends, we predict that future telepresence applications will focus on enhancing immersion and the user's sense of place and presence by using multiple modalities. In the context of dance, this means that virtual dance, like real dance, will be an activity that engages all the dancer's senses.

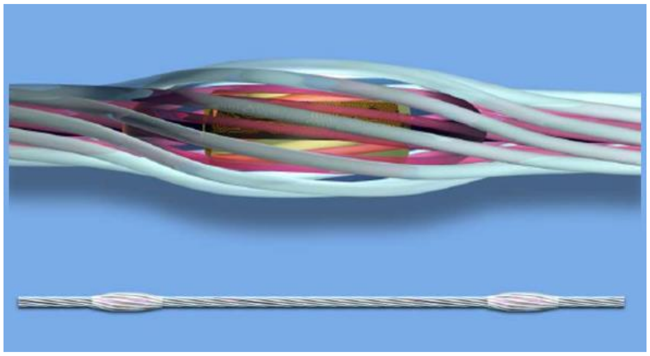

Figure 2. Electro-active polymer yarn with embedded actuator-sensor pair[9]

SYSTEM OVERVIEW

The *disDans*, referring to 'distance' and 'dance' and thus, dance at a distance, is a combination of various subsystems that augment the current methods of telepresence and attempt to provide an immersive experience by merging the modalities of vision, touch/feel and sound. At the heart of the proposal, is the concept of Augmented Reality using smart glasses. The glasses are used to project virtual dancers in the environment around a user. It is with these avatars and holograms that the users would interact and dance. These visual projections are further augmented by 'surround sound' audio instructions. The last layer of the immersive experience adds the element of touch using smart fabric costumes. *disDans* would map the area of contact between the two dancers at every point during the choreography. This mapping of the contact area is projected on to the costumes of the dancers, which are made out of electro active polymer (EAP) yarn. Each thread of the yarn is embedded with a number of sensor-actuator pairs, which control the polymer threads to expand or contract as per the mapping projections. A single sensor-actuator pair controls a specific length of the thread and thus, the smaller the length of the thread per pair, the higher the accuracy and better the experience.

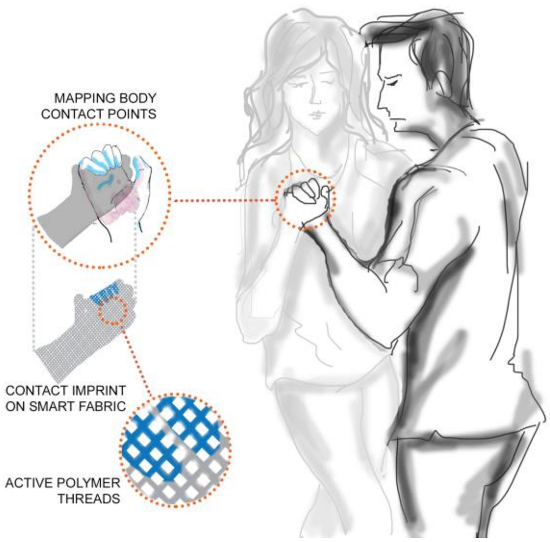

Figure 3. Real-time mapping of contact points and their projection on the smart fabric

APPLICATIONS

Multi user experience scenario

In the first case, we have two users using *disDans* to dance together, while not being physically present in the same space. Thus here, we make use of real-time motion capture and relay, simultaneously. In addition to the system requirements (as described in the earlier section), this scenario is realized with the help of motion capture technology, using Kinect sensors. The body movements of the two dancers are recorded and converted into 3D holographic representations. These representations are projected as virtual dancers, visible to the other user through his AR glasses. It is with these projections that the users dance. The haptic feedback and the touch sensations are also defined by live body contact mapping using the sensor-activator pairs.

disDans makes it possible for users to interact with each other just for fun, or for dancers and choreographers to collaborate on projects over long distances. It also acts as a tool to record and document one's choreography, which can be easily reproduced later. As a second case to this scenario, we can have multiple users as well. For example, a dance teacher can teach a number of other students, who may as well be at different places, simultaneously. The teacher can easily switch the display system from a single display to a multiple display (a virtual classroom), which will make it possible to see all the students together and thus provide them with necessary feedback.

Single user experience scenario

The second case is a simpler version of the first, which does away with real time projections. In this case, the single user dances with avatars that have a pre designed animation (dance choreography on specific soundtracks). The user shall be able to download these choreographies and use them for private lessons. A pool of such animated choreographies can be developed which will keep on growing as per the demand. This case is useful where it is difficult to arrange live telepresence or simply as a single player game tool.

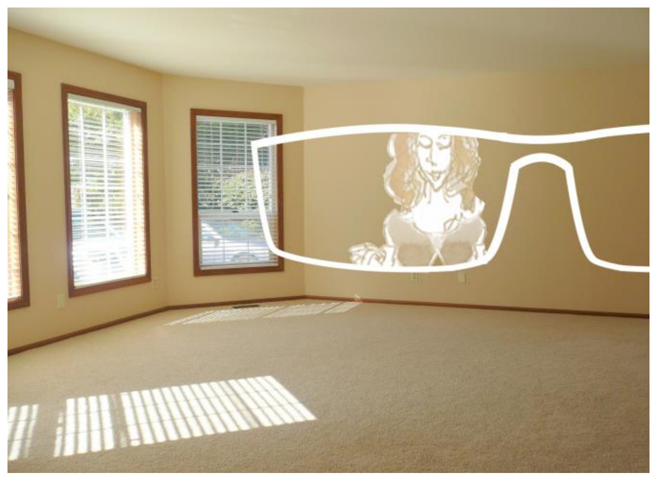

Figure 4. Virtual dance partner as seen through the Augmented Reality glasses

Extension

The setup may be extended and used to develop an online social dance network where each user shall have a customizable profile. As the user completes more classes, he is awarded skill levels, starting from the occasional, and beginners to the advanced dancers. Feedback and reward systems would promote users to take further classes and gain confidence. This portal shall act as a platform where all the dancers can come together, interact, share experiences and learn from each other. Regular social dance events could also become a part of the community.

DISCUSSION

The augmentation of the technology of telepresence and intangible virtual representation by incorporating the tangible element of touch holds a lot of potential for research and development, and can prove to be a great tool in various applications. For example, doctors sitting in metro cities, would be able to reach patients in remote parts of the world and students could have access to real-time personalized lessons in various fields like martial arts. It would allow mute and other differently abled people a different method to communicate and express themselves, and on a more subtle note, it would allow users to touch and feel their loved ones, sitting miles apart.

Although the concept is grounded in state of the art interaction technologies and future predictions based on current research, there are a few points worth discussing. While dancing, one not only feels the touch of the partner, but also the weight in terms of a resistive force (a push or pull). Thus, simulating touch using pressure on the skin with interactive fabric only captures one part of the experience. It is possible that the proposed augmentation may still be strong enough to overcome the lack of the factor of 'force', but on the contrary it may also only make its absence more pronounced. An interesting field of study in the future is thus the minimum dimensions that are required to turn a simulated virtual environment 'real' for a human mind.

Adding on to the above, some social dance forms require one of the dancers to hold or lift the other, in which case, movement of one is dependent on the other's 'hold'. The inability of a strictly virtual system to satisfy this makes *disDans* unsuitable for multi experience scenarios in certain social dance forms, and probably also for the more advanced levels in some others. Although *disDans* is primarily conceptualized for beginners and middle level dancers (in a multi user scenario), and for advanced dancers (in single user scenarios), excluding the scenarios that depend heavily on 'hold', it would be interesting to know how this new dimension could be integrated, if at all. Another area associated with the concept worth studying, is the stability of the 3D animated avatar and projection overlays on the actual field of vision and how the spatial visualization ability of the user responds to it.

Conclusion

We have briefly reviewed the current state-of-the-art within the fields of dance technology and telepresence. We then presented the concept of *disDans*, a future tool for social dancing that brings together users who are not physically present at a given space. It combines the technologies of motion capture, augmented reality, telepresence and electro-active polymer clothing to create an immersive experience. In the process, we provided two possible scenarios to elaborate the utility of the proposed system. Finally, we discussed further research potentials, the implications and also the current probable limitations of the system.

ACKNOWLEDGMENTS

We would like to thank Ylva Fernaeus, Associate Professor at the department of Media Technology and Vincent Lewandowski, PhD student in Human Computer Interaction, both at KTH, Royal Institute of Technology, Sweden.

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