



Improvising virtual dancer meets audience: Observations from a user study

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Abstract

The interdisciplinary project *AI_{am}* explores the potential roles of artificial intelligence in dance. One of the aims of the project is to create a performance where a human and a virtual dancer interact in real time in a mutual exchange where the human dancer and the avatar learn from and inspire each other. Apart from enabling an engaging experience, this kind of interaction would potentially also encourage movements that might otherwise not emerge from human improvisations. As a first step towards this goal, a method for generating novel dance movements from recorded motion sequences has been created. The next step is presented in this paper: an interactive setup where visitors can control parameters governing the avatar's improvisations. A user study of the installation indicates that the avatar's movements are interesting, engaging and inspiring. Implications of these results for future work are also discussed.

Keywords

Dance, Improvisation, Creativity, Art installation, Human-computer interaction, Expressive movement, Machine learning.

Introduction

The interdisciplinary project *AI_{am}* brings together the two seemingly disparate fields of artificial intelligence and dance to investigate the possible effects of their cross-fertilization. The ultimate focus of the project is to find out how AI can be used to transform the traditional exclusivity of dance to human bodies into a live interaction between physical and virtual bodies. One of the goals is to create a performance in which a human dancer and a virtual dancer have a fluid and interactive duet in real time.

As a first step towards this goal, a method for analyzing and generating movements has been developed. A small database of dance movements was recorded and reduced to a "pose map". An "improvisation algorithm" for automatic exploration of this map was then designed, traversing neighborhoods near observed poses and thereby reconstructing and synthesizing combinations of familiar and novel movements. These movements were manifested in the form of a dancing avatar.

The next step involved testing the software in the studio with the dancer in the research team, assessing its effectiveness as a tool for inspiring new and creative movement

choices. The avatar's movements were observed, then imitated and used as a stimulus for further invention and development by the dancer. She confirmed that the software was indeed a useful tool for both improvisation and composition, and ultimately a promising partner for a stage performance. (Berman and James 2015)

Following this confirmation, it was determined that non-specialists should also be consulted as a future audience. An interactive art installation was determined the optimal way to introduce non-specialist audiences to the concept of a virtual improvising dancer. Participants were invited to manipulate its movements through the use of a touch interface. This opportunity was taken to collect feedback about how the participants felt about observing and interacting with the dancing avatar.

The paper begins with a description of the improvisation algorithm developed within the project. This is followed by a presentation of the interactive installation and observations from the user study. The presented project is then positioned in the context of related work. Finally, some conclusions are drawn.

Improvisation algorithm

Our method for generating novel movements utilizes a database of recorded human motion sequences which is analyzed statistically (Berman and James 2014). For purposes of simplification, the motion analysis focuses on the postural content of movements rather than their temporal dynamics. In other words, the analysis only deals with how limbs and joints are configured in particular moments, rather than how poses within a movement develop over time.

By performing a statistical analysis which reduces the complexity of the training data, a "map" of possible poses is created, containing regions of observed as well as unfamiliar poses. The analysis consists of two steps: First, recorded movements are stored as vectors containing orientation data for each joint, represented by unit quaternions (4 values). Secondly, the dimensionality of the data is reduced by nonlinear kernel principal component analysis (KPCA) (Schölkopf, Smola, and Müller 1998).

A motion database was created by recording about 5 minutes of material. The moves were performed by the team's dancer and were derived from poses that relate to certain spatial points, and the movement that arises from moving back

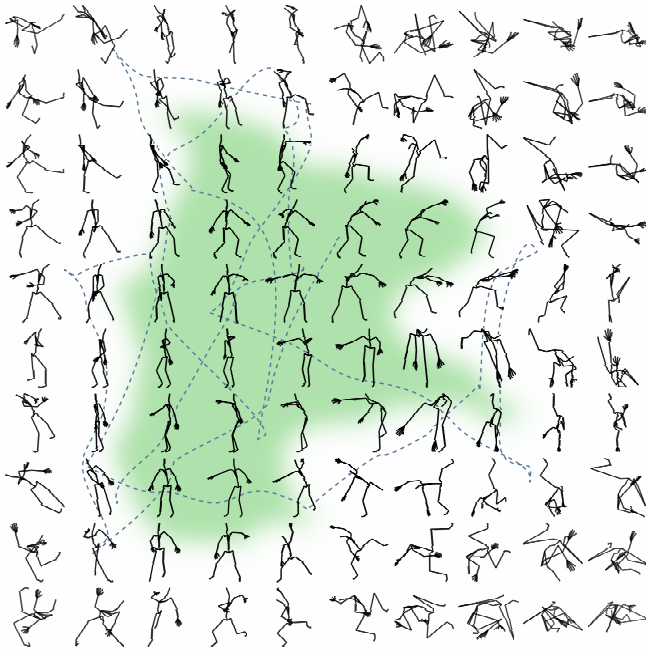


Figure 1: An example of a 2D pose map and a generated movement path. The green area represents the region of observed poses, while the surrounding areas contain poses without any direct equivalents in the training data. The blue dotted line represents an example of an automatically generated trajectory with a high novelty parameter. For the actual experiment, a 7D map was used.

and forth between these poses. A skeleton model with 52 joints was used, out of which 21 finger joints with static orientations were excluded from the analysis, yielding $31 \times 4 = 124$ input dimensions. By KPCA the database was reduced to a pose map of 7 dimensions, a value constituting a reasonable trade-off between simplification and accuracy.

A method for automatic exploration of the pose map was then designed. Trajectories across the map are generated by an algorithm and can then be synthesized as full movements by sequencing the constitutive poses denoted by the path. The algorithm was designed so that it would primarily generate paths in the vicinity of observed poses, thereby producing somewhat realistic and familiar output. On the other hand, it should also expose novel poses beyond observed territories. The requirements were satisfied by an algorithm based on randomness, attraction to observed poses (familiarity) and deviation from observed poses (novelty):

1. Select a random observed pose in the map as the departure point p
2. Generate a set of destination candidates $\{q_i\}$, where each candidate is a random observed pose plus a random vector of magnitude N (the “novelty” parameter)
3. Choose the destination q as the candidate among $\{q_i\}$ whose distance to p has the smallest difference from the preferred distance E (the “extension” parameter)
4. Choose some intermediate points between p and q , where

each intermediate point lies between a point on the straight line between p and q and its nearest observation in the map (closer to the nearest observation for lower N values)

5. Smooth the resulting path using spline interpolation
6. Create the next trajectory by treating the current destination as a departure and repeating steps 2-5

Figure 1 shows the contents of a pose map and an example of a generated trajectory.

Interactive experiment

The most recent phase in the project is an interactive experiment where the improvising avatar is projected on a screen in simple stickman graphics (figure 2), while its behavior can be controlled in real time by audience members utilizing a tablet (figure 3). The graphical user interface consists of three sliders corresponding to different improvisation parameters (figure 4).¹ Conceived and realized through a participation in the ARTSHO5 exhibition in Istanbul (November 2014), this occasion allowed us to observe and assess the responses evoked in the participants in order to inform continuation of the project. The experiment enabled several questions to be asked to an audience of non-specialists: Are the avatar’s movements interesting and/or inspiring? Is the user interface intuitive and engaging? How is the simple appearance of the avatar received?

Results

About 20 people interacted directly with the installation, and 7 user experience questionnaires were filled. Participants ranged from ages 18 to 55 including students, art bloggers, artists, and teachers. The reception of the improvising avatar was very enthusiastic. 6 out of 7 found the installation easy to operate. All found the movements interesting, with excitement and curiosity being the most popularly reported emotions felt by participants while interacting with the avatar. 4 found the stickman appearance engaging. Some liked that the movements were very clearly visible, while others could relate emotionally to the avatar.

During the presentation of the software, some audience members laughed uncontrollably at the strangeness of some of the avatar’s moves. Others were stunned by the complexity of its novel movements. Some audience members even tried to imitate the avatar’s movements. Although the intended interaction was through the tablet, some participants reacted kinesthetically with full body motion, turning the installation into a “dance karaoke”. Such participants seemed to become quite immersed in following the avatar’s movements and only let their focus move away from the avatar after they had become too tired to continue. These participants were not inclined to interact through the tablet.

Suggestions from participants included a higher resolution, a more anatomically correct representation, and a variety of avatar appearances to choose from. One participant proposed projections of the avatar on all four walls, enabling a more

¹Videos can be found at http://timebend.net/AI_am/ISEA2015/

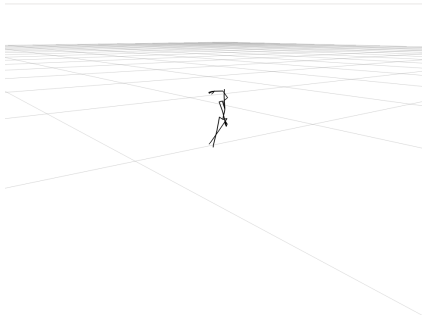


Figure 2: Screenshot of the avatar.



Figure 3: Participant using tablet.

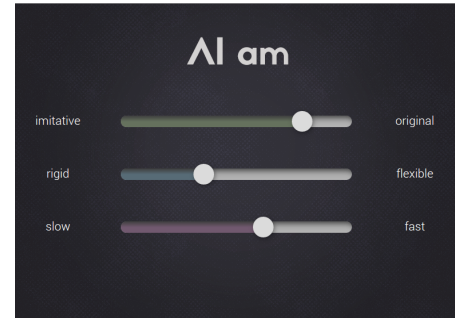


Figure 4: The user interface.

immersive experience. Another person suggested to introduce the installation to children because they would gladly follow the avatar in its dance.

One possible improvement of the user interface was identified. The sliding bar controlling the degree of novelty in the avatar's movements used the terms "imitative" vs "original", which caused misunderstandings as "original" was confused with the reference to the training data given to the avatar; the term "novel" might have been a better choice.

Related work

The AI.am project explores the use of software to develop novel movements and stimulate choreographic ideas. A few precursors to this work deserve mentioning. The interactive software LifeForms was used by Merce Cunningham as a choreographic tool in the creation of the performance Trackers (Schiphorst 2013), and Wayne McGregor and his dance company have used Choreographic Language Agent (CLA) created by OpenEnded Group in rehearsal as well as development (deLahunta 2009). The abstract geometric forms generated by the CLA software have recently been replaced by a more human-like shape, used as an "eleventh dancer" in the studio (Rothwell 2014). There are also related examples of real-time interactions between virtual and human dancers, e.g. recent work at Deakin Motion.lab where an avatar projected on stage recognizes and responds to the movements of a human dancer (McCormick et al. 2013). In contrast to these examples, the presented project combines computerized generation of novel movements with real-time interaction between software and dancer.

Conclusions

Despite the small number of participants in the user study, some conclusions may be drawn. The user interface was fairly intuitive, and the avatar's movements were generally found to be interesting and engaging, despite the simple visual appearance. The most novel expressions by the virtual dancer caused both laughter and amazement in the audience. The most surprising outcome was the "dance karaoke" that emerged spontaneously. All in all, the results indicate that an interaction with this kind of kinaesthetically creative avatar can be both interesting and rewarding, and that a more compelling and immersive form of interaction could strengthen this potential even further.

In future studies, it would be interesting to involve more dancers in evaluations of the software. This would enable specialist feedback regarding movement qualities and choreographic potential. Planned future work will also explore real-time input from motion sensors enabling a full body kinaesthetic interaction between a dancer and the avatar. In our eyes, the current experiment confirms the relevance of this pursuit.

From a more general perspective, the study suggests that novel movements generated by software can engage and inspire minds and bodies – an insight that hopefully can be generalized beyond the methods and approaches adopted in this specific project and challenge common conceptions about creativity and autonomy in machines.

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