AI Meets Holographic Pepper's Ghost: A Co-Creative Public Dance Experience

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Figure 1. LuminAI Installation.

Abstract

In this demonstration, we present a holographic projected version of LuminAI, which is an interactive art installation that allows participants to collaborate with an AI dance partner by improvising movements together. By utilizing a mix of a top-down and bottom-up approach, we seek to understand embodied co-creativity in an improvisational dance setting to better develop the design of the modular AI agent to creatively collaborate with a dancer. The purpose of this demonstration is to describe the five-module agent design and investigate how we can design an immersive experience that is design-efficient, portable, light, and duo-user participation. Through this installation in an imitated black box space, audience members and dancers engage in an immersive co-creative dance experience, inspiring discussion on the limitless applications of dance and technology in the realms of learning, training, and creativity.

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1 Introduction and Background

Creativity is an essential element of human cognitive capacity [1]. According to Glaveanu [3], creativity is a multi-dimensional process that involves the interaction of socio-cultural and psychological factors. This process entails working with materials that are influenced by cultural elements that take place within a shared space, ultimately resulting in the creation of artifacts that are deemed novel and meaningful by individuals or communities in a particular context. Key attributes of creative ideas include being novel, surprising, and significant (or valuable). i.e, interesting, useful, or beautiful [2] [3]. One highly creative activity is the art of dance improvisation. Movement improvisation is a form of dance that relies on the dancer's ability to create spontaneous and in-the-moment movements without predetermined choreography [12]. To provide examples, a novel idea in dance might involve the use of an unexpected body part, a surprising idea might be found in a dancer's use of timing, an interesting idea might juxtapose unexpected physical symbols or gestures, and a beautiful idea might be found in a tender moment of contact between two dancers. Although creativity in the context of artistic dance expression can be readily recognized through visual, emotional, and physical means by a human, its conceptualization through language and quantitative measurement can be a more complex endeavor, which is why the work of understanding and quantifying creativity in dance is challenging. In dance improvisation, the emphasis on quantifying the experience is centered around the process of creating and exploring movement rather than fixating on the final outcome or resulting artifact [10], owing to its ephemeral nature. Various factors affect movement generation. Dancers may draw on their prior experiences, current emotional state, cultural background, and ideas to inspire their movements, or may respond to external stimuli such as music, the environment, or other dancers, all contributing to its multi-faceted nature [10] [14]. Dance improvisation is not usually conducted in isolation, and creative expression through collaborative efforts or otherwise known as co-creativity holds significant importance in shaping our shared human experience [1]. Co-creativity includes the experience and presence of another individual, whether that be a human counterpart or an AI agent to explore how two people can collaborate and engage together to create a shared artifact (in-tangible or tangible) [5]. This requires that a creator widen their perception to include a meaning-making relationship with a co-creative partner. Therefore, this work studies co-creativity within the specific context of improvisational dance because it involves making immediate and real-time choices that consider a myriad of stimuli. The recent explosion of generative AI tools, namely GPT-4 and Stable Diffusion are harnessing this concept of creativity, and AI is now becoming more than just a tool, it is an intelligent partner. However, as common as this experience is becoming in our lives, it rarely defines our interactions with technology in the creative art of dancing. Dance technology research has primarily focused on supporting movement notation, designing code-based choreographic and assessment tools, and creating performance visualizations [11]. AI has the capability and advantage of analyzing movement patterns well suited to the complex intertwining factors of the body, environment, and co-creative nature of dance. Considering all these viewpoints, we utilize AI and motion capture to design a dance improvisational tool called LuminAI, to synthesize and adapt the unspoken co-creative aspects that go beyond the abilities of the human eye [8] [9]. The purpose of this ongoing research seeks to better understand embodied human co-creativity to design an artificial intelligent agent that can co-create with people. This demonstration expands the design of LuminAI and investigates how we can design an immersive experience that is design-efficient, portable, light, and which affords performer and audience engagement. Through this work-in-progress work, we aim to impart invaluable information in understanding human co-creativity in movement as well as designing a co-creative AI technology, while also gaining new perspectives to recognize the deep value of embodied choices. The next section will go into more detail on the agent design followed by the installation design.

2 LuminAI Agent Design

The three-module pipeline of this agent has been described by Lucas et al. [7]. In this demonstration, we expand the design into a five-module pipeline that aims to answer the following research question: How do we design a modular system for building embodied co-creative agents?

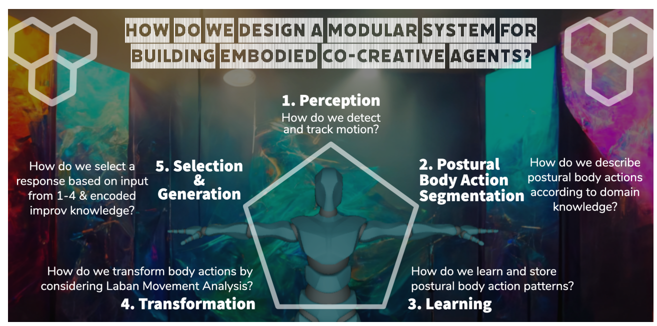

Figure 2. Five Module Pipeline.

The five-module pipeline is outlined as followed by Figure 2: 1) Perception module which captures the motion and key body joints that can either use a Rokoko motion capture suit worn by a dancer or an Azure Microsoft Kinect; 2) Postural Body Action Segmentation module that segments postural body actions temporally every three seconds; 3) Learning module that stores body movements from dancers in a Mongo database, saves a Body Frame for each frame of motion, and encodes parameters about the body action adapted from the methodology of Viewpoints [4] and Laban Movement Analysis (LMA) [6] such as energy, tempo, size, velocity (per joint), angular velocity (per joint, in quaternions), acceleration (per joint per frame), angular Acceleration (per joint per frame, in quaternions), Laban's sudden effort as one of the indices of jerk frames, Laban sustained effort as one of the indices of smooth frames, and in terms of the geometric qualities defined by Laban's conception of space of how a body action is encoded into the different planes and vertices of an icosahedron (the shape Laban uses to reason about movement) [9]; 4) Transformation module that takes motion input and transforms postural body actions using LMA; and finally, 5) Selection and Generation module that allows the agent to select and generate an intelligent response and present it on the Hologauze. More specifically, LuminAI is capable of transforming movements through a variety of methods using LMA. We conducted small focus groups with pre-professional dancers to gain an understanding of the strategies they use to transform and respond while improvising with a partner. These transformations include mirroring body movements across the body (matching left-side body movements to the right and vice versa), making a movement more sustained by smoothing out jerk frames, making a movement jerkier by shortening sustained frames, and reflecting movements across the vertical, horizontal, and sagittal frames of the Laban icosahedron. The selection and generation module is a decision-making module that allows the agent to choose responses based on various criteria. These include modifying the movements based on Laban criteria from the transformation module, finding similar or contrasting movements based on Viewpoints predicates, or simply mimicking the dancer. The use of LMA has been observed in the context of HCI for the purpose of formally representing domain dance knowledge and for capturing pertinent features from human movement which can subsequently be interpreted by a computer [13]. The next section will describe our installation design.

3 Installation Design

To design our installation design, we devised the following question to guide our exploration: How can we design a public installation that presents LuminAI in an immersive way and allows dancers and audience members to engage in the same co-creative dance experience? We identified the following requirements: The installation must 1) allow both dancers and audience members to view the agent; 2) be design efficient; 3) be portable and modular, and 4) be lightweight. Becoming design efficient means creating a design that achieves its intended purpose with minimal waste of resources such as time, money, materials, and energy. We sketched and explored three design alternatives. The conceptualization was first inspired by the notion of the "Pepper's Ghost" illusion. This effect, which gained popularity during the 186 0s, is a visual illusion method that produces the effect of a transparent or ethereal image seemingly manifesting in a tangible environment. It is created by reflecting an image or object off of a large sheet of glass or plexiglass, which is positioned at an angle between the audience and the stage. The glass is typically invisible to the audience, and the reflected image or object appears to be floating in mid-air or positioned on the stage. Well-known examples include the Haunted Mansion ride at Disney World, the 2012 Tupac Coachella festival, and the 2014 Billboard Music Awards with Michael Jackson. We set out to design and manufacture a low-cost version of these examples. Our first design exemplified in Figure 3 utilized a three-sided plexiglass object. This design deployed three pipe and drape backdrops, a short-throw projector, a projector screen, and a stage riser to realize the effect. The pipe and drape allowed a customized configuration suitable for the execution of public spaces. The

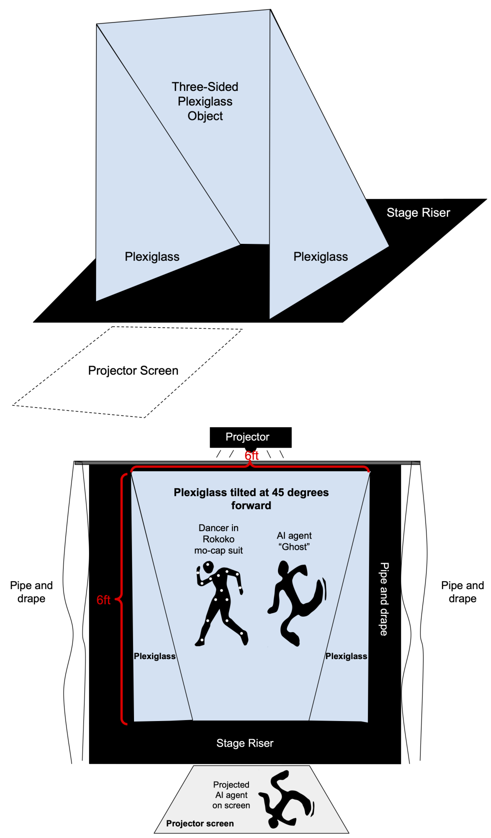

Figure 3. Design 1 Incorporating Pepper's Ghost Illusion.

proposed design operated as followed: a projector fixed to the ceiling projected the AI agent onto a screen, which was then reflected onto a free-standing plexiglass object comprising three panes. The front pane was tilted at a 45-degree angle to create the illusion and reflect the AI agent. The dancer would stand behind the plexiglass wearing a Rokoko motion capture suit, which will allow their movements to be captured and transformed through the LuminAI software. The stage riser elevated the dancer and the plexiglass object, concealing the projector screen from the audience to preserve the delusion. However, the complexity of the three-sided panels did not fulfill our requirements. Figure 4 represented our second design iteration, incorporating two key changes:

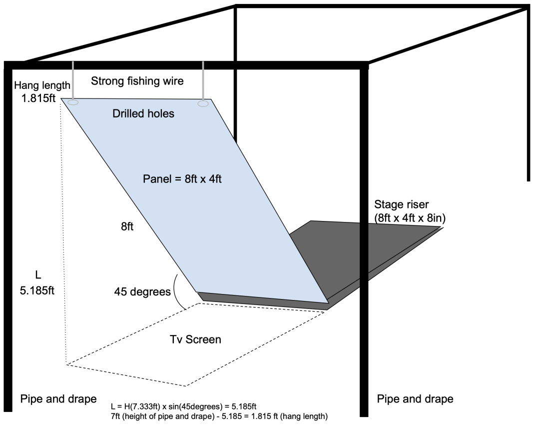

Figure 4. Design 2 Eliminating Three-Sided Plexiglass.

1) employing a single plexiglass panel, and 2) substituting a TV for the projection screen. To enhance design efficiency, we created a streamlined installation method by lasering holes in a single panel that could be attached to the pipe and drape. To optimize the image display, we utilized an LCD TV, reducing the number of components necessary to project onto the plexiglass. However, we encountered a significant obstacle with this design, as the plexiglass was ultimately too heavy to meet our portability requirement. Given this requirement, we revamped the experience to en-

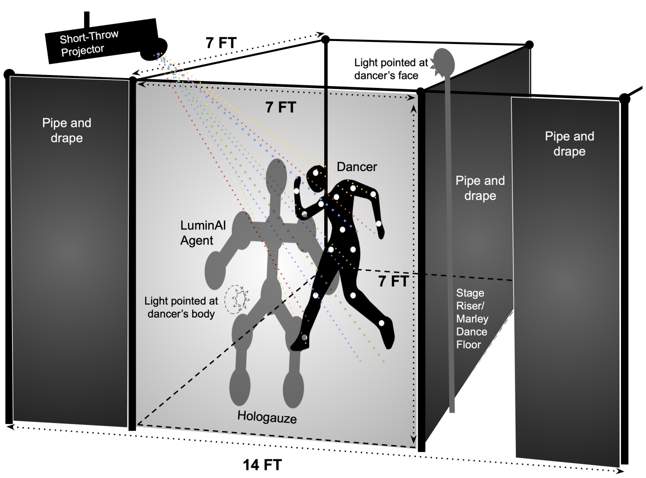

Figure 5. Design 3 Including Hologauze.

compass cutting-edge technology. Our final design, shown in Figure 1 and 5, incorporates Holotronica’s patented Hologauze screen technology. Composed of a semi-transparent mesh fabric, Hologauze displays holographic-looking images when paired with projection mapping technology. The mesh structure of the screen allowed the image to appear to float in mid-air, providing a unique and immersive visual experience. We tested the screen with a short-throw projector and found that it created a stunning effect without the need for bulky equipment or a complex setup. The primary challenge was achieving an optimal lighting balance to effectively illuminate the agent, the dancer’s face, and their body movements for the audience. The next section will describe preliminary observations as a result of two public exhibitions.

4 Preliminary Observations from Public Use

Upon completion of the installation, we tested it on two occasions: 1) a University-wide event; and 2) a museum gala night. Preliminary testing revealed challenges related to audience engagement, transparency in AI capabilities, and participant-agent interaction, which will inform subsequent redesign efforts.

Through observation and initial conversations with participants, we discovered the following preliminary findings:

First, the installation did not afford immediate audience participation with LuminAI as opposed to performers’ interaction. This may be due to two reasons: 1) the lack of social engagement offered by the imitated black-box space; and 2) an initial period of intimidation by being spotlighted on a makeshift stage. Future iterations should consider a more inclusive space for audience engagement, opting for a circular, cylinder, or two-panel Hologauze scrim without the full pipe and drape set.

Second, the audience wrongly perceived the agent’s capabilities, believing it generated pre-authored movements. It was not explicitly apparent that AI was being utilized on any design level due to initial movement lag and mimicking offered by LuminAI. This can be attributed to the phenomenon known as the tale-spin effect [15], which refers to a potential problem with AI systems, in which the system generates a superficial perception of simplicity. The effect is a concern because it could lead to a situation in which the system generates convincing but false information or narratives, which could have serious consequences if the information is used to make decisions or take action. The effect could also make it difficult for humans to detect when an AI system is producing misleading information. To address the tale-spin effect, future work can explore design iterations to ensure that the AI system is transparent and accountable in its decision-making processes and is able to identify, correct, and communicate false information or narratives through two-way interaction.

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