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(Choreo)-Haptic Experiments: Kinaesthetic Empathy and Non-Sighted Dance Audiences



Project introduction

The 'Haptic Experiments' project explores how blind dance audience members can use their hands to experience the dynamic qualities of live dance performances through their sense of touch. A prototype under the name *Choreo-haptic* was completed as part of the first phase of the project, which was funded by an AHRC Digital Transformations Research Development fund (Feb – July 2012). This includes a haptic pad, on which blind users place their palms and fingers in order to receive vibrations which aim to make them feel aspects of the movement, such as softness or circular patterns, while dancers perform live. The popular technology of Microsoft Kinect was used to track the dancers' movement and trigger vibrations in motors embedded in the pad that respond real-time to the data received from the Kinect. The *Choreo-haptic* has generated very enthusiastic responses amongst blind participants who tested it. The development phase culminated with a proof of concept, which will be

expanded both technically and conceptually within 2013-14, leading to a commercialisation phase. The research process was practice-led, and focused on to what extent haptic technology can support blind members of the dance audience experience effects of kinaesthetic empathy via their sense of touch, similar to those experienced by sighted members of the audience, who access the performance via their sense of vision. One of the main outcomes of the development stage was the realisation that in order for the haptic pad to be designed most effectively and have its maximum effect on the user, it should be treated as choreographic medium. This element will be pursued further in the next phase of development. Another outcome was the discovery that the *Choreo-haptic* device can be used as educational tool for blind children. The interdisciplinary research team included dance and education researchers as well as information technology specialists, all of whom were based at the University of Edinburgh.

Team

Dr Sophia Lycouris (Principal Investigator)
dance specialist – choreographer, Edinburgh College of Art

Wendy Timmons (Co-investigator)
dance specialist, School of Education

Dr Mark Wright (Co-investigator)
technology specialist, School of Informatics

Dr John Ravenscroft (Co-investigator)
visual impairment specialist, School of Education

Stathis Vafeias (Research Assistant)
motion tracking specialist, School of Informatics

Lauren Hayes (Technical advisor)
haptic technology specialist, Edinburgh College of Art

John Newing (participant)
visual impairment advisor, independent

Technical specification

a. Motion tracking technology: Microsoft Kinect

Technical Details: The technical setup for the Kinect consists of two different components: the sensing component and the control component. On the sensing side of the system, an RGB-D sensor is used, Kinect[1] from Microsoft, to acquire depth and color images from the scene. The sensor receives depth images of resolution 640x480 at a frequency of 30 hertz. The purpose here is to make an abstract representation of the dancer's motion, and this representation aims to capture both the large body translation movements in the scene and the change of body posture throughout the dance.

Algorithm Overview: The process flow chart has four basic processes that work in a serial scheme (fig. 1). In step one the input from the sensor and segment the body of the dancer is received, body segmentation is provided by the OpenNi[2] sdk. Although the OpenNi framework provides body skeleton information, it is not used since dancers tend to do complex moves and go into strange poses and the skeleton tracking fails to follow the dancer's body. To acquire the necessary feature information, the segmented pixels of the body are used, as seen in fig. 2, and the depth information provided for these features. The next step is to extract the features based on the body segmentation. Step 3 is where the mapping is executed, the features are translated into a signal of 30 intensity values between 0 and 255. Step four is the transmission of the data to the computer that controls the haptic device.

Features: To capture the spatial movement of the dancer a single feature is used, which is the centre of mass of the dancer's projection on the image plane. To compute the centre of mass, the central moments of the segmented 2D image are used and then the depth information is acquired that so the 3D physical space can be tracked. To capture the motion of the dancer, a different set of features is used, which are based on the convexity defects of the figure's outline. Such features are represented by the depth of the defect, what is the maximum distant point of each segment of the convex hull to the actual shape contour, and the position of this point in 3D space. In the case of arm extensions, the depth value increases and through correlation with the position of the defect, it becomes possible to capture which part of the body is moving, how rapid the movement is and how much it affects the body posture. The calculation of the contour is using the algorithm of Suzuki[3].

Mapping: While mapping the features on the 5x6 motor board, a simple scheme is followed. First the signal is localised on the board according to the 3D position of the centre of mass, which defines the focus point of the signal. Around the focus point, various motors from the largest 20 defects in the feature set are activated, according to the spatial relationship of the defect point and the centre of mass. The intensity of the vibrations are defined according to how much the motion affects the posture of the dancer. (by Stathis Vafeias)



(by Stathis Vafeias)

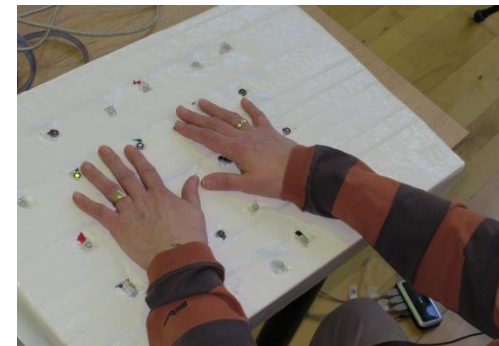
b. Haptic technology: vibrotactile motors and MAX/MSP programming environment (by L.Hayes)

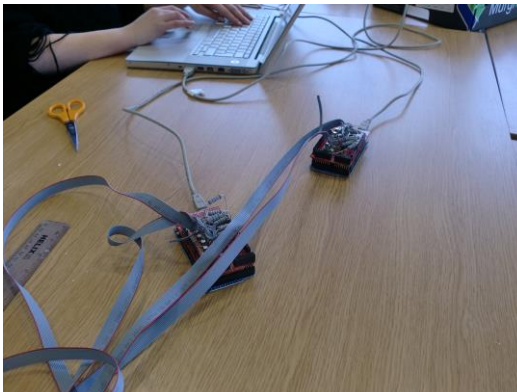
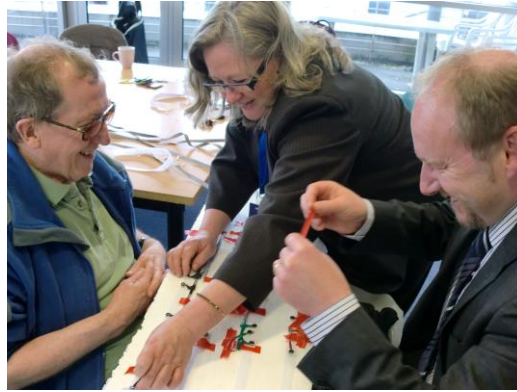
The motors embedded in the haptic pad are vibrotactile motors used in mobile phones (www.pagemotors.com).



The programming environment which supports the haptic pad is MAX/MSP. This is a graphical programming environment for music and media applications. In addition, Maxuino is used to enable communication with three Arduino Mega microcontroller boards from within Max. "Maxuino is a collaborative open source project for quickly and easily getting the Cycling 74 Software/ Max 5 talking to the i/o Arduino board. This allows Max to read analogue and digital pins, write to digital and PWM pins, control servos, listen to i2c sensors" (<http://www.maxuino.org/about>). "Arduino is a tool for making computers that can sense and control more of the physical world than a desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board." (<http://arduino.cc/hu/Guide/Introduction>). The code developed for this application receives OSC (Open

Sound Control) messages over a network from the PC which controls the Kinect, scaled between the range 0 - 255. There are 30 separate streams received, representing the 6x5 array of the haptic board (for more information on OSC, please see <http://opensoundcontrol.org/introduction-osc>). This data is rescaled between the range 0. to 1. and mapped it to 30 pulse width modulation pins of the Arduino boards. This enables a perceivable analogue increase in vibration intensity from nothing to full vibration. The maximum and minimum can also be adjusted to adapt to the users sensitivity. So far this has not been required. However, the scaling can also be adjusted logarithmically, to enable a more heightened sensation, which is required by users of older age, who have decreased sensitivity. The haptic device built for this application is an adapted version of the glove described in (http://www.nime.org/proceedings/2011/nime2011_072.pdf). It uses 30 motors, arranged in a 6x5 array. A more complex circuit was designed to allow the larger demand of several motors per Arduino board. Three versions of the haptic pad were developed, as a result of tests with blind participants who felt that the haptic feedback they were receiving would be more efficient, if the motors were placed closed together.





Originality – research question

The *aim* of this project is ***to investigate, if and how, the kinaesthetic empathy experienced by sighted dance audiences can be also experienced by blind dance audience members***. More specifically, this project explores the potential of using touch instead of vision in order to generate kinaesthetic empathy in blind dance audience members with the support of appropriate motion tracking and haptic technologies of low cost. One aspect of the **originality** of this project is that **it expands existing and very current research in the field of dance studies** (see Watching Dance project, led by Prof. Dee Reynolds at the University of Manchester between 2008 and 2011, which focuses on the role of kinaesthetic empathy in the viewing experience of dance audiences, , www.watchingdance.org) **to a new area** (blind dance audience members), and in doing so it aims at widening access to dance performance for a disadvantaged group.

The main research question explored in this project is: ***It is possible to generate effects of the viewing experience of dance (or aspects of this experience) without using vision?*** Following this, another aspect of the **originality** of this project is that it focuses on the experience of the viewer and, as a result of this, **the prototype of a haptic device developed in the first phase of this project was approached as a means to create an equivalent experience for blind audience members and not as a tool aiming to translate dance movements to vibrations for them.**

Rigour – process

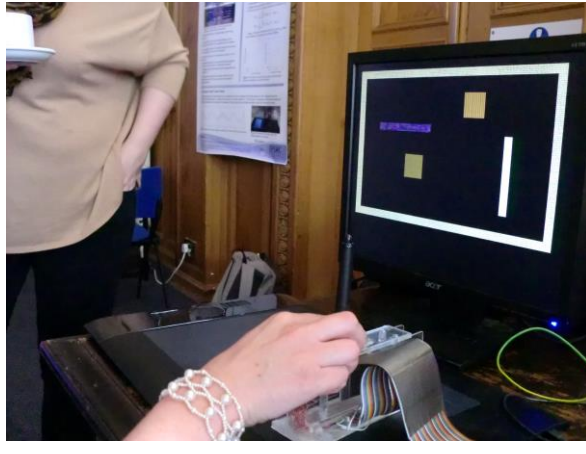
Two criteria determined the nature of the research process:

a) it was important to work towards developing a **non-intrusive technological device**. This was determined by the assumption that, during a dance performance, the performance space becomes a landscape in which the eyes of sighted audience members are free to wander on the basis of what attracts or keeps their attention. To generate an equivalent experience for blind audience members via touch, a haptic pad was necessary (instead of a glove, a suit, or even a haptic chair) to provide a haptic performance space in which the blind users' hands and fingers could also wander freely to find and receive appropriate vibrations. Through exploring further this idea during the project, it became clear that it was necessary to approach the haptic pad as choreographic space and the vibrations as choreographic medium in its own right.

b) the research process was practice-led. More specifically, a **choreography-led process** was adopted, in the sense that choreographic criteria determined the stages and parameters of the research process. My long-term choreographic interest in how the dynamic qualities of dance movement trigger effects of kinaesthetic empathy in sighted audience members determined the choreographic experience sought in an equivalent format for blind audiences. The aim was to capture in some way the dynamic qualities of the dance performance (or aspects of these qualities) and then

use this information to recreate an equivalent experience for blind dance audience members, which would allow them to 'feel' effects of kinaesthetic empathy. In this way, driven by a choreographic agenda, the project was designed to deliver a series of interventions offering to the participants something they had not encountered before, a dance performance experience specifically designed for blind audience members and based on the effects of kinaesthetic empathy. These interventions were delivered in workshops, in which participants of different age groups tested the device, provided feedback about its technical aspects, and commented on the experience, as part of unstructured interviews.

c) kinaesthetic empathy: it was difficult to investigate the specific ways in which kinaesthetic empathy was experienced by participants. In any case, specialists in this area have conflicting views about the specific ways in which observers experience internally the movement they observe. Some suggest that the observer feels as if they are performing the observed movement. Others argue that the image of the externally performed movement is generated in the mind of the viewer and triggers the sensation. Kinaesthetic imagination is also often mentioned. However, more recent positions which emerged from the research undertaken within the project Watching Movement (mentioned in the Originality section of this document) introduced kinaesthetic empathy as an **affective** phenomenon. This project is in line with this position, given that all participants reacted to the vibrations in some way or other, but there was no commonality of image or sensation between them.



Outcomes

a. effectiveness of the device: positive feedback was given by blind participants including references to movement types 'felt', such as tapping movement or circular movement. Positive feedback was also given by sighted audience members who tested the device facing away from the dance, and enjoyed concentrating on their sense of touch. Finally school children in the Royal Blind School used the device in pairs, one child performing movement and the other receiving/interpreting the vibrations on the pad.

b. concept: the idea of the haptic pad as a performance landscape evolved into the idea of the pad as choreographic space, and the vibrations as choreographic medium. This realisation determines the logic of the next phase of the research, in which different models of capturing movement will be explored separately from the exploration of the choreographic behaviour of the vibrations (or other types of haptic stimuli), with a view of combining the two elements at a later stage.

c. technical development: a proof of concept together with a physical prototype are now available to initiate conversation with industrial partners and facilitate the process of commercialisation. Once fully developed, the new device will offer blind people a much better access to the experience of viewing dance, than the traditional method of audio description, used up to this point. This approach could be developed further to enhance the attendance of other movement-based activities (such as sports) for both blind and sighted people.

Significance – funding - dissemination

The project has received a Digital Transformations Research Development Fund (£29,105) from the Arts and Humanities Research Board (Feb – July 2012), and an Investment for Knowledge Transfer Fund (£11,766), from the University (Sept – Dec 2012).

Conferences and events:

- **Digital scholarship:** day of ideas 2, University of Edinburgh, 2 May 2013.

- **Multimodal Communication:** Language, Performance and Digital Media Conference, Technical University of Lisbon, Portugal, 2-3 May 2013.

-**Moot: Digital Transformations** event, AHRC, London, UK, 19 Nov 2012.

-**Kinesthesia, Empathy and Aisthesis in Music and Dance** Symposium, Institute for Advanced Study, Bremen, Germany, 11-12 September 2012.

- **Somatics and Technology** Conference 2012, University of Chichester UK, 22-23 June 2012.

-**Dissemination event** for specialists on haptic technologies, motion tracking, choreography, blindness and venue managers, University of Edinburgh, UK, 28-Aug-2012.

- **Networking event** for specialists on haptic technologies, motion tracking technologies, choreography, blindness, University of Edinburgh, UK, 17-Jul-2012.

Partners and Collaborators

- Scottish Ballet, Glasgow, UK
- Royal National Institute for Blind People (RNIB), Edinburgh, UK
- Royal Blind School, Edinburgh, UK
- University of Exeter, UK
- Blazie (Access Technology for Blind and Visually Impaired People), UK
- Immersion – Haptics for the Digital User Experience, San Jose, California, USA
- Technical University of Lisbon
- Institut National de Grenoble, Grenoble, France

