Full-Body Interaction in a Remote Context: Adapting a Dance Piece to a Browser-Based Installation

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ABSTRACT

This paper describes the process of adapting a dance piece to an interactive installation. To cope with COVID-19 restrictions, the installation runs on a browser, allowing for remote access, and is based on camera tracking of movement. We describe the adaptation of the dramaturgy, with a primary focus on translating the interaction design aspects from the performance to the browser-based installation. We invited five users to test our working prototype, and we report on their feedback. This paper offers insights on how to adapt a dance piece to an interactive browser-based installation. We also highlight the benefits of using machine learning for motion capture in this context. Finally, we identify the potential of using interaction design with sound for embodied perception.

CCS CONCEPTS

• **Applied computing** → **Media arts**.

KEYWORDS

Full-body Interaction Design, Web Installation, AudioVisuals

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1 INTRODUCTION

In this paper, we present the adaptation process of an existing dance piece to an interactive browser-based installation. The original performance piece, Connection Retrieval, was centered on technology-mediated connections between two dancers; the interactive soundtrack of the piece was based on full-body tracking of the dancers. COVID-19 restrictions led to a rethinking of the piece. We decided to adapt it into an installation, that we entitled Digital Connection Retrieval. It employs full-body interaction in the browser, using a webcam to track the user's movement, to manipulate audio and visual content. It applies a JavaScript-based machine learning model to assist in the body tracking process.

This adaptation led to the main research question of this study: *how to design an adaptation of a dance performance into a browser-based interactive art piece, using embodied interaction relying on machine learning?* Our hypothesis is that the users should be placed in the performance, allowing them to experience in the first person the main dynamics that the original performance wanted to convey: in this case, the idea of connection between humans through technology, and the role of sound in this connection. Additionally, we posed a secondary research question: *what is the potential for engagement in a typical laptop setup, compared to a more traditional gallery-type of installation, with a larger screen?*

2 BACKGROUND

The use of technology in dance is a vast field. A recent study identified the related wishes and needs from the dancers' perspective [11]. In this context, many researchers have relied on Laban Effort theory [9] to extract information about the body. An important example is the development of a machine learning algorithm that relies on the Laban movement analysis [15]. Recent research has further investigated machine learning, to create prototypes using new interactive tools for embodied interaction [14].

There is also some overlap between research in sonic interaction design and full-body interaction. The field of sonic interaction design "explores ways in which sound can be used to convey information, meaning and aesthetic and emotional qualities in interactive contexts" [4]. Within the frame of sonic interaction design, some notable examples on embodied interaction emerged, spanning from sensor-based performances [16] to musical gesture [6]. Embodied interaction design for movement and sound has been widely used in performances, demos or artworks (e.g. focusing on social interaction [2], or transforming movement into music [13]). In this context, machine learning has been increasingly used (e.g. Wekinator enabling technology [3] and for gesture mapping [17]).

The adaptation of performative artworks into installation has a long tradition. For instance, Correia [1] discussed the adaptation from audiovisual performance to browser-based artworks. Masu

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Figure 1: Image from the original performance piece

et al. [10] proposed the adaptation of a music piece into a VR installation. There are few examples of dance pieces adaptation. For example, the dance piece "Dividual Plays" was adapted into an exhibition that "allows the visitors to explore and create their own body movements correspond with the experience of the dancers" [8]. Another dance piece was recently transformed into a VR environment, where users could explore different animated visuals and create their own choreographies [7]. However, the use of full-body interaction in a browser-based installation, based on a pre-existing dance piece, is still unexplored.

3 ADAPTATION AND DESIGN

3.1 The Original Dance Piece

The original dance performance, Connection Retrieval (figure 1), was authored by a professional choreographer (the second author of this paper); the sound designer of the original piece is the primary developer of the installation presented in this paper (the first author). The piece was developed under the scope of Moving Digits project (https://movingdigits.eu) and performed in Tallinn, Estonia and Düsseldorf, Germany.

In the performance, the forms of performativity were studied in technologically-enhanced circumstances, where the body is touched by, interacts with, and incorporates the effects of technology used to control different sonic components. Technologically-wise, the piece relied on a live motion capture system coupled with digital audio and video, building a multi-layered narrative in dialogue with the dance. Dance-wise, the piece relied on task-based improvisation, where tasks were used as guides to create movement and to connect to the other. Additionally, the dancers' embodied perception of the interactive technology was quite important, as the dancers had to filter the interaction through their kinaesthetic thinking, focusing inwards as in somaesthetic design [5]. In particular, as they were directly controlling the sound with the dance movements, they had to *learn to play*, and this affected their inner perception.

Dramaturgically, the piece creates an arch where two dancers on a stage progressively get more intimately connected throughout three scenes, evolving from noisy sounds to harmonic ones. Each scene had a different interaction with the sound and a different choreographic task; the details are described fully in [12]; we present here the main elements on which we based the development of the interactive installation.

The **first scene** used a *crackling* sound as the main sonic interaction design element. The two dancers are relatively far from each other, inhabiting their own areas on stage; the only connection is that the second dancer imitates the first. The main instrument in the **second scene** was a *percussive* sound triggered by the dancers. The two dancers are spatially closer, in a shared space with eye contact but without physical contact. The **third scene** was centered around a *cello drone* sound. The two dancers finally get to share an intimate space, reciprocally influencing the movement and therefore reaching a close connection.

3.2 Brainstorming and Design Aims

To plan the adaptation of the piece into an installation, we conducted a brainstorming session, including the choreographer (the second author), the sound designer (the first author) and two dancers. The main point we had to solve was how to **present the overall dramaturgy in a non-linear way** while maintaining the core idea of building up a connection between bodies. In order to address this issue, we developed the following strategies.

In the original piece, the connection between the two dancers gradually builds throughout the entire piece, with sounds progressively changing from noise to harmonic timbres. In the installation the user should be able to explore different dramaturgical moments. Therefore, aiming to **facilitate a sense of connection between a user and the dancer**, we decided that users would trigger different recordings of the dancers' movement using similar gestures to the dancers. We then recorded these videos. The idea of effort and gentleness of the movements (in the video and of the users) is derived from the Laban theory on movement effort [9].

At the same time, we aimed to **enable the user to partially experience the change of embodied perception through sound** that characterized the dancers' experience while performing the piece. Therefore, in the installation, we decided to create a situation where the *user's body movement* influenced the *manipulation of the sound*, allowing them to experience a similar technologically-mediated embodied perception to the one of the dancers in the original piece. We decided to use the same sonic approach as in the performance – that is: the same type of sounds; the same meaning of sounds; and a similar expressiveness of the interaction – towards building a common dramaturgy. The details about the video and the sound design are provided in the next section.

3.3 Design and Implementation in the Browser

We decided to implement Digital Connection Retrieval in JavaScript (JS) and HTML so that it could entirely run in a browser with a straightforward setup, to make it easy to set up in light of existing COVID-19 restrictions. The only requirements would be a computer with a webcam. We implemented the installation using p5.js [1], a framework designed to support interactive audiovisual content in web development. As the primary interaction tool, we decided to rely on a webcam, as this is a standard device and could ensure that more people would try it. To track the body of the user, we used posenet.js [2], a JS machine learning model trained to track people in video streams. The use of the library with the machine model trained to recognised human poses allowed us to track the body without an external motion sensor (for instance, a Kinect), while

[1] p5.js (https://p5js.org) is a JS framework based on Processing (https://processing.org)
[2] PoseNet (https://ml5js.org/reference/api-PoseNet/) is a full-body tracking function of the ml5.js library (https://ml5js.org)

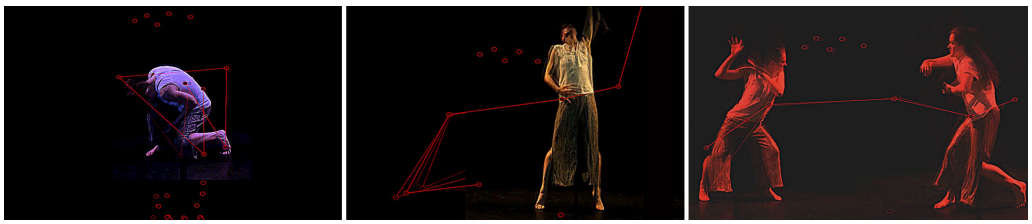

Figure 2: Frames from the installation videos: Left - Crumbling video; Center - Effort video; Right - Gentle video

at the same time it gave more flexibility in light conditions when compared to traditional computer vision approaches.

After the first tests, we realized that it would be essential to give visual feedback to the user about what s/he is doing, so we decided to overlay a skeletal avatar to the videos, (as in figure 2). The simplification of the *avatar* represented as a very minimal skeleton was also driven by the design choice of focusing on the proprioception, facilitating user to focus inwards (similarly to the somaesthetic design perspective by Höök et al. [5]). An interesting element that we observed while developing the installation was that the small latency of the app resulted in enhancing the proprioception of one's body form and gesture, as a person is moving with a past image of oneself: it creates a duet with a micro-historical reflection of the body of the user. We also decided to use the simplified avatar representation as a mediator between the user, the sounds, and the video: the user interacts with the avatar, and the avatar is mapped with the audio and visual material. Therefore, the avatar facilitates the interaction with the sound.

To develop the **design aims** identified before, we implemented **specific mapping strategies**. Below we detail the three main interaction possibilities that corresponded to the three main instruments/scenes of the original piece.

3.3.1 Crackling sound - Crumbling video. The crackling sound and the crumbling video would be triggered when the user is in a **"closed" position**, exploring his/her own intimate space, meaning that the hands have to be close to each other and near the torso. When the threshold is reached, one of the crumbling videos would be randomly selected and reproduced along with the crackling sound. The videos represents dancers' crumbling movements starting from a static standing position, and are reproduced in the central part of the screen, overlapped with the user's skeleton. The crumbling videos are reproduced only one at a time, so the dancer would always be "alone" on the screen (figure 2, left). We located these videos in the central part of the screen, hoping that this could facilitate a connection between the user and the one dancer, (looking for) intimacy, by exploring intimate spaces.

3.3.2 Percussive sound - Effort video. The videos and sounds for this section are triggered with **arms pointing upwards** (figure 2, center). The movement in the video expresses effort with dancers raising of one arm above the head. This gesture resembles the idea of effort. In this case, each hand corresponds to a different video and a different percussive sound, so that it is possible to create different connections between them alternating the hands. The corresponding videos contain movements that are similar to the gesture needed to trigger it (with dancers raising their arms).

3.3.3 Cello sound - Gentle video. This interaction possibility would correspond to the exploration of the outer space of the body. The cello sound is triggered when the **hands of the user are at a distance larger than the shoulder width**. The cello volume is proportionally mapped to the distance of the two hands; the further apart the hands are, the louder the cello is. The same strategy is applied to the video (figure 2, right) as the alpha channel of the video is also proportional to the distance between the hands, with minimum transparency in the maximum distance. In this case, the video resembles the kind of caressing of the final part of the performance; there are always two videos of dancers, and the movements in the video are gentle. Therefore, it suggests a connection between the two dancers with the user avatar in between. Their visibility, hence the multiple connections, grow stronger proportionally to the user exploration of outer space (by opening the arms).

4 EVALUATION AND RESULTS

In order to test our installation, we invited five persons (four researchers and one musician, three male and two female) to explore it (figure 3). We asked every participant to test it twice, first with a large screen and a projector, then with the screen of a small laptop computer. The former correspondents to the typical setup of an interactive installation, the latter was meant to assess if it could be successfully experienced by users with their own computers. Each participant went through the same procedure: 1) they were welcomed and briefly introduced to the work; 2) they could explore the installation with the large screen for as much time as they wanted; 3) they were interviewed about their experience; 4) they were asked to try the installation again, this time on a laptop screen; 5) they were interviewed again with a focus on the distinction between the two experiences. The questions in the semi-structured interviews primarily focused on the connection users established with the installation. We coded the interview data and clustered it according to similarities. We report here the main points that emerged.

Sonic exploration. Three participants focused on the exploration of the sounds. A participant started his exploration of the installation by systematically exploring the different types of sound corresponding to the body movement. In part of his exploration, another participant used his body almost as a musical instrument, with musical intents, while interacting with the installation.

Connection with the videos. One participant perceived that the dancers were mimicking what he was doing and found this interesting. Another participant related to the visual in the opposite manner, as she was actually mimicking the different poses and movements of the recorded dancers. In these two cases, the participants experienced a connection with the dancers.

Screen comparison. All the participants' statements about the possibility of running the installation on a desktop computer were aligned: it was usable but less attractive. In particular, one participant felt more connected with the dancers in the bigger screen.

Figure 3: One of the participants testing the installation

5 DISCUSSION AND CONCLUSION

In this paper, we presented the process of adapting a dance piece to a browser-based interactive installation. The installation runs on a browser, using a common computer with a webcam.

The primary contribution of this paper is the overall **adaptation process**. We suggest that an important approach to design mappings strategies is to account for the original dramaturgy. In this paper we followed this approach for each scenes of the performance, transforming them into three distinct mappings and sonic interaction designs that translated the original concept.

This paper also provides a case study on how to **present interactive art remotely** and overcoming COVID-19 limitations. The possibility of running the installation entirely from the browser can also be useful in other scenarios, where visiting an exhibition can be unfeasible (for example, due to health or accessibility conditions). However, the hypothesis of running it at home on a small personal computer may not be ideal, at least without an external screen. Results demonstrated that the larger screen led to a higher feeling of connection with the dancers.

This study also demonstrates **the potential of combining machine learning for more robust motion tracking** in a browser with a webcam. There has been an increased interest in machine learning for new creative possibilities (e.g. [14]), and our research presents a case study in the use of these techniques to reinforce the portability of motion tracking to more challenging scenarios (e.g. ´domestic´ usage with varied lighting conditions).

This paper also discusses **technologically-mediated embodied perception through sonic exploration**. This is not a complete novelty, as it also emerged in feedback from the dancers of the original piece [12]. However, the use of this approach to adapt an artistic concept of a dance piece into a browser-based interactive installation is novel. We believe that this paper can assist in adapting performance art pieces into interactive installations.

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