Joint Research in Dance and Computer Science: Emotion recognition as an interaction for an augmented dance show

Alexis Clay* — ESTIA Recherche
Nadine Couture† — ESTIA Recherche
Jean-Baptiste de la Rivière‡ — Immersion R&D
Gaël Domenger§ — Malandain Ballet Biarritz

ABSTRACT

We describe the joint research that we conduct in gesture-based emotion recognition and virtual augmentation of a stage, bridging together the fields of computer science and dance. After establishing a common ground for dialogue, we could conduct a research process that equally benefits both fields. As computer scientists, dance is a perfect application case. Dancer's artistic creativity orient our research choices. As dancers, computer science provides new tools for creativity, and more importantly a new point of view that forces us to reconsider dance from its fundamentals. In this paper we hence describe our scientific work and its implications on dance. We provide an overview of our system to augment a ballet stage, taking a dancer's emotion into account. To illustrate our work in both fields, we describe four events that mixed dance, emotion recognition and augmented reality.

Index Terms: J.5 [Computer Applications]: Arts and Humanities—Arts, fine and performing

1 INTRODUCTION

Joint research between a technical domain and an artistic domain seems a difficult task at first glance. How to conduct research in Science and Arts at the same time? Augmented Reality (AR) seems to be able to give a way to answer. A growing interest has risen particularly from the artistic community. Within the scope of our research in AR and human-machine interaction, we developed a close relationship between a research laboratory and a ballet dance company. Our interests lie in gesture-based emotion recognition and the augmentation of a ballet stage during a dance show.

Mixed Reality [17] is an interaction paradigm born from the will to merge computers processing abilities and our physical environment, drawing a computer abilities out from its case. The goal is to eliminate the limit between the computer and the physical world, in order to allow interweaving information from the real world and information from the virtual world. On the continuum of Mixed Reality, from real word to virtual word, the AR paradigm appears. AR consists in augmenting the real world with virtual elements such as images. For example, scanner information of a patient, collected before surgery, can by directly projected onto the patient during the surgery [13], virtual information is then added to the physical space.

We seek to explore the potential of AR in the context of a ballet dance show to better convey the choreographer message and suggest innovative artistic situations. Several augmented shows were conducted since about fifteen years ago. The evolution of technologies and systems in the field of AR allowed performance artists to use them as tools for their performances. First, The Plane [19] unified dance, theater and computer media in a duo between a dancer and his own image. With more interactive features, Hand-Drawn Spaces [15] presented a 3D choreography of hand-drawn graphics, where the real dancer's movements were captured and applied to virtual characters. Such interaction coupled with real time computing were achieved in "The Jew of Malta" [16] where virtual buildings architecture cuts and virtual dancer costumes were generated, in real time, depending on the music and the opera singer's position on the stage. However, as far as we know, using emotion recognition to enhance spectator experience by the way of AR in a ballet dance show is a new challenge. This is the aim of our thought and of our prototype described in this article.

Computer-based emotion recognition is a growing field of research that emerged roughly fifteen years ago with R.W. Picard's book "Affective Computing" [18]. The process of emotion recognition is usually divided into three steps: capturing data from the user, extracting emotionally-relevant cues from this data, and interpreting those cues in order to infer an emotion. Main issues in this area cover the identification and validation of emotionally-relevant cues according to different affective channels (e.g. facial expression, voice subtleties), and interpreting those cues according to a certain model of emotion [8]. In our work on emotion recognition, we rely on Scherer's definition of emotions [20], whereas we consider "affect" to be a generic term, emotions being a category of affect.

In the following, we describe how we conducted a research jointly between the computer science field and the dance field, taking from each domain to progress in the other. We describe the computer systems used for recognizing emotions and augmenting a ballet dance show, as well as how those technologies were used for research in dance. We then describe four events that we jointly conducted. One is dominantly scientific, another one is dominantly artistic, the third is a balanced mix of both. Finally, the last one concludes our research within the CARE project [3] and gathers technologies, methods and artistic reflexions that arose during the project.

2 GESTURE-BASED EMOTION RECOGNITION

There is a large literature about bodily expression of emotions. Darwin [10] listed several body movements linked to different emotions. In the field of psychology, de Meijer [11] identified and validated, through human evaluations of actor performances, affect-expressive movement cues, such as trunk curvature, position of hands or velocity of a movement. Later, Wallbott [21] conducted a similar study with different sets of emotions and body movements. The analysis of evaluation data enabled both of them to compute the weights of each movement cue in the expression of a set of particular emotions. Coulson [9] extended this research by working on affective cues in static body postures. In the domain of dance, Laban's Theory of Effort is a seminal work focused on expressive movements. As a choreographer, his work was drawn from and applied to dance. Laban divides human movement into four dimensions: body, effort, shape and space [14]. These dimensions focus on describing the expressiveness of a gesture by identifying how a particular gesture is performed, as opposed to what gesture is performed. In the field of computer science, the Infomus Lab

*e-mail:a.clay@estia.fr
†e-mail:n.couture@estia.fr
‡e-mail:jb.delariviere@immersion.fr
§e-mail:g.domenger@malandainballet.com

in Genoa based their research on Laban's theory to identify and validate formally-described cues for computer-based recognition. Their studies cover several artistic contexts such as dance [6] and piano performances [7].

This research frame pushes the dancer to question himself on what is "interpretation". Sharing emotions with an audience and a computer are clearly two different things, which nevertheless implies the same process of research. This process that goes through his body and implicates his mind follows a long tradition of research and theories that dance carries through history to its today practice. The body being the focus point of dancers, the whole process questions the relationship that the dancer developed during his career between his mind and his body. It forces him to come back to basics and fundamentals. What is space? What is time? What are the others? Here are the questions that he has to ask to himself and to the computer. Computer-based emotion recognition forces us to establish a distinction between emotions and their expression. This nuance implies a deeper analysis of movement qualities and on the ways we have to translate them into a computer language. This translation needs to be regularly upgraded each time scientists and dancers manage to move forward together. The relationship between scientists and dancers remain, in that research, at the centre of every progress made by the computer concerning recognition of emotions through observation of movement. It is somehow imperative for the scientist to understand the modifications of qualities produced by the dancer's dance in order to refine the recognition parameters given to the computer. The dancer in his side needs to explain and dissect his practice to reach a better understanding by the computer. This whole process generates an atmosphere that is clearly particular and unusual for the practice of dance. We have reached a point where we can observe the apparition of emotions that needs to take their place in the global experiment that scientist and dancer are going through, together.

3 AUGMENTING A BALLET DANCE SHOW: USE CASE

We developed a framework to augment a ballet dance show built on several applications, which aims at providing with a generic and reusable solution for augmenting a performing art show.

3.1 Augmented technologies, a support for research in dance

The different propositions made by AR technologies allow dance to step forward in its principles and to share the staging process with other art forms that have not participated until today to its development. The different steps of research that have been made to understand the particularities of the relationships between humans and machines have generated an aesthetic of its own that we find interesting to include into the staging work. To correspond with that aesthetic we observed that the collaboration between science and the particular art form of dance has created a form of thinking that could also be included in the staging process and that would give access to the audience to the questions generated by our research. We would like as well to build a story line that strips the modalities of that research on emotion and give meaning to its presentation as a show. The materials of texts, graphics, sounds, lights, that represent this research need something to link them to each other to be able to appear on stage and create an artistic logic reachable and clear for the audience. The tools proposed by AR technologies offer the opportunity to bring forward research on dance and help dancers finding solutions on the path of sharing with an audience the emotions that are being exchanged between a machine and a human.

3.2 Capturing the movement

The Moven suit is a motion capture suit that uses 16 inertial motion trackers composed of several inertial measurement units (3D gyroscopes) positioned on all the joints. The body model is a biomechanical model composed of 23 segments. Sensors allow for absolute orientation of each segment; translations are computed from each segment's orientation. Moven Studio is a commercial solution software provided by XSens with the Moven motion capture suit. Its role is to acquire and process data in real time from the suit. It also offers an interface for post-processing of recorded movements. Network features allow Moven Studio to send motion capture data over the network.

3.3 Recognizing emotions

eMotion is a computer-based gestural emotion recognition system that was developed in the fram of the CARE project. It relies on three successive steps: acquiring data, extracting gestural and postural emotional cues, and interpreting them as an emotion. eMotion relies on gestural cues drawn from de Meijer [11] for inferring an emotion at each frame. Those cues are verbally described and have to be interpreted to be implemented in a computer system. De Meijer's work provides, along with those cues, their respective weight for interpreting an emotion. We hence interpret an emotion as the one corresponding with the maximum sum of weighted characteristics values, using de Meijer's weights values.

The eMotion software relies on motion capture which can send over the network the coordinates of 23 segments of the dancer's body in an open XML format. From the flow of coordinates provided by the Moven application which is described in 3.2, the eMotion software computes trunk and arm movement, vertical and sagittal directions, and velocity. The interpretation is then performed by choosing the maximum weighted sum of each cue over each of the six basic emotions: joy, sadness, anger, disgust, fear and surprise. The eMotion application delivers an emotion label at each frame and is able to send it over the network through an UDP connection.

3.4 Creating visual augmentations

3DVIA Virtools is a software edited by Dassault Systme which allows for quickly designing interactive immersive worlds. Virtools is not a modeling software; 3D models can however be imported from dedicated modelers such as 3DSMax. Virtools offers a visual way of setting up a virtual world and its interactions. A scene is composed of 3D objects. Each object can be given a behaviour through the use of behavioural blocks. Those blocks encapsulate atomic behaviours (e.g. translate, rotate). Through the graphical interface, a user can assemble and link those atomic blocks to create a patch that defines an object's behaviour. Patches for different objects can be linked, thus creating interaction.

Virtools offers specific tools for creating augmented reality setups, and additional blocks can be coded and added to the software's libraries. We hence developed new input blocks to receive movement data from the motion capture suit, and to receive recognized emotions from the eMotion software. This allowed us to use movements and emotions as main inputs in the virtual part of our augmented stage.

The final system can be distributed over three computers, using UDP network connections to transmit the data. Moven studio is indeed able to transmit movement data to both the eMotion software and the Virtools system. The eMotion software recognizes emotions in real-time and transmit them to the Virtools system, enabling it to use both movements and emotions for interactions.

Using network transmissions to link the systems allowed us to easily connect other systems to our setup. In the next section, we describe an augmented dance show which we performed, and which features additional systems such as emotion-driven music generation.

4 EXPERIENCE AND EVENTS: BASES OF JOINT RESEARCH

Joint research can only be performed through constant interaction. Scientific and artistic worlds, although very close on some points, also show differences. The first step towards collaboration is hence to create a common ground for mutual understanding. This can only be achieved with frequent interaction and, if possible, by integrating each partner into the other ones activities. During the CARE project, we tried to maximize our interactions. Artists heavily participated in scientific meetings, and scientists got involved in setting up performances, thus building a common background and way of working. Noticeable joint experiences include jointly-written scientific publications, participations in "Festival des Ethiopiques" in Bayonne in 2009 and 2010, and a staged augmented perfomance played at Biarritz Casino Theater.

4.1 Affective dance collection

In order to design augmenting modalities and test the recognition of emotion by the eMotion module, we collected motion-captured movements of a dancer. Dance sequences were performed by a single professional ballet dancer (see figure 1). Recordings were performed using the Moven capture suit, a firewire video camera and a camcorder. Expressive dance improvisations were collected in two sessions. In the first one, the dancer was told a single emotion label from our chosen set. Each affective state had to be performed three times. The 24 resulting sequences were randomly performed. The second session mixes the Ekman's six basic emotions [12]. Seven pairs were studied and randomly performed. This recording session allowed us to obtain 31 affective dance sequences as a collection of materials. Seven human evaluators were asked to choose, for each sequence, the emotions they thought the dancer expressed among the set of eight emotions. These sequences and their evaluation provided us with testing material for our eMotion application. These recollection sessions were clearly scientifically-oriented, though their setting proved interesting from an artistic point of view, as the dancer explored how to express a particular emotion through an improvised dance.

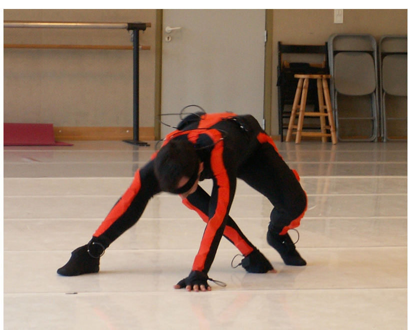

Figure 1: the Dancer wearing the Moven motion capture suit.

4.2 Ethiopiques: an improvised augmented show combining dance, music, text reading and a virtual world

This event took place in Bayonne, South-West of France, in March 2009 (see video on [4]). It took the form of an improvized show in one of the artists' flat and was open to the public, providing a comfy, but a bit strange atmosphere. A saz (a kurd lute) player and an accordion player improvized a musical atmosphere over which poetry was read. A professional dancer wore the Moven motion capture suit and improvized a dance over the music and text. Then, a 3D skeleton of the dancer was projected onto the wall. At the same time, a draftsman triggered flash animations in real time that superposed with the virtual scene. At the beginning of the show, the dancer was in a separate room. The audience could only see its virtual *alter ego* projected on the wall, and the superposed flash animations (as in figure 2). In the end of the show, the dancer moved and danced within the audience, which at this moment could see the real dancer interacting with them. The virtual dancer, the real dancer and his shadow on the wall formed a trio of dancers that bridged together the virtual and the physical world, as the three of them interacted with themselves, the audience and with the flash elements that were superposed to the 3D scene.

Figure 2: Scene of the Ethiopiques show with the dancer, his virtual representation, and virtual elements surimposed to the scene.

4.3 An open danced talk

The danced conference form is still rarely used but has been applied to domain such as paleoanthropology [1] and chaos theory [2]. In this danced conference, we mixed scientific communication and improvized danced to withdraw from the classical forms of scientific presentation and artistic representation. The dancer wore the Moven motion capture suit and improvized over a text, accompanied by music and lights. The form of a danced talk became naturally when trying to bridge the domains of computer science and dance. This form allows the dance audience to integrate a research problematic and processes, and allows the scientific audience to withdraw from a purely technical approach and better grasp the interest of research on emotion recognition. In the frame of our research, the danced talk explicited a constant and rewarding interaction between dance and research and allowed an equally rewarding interaction between dancers, researchers and the audience.

4.4 Staging of the research process: a milestone in joint research

In March 2011, we presented at the Casino de Biarritz an augmented dance show: CARE project, staging of a research process. The show was composed of two parts. The first part was a danced conference. The project coordinator presented the CARE project and its different findings, from the theoretical ones to its concrete applications. This presentation was accompanied by demonstrative applications and videos, and a dancer improvized a choreography on the sound of the presenters voice. The dancer also included demonstration of both software and hardware developed during the project within his dance. The second part was an augmented dance show showing the research process that had been undergone both by scientists and artists in the preceding years. It was itself divided in seven parts, showing the gradual improvements and findings.

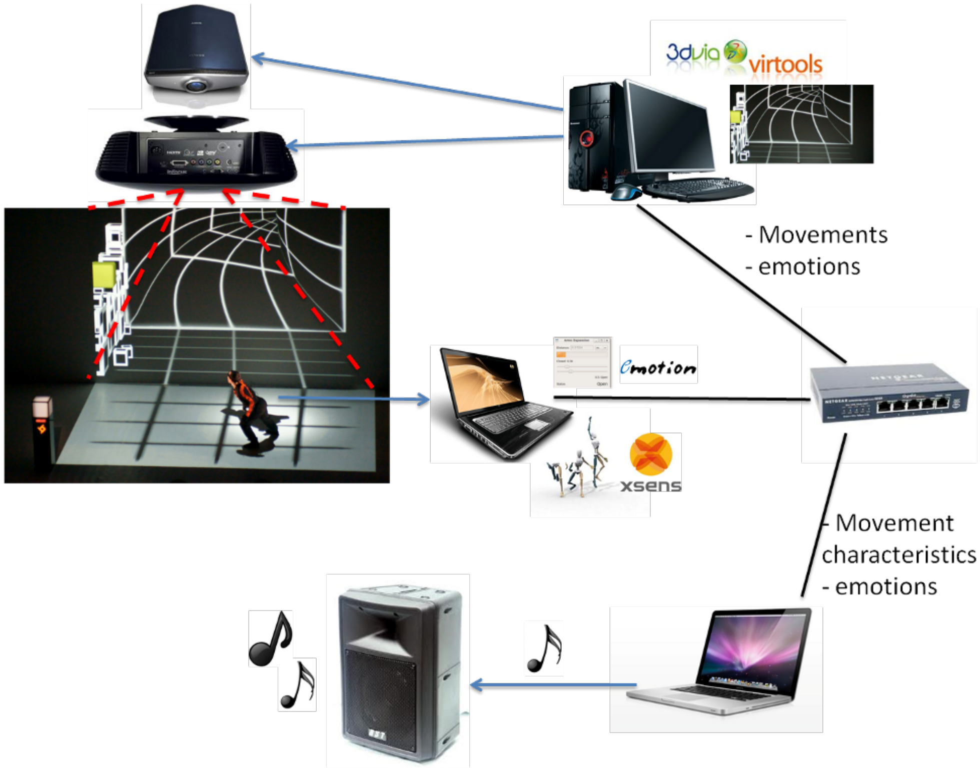

Figure 3: hardware setup for the augmented dance show.

The core of our setup was the trio of applications presented previously, completed by a music generator from an invited research team (see image 3). The system was composed of three PCs on a network. The first PC gathered the MVN motion capture application and the eMotion software. This PC sents three kinds of data over the network: motion capture data from the MVN studio application, movement characteristics (e.g. trunk curvature, arms expansion) and emotions from the eMotion software. The second PC featured the interactive virtual world. It received the motion capture data and the recognized emotions. The visual output was then derived to two video-projectors. This set of two video-projectors allowed to project on both the back and the floor of the stage. The third PC received movement characteristics and emotions. It featured a music generation program that used recognized emotions as an input to create adequate pieces of music. Specific sounds were also played when receiving some movement characteristics.

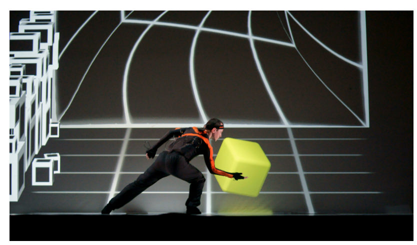

Figure 4: Scene of the augmented show: the dancer manipulating a virtual cube.

The several parts of the show allowed both technical experimentation and scientific and artistic research. The dancer was able to project his movements on a virtual avatar; replays of previously recorded sequences allowed him to dance with himself. 3D objects could be attached to the dancers limbs and manipulated (see image 4). 3D was also explored in a successful final part. A video of the show is available at [5].

5 Conclusion

For computer scientists, such a collaboration is an occasion to explore the domain of dance and to study body language and movements in order to allow a computer recognizing the emotion expressed by a dancer. For dancers and choreographers, it is an occasion to go back to the source of movement and to re-question the fundamental themes of dance, time, space, and the others, while being able to see its animating concepts shape themselves as a virtual representation casts in the real world. The first step of the collaborative research was establishing a common ground for dialogue. For scientists, it allowed understanding some of the world of dance and the significance of some concepts such as time, space, and the other. For dancers, it opened the doors on the reality of scientific research and to better understand what it could and could not bring to dance. We hence experienced conducting research jointly, between the computer science domain and the dance domain. Such a collaboration brings forward many advantages. For scientists, dance and dancers can be used as an application case and an experimental tool. Artists creativity makes them formulating new needs that drives research forward. For dancers, science presents itself as a world to explore throughout their arts. Its constant questioning and attempts to model reality implies revisiting the fundamentals of dance. Finally, developed technologies provides artistic tools for visiting new virtual worlds.

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