Moving Digits: Augmented Dance for Engaged Audience

Duration: 2 years (Oct/2018 – Sep/2020)
URL: www.movingdigits.eu

Originality

The 2-year project aims to enhance audience understanding and engagement in contemporary dance performances, and to allow to experience dance in an augmented way (even after the performance). Its originality lies in combining, on the one hand, co-design (with dancers and choreographers) of systems for augmenting performances through technology with, on the other hand, audience studies assessing the impact on engagement of those systems. To achieve this, novel interactive systems were designed for sensing dancers' bodies and for visualizing less visible aspects of movement.

Significance

The project is being implemented by an international consortium involving 7 partners from 4 countries, with Correia as principal investigator. The project was co-funded by the EU with €200k, in the scope of the Creative Europe programme (total budget: €333k). It was awarded 2 additional funds: from the EU STARTS program (€15k); and from the Madeira Regional Government (€33k). It resulted in a performance in one of the main venues in Germany for contemporary dance, Tanzhaus NRW. It also resulted in two peer-reviewed full papers, published at the ARTECH conference and Creative Technologies journal. Additionally, it led to 4 invited talks and originated new software development, released as open-source. It attracted media attention in Portugal.

Rigour

Participating dancers and choreographers were selected through a call, which attracted 92 international respondents, from which 10 were selected. The project employed a User-Centred Design methodology and has involved multiple stages: 4 workshops in Portugal, Estonia and Germany, involving all artists; and 1 artistic residency in Estonia with 4 choreographers. It also involved a mixed-methods approach, combining focus groups, brainstorming, interviews and observation. In the first workshop, we identified ideas for dance visualization. A second workshop tested prototypes developed. In the artistic residency, 4 choreographies we created. In the third workshop, the 4 choreographers worked with the larger group to prepare the final performance. In the fourth workshop, the artists ported their performances to Virtual Reality (VR), for a future exhibition.

Table of Contents – Documentation

Documentation

Performance, Tanzhaus NRW (Kleiner Saal), Düsseldorf, 26/10/2019

All photos from this performance by: Yulia Reznikova

Photos of Choreography: (Im)possible Bodies – The Beautiful Glitch

Concept: Sylvia Rijmer
Performers: Maria Pyatkova, Teresa Alves da Silva


Photos of Choreography: E-motional Landscapes

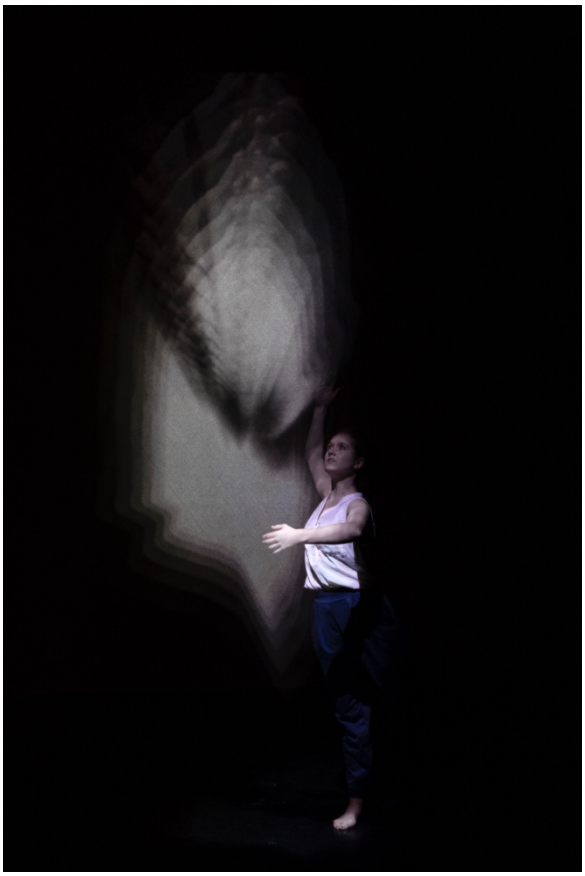
Concept: Outi Elena Valanto
Performers: Deva Schubert, Eleonora Siarava, Juan Felipe Amaya Gonzalez


Photos of Choreography: A Dance to Remember

Concept: Simona Deaconescu
Performer: Kadri Sirel

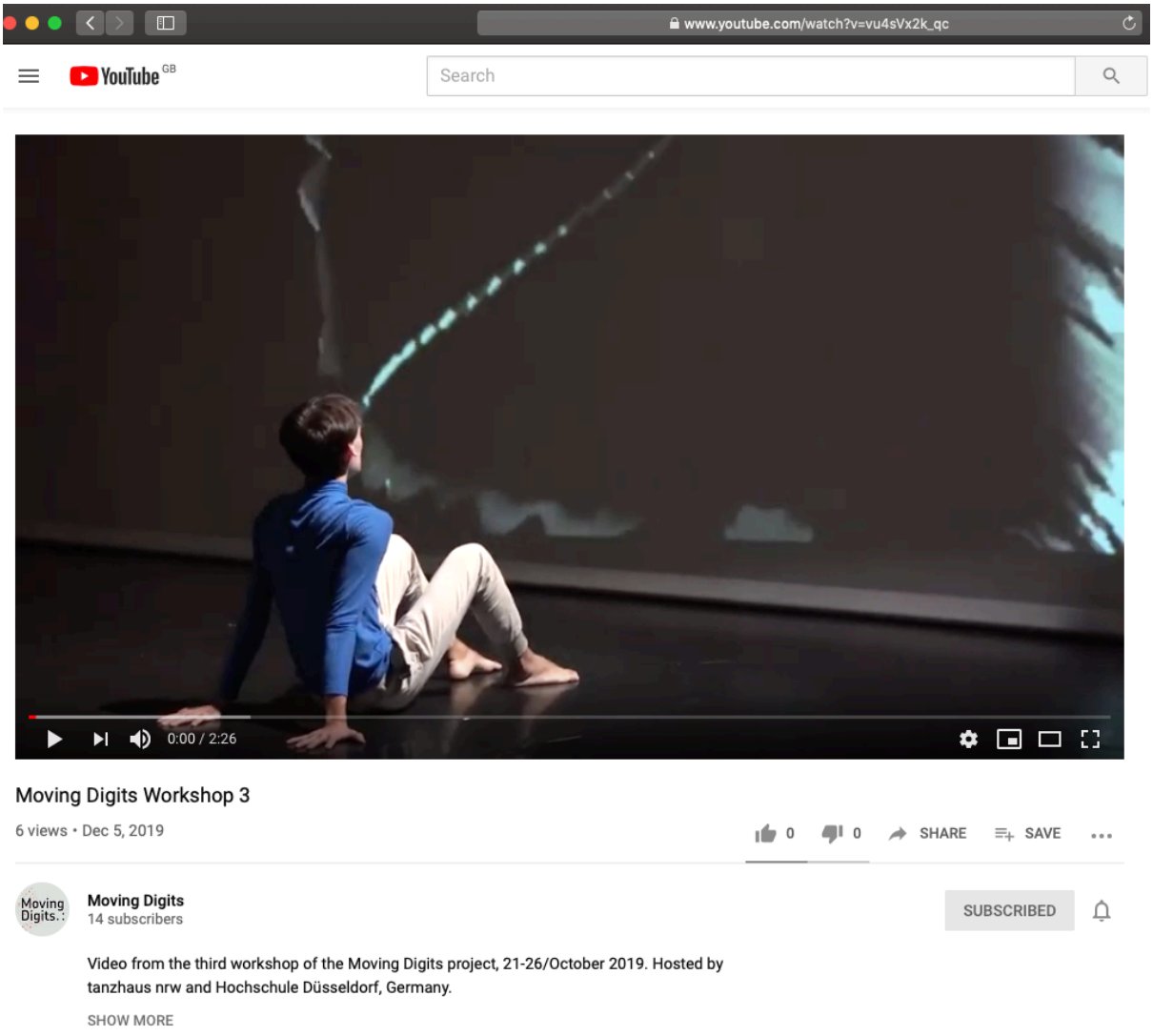
Photos of Choreography: Connection Retrieval

Concept: Hanna Pajala-Assefa
Performers: Einav Katan-Schmid, Ella Tighe



Video of Performance

https://www.youtube.com/watch?v=vu4sVx2k_qc



Promotion of Performance by Tanzhaus NRW: Programme

Showing Tanzcamp

Vorhang auf für die Tanzcamp-Teilnehmer*innen! Eine Herbstferienwoche lang lädt das Tanzcamp alle Tanzinteressierten zwischen sieben und 17 Jahren mit und ohne Behinderung und mit und ohne Tanzerfahrung ein, die eigene Bewegungssprache zu entdecken, auszutesten und weiterzuentwickeln. Die internationalen Dozent*innenteams sind ebenfalls mixed-abled, das heißt jeweils ein*e Dozent*in mit Behinderung und ein*e Dozent*in ohne Behinderung arbeiten in Zweierteams zusammen und bringen sowohl unterschiedliche urbane als auch zeitgenössische Tanztechniken ein. In Kooperation mit der Un-Label Performing Arts Company aus Köln werden außerdem neue kreative Methoden ausprobiert, erforscht und geprüft.

Dozent*innen: Marie-Zoe Buchholz, Tanja Erhart, Vicky Malin, Wilhelmina »Willie« Stark, Miro und die Creability Künstler*innen-Gruppe von Un-Label.

Fr 18.10. 18:00
Großer Saal, Eintritt frei
Dauer: 60 Min. / Bitte Tickets unter ticketservice@tanzhaus-nrw.de reservieren // Alles zum Programm des Tanzcamps vom 14.10. – 18.10., tgl. 10:30 – 16:00, unter www.tanzhaus-nrw.de

Das Tanzcamp wird unterstützt durch Take-off: Junger Tanz, gefördert durch das Kulturamt der Landeshauptstadt Düsseldorf sowie das Ministerium für Kultur und Wissenschaft des Landes NRW. In Kooperation mit der Un-Label Performing Arts Company aus Köln statt.

take off Junger Tanz Düsseldorf

Showing MOVING DIGITS

Mixed Reality und Tanz sind die Themen des internationalen Residenzprojektes MOVING DIGITS, das nun in Düsseldorf Halt macht. Eine per internationalem Open Call ausgewählte Gruppe von Choreograf*innen und Tänzer*innen setzt sich mit digitalen Technologien, ihrer tanzkünstlerischen Dimension und Strategien der Publikumseinbindung auseinander. Software-Spezialist*innen der Hochschule Düsseldorf im Bereich Medien und Visualisierung sowie des portugiesischen Instituts für interaktive Technologien entwickeln die Prototypen mit den Künstler*innen. Nach Residenzen in Tallinn und Funchal werden die begonnenen Projekte in Düsseldorf fortgesetzt und erste Zwischenresultate der Recherchen gezeigt, bevor 2020 in Tallinn die Abschluss-Präsentation stattfindet.

Sa 26.10. 17:00
Kleiner Saal, Eintritt frei

MOVING DIGITS ist ein Kooperationsprojekt von Madeira Interactive Technologies Institute, Sõltumatu Tantsu Lava Tallinn, Hochschule Düsseldorf und tanzhaus nrw, gefördert durch die EU im Rahmen von Creative Europe.

Co-funded by the Creative Europe Programme of the European Union

Moving Digits.:

13 So 15:00 S. 29
Claire Cunningham
»Thank you very much«

18 Fr 18:00 S. 45
Showing Tanzcamp
Mixed-abled

19 Sa ab 18:00 S. 47
The Waack Off Battle
Hosted by Yeliz Mānuka

Sa 20:00 S. 30
Anna Till & Katia Manjate
»Life in Numbers«

20 So 18:00 S. 30
Anna Till & Katia Manjate
»Life in Numbers«

23 Mi 17:00 S. 51
Offene Probe »Mischpoke« von Barbara Fuchs
Reihe Kleine Monster

25 Fr 20:00 S. 33
Marlene Monteiro Freitas
»Bacchae – Prelude to a Purge«
Reihe GROSS TANZEN

26 Sa 17:00 S. 45
Showing MOVING DIGITS
Labor

Sa 19:00 S. 33
Physical Introduction vor
»Bacchae – Prelude to a Purge«

Sa 20:00 S. 33
Marlene Monteiro Freitas
»Bacchae – Prelude to a Purge«

31 Do 20:00 S. 35
Via Katlehong / Gregory Maqoma
»Via Kanana« Reihe GROSS TANZEN

Fr 01.11. 19:00 S. 35
Physical Introduction vor »Via Kanana«

Fr 01.11. 20:00 S. 35
Via Katlehong / Gregory Maqoma
»Via Kanana«

Vorschau November

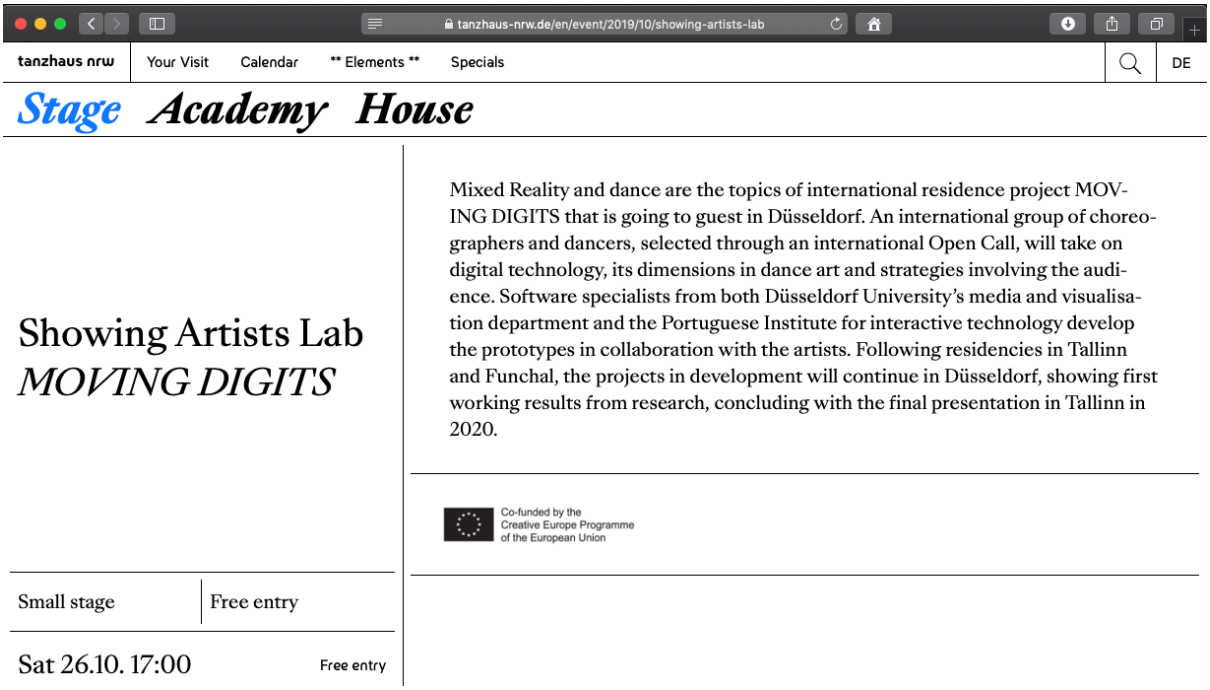
Sa 09.11. 20:00
Anne Teresa De Keersmaeker / Rosas
»Fase, Four Movements to the Music of Steve Reich«

Fr 15.11. 20:00 + Sa 16.11. 20:00 + So 17.11. 15:00
Anne Teresa De Keersmaeker / Rosas
»Bartók / Beethoven / Schönberg«

10

OKTOBER 2019

Promotion of Performance by Tanzhaus NRW: Website



Promotion of Performance by Tanzhaus NRW: Info sheet

Showing 26/10/2019, 17h
tanzhaus nrw, Düsseldorf

Performance 1 - (Im)possible Bodies: The Beautiful Glitch
Concept: Sylvia Rijmer
Performers: Maria Pyatkova, Teresa Alves da Silva

Performance 2 - E-motional Landscapes
Concept: Outi Elena Valanto
Performers: Deva Schubert, Eleonora Siarava, Juan Felipe Amaya Gonzalez

Performance 3 - A Dance to Remember
Concept: Simona Deaconescu
Performer: Kadri Sirel

Performance 4 - Connection Retrieval
Concept: Hanna Pajala-Assefa
Performers: Einav Katan-Schmid, Ella Tighe

Technical team: Jochen Feitsch, Raul Masu, Stephan Jürgens
Hosted by: Stefan Schwarz, tanzhaus nrw
Additional project team: Chris Geiger, Evelyn Raudsepp, Hugo Silva, Ivana Druzetic, Nuno Correia, Triinu Aron, William Primett
Animations (performance 3): André Carrilho

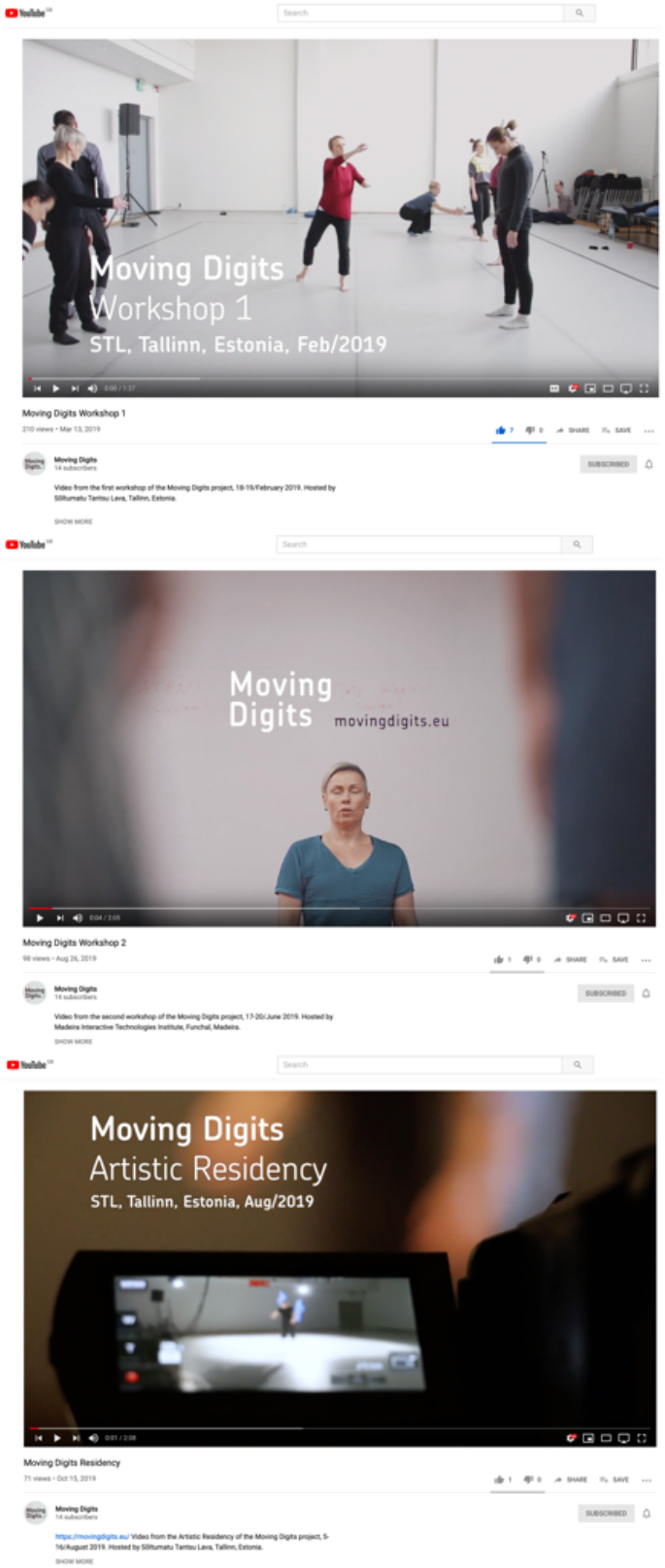
Project partners: Madeira Interactive Technologies Institute (M-ITI, Portugal), Hochschule Düsseldorf (HSD, Germany) and Sõltumatu Tantsu Lava (STL, Estonia). Associated partners: Instituto de Telecomunicações (IT, Portugal), Plux (Portugal), tanzhaus nrw (Germany) and University of Greenwich (UK)

www.movingdigits.eu

Performance preparation

Videos: Workshops 1 and 2, Artistic Residency

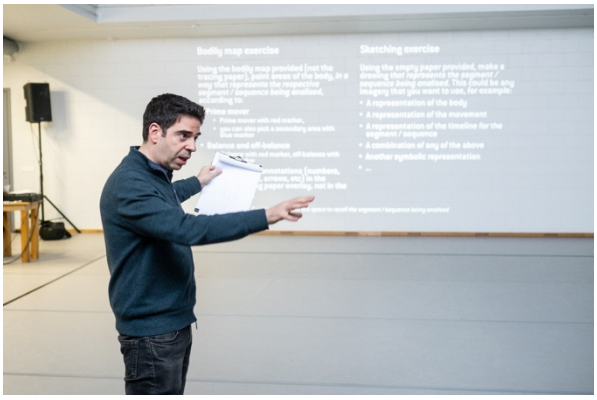
Workshop 1: https://www.youtube.com/watch?v=yvD0D555PLc
Workshop 2: https://www.youtube.com/watch?v=K6KYOnM5fyw
Artistic residency: https://www.youtube.com/watch?v=TUPDIwhmPZM



Photos: Workshop 1, 18-19/Feb/2019 (Sõltumatu Tantsu Lava, Tallinn)

Photos by: Aron Urb



Photos: Workshop 2, 17-20/Jun/2019 (Madeira Interactive Technologies Institute, Funchal)

Photos by: Nuno Andrade



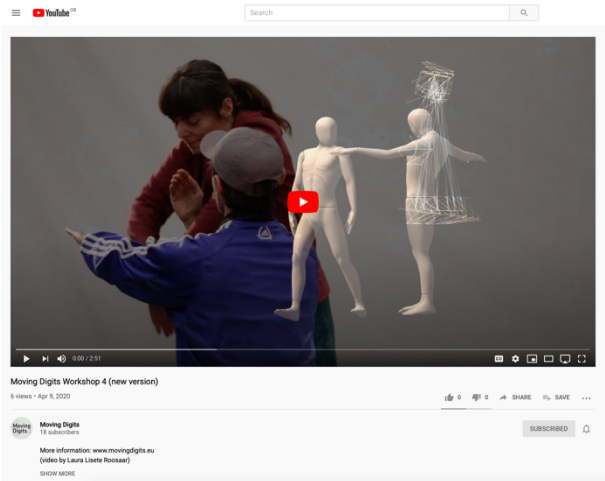
Photos: Artistic Residency, 5-16/Aug/2019 (Sõltumatu Tantsu Lava, Tallinn)
Photos by: Stephan Jürgens




VR preparation
Workshop 4, 9-13/Mar/2020, (Sõltumatu Tantsu Lava, Tallinn)

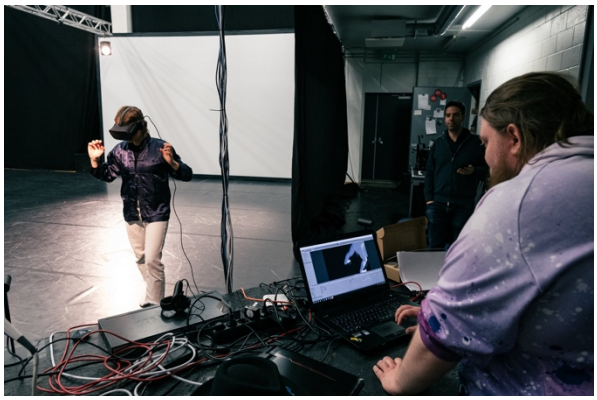
Video:

https://www.youtube.com/watch?v=Tb4i8-3Zrqw



Photos:

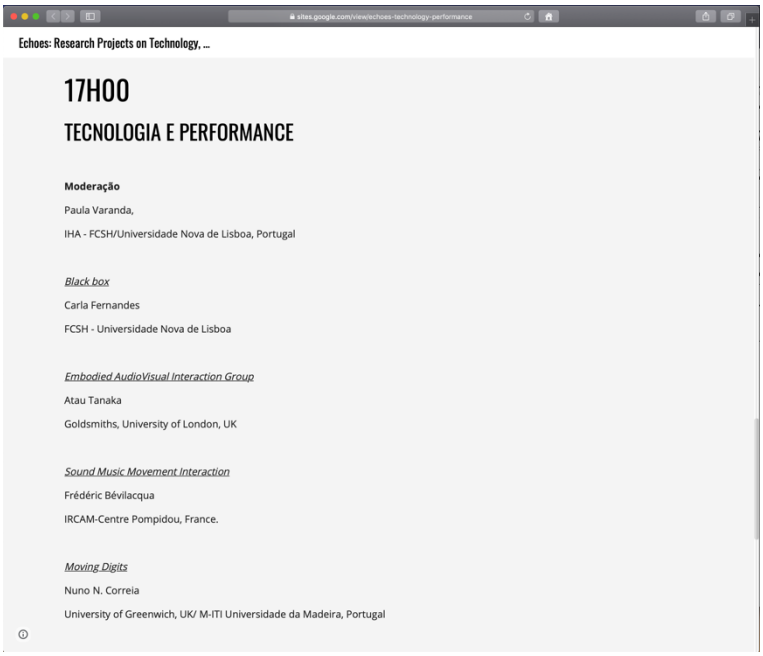
(by Aron Urb)



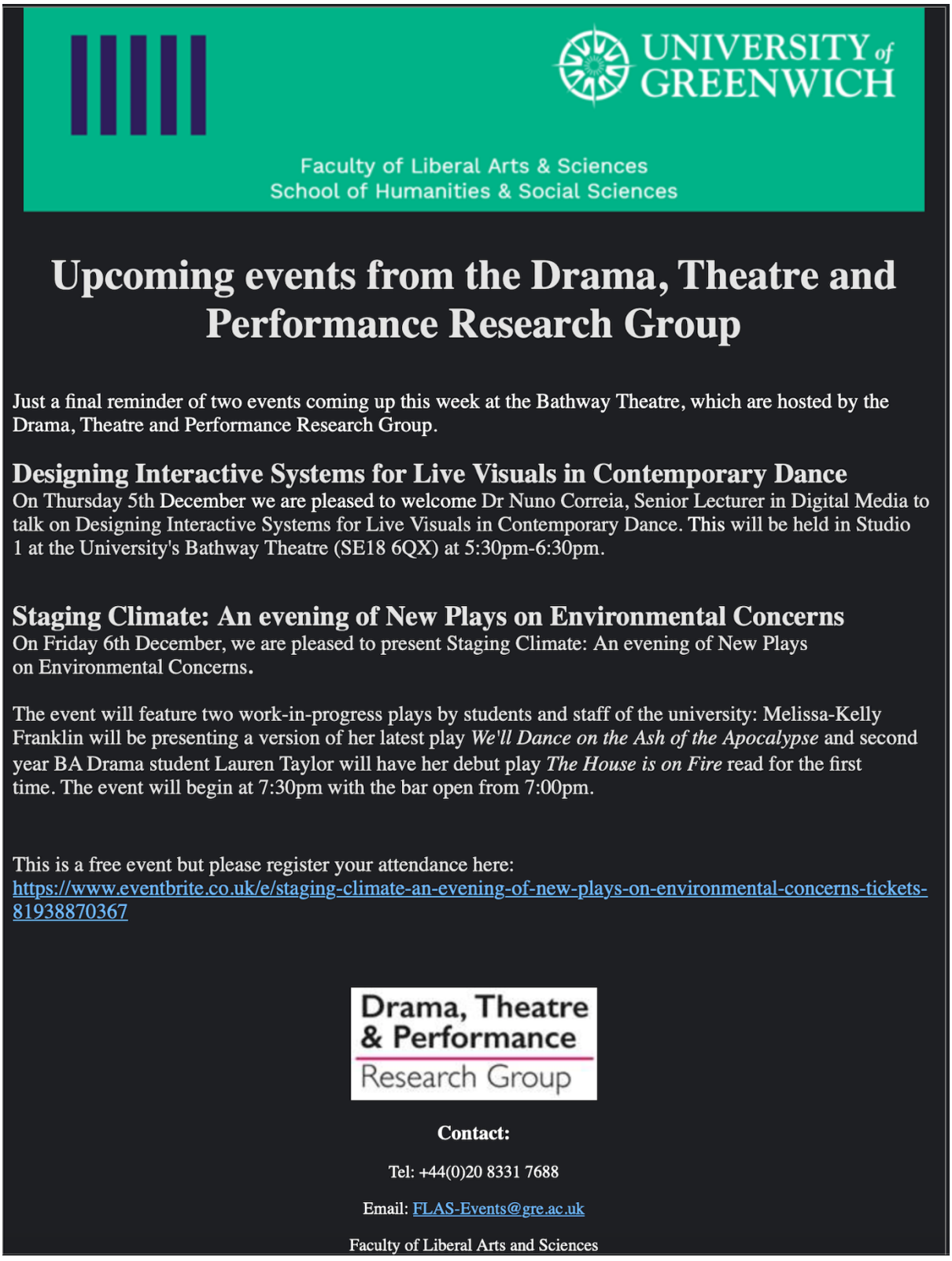
Talks

Photos: Talk at University of Madeira, Funchal, 10/5/2019

Documentation: Talk at Echoes Symposium, Lisbon, 29/11/2019



Documentation: Talk at Drama, Theatre and Performance Research Group, University of Greenwich, London, 5/12/2019



UNIVERSITY of GREENWICH

Faculty of Liberal Arts & Sciences
School of Humanities & Social Sciences

Upcoming events from the Drama, Theatre and Performance Research Group

Just a final reminder of two events coming up this week at the Bathway Theatre, which are hosted by the Drama, Theatre and Performance Research Group.

Designing Interactive Systems for Live Visuals in Contemporary Dance

On Thursday 5th December we are pleased to welcome Dr Nuno Correia, Senior Lecturer in Digital Media to talk on Designing Interactive Systems for Live Visuals in Contemporary Dance. This will be held in Studio 1 at the University's Bathway Theatre (SE18 6QX) at 5:30pm-6:30pm.

Staging Climate: An evening of New Plays on Environmental Concerns

On Friday 6th December, we are pleased to present Staging Climate: An evening of New Plays on Environmental Concerns.

The event will feature two work-in-progress plays by students and staff of the university: Melissa-Kelly Franklin will be presenting a version of her latest play *We'll Dance on the Ash of the Apocalypse* and second year BA Drama student Lauren Taylor will have her debut play *The House is on Fire* read for the first time. The event will begin at 7:30pm with the bar open from 7:00pm.

This is a free event but please register your attendance here:
https://www.eventbrite.co.uk/e/staging-climate-an-evening-of-new-plays-on-environmental-concerns-tickets-81938870367

Drama, Theatre & Performance Research Group

Contact:

Tel: +44(0)20 8331 7688

Email: FLAS-Events@gre.ac.uk

Faculty of Liberal Arts and Sciences

Press

Funding award (Portuguese newspaper)

www.dnoticias.pt/5-sentidos/m-iti-entre-as-associacoes-apoiadas-pela-europa-criativa-NH3458791

M-ITI entre as associações apoiadas pela Europa Criativa

AGÊNCIA LUSA / MADEIRA / 24 JUL 2018 / 14:04 H.

O Instituto de Tecnologias Interactivas da Madeira (M-ITI) e a associação cultural Sete Sóis Sete Luas terão projectos culturais apoiados pela Europa Criativa, com um total de 400 mil euros, revelou a União Europeia (UE).

Segundo a Europa Criativa, cada uma daquelas duas estruturas receberá 200 mil euros de financiamento para iniciativas culturais de pequena escala, no âmbito do Programa de Apoio a Projectos Europeus de Cooperação 2018.

Este programa tem um total de 41,5 milhões de euros (ME) de financiamento disponível para 101 projectos europeus, dos quais 84 são de pequena dimensão, e 17 de grande escala.

No que toca a projectos de pequena escala, tinham sido submetidos 13 propostas portuguesas, enquanto líderes de projecto, mas foram seleccionadas apenas duas, do M-ITI e da associação Sete Sóis Sete Luas.

No entanto, há mais entidades portuguesas envolvidas neste programa de pequena escala, enquanto parceiras de outros projectos europeus: a Companhia de Dança de Almada, a associação Materiais Diversos, o município de Santa Maria da Feira, as associações ADM Estrela, Griot, DuplaCena e Curvaturva e a Faculdade de Letras da Universidade de Lisboa.

Nos projectos de grande escala, Portugal tinha apresentado uma candidatura enquanto líder de projecto, mas não foi seleccionada.

No entanto, há várias estruturas culturais portuguesas enquanto parceiras de outros projectos-líder, que beneficiarão de uma parcela de financiamento.

A Direcção-Geral do Livro, Arquivos e Bibliotecas participará num projecto sobre gestão de arquivos, proposto pelo Ministério da Cultura de Espanha, com um total de 1,5 milhões de euros de financiamento.

A Culturgest estará envolvida num projecto liderado pela organização não-governamental Bunker, da Eslovénia, com um financiamento total de dois milhões de euros, e o Centro Cultural de Belém volta a estar envolvido no festival Big Bang (1,9 ME), uma ideia da organização belga Zonzo Compagnie.

A Artemrede - Teatro Associados estará ligada a dois projetos europeus de grande escala: o francês "Reshape" (598 mil euros) e o italiano "Be SpectACTive!" (dois milhões de euros).

A Fundação Calouste Gulbenkian e a editora Mapa das Ideias participarão num projeto sobre estratégias culturais (1,1 ME) da fundação italiana Fitzcarraldo, a associação cultural Anda&Fala estará envolvida no Festival der Regionen (um milhão de euros) da Áustria, e a CTL - Cultural Trend Lisbon participará no "European Music Market Accelerator" (1,5 ME), organizado pela francesa MAMA.

Tópicos

ASSOCIAÇÕES - CANDIDATURA - COOPERAÇÃO - CULTURA - DANÇA - ESPANHA - EUROPA - FESTIVAL - FINANCIAMENTO - FUNDAÇÃO CALOUSTE GULBENKIAN - LISBOA - LIVRO - M-ITI - MADEIRA - MUNICÍPIO - PORTUGAL - TEATRO - TECNOLOGIAS - UNIÃO EUROPEIA

Mini Eco Bar recebe esta noite festa de lançamento do MADEIRADiG 2019
5 sentidos Actualizado há 6 horas

Amanhã há 'FLOR' no Atlanticulture Center
5 sentidos Actualizado há 7 horas

Exposição 'O essencial é invisível aos olhos' destaca papel dos voluntários
5 sentidos Actualizado a 14/11/2019 18:15

Artista plástico Diogo Goes com agenda cheia ao longo do mês de Novembro
5 sentidos Actualizado a 14/11/2019 18:02

Conheça as propostas do roteiro desta quinta-feira
5 sentidos Actualizado a 14/11/2019 18:00

Daniel Caires anima 'after-parties'do congresso da APAVT
5 sentidos Actualizado a 14/11/2019 15:41

'Sons da Adega' inicia amanhã concertos no Instituto do Vinho
5 sentidos Actualizado a 14/11/2019 14:56

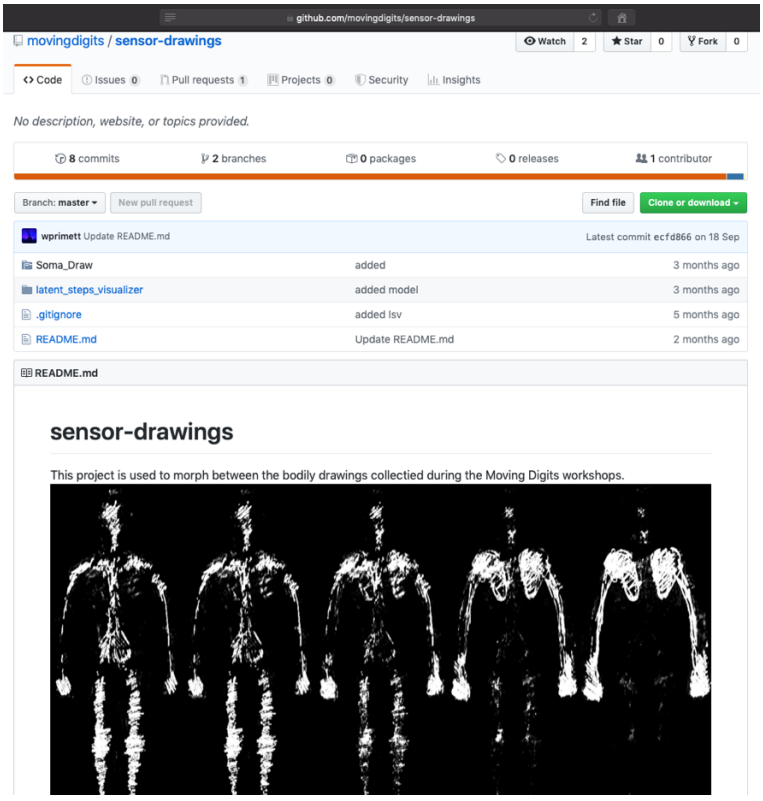
Norberto Cruz é convidado de honra em "proposta improvável" da OCM para este sábado
5 sentidos Actualizado a 14/11/2019 11:05

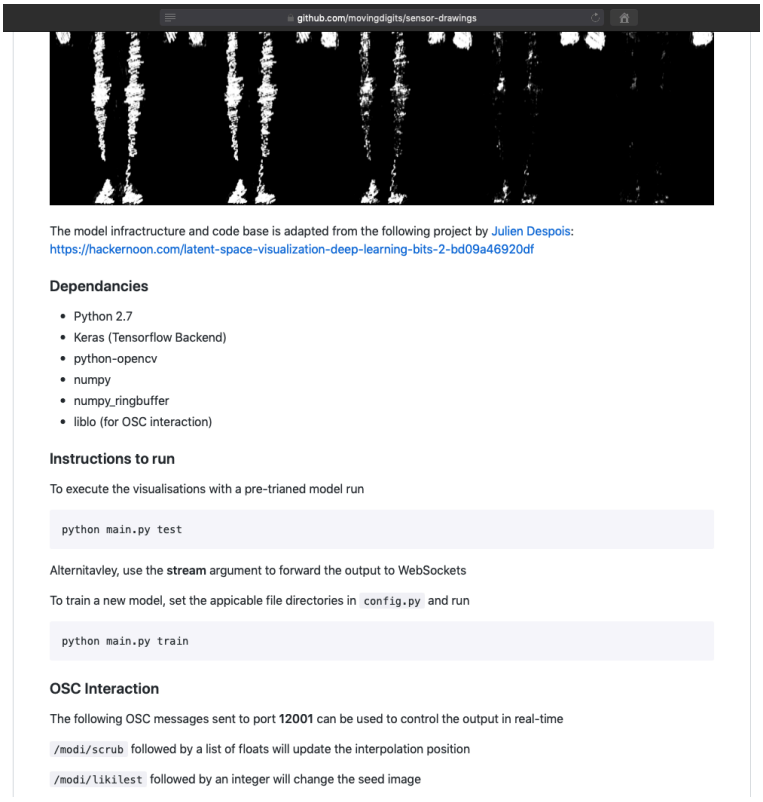
José Cid promete continuar a cantar "canções de amor e ternura"
5 sentidos Actualizado a 13/11/2019 23:38

Harry Styles dos One Direction actua em Maio em Portugal
5 sentidos Actualizado a 13/11/2019 15:32

Software

https://github.com/movingdigits/sensor-drawings





Peer-reviewed Article 1 (Conference proceedings)

Masu, R., Correia, N. N., Jurgens, S., Druzetic, I., & Primett, W. (2019). How do Dancers Want to Use Interactive Technology? Appropriation and Layers of Meaning Beyond Traditional Movement Mapping. *Proceedings of the 9th International Conference on Digital and Interactive Arts*, 1–9. https://doi.org/10.1145/3359852.3359869
GALA URL: http://gala.gre.ac.uk/id/eprint/25892

How do Dancers Want to Use Interactive Technology?

Appropriation and Layers of Meaning Beyond Traditional Movement Mapping

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ABSTRACT

There has been an increased interest in HCI research regarding the possibilities of interactive technology applied to the field of dance performance, particularly contemporary dance. This has produced numerous strategies to capture data from the moving bodies of the dancers and to map that data into different types of display formats. In this paper, we look at the role of interactive technology in dance performance from a broader perspective, aiming at understanding the needs of dancers and their relation with the audience. To this end, we ran a focus group with ten dancers with expertise in technology. We analysed the focus group using thematic analysis. We discuss the implications for design of our results by framing the role of technology in dance performance, proposing design guidelines related to the communication to the audience, use of technology, and mapping. Moreover, we propose different levels of ambiguity and appropriation related to the creators of the performance and the audience.

CCS CONCEPTS

• **Applied computing → Performing arts; • Human-centered computing → User studies**; *Interaction design theory, concepts and paradigms*.

KEYWORDS

Dance performance, HCI, design guidelines, UCD

1 INTRODUCTION

In the last decades, interactive digital artefacts have become ubiquitous, and their applications have gradually evolved from workplace to everyday lives and culture. This tendency has been identified as third-wave HCI [7]. With this tendency, user experience has become central in HCI discourse [37]. It has also emerged that users tend to appropriate digital artefacts in different ways [19]. Consequently, the use and meaning of artefacts might become ambiguous, and potentially open to many interpretations [22]. In general, understanding the needs of the user has become a fundamental design activity [4], and users started to be involved in the design process.

Among the variety of contexts touched by the spread of application areas in HCI, dance performance has gained increased attention, (e.g. [11], [21], and for contemporary dance see [18]). From a computing perspective, interactive technology for dance performance can be viewed as a system including inputs (e.g. sensor technology [21]) and outputs (e.g. display strategies [23]). Related studies have analysed dance performance from a segmented perspective, mainly focusing on movement characteristics or display approaches.

Contemporary dance performance represents a complex scenario of use of interactive technology. To begin with, it is composed by two main activities: the preparation of the performance, and the performance itself; the preparation of performance is itself a development process where "choreographic material" is generated [24]. Moreover, different categories of users (dance artists: choreographers and dancers) are involved in contemporary dance performance. As depicted in the

framework proposed by Butterworth these two main categories might play different roles [10]. Therefore, we argue that designing interactive system for dance performance requires a multifaceted approach from HCI, which takes into account the different roles of the technology in creating meaning in the overall dance performance, and the different needs of users.

In this article, we address these aspects by using early-stage co-design activity. Namely, this paper presents a focus group with ten dancers and proposes design guidelines based on the analysis of the respective results. The main objective of the focus group was to inquiring dance artists (dancers - choreographers) about a general research question: *What is the role of digital systems in dance performance, in particular, interactive technology and visualization?*

A secondary objective of the workshop is to understand how that role influences the dancers' communication with the audience. By this, we mean the communication from the performers to the audience, and the audience's understanding of that communication. Audience participation (communication from the audience to the performers) is out of scope for this study; it is in itself a vast topic that merits separate research. Methodologically, a novelty of this study is the involvement of users in the very initial phase of the design, inquiring possible users about the role of interactive technology in dance performance.

The rest of the paper is organized as follows: section 2 presents related works in the field of interactive technology for dance performance and on third-wave HCI; section 3 describes the focus group and section 4 the results; section 5 presents design guidelines based on the results, section 6 discusses the design implications of our findings; finally, section 7 concludes by pointing out future steps in the project and future works in general.

2 LITERATURE REVIEW

The literature review covers two main areas. *Interactive Technology in Dance Performance* discusses how digital technologies have been used as input and output in dance performances. *Designing Digital Artifacts in Third-Wave HCI* presents relevant concepts in HCI and related methodologies.

2.1 Interactive Technology in Dance Performance

The use of interactive technologies in contemporary dance, on stage, alongside dancers, already has a long and established tradition. One relevant example is the work of Mark Coniglio with MidiDancer (1989), a software that allowed a performer to control music[1]. A more recent example is the work of Frieder Weiss with the system EyeCon (2004), which allows movement to control several aspects of a performance [36]. Dance artists, researchers and educators have been extensively exploring interactive digital technologies in workshop and rehearsal situations [16], and in public performances and installations [26].

Different types of inputs can be used to obtain the respective dance data sets. One possible categorisation of such technology is proposed by Alaoui and colleagues [21], who distinguish among (i) positional data which are retrieved by employing motion capture systems; (ii) movement dynamics (such as acceleration/deceleration), which are recorded by means of inertial sensors; and (iii) physiological information, which can be obtained from biosignal sensor technologies.

Motion and physiological data collected through input technologies has mostly been used to obtain insights from the dancer's body, resulting in sonification [3], visualisation [23], and/or interaction with any other choreographic elements (e.g. scenic design [35], light design [8], costumes [6]). Technological artefacts, which provide the tools for such interactions, have used different mapping strategies spanning from direct mapping [36] approaches to agent-based methods [20]. Visualization strategies include visualization of moving data [5], and visualization of movement qualities [21], or more complex visualization of features extracted using different layers of analysis [11] and practitioners/artists using data art and digital performance (e.g. Choreographic Coding Labs/Motionbank[2]). To conclude, pre-recorded data has been used to generate graphics synchronised with animated skeletal representations of the movements using machine learning strategies [33].

In some cases, these studies produced design suggestions or guidelines [36] and framework [11]. However, they tended to tackle specific aspects of movement or specific choreographies. With this paper we extend these works proposing high-level design guidelines for interactive technology for dance performances, addressing both input and output technology, as well as the needs of the main users (dance artists) and context of use (dance performance).

2.2 Designing Digital Artefacts in Third-Wave HCI

2.2.1 Appropriation and Ambiguity. Within the context of third-wave HCI, where our study is situated, researchers started to investigate the creative uses of interactive digital artefacts [7]. In this perspective, artefacts can be used (appropriated) in ways that the designer did not expect [19] and the technology can assume multiple or adaptive meanings. Users appropriate the technology by imposing their own meaning. Dix defined appropriation as "improvisations and adaptations around technology" [17]. Aligned with this idea, Dourish proposed that to foster appropriation, design should aim to support multiple perspectives on information [19]. These multiple perspectives reflect the idea of ambiguity. Ambiguity was studied from a design perspective by Gaver, who proposed three different categories: *ambiguity of information* when the information is presented ambiguously; *ambiguity of context*, different context give to technology different meaning; *ambiguity of relationship*, each user has a

[1] http://troikaranch.org/artistic-directors/

[2] http://motionbank.org/

different relationship with a piece of technology. These perspectives have been prolific as design principles for artistic branches of HCI, such as music [38] and artistic installations [27]. In the area of dance, need for appropriation emerged in the design process of creative support tools for choreographers' notation [13].

2.2.2 Design of Interactive Artefacts in Third-Wave HCI. In third-wave HCI, the user increasingly becomes central in the design process of digital artefacts. User-Centered Design (UCD) is "a term to describe design processes in which end-users influence how a design takes shape" [1]. In this perspective, the design process should involve the user, in order to understand their needs in relation to the usage of the technological artifacts [4]. In addition, co-design literature underlines the increasing importance that involving users in the early stages of the design process has gained. Sanders and Stappers stressed the importance of what they call *front end*, formerly defined as "pre-design", a phase of the design composed of those activities that take place in order to inform the general understanding of users and contexts of use: "the goal of the explorations in the front end is to determine what is to be designed and sometimes what should not be designed and manufactured" [30]. Figure 1. represents the design phases as described by Sanders and Stappers: the "front end of the design process has been growing as designers move closer to the future users" [30].

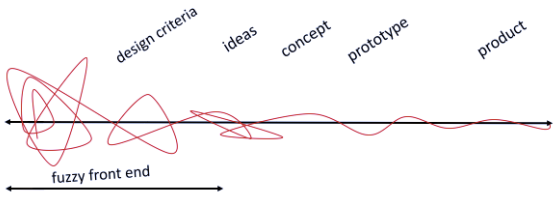

Figure 1: Design phases as proposed by Sanders [30].

Co-design approaches have been successfully used within artistic branches of third-wave HCI. For instance, UCD has been used to investigate the potential of sonic interaction in personal usage scenario [32]. Similar approaches have also been used to design specific artifacts, such as musical instruments [34], audiovisual toolkits [15], and multi-modal installations [29]. Core and colleagues [14] adopted participatory approaches to design pedagogical tools for young children that combine music technology and movement with real time algorithmic composition [28]. In the area of technology for dance, UCD has been used to design tools whose porpoise is to help the choreographic process. In particular, Ciolfi Felice and colleagues designed and developed a tablet application to support choreographers' work using animated notation [12, 13].

2.2.3 Co-Design and Technology for Dance Performance. Within the specific context of technology designed for dance performances, UCD is still scarcely explored, although, in recent years some projects started to involve users in the design process. For instance, Schofield et al. [31] used participatory design workshops to involve teenagers in the design process of an artefact for dance performance. The objective of such process was to teach the participants to code: during the process the participants have learned simple coding activity while actively participating in the co-design process. Alauoi and colleagues [2] involved dancers in a participatory design in their research. Their starting point/objective was pre-defined: they aimed to design an interactive system based on movement qualities, providing visuals based on Mass-Spring Systems. Another example can be found in a project by Landry and Jeon who involved dancers in the design of an audio-visual system, but they involved only after that a first prototype was already implemented [25].

Despite being valid in defining technological specifications and producing valuable artefacts, the studies mentioned above started the design process either with a clear technology, or choreography in mind. Therefore, there is a lack of general design guidelines considering the roles of technology within the context of use: in the creation and in the performance of a dance piece.

In this paper, we address the design of technology for dance performances using UCD approach, involving the users since the earliest stage of the design process.

3 THE STUDY

To address our research question regarding the role of technology in dance, with the involvement of dancers, we organized a two-day co-design workshop. The workshop consisted of a series of design exercises, including a focus group. For the scope of this paper, we will present and analyse the focus group component of the workshop.

3.1 The Focus Group

The objective of the focus group was to gather data about the role of technology in dance, aiming to identify needs, criteria and requirements of dance practitioners. We were also interested in the role technology might have as mediator among dance artists, and between dance artists and their audience. Therefore, we structured the focus group around the following four main topics, which align with our research objectives: communication to the audience in dance performance; the role of technology in dance performance; in particular: the role of interactive technology; and the role of visuals. The purpose of this focus group was to frame the initial requirements for a future prototyping process. In this way, we followed a design perspective, informed by studies presented in the section 2.2: we started by questioning the users about their needs. The users (in this case, the dance artists) were involved from an early stage to identify needs and requirements regarding interactive and visualization technology in dance, which will be the basis for future steps in the co-design process. The focus group took place in the dance studio of Sõltumatu Tantsu Lava (STL) in Tallinn (Figure 2.) and lasted for approximately two hours.

Figure 2: The setting of the focus group.

3.2 Participants

The participants were selected using an open call, disseminated through mailing lists related to contemporary dance. Ninety-two dancers applied to the call (73 female, 19 male). Each candidate was independently evaluated by six members of our team, according to i) their Curriculum Vitae as dancers, ii) previous experience with technology in dance and iii) motivation and expectations regarding the workshop. Finally, the scores were discussed and moderated. Ten dancers were selected (nine female, one male, from eight countries) and all of them participated in the study. We covered travel expenses and paid a fee for each dancer. Due to the competitive selection, all ten participants had considerable experience in contemporary dance as performers, some of them also as choreographers.

In particular, all the participants had previous experience as professionals dance artists in projects that involved technology. In most cases, our participants had experience both as dancers and as choreographers. The type of technology that our participants have used in previous works rages from VR, 3D modelling, streams of social media, different types of hardware (including Kinect and Arduino), and software (Max/MSP, openFrameworks, Processing). Referring to the different roles the dancers and choreographers have in the creative process of producing a dance piece, our participants reflect those scenarios where there is a choreographer leading the decisions. Referring to the model proposed by Butterworth, participants reflect mainly case one and two, where the choreographer is the author creating the piece [10].

3.3 Data Collection

We recorded audio and video and took hand-written notes during the focus-group. We transcribed and anonymised the interview data and refer to participants as P.1-P.10. The transcription has been controlled by two researchers.

3.4 Data Analysis

The focus group was analysed independently by two researchers using thematic analysis [9], then these analyses were cross-checked and harmonised. All the transcriptions of the focus group have been coded, the different codes have been harmonised, and finally the codes were grouped into themes. The analysis produced six themes, each with sub themes.

4 RESULTS

In this section, we present the results of the thematic analysis. The outcome of the analysis of the data consists of six main themes with several sub themes.

4.1 Theme 1: Audience Characteristics

The first theme concerns the characteristics of the audience. Our participants consider the audience to be intelligent, but also unpredictable.

- ***Audience is intelligent.*** The audience is intelligent (P.8) – participants aim to make a performance for the most intelligent person in the audience (P.9).
- ***Audience is unpredictable.*** There is uncertainty about the audience: *you really never know who's sitting in this audience* (P.2), also the audience members may have an unexpected response (P.7).
- ***Audience as a close human.*** Finally, there is also a level of closeness with the audience - *like creating this human moment of sharing something common, of human to human* (P.8).

4.2 Theme 2: Communicate with the Audience

Related to the characteristics of the audience, several aspects concerning the communication with the audience emerged. In general, the artists agree that meaning of the experience should not be imposed to the audience.

- ***Not impose one specific meaning to the audience.*** Relying on the fact that the audience is intelligent, the performance should not impose one specific and *didactic* (P.2) or *prescriptive* (P.3) perspective, rather create *multi-layers of meaning* (P.5) and *information* (P.9). Dancers aim at not being didactic and at not controlling the audience, even promoting provocative strategies such as deliberately causing confusion (*un-focusing* P.6). Dancers also do not feel the need to teach (P.2), but prefer to *articulate the performance and balance the clarity*, without overexposing an idea (P.3).
- ***Shared experience with the audience.*** Relying also on the notion of closeness, our participants aim at creating a sense of *togetherness* (P.9) with the audience. The moment of the performance has been described as a shared *intimate* (P.9) experience between artists and audience, *together [...] and in synchrony* (P.6) with the audience.
- ***Create safe environments for the audience.*** Our participants aim to create safe environments (P.5), spaces of intellectual freedom where the audience can come with their own knowledge and their own understanding (P.6).
- ***Considering the audience during the creation process***. In order to check the clarity of *my idea* (P.3) some of our participants invite audience during the rehearsal asking for feedback. Our participants stressed the need of ensure clear *articulation* (P.3) in providing the information to the audience.

4.3 Theme 3: Technology as Co-Shaper of the Performance

Technology has specific characteristics, which enables the dancers to reflect on them during the creative process. In this sense, technology becomes co-shaper of the creation process: *the technology is always creating some [...] setting and then it actually become a dramaturgy* (P.5).

- ***The creative technology.*** The technology is creative: *it's like creative dancers, there is also creative technology* (P.3). This creative technology can *generate creative ideas* (P.2). Therefore, technology may already have a *dramaturgy* (P.5). There is an awareness of the duality in technological creativity: Is it a dramaturgy in the technology itself or is the choreographer that tries to use technology as a dramaturgical tool? (P.1).
- ***Movements fostered by the technology.*** A technological artifact has an impact on the movements, it imposes *physical limitation* (P.3) and proposes new types of *technological gestures* (P.2).
- ***The problem of excessive focus on technology.*** The technology should never be the focus of a performance (P.9). It should be *subtle or invisible* (P.9). Technology can mesmerise and *fascinate* (P.6) the audience, but it should not be used in this manner: there is a shared need to *express something with it* (P.3).
- ***Integration of the technology in the logic of the work.*** The technology should be *reflected* (P.3) and *integrated* (P.9) in the logic of the performance.
- ***Hacking.*** Our participants describe the process of using the technology as *hacking* the system (P.3), in a figurative sense: dancers are not *using the technology the way that the technology designers meant* (P.3).

4.4 Theme 4: The Problem of Redundancy of Information

One of the main problems that our participants identified is that technology it is often diminishing the layers of meaning in the performance.

- ***Technology is illustrative.*** *Technology is too illustrative, [...] and too connected to what you are doing with movement* (P.6), for this reason it risks to merely duplicate the body (P.4).
- ***Illustration and meaning.*** The visual output is *too graphic, it's diminishing the multi-layered meaning* (P.5). and risks to simply replicate the information (P.6).

4.5 Theme 5: Strategies for Interaction

From an interaction design perspective, some good practices emerged.

- ***Complex mappings.*** Unclear, divergent, or *independent* mappings from input to output technologies could be used to create *counterpoint* (P.9) between the dancers and the technology, avoiding more obvious mappings (P.6).
- ***Interaction Loop.*** Technology could create a complex mirror that challenges the movement of the body (P.9), a sort of *feedback loop* (P.3) that affects the choices of the dancer.

4.6 Theme 6: Strategies for Visuals/Output Adding Layers

This last theme clusters suggestions related to the output of the digital artefact.

- ***Visualize the structure.*** Expose the score before (P.9) or during (P.6) a performance might contribute to adding layers of meaning as it is a *commentary on your own work and it's self-reflexive and it's interesting* (P.6).
- ***Play with time-related elements.*** This might include *displaying what things that happened in the past and [...] resonate [...] in a performance* (P.9), or *traces and the resonance of the movement* (P.1).
- ***Alternative sensorial strategies.*** Our participants also suggested to rely on other sensorial channels, such us *kinetic illustration* (P.5) and *sound* that might be used to *trigger sensation* (P.10). Moreover, sound is *multi-dimensional in space*, and these characteristics makes sound more similar to movement as compared to visuals (P.5).
- ***Capture the Intelligence.*** Several aspects of the intelligence of a body could be captured and revealed: e.g. what's happening in the brain before the movement (P.6), record the thinking process of someone doing something incredibly complex (P.2) and also understand the intelligence of the body (P.5).

5 DESIGN GUIDELINES

Our results support us to propose design guidelines for technology to be used in dance performance. Our design guidelines are organised around three high-level aspects of interactive technology for dancers:

1. **Communication with the audience (from Theme 2)**
   (a) Technology should not impose one single perspective to the audience.
   (b) Technology should contribute to create multiple layers of meaning.
2. **The role of the technology in the creation of the piece (from Theme 3)**
   (a) Technology should provide space for appropriation, enabling the dancer to give their own use and meaning - facilitate customization might be a possible strategy.
   (b) Technology should be easily included in the dramaturgy of the performance - make it meaningful for the performance.
3. **Input and output strategies (From Themes 4, 5, and 6)**
   (a) Technology should not repeat the information that the dancer is already giving with their movement (avoid overly clear mappings) (Theme 4).
   (b) Technology should have a complex input-output mapping, which might be used to create a loop between technology and dancers (Theme 5).
   (c) Technology should facilitate adding information contributing to multiple meanings of the performance (Theme 6). Examples that emerged in the analyses of focus group include: (i) *showing non visible elements* (either inner elements of the dancers or micromovements), (ii) *shifting the temporal dimension of the performance* (e.g. showing, in time lapses, residuals aspects of movement), (iii) *showing the structure (score) of the performance.*

6 DISCUSSION

Based on the results of the analysis of the focus-group we discuss the role of technology in contemporary dance performance; we then discuss modularity and mapping aspects of the guidelines. Finally, we discuss our finding with the lens of appropriation and ambiguity in HCI.

6.1 The Role of Technology in Contemporary Dance Performance

Technology plays a crucial role as co-creator of performances, but it should not be the focus. A piece of technology already has its own pre-existing dramaturgy, it imposes specific problems or limitations to the choreographer, which need to be incorporated in the ideas and meanings of the performance (Theme 3). In order to use technology in a meaningful way that is harmonised with the overall performance, dance artists need to appropriate the technology and give it a new meaning that is aligned with the dance piece. A performance should be composed of multiple layers of meaning (Theme 2), and technology should contribute to this multifaceted structure (Theme 4, 5, 6). In Theme 4, it emerged that our participants have had issues with technology when it adopts overly clear mappings, since in this case it repeats the same information of the body, creating an issue of redundancy of information. This repetition diminishes the layers of meaning of the performance. Consequently, our participants tend to dislike this characteristic of the technology, as they aim to create rich and multi-layered performances.

The need of structuring the meaning of a performance is connected to the characteristics of the audience. In Theme 1, it clearly emerged that our participants consider the audience to be intelligent. For this reason, dancers avoid having one clear meaning in the performance. On the contrary, our participants aim to have multi-layered meaning (Theme 2). We argue that technology should support this approach. Successful strategies for designing interactive technology for dancers could include either creating interactive mirror loops or by adding elements to the performance, for instance i) reveal hidden aspects of the performer, ii) play with time lapses, or iii) exposing structural elements of a performance. In general, one-to-one linear input-output mapping appears not to be fruitful in the context of dance performance, as it tends to visualise elements that are already clear in the movement of the body.

6.2 Modularity and Mapping

To achieve the principle outlined by our guidelines we propose the adoption of modular strategies in the design of interactive technology for dance performances. In particular, we propose the following points to help designers to address the proposed guidelines: (i) use different elements – building blocks – as output technology (audio or visual), these different elements should already provide functionalities that facilitate multiple usages (for instance different image processing algorithms that can be applied on the same material); and (ii) provide users with the possibility of customise mappings between the input and the output technology (for instance, giving to the choreographers the possibility to choose how to map input data on given processing algorithms).

These suggestions can help designers in applying the guidelines. Firstly, a modular structure composed of different building blocks can facilitate the choreographers to use technological artefacts during the process of creation. The modular structure facilitates different usage of the artefact itself, as each user can create different combinations of the building blocks. Therefore, each choreographer can have space to appropriate it according to their idiosyncratic characteristics.

These possibilities mentioned above can contribute to support the choreographers to include technology in the overall dramaturgy logic. Secondly, designing different functionalities for each output object reflects the guideline of complex input-output strategies. The combination of modular strategies with different functionalities and open mappings will help the user (choreographer or dancer) to employ technology to create multiple layers of meaning to propose to the audience.

6.3 Appropriation and Ambiguity in Interaction Design for Dance Performance

Our participants' need for reflecting and integrating technology in the performance reverberates with the design concept of appropriation. Similarly, the need for adding layers of meaning and not imposing one single meaning in a performance resonates in the design concept of ambiguity. In Theme 3, it emerges that the dancers' use of interactive technology implies a second creative process, whose outcome is a performance. During this process, the dancers need to appropriate the technology [17]. Moreover, the idea of layering the information is also similar to the idea of designing for appropriation proposed by Dourish: supporting multiple perspectives on information [19]. In this sense, there are two faces of appropriation: dancers appropriate the technology to create multiple layers of meaning in the performance, and the layers of meaning supports the audience to appropriate the content of the performance.

Therefore, we argue that an interactive digital artefact designed for dance performance should take into account these aspects, and not impose one restricted meaning or use, nor of meaning. On the contrary, it should support dancers to appropriate it, to embed it in the performance and contribute to the multiple layers of meaning. To this end, the artefact should already have ambiguous characteristics that facilitate the appropriation process, as advocated in [22], rather than impose one clear usage. In Theme 4, 5, and partially 6 it emerged that ambiguity can be used to build the multi-layered meaning of the performance. Therefore, adding ambiguous elements in the technology (e.g. in the rich and complex mapping possibilities from input/interaction to output/display) could enable dance artists to create those multiple layers of meaning. Based on the discussion above, we highlight two different types of ambiguity that facilitate appropriation:

- *Ambiguity of use* of the artifact, that facilitate the choreographer to *appropriate* the technology and use it in the process of creating the performance integrating it in the creative process.
- *Ambiguity of mapping and meaning* of the artifact, that facilitate the *audience to appropriate* the meaning of the performance.

7 CONCLUSION AND FUTURE WORK

Compared to other studies that focus on input, output, or mapping strategies in dance (e.g. [11, 21, 36]), this paper extends those studies by providing designers with a higher-level view of the role of technology in the dance performance context. We advocate that our guidelines can assist in the definition of choices and specifications for interaction design in dance. Methodologically, compared to other related studies [2, 25, 31], we adopted a UCD approach from an earlier stage, before any initial conceptual design. Thanks to this fact, our contribution addresses the role of technologies from a systemic level in the general context of a dance performance. Future works will include developing interactive prototypes based on the guidelines and evaluate them with dancers.

To conclude, in this paper we presented a focus group study on the role of interactive technology in dance performance. The participants were ten dancers with a background in dance performance with technology. The results of the focus group allowed us to frame the role of technology in dance, discuss how this contributes to the communication to the audience, analyse appropriation and ambiguity in this context, and propose design guidelines.

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Pathways to Live Visuals in Dance Performances: a Quantitative Audience Study

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Abstract

INTRODUCTION: We present an audience study investigating the impact of different technologies to create visuals in dance performances.

OBJECTIVES: We investigated four conditions: motion capture, sensors, camera image, and minimal interaction; and four variables: how much did the audience perceive a connection between the body and the visuals; the visuals as merely copying the dancer; how much distracting were the visuals; and how much did the audience enjoy the visuals.

METHODS: We used a questionnaire to collect data. We analyzed it using Friedman's test, and Spearman's correlation test.

RESULTS: The audience perceived a stronger connection in the camera condition, but in the same condition, visuals tend to be merely copying the dancer. We also suggest that the perceived connection has a positive correlation with enjoyment, while distraction has a negative correlation.

CONCLUSION: Our results help to highlight the impact that different technology have on live visuals for dance.

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Keywords: audience study, dance, live visuals, interaction design

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1. Introduction

There has been a growing interest in the use of interactive live visuals in contemporary dance performance. Some important examples include the works of Frieder Weiss and collaborators [1], Klaus Obermeier [2], OpenEndedGroup [3] and Rhizomatics [4]. However, there is still a lack of understanding of how audiences value the inclusion of live visuals in dance performances, and how they perceive the interactive aspect of these visuals.

We organized a public performance in order to gain an understanding of the audience's perception of live visuals in contemporary dance, and what interaction design elements might be more conductive to audience enjoyment and understanding of the visuals. The performance consisted of four different dance pieces with four choreographies, using four different designs for live visuals. During the performance, we conducted an audience study: we asked audience members to fill in a questionnaire, with questions related to the visuals. The same questions were asked for each of the four performances.

In this paper, we start by presenting related work and literature, then we briefly describe the different choreographies and the design of the visuals. Then we describe the methods used for the audience study. We then present the results, and a discussion on implications for the design of interactive visuals for contemporary dance.

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2. Background

2.1. Live visuals in performance arts

With the developments in multimedia computing since the last part of the 20th century, performance arts in general have been adopting interactive visuals ("real-time visuals" or "live visuals") in performance. Live visual artists within music performances (also named as VJs or Video Jockeys) wish to "adapt and appropriate technology in order to attain expression through visual media" [5]. In some cases, live visuals may lead to additional understanding for audiences regarding electronic music performances, particularly laptop performances, where the musical interaction might be harder to perceive [6]. Live visuals have also been extensively used in theatre, and have become embedded in the dramaturgy: the "story is being told by both mediums", enabling the audience to "focus attention on the connection between performer and digital environment" [7]. In dance, artists have been exploring "the role of digital visualization in choreography, dance performance and documentation". An example of this exploration is the project Choreographic Morphologies [8], where motion capture data is used for 3D visualizations. Another relevant example is the project Phantom Limb, which proposes "virtual body extensions": digital visuals conceived as artificial composites of the performer's body [9]. Advances in machine learning have also been used to create visuals, trained with dancers' data, allowing to respond to "the idiosyncratic movements of an individual dancer" [10]. Masu et al. conducted a study with dancers and choreographers aiming to understand how dance artists wish to use technology in dance, in particular live visuals [11].

2.2. Audience studies in digital performance

The growing use of technology in dance, and performance arts in general, has led to several audience studies regarding the reception of these technologies. In music, a relevant topic has been the connection between the technology adopted and the audience enjoyment of the performance. Bin et al. examined the impact of familiarity with a Digital Musical Instrument (DMI) on the understanding and enjoyment of a performance [12]. The results of this study suggested that previous knowledge about the DMI facilitated the understanding of the performance, but not the enjoyment. In a follow-up study, the same authors investigated the effect of gesture size on audience perception of DMI performances [13]. The results suggested that the size of the instrument (and consequently of the gesture) might have an impact on the audience appreciation of performances. Another topic that emerged in related literature is the understanding of errors in performance with digital technology. Another study by Bin and colleagues investigated the perception of error in DMIs performances, and how this affects the enjoyment of the performance [14]. Interestingly, they did not find any strong correlation between error perception and lack of enjoyment of the performance.

A recent study investigates the combination of audio and visual elements in audiovisual performances [6]. The results suggest that two design strategies might support audience understanding of an audiovisual performance: audiovisual entities, an object-oriented approach to composition consisting of multiple sounds, each with unequivocally associated images; and sounding figurations, visual elements that can be drawn during the performance and whose parameters are mapped into sound. In theatre, Cesar et al. [15] have studied the impact of tele-presence in performances, using galvanic skin response sensors to analyze the engagement of remote theatre audiences. Radbourne et al. [16] conducted focus groups to assess quality in theatre plays, particularly regarding potential re-attendance.

Regarding dance, the research project "Watching Dance: Kinesthetic Empathy" [17] combined qualitative methods and neurophysiological research to analyze how spectators respond to dance, both during and after the performance. Albert [18] studied how dancers and audience members react to movement in social dance (both improvised and choreographed) by using conversation and video analysis. The understanding of movement qualities by audiences was the focus of a study by Mentis and Johansson, relying on qualitative methods and analysis of recorded material [19].

3. Research Questions and Hypotheses

3.1. Research Questions

The above related research proposes strategies to use technology and visuals in dance, and presents several approaches towards audience studies in performance arts. However, there is a lack of investigation in the actual audience reception of live visuals in dance. Therefore we propose the following Research Questions (RQ).:

- RQ1 What technological settings for interactive visuals in dance a) allow to understand the connection between the body of a dancer and the visuals, b) allow to create visuals that are not redundant and merely copying what the body is already visibly doing?

- RQ2 What perceived elements in visuals impact the overall enjoyment of a dance performance? In particular, we will focus on three perceived elements (related to RQ1). The perceived elements are: a) the perception of a connection between the

visuals and the dancers; b) the level of novelty that the visuals introduced to the performance as compared to the body movement of the dancer(s) on stage; and c) the level of distraction that the visuals introduce to the performance.

We conducted our research by implementing four technological conditions, using common interactive technologies in dance for gathering data from the dancers' body: motion capture, sensors and video camera. Condition C1: full-body motion capture (tracking suit) as input; condition C2: specific information about the body using sensors, either biological data or position, as input (be it in-body or off-body); condition C3: the image of the body with a camera as input; condition C4: small amount of movement data captured from the body, used rarely (minimal interaction condition), specifically: sporadically tracking speed of movement of the dancer using a camera and mapping this to subtle visual effects (such as a slight rotation of graphics).

The four dependent variables we collected data on are: V1) the perception of a connection between the visuals and the dancers; V2) the added value the visuals introduced to the performance as compared to the body movement – to measure this we asked it in a reversed manner, inquiring if the visuals were merely copying the body; V3) the level of distraction that the visuals introduce to the performance; and V4) the overall enjoyment of the visuals in the performance.

The first two dependent variables are grounded in previous phases of the project and previous literature, and derive from the design guidelines we developed during a participatory stage between a team of designers, developers and dancers [11]. Regarding connection to the design guidelines, dependent variable V1) is connected to guideline 3c) "Technology should facilitate adding information contributing to multiple meanings of the performance". Dependent variable V2) is connected to guideline 3a) "Technology should not repeat the information that the dancer is already giving with their movement".

Concerning previous literature, this work is also grounded in the studies developed by Bin and colleagues [12–14]. In their work, the authors explored the effect of different elements of musical performance in either audience understanding or enjoyment. Another recent study that influenced the design of our research was conducted by Correia et al. [6], investigating which design strategies might better support audience understanding of an audiovisual performance. Their research defined specific conditions in which visuals support the understanding of a performance. In addition to those elements derived from the guidelines, we collected information about how much the visuals were distracting (variable V3), and how much they contributed to enjoyment (V4).

3.2. Hypotheses

RQ1 What technological setting for interactive visuals?

- H1 The main hypothesis is that the distributions of the values of the four variables in the four conditions are not equal; in detail we have the following specific hypotheses related to the four variables :
- H1a) related to V1 - Connection: we expect that in the camera condition C3 will have higher rates than the sensors condition C2 and the minimal interaction condition C4, this is because the camera as input has a strong relationship with the actual image of the dancer.
- H1b) related to V2 - Merely copying: we expect that the camera condition C3 will correspond to a higher perception of duplication and redundancy, while sensors C2 will have lower values, because the information acquired as input in the interaction of the visual is less related to body and only to specific parameters. We also expect minimal interaction C4 to have lower values, due to the lack of input data.
- We have no expectation on the distributions of the V3 - distraction and V4 - enjoyment variables.

RQ2 What perceived elements in visuals impact the overall enjoyment?

- H2a) V1 connection and V4 enjoyment: the perception of a connection between the visuals and the dancers should increase the enjoyment of the visuals.
- H2b) V2 merely copying and V4 enjoyment: the level of novelty that the visuals introduced to the performance as compared to the body movement should increase the enjoyment of the visuals.
- H2c) V3 distraction and V4 enjoyment: the level of distraction that the visuals introduce to the performance should decrease the enjoyment of the visuals.

4. Methods

4.1. Description of performances

The performance consisted of four contemporary dance pieces:

- The Beautiful Glitch - Condition C1: motion capture (tracking suit)
- E-motional Landscapes - Condition C2: sensors as input

- Connection Retrieval - Condition C3: camera as input
- A Dance to Remember - Condition C4: minimal interaction

In The Beautiful Glitch, a piece for two dancers, there is an exploration of the limits of motion capture, and the expectations of the audience regarding the reliability of technology. Only one dancer is tracked by the motion capture system (a suit incorporating motion sensors). The visuals include real-time visualizations of the body, created through motion capture data. E-motional Landscape explores the relation between the dancer's body and the space. Data from the dancers is collected based on a breath sensor and their position on stage, tracked by a camera. In a smaller segment, another camera is used to film the space, which is shown in the visuals, but this is considered out of scope for our study (as we are focusing on connection of visuals to the body, not the space). Connection Retrieval explores the connection between two dancers, who are either trying to connect or avoiding each other. In parts of the piece, one of the dancers is represented through the visuals on the screen, sparking a reaction from the other dancer. In other parts, both dancers are represented on the screen, affecting the movement on stage. In this piece, the camera is used as an input. A Dance to Remember is a solo piece, and consists of a dialogue between a dancer and an on-screen abstract avatar, that reacts to the movements and attitudes of the dancer and gives her advice. The avatar is actually controlled off-stage by the choreographer, creating the illusion of a virtual assistant. There is minimal captured data from the dancer as input.

All the performances took place in the same space, a black box theater at Tanzhaus NRW (Düsseldorf), in October 2019. In the scope of the Moving Digits project (movingdigits.eu) the dancers have been part of a team that, on average, participated in two previous design workshops, in the same year. The performances were the result of a two-week residency where the choreographers and the technologists worked together. Before the performances the dancers, the choreographers and the technologists rehearsed the four performances in a five-days workshop.

4.2. Questionnaires

The questionnaires contained a demographics section and the following questions, repeated 4 times (one group of questions per performance):

- a) Did you perceive a connection between the actions of the dancers and the visuals?
- b) Were the visuals on the screen merely copying the actions of the dancers?
- c) Did the visuals distract you from following the dancers' performance?
- d) Describe with a couple of words the relation between the actions of the dancers and visuals:
- e) Did you enjoy the visuals in the performance?
- f) Please add a couple of words regarding your opinion on the visuals:

Questions d) and f) are open-ended, and out of scope for this study. The other questions consist of 5-point Likert scales, where 1 represents "strongly disagree" and 5 "strongly agree".

4.3. Participants

We distributed the questionnaire to the audience members of the performance. The choice of filling the questionnaire was voluntary. 24 members out of a total audience of 26 (11 female and 15 male, age ranging between 24 and 62) filled in the questionnaire. This scenario of participants is imposed by the setting (a public performance). It might introduce some bias, as it can result in involving more interested audience members. This represents a limitation of this study.

4.4. Description of procedure

The audience members were asked to fill a questionnaire at the end of each performance, played in succession, one after the other. The test was repeated with four different performances. At the beginning of each performance, the audience members were asked to read the questions; this way, we aimed to limit the bias/learning effect form the performance. At the end of each performance, the participants were asked to answer the respective questions. The procedure involved repeated measures, as the same audience rated all the variables in four performances.

4.5. Analysis

Friedman's test is used to test for differences between groups when the dependent variable being measured is ordinal and Spearman's correlation test is a non-parametric measure of the strength and direction of association that exists between two variables measured on at least an ordinal scale.

Comparison of the four conditions. To compare the four variables in the four conditions, we used a Friedman test. As we obtained statistical validity in rejecting the null Hypothesis in all the four variables, we proceeded with pairwise comparisons. A detailed analysis is reported below. We performed a Friedman test comparison among conditions because:

- we had four groups;

- we had repeated measures / related samples;
- we had Likert scales, that is, an ordinal data set, therefore, the parametric assumption was not met.

We repeated the Friedman test four times, one for each variable.

Correlation of the dependent variables. We also studied the correlation between 1) the connection between the visuals and the body and enjoyment; 2) visuals merely repeating the body and enjoyment; 3) the distraction of the visuals and the enjoyment. To study the correlation, we considered the four performances as the same dataset and performed a correlation using Spearman's p (rho) correlation as:

- we had to correlate two variables;
- we had Likert scales, an ordinal data set, therefore the parametric assumption was not met.

We repeated the Spearman's test three times, one for each comparison.

5. Results

5.1. Comparison of the four conditions

Concerning the comparison among the four conditions, the results of the analysis support us in rejecting the null hypothesis about the distribution in each of the four variables. Below we detail the results for each variable.

Independent Variable: V1) Connection. Concerning the perceived connection between the visuals and the body variable, a Friedman's test for related samples was used on the recognition scores in the four conditions. Differences across conditions were significant, Fr(2)=18.149, p<.05. (Table 1)

Table 1. Results of Friedman test on Connection Variable

N	24
Test Statistic	18.149
Degree of Freedom	3
Asymptotic Sig.	<0.001

We also found statistical significance in two pairwise comparisons. Significance has been adjusted by the Bonferroni correction for multiple tests. We found significance in the following pairs:

- condition 2 – condition 3 (test statistic = -1.27, p = 0.004, effect size = 0.25)
- condition 1 – condition 3 (test statistic= -1.08, p = 0.022, effect size = 0.22)

Independent Variable: V2) Merely Copying. Concerning the visuals merely copying the body variable, a Friedman's test for related samples was used on the recognition scores in the four conditions. Differences across conditions were significant, Fr(2)=27.817, p<.05 (Table 2).

Table 2. Results of Friedman test on Merely Copying Variable

N	24
Test Statistic	27.817
Degree of Freedom	3
Asymptotic Sig.	<0.001

We also found statistical significance in two pairwise comparisons. Significance has been adjusted by the Bonferroni correction for multiple tests. We found significance in the following pairs:

- condition 2 – condition 3 (test statistic = -1.16, p = 0.010 ,effect size = 0.23)
- condition 3 – condition 4 (test statistic = -1.77, p < 0.001, effect size = 0.36)

Independent Variable: V3) Distraction . Concerning the distraction of the visuals variable, a Friedman's test for related samples was used on the recognition scores in the four conditions. Differences across conditions were significant, Fr(2)=8.186, p<.05 (Table 3)

Table 3. Results of Friedman test on Distraction Variable

N	24
Test Statistic	8.186
Degree of Freedom	3
Asymptotic Sig.	0.042

We did not find statistical significance in any pairwise comparison, for the variable distraction.

Independent Variable: V4) Enjoyment. Concerning the enjoyment of the visuals variable, a Friedman's test for related samples was used on the recognition scores in the four conditions. Differences across conditions were significant, Fr(2)=9.582, p<.05 (Table 4)

We did not find statistical significance in any of the pairwise comparisons, for the variable enjoyment.

Table 5 reports the medians of the four variables in the four conditions.

5.2. Correlation

We also performed a Spearman's test to investigate the correlation between each of the first three variables with the enjoyment of the visuals. For correlation, we looked at the four conditions together.

Table 4. Results of Friedman test on Enjoyment of the Visuals Variable

N	24
Test Statistic	9.582
Degree of Freedom	3
Asymptotic Sig.	0.022

Table 5. Overall trend of the 4 variables with the 4 conditions ([*] or [**] – statistical validity in pairwise comparison)

Variables	C1 Motion Capture	C2 Sensors	C3 Camera Image	C4 Minimal Interaction
Connection	4 [*]	3.5 [**]	5 [*] [**]	4
Copying	2	2 [*]	4 [*] [**]	1 [**]
Distraction	3	3	2.5	1
Enjoyment	4	3	5	3.5

Correlation between V1) connection and V4) enjoyment. Results of the Spearman rho test show a significant correlation (r = 0.497) between the perceived connection between visuals and the body and the enjoyment of the visuals ($p < 0.001$). High connection corresponds to high enjoyment.

Correlation between the V2) merely copying variable and the V4) enjoyment of the visuals. Results of the Spearman rho test show a non-significant correlation (r = -0.349) between the visuals merely copying the body variable and the enjoyment of the visuals ($p = 0.636$). This correlation is not statistically significant.

Correlation between the V3) distraction and the V4) enjoyment of the visuals. Results of the Spearman rho test show a significant correlation (r = -0.349) between the distraction of the visuals and the enjoyment of the visuals ($p < 0.001$). Low distraction corresponds to an increase in the enjoyment of the visuals.

6. Discussion

Based on the results of our analysis, we can propose the following reasoning related to our hypotheses.

6.1. Research Question 1

Concerning H1a): we can confirm that the camera condition C3 was more effective in creating a direct connection with the body (V1) compared with the sensors condition C2 and the motion capture tracking suit condition C1. Therefore we can argue that our hypothesis H1a) related to which condition was more effective in creating a connection between visuals and dancers was partly verified (C3 was more effective than C2).

This result is not surprising, as the camera was acquiring the full body information of the dancer, while the sensors could obtain only specific parameters. The camera condition C3 also had a higher median than the motion capture condition (tracking suit) C1. This is of interest because the tracking suit still has a connection with the full body (though possibly less obvious, as it is reconstructed visually as an avatar). More relevant is also that the pairwise comparison between the camera C3 and the minimal interaction C4 condition had no statistically significant difference. Therefore, we have to reject the hypothesis of the second part of H1a) concerning connection (C3 was not more effective than C4). This is particularly interesting as the visuals in the minimal interaction C4 condition were not based on significant information from the body. We speculate that in the minimal interaction condition, the direct connection was so absent that the participants created their own connection based on the dramaturgical development of the piece.

The visuals merely copying the body (V2) median was higher in the camera condition C3 compared to the sensor C2 and minimal interaction conditions C4; this confirms our hypothesis H1b) (visuals in C3 were more copying the body than in both C2 and C4). This result is not surprising, but still it is a contribution to the debate on how to use visuals in dance.

6.2. Research Question 2

Concerning correlation, the results of our statistical analysis allowed us to confirm two out of our three hypotheses. In particular, the connection between the visuals and the dancers has a direct correlation with the enjoyment of the visuals (hypothesis H2a). This means that the audience appreciated the fact of perceiving a connection between the performer's actions and the visuals. This result is also aligned with the previous study on audiovisual performance by Correia et al. [6].

Our results also verify our correlation hypothesis H2c): the level of distraction of the visuals has a negative correlation on the enjoyment of the visuals. This is aligned with the focus group in the preliminary phase to this study [11]. Again this result is not surprising, but it still contributes to the discussion on visuals in dance. Concerning H2b): our results are aligned with our hypothesis (negative correlation between merely copying and enjoyment), but we did not have statistical validity to confirm this.

7. Limitations and future work

This study relied on four different performances. Although the development team was the same among the four pieces, this was not a controlled experiment type of study. For this reason, other elements, such as: choreographic or dramaturgical choices that are

idiosyncratic to each choreographer; individual dance style of the dancers; or the specific visual effects that each piece used; probably had some impact over the results. This is the main limitation of the study. The choice of the setting is derived by the main framing of the project Moving Digits, whose primary goals are related to core artistic production.

The choice of an in the field setting offered us the possibility to observe and study the impact of the different technologies in a scenario that represents well the real context of dance performance, where the different elements are not separated, nor separable, in a complex ecology. We advocate that future studies that point toward a more controlled-condition context might be useful to further investigate the topics discussed in this article. Another element that might also deserve specific investigation is the impact of different visual choices over the perception of interaction. Based on the limitations described, we suggest the reader to approach our results as recommendations, or suggestions, rather than prescriptive or strict guidelines.

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