MR. Drone: Performers' Perception Towards Augmented Drone Avatars

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Abstract

Robots and drones are increasingly used in social roles, including emergency response, surveillance, entertainment, companionship, and creative performances. Through these studies, co-located drones have been observed to evoke emotions such as calmness, gentleness, or even therapeutic effects when designed with soft movement, ambient sound, and when communicating intent. This highlights that perception of the drone may vary depending on its form, motion, and the context in which they are used. Drones have been developed as co-performers in improvisational dance where spontaneity and open-ended expression are important. However, due to their default physical form factor, dancers often perceive drones as rigid, controlling, or intimidating. Recent studies in Human-Robot Interaction (HRI) have integrated Extended Reality (XR) to augment the forms of the robot thereby affecting its perception by humans. This thesis attempts to explore XR in co-located drones during dance performances through the use of augmented avatars. First, we conducted a co-design workshops with dancers to identify features and visual effects that shape drone perception. Next, this informs the integration of drone avatars in an XR environment where human dancers can perform with co-located semi-autonomous drones. Finally, we will conclude with a user study to evaluate whether these augmentations affect the dancers perceptions towards the drones. This thesis contributes to the growing body of literature that has explored how XR augmentations may re-shape social robotics.

Keywords: drones, perceptions, augmentation, avatar, improvisational dance, co-located human-drone interaction, extended reality, semi-autonomous UAV

Contents

Chapter 1

Introduction

1.1 Overview of the Current State of Technology

Drones have been explored across various domains, including emergency response, entertainment, communication, and many more (Herdel, Yamin, & Cauchard, 2022). Beyond physical assistance, they have also been utilized for emotional support and human interaction. Recent studies highlight how drones can bring relaxation by supporting somaesthetic interaction, improving bodily awareness, and mindful movement through intentional, close-range motion (La Delfa et al., 2020). These findings show how drones can shape embodied perception and facilitate immersive co-located human-drone experiences, emphasizing the importance of agency, control, and environmental context in how users interpret and respond to them. In addition to somaesthetic interaction, drones have been observed to be synchronizing companions for captivating performances, working alongside human dancers to create visually engaging interactions. These interactions influence how drones are perceived, not only as tools but as expressive co-performers. Existing research on improvisational dance shows that drones respond to real-time feedback, enabling new forms of choreographed movement (K. Dong, Zhang, Chang, Chirarattananon, & Lc, 2024). Thus, drones have potential not only as technical devices but as interactive agents that shape how performers experience movement and co-presence.

In creative and performative settings, drones have been used in light shows and dance performances for entertainment purposes. These applications indicate their ability to improve artistic expression through movement and synchronization. Drones in performance art vary in form factor depending on their intended role. They can be small, designed for fast movements, while others are larger, equipped with lights or projection capabilities to create visual effects. The number of drones used in performance also varies; a single drone may act as a co-perfomer, engaging in improvisational dance routines with human performers, whereas multiple drones may operate as a coordinated ensemble (K. Dong et al., 2024; Eriksson et al., 2019). Improvisational dance, defined by its spontaneous, unscripted nature, and emphasis on open-ended creative expression based on the dancer's kinesthetic awareness and real-time responsiveness (K. Dong et al., 2024). In such contexts, improvisation becomes a key mode of interaction, allowing both human and non-human performers to co-create movement that is fluid, emergent, and exploratory. The role of drones in dance performances can range from companions to instructors. A study in improvisational contexts indicates that drones often take the lead in movement exploration, engaging with human dancers as co-performers. However, this limits the opportunities for dancers to initiate movement or shape the interaction themselves (K. Dong et al., 2024). Their ability to move in three-dimensional space offers new possibilities for choreographers to explore space and movements in unconventional ways. In creative contexts, most drones operate along pre-programmed paths, functioning as semi-autonomous Unmanned Aerial Vehicles (UAVs), while some are capable of responding dynamically to human gestures (Eriksson et al., 2019; K. Dong et al., 2024; Cauchard et al., 2019; La Delfa et al., 2020). As drones continue to evolve, their role in creative contexts expands, offering new ways to explore creativity, spatial interaction, and movement improvisation.

Yet, despite their growing presence in the performing arts, drones, which has been referred to as a semi-autonomous UAV are often perceived as commanding and intimidating, particularly when positioned as co-perfomers. Rather than fostering mutual interaction, their mechanical nature and pre-programmed behaviors often lead human dancers to follow the semi-autonomous UAV's lead, creating an imbalance in the exchange (K. Dong et al., 2024). This dynamic makes the dancers feel constrained rather than motivated in their performances. This perception creates a barrier to natural interaction and engagement between human performers and drones. As a result, there is a need to explore methods that can mitigate the authoritative nature of semi-autonomous UAVs while enhancing their expressiveness in dance performances.

Despite these challenges, the potential for augmentation to reshape the perception of drones, particularly semi-autonomous UAVs in performance contexts remains largely unexplored. Research in Human-Robot Interaction (HRI) and Human-Computer Interaction (HCI) suggests that augmenting robots enhances their ability to communicate and interact with humans (Suzuki, Karim, Xia, Hedayati, & Marquardt, 2022). Building on this, integrating mixed reality (MR) into a semi-autonomous UAV can create an immersive and dynamic experience, improving how performers engage with these aerial robots. Given this, the study explores how augmented drones, functioning as semi-autonomous UAVs, can act as performative avatars in dance improvisation. Through augmenting visual overlays, its aim is to redefine the role of semi-autonomous UAVs in creative and performative contexts, transforming how they are perceived in dance and fostering greater acceptance within human-centered performances.

Integrating these visual elements enables drones to appear more interactive, reducing their robotic nature and making them more adaptable for dance performances. However, their mechanical behavior, such as hovering and abrupt movements, combined with their lack of expressiveness, creates a barrier to interaction (K. Dong et al., 2024). Leveraging augmentation in a semi-autonomous UAV with avatars can soften their authoritative presence, allowing dancers to perceive them as an engaging co-performer rather than rigid, pre-programmed robots. This study investigates these dynamics through the central research question: ***How is an augmented drone as a performative avatar perceived in an improvisational dance context?***

1.2 Research Objectives

This study seeks to explore the potential of augmented drones as performative avatars in improvisational dance. Specifically, it investigates how Mixed Reality (MR) enhancements can transform the initial perception of drones as commanding into more expressive and less intimidating, fostering a natural and engaging dancing environment.

The specific objectives of this research are as follows:

1. To identify the features relevant to designing the augmented appearance of the drone.
2. Integrate the identified features within a space where the drone is augmented and pre-programmed for a dance context.
3. To evaluate the impact of the XR augmentations in drones as partners in improvisational dance.

1.3 Scope and Limitations of the Research

The scope of this research is limited to the examination of augmented semi-autonomous UAV within a dance improvisation context, wherein movement emerges spontaneously rather than pre-established choreography. The study does not extend to applications such as fully automated choreography, sports training, or physical therapy. The study does not generate independent choreographic sequences; instead, it focuses on pre-programmed movements based on established drone movement trajectories (K. Dong et al., 2024). These semi-autonomous UAV behaviors are designed to align with three distinct segments of the dance experience: pre-dance, during dance, and post-dance. The study emphasizes upper-body and full-body movement guidance, without addressing complex, footwork-heavy techniques. A co-design approach involving experienced dancers informs the form factor and expressive behavior of the augmented semi-autonomous UAV. While the drone operates along fixed paths within a structured routine, dancers move freely and improvisationally. This does not respond or adapt to the dancer's movements in real time. Each session's avatar behavior is pre-scripted and does not evolve dynamically based on dancer input.

The implementation uses DJI Tello EDU drone and Meta Quest headset to deliver mixed reality augmentation. Experiments will be conducted indoors in a controlled 2×2×2 meter space, with the semi-autonomous UAV flying at a fixed height range of 0.5 to 1.8 meters to ensure stability during improvisation. As mixed reality visuals are visible only through the headset, future work could explore strategies to extend or externalize the experience for audience-facing or shared contexts. The study does not address outdoor environments, large-scale performances, or integration with external motion-tracking systems. Given these constraints, the study focuses on enhancing the perception of drones as engaging dance co-performers in smaller, more controlled settings. Although the drone's movement is scripted, it is designed to simulate responsiveness through carefully timed sequences and synchronized avatar behavior. However, the system does not feature real-time interactivity or adaptive feedback mechanisms. Performance may also be affected by Wi-Fi connectivity or command latency, as communication relies on UDP over a local network.

The evaluation of the augmented drone system focuses on how its presence shapes dancers' perceptions of interaction, agency, and expressiveness during improvisational movement. Instead of examining long-term skill development, the study centers on short-term experiences. A within-subjects design compares two conditions: interaction with a physical drone alone and with an augmented mixed reality (MR) version. Data will be gathered through standardized questionnaires, semi-structured interviews, and video-recorded analysis. Only performers who pass the screening will be invited to participate, ensuring that the focus remains on artistic interaction. Rather than measuring technical accuracy or movement skills, the study explores how dancers experience the drone in the moment.

1.4 Significance of the Research

Drones are often associated with surveillance, industrial applications, or remote-controlled operations (Herdel et al., 2022). This perception creates a psychological barrier that limits the potential of drones in interactive and expressive domains, such as performing arts. By redefining drones as performative avatars, this research challenges that perception and demonstrates how drones can become engaging, expressive, and collaborative robots rather than imposing.

This study addresses the problem of intimidation by integrating Mixed Reality (MR) to create an intuitive and interactive dance environment for dance performances. Rather than being perceived as rigid and mechanical, the semi-autonomous UAV is designed to offer real-time movement guidance through visual overlays, haptic feedback, and audio cues. This shift transforms drones into active co-performers in the creative process, allowing performers to engage with them in a way that feels natural.

From a technical perspective, this research contributes to the advancement of co-located human-drone interaction by redefining human perception towards drones as co-performers. By leveraging augmentation, the study introduces new methodologies to make dance improvisation more immersive, adaptive, and engaging.

Beyond Computer Science, this research has broader societal implications in the fields of performing arts, creative technology, and movement education. It expands the potential for innovation within these areas, offering new opportunities for exploration and development. The study's outcomes could inspire innovations in embodied learning, which can be an educational approach that emphasizes physical and virtual interaction to develop spatial awareness and motor skills. The integration of drones and MR feedback may lay the foundation for immersive educational tools, enabling real-time movement analysis and improving learning experiences in dance, theater, and other movement-based disciplines.

By transforming drones from intimidating machines into expressive robots, this study reshapes the narrative of co-located human-drone collaboration. It provides a new perspective on drones as extensions of the human body, enhancing the emotional and performative dimensions of movement. This research establishes a foundation for future studies in MR-driven drone assistance, expanding the possibilities for artificial intelligence-supported choreography, real-time motion analysis, and intelligent performance augmentation.

Chapter 2

Related Literature

2.1 Social Robots in Human Interaction

Social robots in human computer interaction (HCI), robotics, and artificial intelligence to support engagement between humans and machines. Many social robots are used in healthcare, education, and entertainment because they can interact using verbal and nonverbal cues (Belpaeme, Kennedy, Ramachandran, Scassellati, & Tanaka, 2018). Advances in machine learning and natural language processing have improved their ability to respond to human emotions more effectively (Su et al., 2023).

In healthcare, social robots are utilized to support mental health by offering assistance to individuals with mental health conditions. Some studies suggest that they have the potential to improve emotions among users during and after interaction (Prescott & Robillard, 2021). Moreover, they are utilized to support those who want to learn another language, whether in acquisition or practice (Park & Neumann, 2024).

Initially, social robots were developed to assist and improve efficiency in caregiving, customer service, and other service-oriented tasks. Technological advancements have expanded their scope from assistance to performative applications over the past years, such as interactive storytelling, theater, and dance. This transition–assistance to performance–involved redefining the initial role of social robots to aid in artistic collaboration, rather than mere helpers in tasks.

In these contexts, social robots contributed to immersive artistic productions by reacting to human movements and adapting to live environments. Having the ability to perform precise motions allowed them to be valuable tools in choreography, stage direction, and audience engagement. A study by Abad et al. (2018) explored the incorporation of an autonomous mobile robot with a dance performance at a festival. The study focused on integrating a low-cost robotic platform into choreography to develop a system architecture to match the artists' requirements, such as precision, synchronization, and robust robot movements. It demonstrated how robots can contribute to a performer's artistic expression and highlighted their potential to be a creative collaborator in dance and theater.

Although they have been successfully applied in healthcare and other service industries, the transition to a performative role leaves several gaps in adaptability, expressiveness, and audience engagement. Robots struggle to replicate human expressiveness due to reliance on pre-programmed gestures (Cavallo et al., 2018).

On the other hand, human performers can naturally adjust their actions based on their interactions with other performers and the audience's reactions, while generating human-like expressiveness in robot motions remains challenging. Recent frameworks such as EMOTION (Huang et al., 2024), aim to enhance non-verbal expressiveness; still, challenges remain in real-time adaptation and emotional nuance.

Social robotics systems have played an important role in HRI, with applications ranging from companionship to performative engagement. An example is PARO, a robotic baby seal that is used in healthcare settings that require emotional support. It responds to cues from touch, sound, and movement to foster engagement with users (Shibata et al., 2021). It has been used in therapy for autistic children and in elder care, demonstrating the potential to encourage emotional interaction. Its lifelike behaviors contribute to immersive storytelling and suggest potential exploration in performative settings (Chevallier, 2023). However, despite its success in promoting interaction, its primary function remains assistive rather than performative, limiting its suitability for creative or movement-based applications.

On the other hand, KASPAR is a minimally expressive humanoid robot that is designed to help with HRI studies. This humanoid robot presents an application in robot-assisted interactive play and therapy, while illustrating the role of interaction, body language, and gestures. The areas in which KASPAR was studied showed how a robot can be operated to fulfill its role in social interaction scenarios (Dautenhahn et al., 2009). Though not explicitly designed for performance, KASPAR's implementation in collaborative play indicates its potential to contribute to interactive and synchronized performative contexts.

Most of the current robots have designs that mimic human movement as it is perceived as more natural and relatable. However, they have different physical properties that force a limit to these human-like movements. In HRI, motion plays an important role in how humans perceive robots, having their non-verbal motion cues to express intentions, emotions, and social cues. In designing these robots, dance can be used as an inspiration for expressive robotic motions beyond just mere mimicry (Abe, 2022).

Whether intended or not, robotic motion is inherently expressive as humans perceive that a robot's movement is influenced by context, intent, and expression (LaViers et al., 2018). Somatic movement practices (body-based), such as the Alexander Technique, Feldenkrais Technique, Body Mind Centering, Pilates Method, and Contact Improvisation to name just a few, can emphasize how each movement feels rather than just how it looks and can improve HRI (LaViers et al., 2018).

In the study by Shinozaki, Oda, Tsuda, Nakatsu, and Iwatani (2006), Study of Dance Entertainment Using Robots, robot dancers introduce a new form of entertainment in which people can watch and interact during the performance. The robot's ability to engage during the performance can redefine how humans perceive it as a partner in entertainment. As robots are used for entertainment, these robots do not need any physical strength as long as they are capable of interacting with humans — this can be through pre-programmed choreography (non-real-time entertainment) or through interactive features that enable the robot to adapt to the audience's reactions (real-time entertainment) (Shinozaki et al., 2006).

These examples reflect the versatility of social robotic systems and their potential for adaptation in artistic collaboration, showing how expressive interaction can be designed in non-humanoid agents such as drones. These works inform our understanding of robotic social participation. However, our study extends this by exploring how augmented drones — rather than humanoid robots — can serve as expressive co-performers in improvisational dance.

2.2 Drone-based Interactive Systems

The emergence of human-robot interaction has led to the rise of human-drone interaction (HDI). Drones have been utilized for human benefit, promoting HDI. For instance, drones are used as jogging companions; drones serve as entertainment, and drones that support somaesthetics increase human bodily awareness. This indicates the various capabilities of drones to improve human quality of life. For instance, the Joggobot (Graether & Mueller, 2012), which is utilized to accompany human joggers, explores how a flying robot can serve as a jogging companion, enhancing the jogging experience through exertion-focused design. Their research provides valuable insights into the development of co-located human-drone interaction by addressing challenges in embodiment, control, personality, and communication.

Similarly, another existing system that promotes co-located HDI, namely, Drone Chi. This study explores drones supporting human bodily awareness through somaesthetic HCI design. Inspired by Tai Chi and meditation, Drone Chi provides a close-range, movement-based co-located human-drone interaction experience. The research emphasizes the role of drones as a design, aerial in expansive 3D space, allowing users to engage with them dynamically and intimately. The study conducted by La Delfa et al. (2020), identified key themes such as looping mental states, environment, agency versus control, and physical narratives, contributing to a deeper understanding of how drones can enhance bodily awareness.

Drones are not limited to providing companionship or enhancing bodily awareness; they also serve as a source of entertainment for humans. Many studies have explored the role of drones in performance, particularly as interactive partners in dance and live shows. For instance, a study by K. Dong et al. (2024) investigated how dancers adapt when improvising with drones, showcasing spatial metaphors in their interactions. Similarly, according to a paper by Eriksson et al. (2019), which examined bodily interaction in drone-assisted opera performances, emphasizing the need for choreographers to adjust their movements to align with drone behaviors, resulting in a shared artistic expression.

Similarly, in the case of drones, the work of Ginosar and Cauchard (2023), At First Light, suggests that while drones show fluid movement and synchronized formations, enabling them to convey complex emotions through motion remains an ongoing challenge. Drones have been incorporated into performances not just as stage props but as active participants in movement-based interactions. Drone Chi (La Delfa et al., 2020) studied bodily engagement, a deeper physical connection between humans and drones by leveraging slow, intentional movements inspired by Tai Chi. By focusing on co-movement and sensory interaction, this study demonstrated that drones with responsive capabilities can enhance their role as companions, fostering a more immersive and interactive experience. Another study in the context of using drones in dancing, the study Dancing With Drones (Eriksson et al., 2019) investigated how human dancers adjust their bodily expressions in response to how intentional or lifelike the drone seems. This study highlights that drones, despite their mechanical nature, can exhibit a physical presence that influences the performer's movement choices. Similarly, the study of K. Dong et al. (2024), Dances with Drones, studied co-located human-drone improvisational dance interactions, finding that dancers often perceive drones as authoritative rather than collaborative partners.

In relation to this study, dancers perceived drones as authoritative rather than collaborative partners, which highlighted the dynamic in which drones appeared to lead the performance (K. Dong et al., 2024). This perception is linked to the drones' programmed behaviors and movement patterns, which made them not respond to the dancer's improvisational cues sufficiently. Due to this, dancers instead adapted to the drones' actions instead which led to a hierarchical interaction dynamic between the drone and the dancer.

This study emphasizes the importance of mutual responsiveness in human-robot interactions within performative contexts. As an example, in the study by Eriksson et al. (2019), researchers examined the ethical and physical experiences of how HDI in choreography stresses how necessary it is for drones to be designed in ways that encourage collaborative and empathetic interaction. Lastly, it also suggests that the drones can constrain the expressive potential of dancers when they view the drones as autonomous and unyielding. Our study builds on these findings by exploring how visual augmentation may reshape drone perception and promote a more balanced performative relationship.

2.3 XR in Drones

Augmentation technologies extend beyond merely enhancing human efficiency (Villa et al., 2023). One area where these technologies have shown significant potential is in co-located human-drone interaction. In this context, the study by Herdel et al. (2022) suggests that augmentation can improve how humans interact with robots, making these interactions more seamless and intuitive. For instance, integrating augmentation technologies into drones has been explored for purposes such as navigation, enhancing their capabilities, and enabling more interactive and responsive behaviors. The ability of drones to move freely in three-dimensional space opens up new possibilities for co-located human-drone collaboration in performance settings. In the study by K. Dong et al. (2024), they demonstrated this potential through their study on dancer-drone interactions, showcasing how drones can guide human movements and the possibilities for collaborative and expressive performances. However, their findings also revealed that drones can appear intimidating during performances. Many participants have discussed that drones tend to be commanding due to their mechanical appearance and rigid movements, which often dominate the space intended for human performers. This observation indicates a significant gap in current research, how to design drones that provide a more natural and approachable co-located human-drone interaction experience, reducing their commanding, authoritative, and mechanical appearance.

Furthermore, studies on human-drone interaction have focused primarily on applications in emergency response, entertainment, and communication (Herdel et al., 2022). This shows that there has been little research on how humans and drones interact during performances, such as in art or dance. Studying this more could help us to see how new technology can make drones more expressive. As these technologies improve, there are more opportunities to use drones in creative and artistic ways.

To address this gap, our study focuses specifically on Mixed Reality (MR)—a form of extended reality (XR) that merges real and virtual elements in real-time using headset-based systems. MR allows performers to interact simultaneously with physical drone behaviors and visual augmentations overlaid onto the real environment. This dual-layered interaction supports a richer co-performance experience by embedding emotional and narrative cues directly into the performative space.

Research shows that XR technologies (including MR, AR, and VR) can enhance social presence and interpersonal connection (Lege, 2024). For instance, a case study by Santini (2024) demonstrated how XR enhanced audience immersion during live performance using surround sound, projected visuals, and interactive systems. Although their work combined VR and AR in flexible installations, our MR approach aims to anchor the augmentation specifically to a physical drone avatar, maintaining real-world spatial dynamics while adding expressive overlays. This approach may overcome common issues in HDI, such as drones feeling impersonal or overly mechanical, by enriching their expressive and narrative potential.

While technological augmentation, through AR and XR, enhances drone responsiveness and interactivity, visual form and narrative framing also play a vital role in shaping how humans perceive and engage with drones. Beyond function and behavior, the embodied appearance of a drone influences whether it is seen as expressive, approachable, or commanding. This opens up new opportunities to explore not just how drones move or respond, but what they represent in perception and emotional terms. One study that delves into this expressive potential is the Drones in Wonderland study, which explores how radical and imaginative drone forms can reshape human-drone interaction (HDI) by leveraging cultural metaphors from myth and fantasy (Cauchard, Gover, Chen, Cartwright, & Sharlin, 2021). Through two user studies – one using static stimuli and another with immersive VR experiences – the researchers found that anthropomorphic and zoomorphic drone designs (e.g., fairy or bird-like drones) were perceived as significantly more friendly and social compared to traditional machine-like quadcopters.

Similarly, our use of MR overlays allows us to explore the emotional and symbolic dimensions of drone design: not just how drones behave, but how they are imagined, felt, and interpreted by performers.

This research highlights how unconventional drone designs can influence user expectations and mental models, suggesting that radical forms may help overcome the lack of real-world experience people have with flying entities. The findings demonstrate that form strongly impacts perceived drone roles across different contexts, with machine-like drones being viewed as more utilitarian while anthropomorphic/zoomorphic designs evoked stronger social responses. The study provides important implications for the design of drones that align with human cultural expectations and interaction metaphors, potentially leading to more natural and engaging HDI experiences.

In relation to this, drones should be as expressive as avatars to make performers feel like they are dancing with a real partner, with MR-based augmented overlays helping to visualize choreography paths. A study by Fitton, Dalton, Proulx, and Lutteroth (2022) stated that AR has been engaged alongside motion guidance systems to improve learning and creativity in entertainment settings. The paper also mentioned that AR can provide performers with real-time feedback by integrating digital information into the real world through avatars as effective dance training tools. However, it must be designed with expressive motion to match human performers. Likewise, the study by Weber and Cook (2022) highlighted that motion-based XR performance systems can create an engaging experience by requiring fluidity and responsiveness, which emphasizes that drones, like avatars, should be capable of having movement qualities that feel interactive.

While drones cannot offer physical touch feedback, MR enables new forms of expressive interaction by visually mediating the relationship between human and drone. A work of Pajala-Assefa (2024) concluded that VR can reshape choreography using movement-based interaction as its foundation. Like VR systems, drones do not give direct touch feedback, so people need to adjust how they interact with them. This paper suggests that using XR or AR can make drones more engaging by letting them express more. It also says XR can help not just show dances but create shared movements between people and digital elements.

The integration of motion capture in live dance performances has laid the foundation for a new field, allowing dancers to embody various avatars in a digital setting. A study by Zhang et al. (2025) examined how the assumption of avatar roles influences movement, improvisation, and perception among dancers. The study's findings showed that dancers used avatars to distance themselves from their habitual movements, exploring new ways of moving through differing physical constraints. The study highlights the role of avatars in redefining physical identity, promoting inclusivity in artistic expression, and deepening connections between diverse bodies and identities within dance improvisation. Therefore, XR plays a crucial role in integrating avatars with drones, opening new possibilities to alter the human perception of drones.

These studies provide a foundation for understanding how MR can transform drone-based performance. Our study narrows this scope by using MR, aiming to transform drones from mechanical tools into expressive, co-creative partners through visual augmentation visible via headset-based MR systems. While prior research explored HDI, XR, and expressiveness in isolation, our work synthesizes these threads by applying MR overlays to live drone interaction within the context of improvisational dance. This opens new avenues for technical innovation and artistic experimentation in co-located human-drone collaboration.

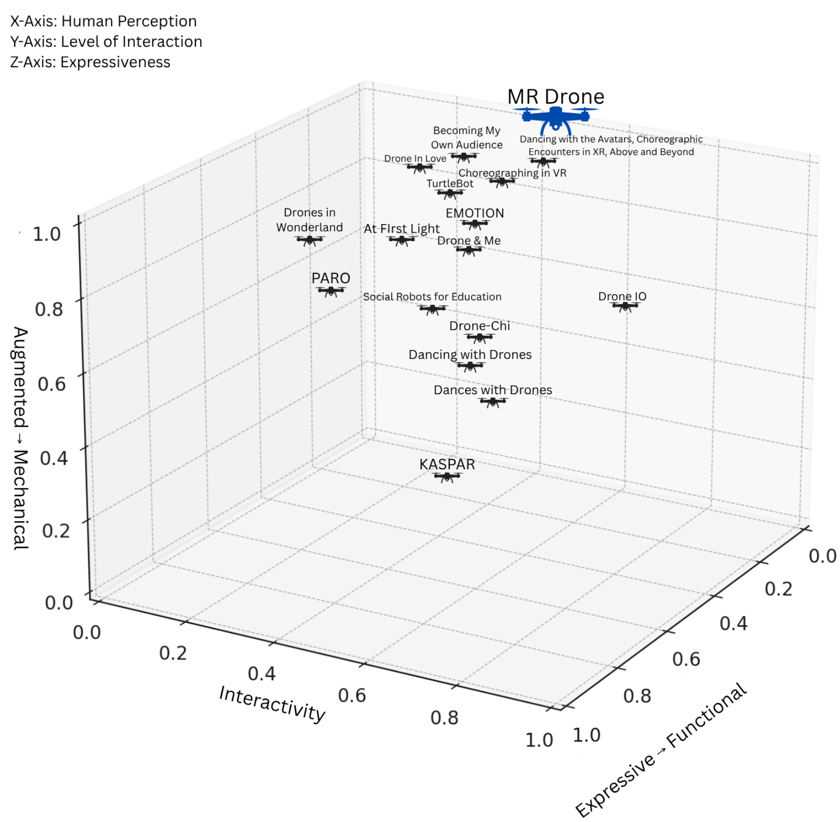

Figure 2.1: MR. Drone leads in expressiveness, interactivity, and partner-like perception.

Chapter 3

Method

3.1 Overview

This chapter outlines the methodology used to design, develop, and evaluate an augmented semi-autonomous UAV intended for improvisational dance within a mixed reality environment. Building on the work of K. Dong et al. (2024) and incorporating principles from performing arts and robotic movement as explored by Madill et al. (2025), the study centers on a single drone as a co-performer. The methodology is organized into three key phases: (1) designing the drone and creating digital assets, (2) implementing the semi-autonomous UAV movement and integrating it into the MR space, and (3) conducting a user evaluation.

3.2 Co-design with Dancers

The first phase of the study focuses on eliciting the drone's movement and appearance in the MR environment. To achieve this, we organized a co-design session with dancers. Participants were recruited through convenience sampling, resulting in three individuals with backgrounds in ballet, contemporary dance, and hiphop. Each had at least seven years of experience in their specified genre of expertise.

During the session, participants were invited to imagine what a drone co-performer might look and feel like within a mixed reality space. Participants engaged in sketching exercises and reflective discussions. They subsequently performed using a lightweight box, acting as proxy for the drone, with their sketched designs attached to simulate a mixed-reality performance.

Participants emphasized characteristics such as ambient presence, gentle motion, and visual softness, often imagining the drone as a glowing or floating form. Instead of rigid or mechanical appearances, dancers expressed a preference for visual metaphors tied to rhythm, care, and affective gesture. These insights became foundational for defining the drone's visual appearance in the MR environment and shaping how the drone's behavior might communicate expressive intent during performance.

3.3 Drone Design

Building on the insights from the co-design session, the drone's visual design was shaped by the sketches and verbal descriptions contributed by participants. Participants visualized the drone not as a mechanical object but as a luminous presence. Their drawings frequently included glowing orbs, flowing trails, and gentle pulses of light, suggesting a preference for abstraction over realism and emphasizing mood, rhythm, and relational energy.

Drawing from these visual and conceptual themes, we synthesized the participants' input into a cohesive avatar model. Using 3D modeling software such as Blender, we developed a layered particle-based design that evoked movement and affect rather than form. This avatar featured subtle glow effects, oscillating visual rhythms, and dynamic transitions between idle, active, and closure states. The final design aimed to amplify the drone's expressive qualities while preserving the improvisational openness that dancers had emphasized, where it serves as a co-performer that could guide and respond without dominating the performance space.

3.4 Drone Movement Programming

The second phase of the study involves programming the movement of the semi-autonomous UAV and integrating its visual design into the mixed reality environment. The DJI Tello EDU drone will be used, selected for its lightweight frame, safety in indoor performance contexts, and programmability via the Python-compatible Tello SDK. The movement of the semi-autonomous UAV is executed through this development kit using Python scripts.

This enables precise execution of timed movement motifs and supports looped and sequenced behaviors that align with performance cues. Pre-programmed trajectories include expressive patterns such as spirals, orbits, and figure-eights, adapted from the movement templates explored in K. Dong et al. (2024) and shaped through insights from our co-design session. Moreover, the drone does not sense or respond autonomously to dancer movement; instead, it operates on a fixed choreography that enables consistent comparison across experimental conditions.

3.5 MR Integration

After programming the semi-autonomous UAV, the design is integrated into a mixed reality environment. Using the Meta Quest's passthrough capability, the drone designs are rendered in alignment with the drone's physical movements. Real-time semi-autonomous UAV position and orientation data are streamed to the MR system via a local wireless connection. This approach ensures precise and stable alignment between the virtual overlays and the semi-autonomous UAV's actual position during flight.

The experience is deployed within a controlled indoor performance environment, defined by a 2×2×2 meter bounded space that balances safe semi-autonomous UAV operation with the expressive range of motion required for improvisational dance. A central movement zone, approximately one meter in radius, allows the performer to move freely while maintaining a safe distance from the semi-autonomous UAV. The space is enhanced with MR overlays rendered through the Meta Quest headset, providing real-time spatial cues to reinforce safe boundaries and guide both performer and drone interactions.

3.6 User Evaluation

The user evaluation investigates how a semi-autonomous UAV, enhanced through MR overlays, can function as a co-performer in an improvisational dance setting. Building on the frameworks of K. Dong et al. (2024) and Madill et al. (2025), this phase combines structured observation with narrative reflection and affective self-reporting to assess perceptual and emotional responses to drone-mediated performance. Each participant will experience two distinct conditions: a Drone-only condition, where the UAV performs motions without any visual augmentation, and an MR. Drone condition, where synchronized mixed-reality overlays are rendered through a head-mounted display. This within-subjects design allows for direct comparison of how visual augmentation affects perceived agency, engagement, and expressiveness.

Twenty participants, aged 18 to 35, will be recruited based on their background in improvisational or contemporary dance, with at least two years of relevant training or experience through professional practice. Participants must be in good health, with no conditions that may interfere with low-impact movement by mixed reality (MR) visuals or drone proximity. Prior experience with MR or drones is not required but will be noted to ensure a balanced sample. Before the trials, participants will complete a pre-study screening and briefing to confirm eligibility, gather demographic information, and identify any health concerns. They must also be willing to engage in MR experiences using a Meta Quest headset and interact with a nearby flying drone. During the study, participants will engage with the drone in each condition and provide feedback through standardized questionnaires, narrative reflections, and semi-structured interviews. This blend of embodied interaction and subjective feedback will offer insights into how MR augmentation transforms the drone's role as a co-located improvisational co-performer.

3.7 Data Analysis

Three key data collection methods will be employed to evaluate the experience. First, qualitative metrics will be obtained through semi-structured interviews to gather insights into participants' perceptions of the drone's expressiveness, emotional tone, and perceived agency. Second, observational metrics will be derived from video recordings of the interaction sessions to examine body language, spatial positioning, and movement patterns during co-located human–drone interaction. This will allow the identification of temporal patterns in human-drone interaction. Third, quantitative metrics from standardized instruments will be summarized statistically. These instruments include the NASA-TLX, Godspeed, Mixed Reality Experience Questionnaire (MREQ), User Experience Questionnaire-Short (UEQ-S), Simulator Sickness Questionnaire (SSQ), and Circumplex Model of Affect. They will help evaluate user engagement, immersion, and cognitive load across conditions.

Overall, the data analysis will triangulate qualitative insights, behavioral trends, and subjective experience. This will clarify how visual augmentation affects the perception of the drone as a co-performer in mixed reality.

3.8 Calendar of Activities

The research process will follow a structured timeline to ensure systematic development, testing, and evaluation of the augmented semi-autonomous UAV system. The activities are divided into distinct phases, including co-design, prototype development, user testing, and analysis, aligning with the study's objectives. Table 3.1 presents a Gantt chart of the planned activities, with each bullet representing approximately one week of work. This schedule ensures that all key components, drone hardware, movement programming, MR integration, and user studies, are completed efficiently within the research period.

	2025									**2026**			
Activity	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
Co-design Workshop	●●	●●●	●●●										
Avatar Planning/Design		●●●	●●●●	●●●●									
Drone Movement Programming				●●●●	●●●●	●●●●	●●						
MR Integration					●●●●	●●●●	●●●●	●●●					
User Evaluation								●●●●	●●●●				
Data Analysis									●●	●●●●	●●●●		
Thesis Writing & Revisions											●●●●	●●●●	●●●●

Table 3.1: Gantt chart of project activities. Each bullet represents approximately one week's worth of activity.

Chapter 4

Co-designing Drone Features with Dancers

4.1 Overview

To identify features relevant to designing the augmented appearance and behavior of the drone, we conducted a co-creative design session involving dancers. Rather than evaluating a fixed prototype, the goal was to allow participants to explore the drone as a potential performative avatar through low-fidelity materials, improvisational movement, and guided reflection, following principles established in performance-centered robotics research (McKendrick, Fartook, Finn, Sharlin, & Cauchard, 2023; Madill et al., 2025; K. Dong et al., 2024). Through embodied interactions and imaginative visualizations, performers articulated their interpretations of how the drone should look, how it should move, and how it might contribute meaningfully to expressive performance.

This co-design session adopted a performer-centered lens, emphasizing the experiential, aesthetic, and emotional dimensions of human–drone interaction. By grounding the drone's expressive design in the creative practices and embodied experiences of dancers, we aimed to uncover visual and behavioral attributes that support relational presence and co-performance in mixed-reality contexts. This method builds on the narrative-reflective framework of Madill et al. (2025), who emphasized archetypal movement and relational framing in interpreting robotic behavior, as well as on K. Dong et al. (2024) structured improvisation and spatial constraint techniques for live dancer-drone interaction.

The goal of this phase was to address Research Objective 1 (RO1). This involved understanding how dancers conceptualize and interpret the drone's visual form and presence when situated within a performance context. Specifically, this phase sought to uncover the aesthetic, symbolic, and emotional attributes that performers associate with drone avatars, as well as how those attributes evolve through embodied interaction. To support this objective, we explored the following sub-research questions through iterative co-design and reflection:

1. How do humans imagine or perceive drone avatars prior to performance?
2. How do humans perceive a low-fidelity co-located drone augmented with an avatar during various distinct phases of interaction?
3. How do their imagined perceptions change after a simulated dance with a low-fidelity drone with an augmented avatar?
4. How do humans perceive a low-fidelity co-located drone augmented with an avatar during an uninterrupted dance routine?

4.2 Participants

We recruited three experienced performers with diverse dance backgrounds using convenience sampling. Each participant had a minimum of seven years of dancing experience and a demonstrated ability to reflect on expressive movement. While not all participants had prior exposure to technology-enhanced performance, all were familiar with interactive media or conceptual tools that enabled them to engage meaningfully with the co-design session. Their embodied expertise and sensitivity to movement aesthetics positioned them as ideal co-designers for investigating how a drone might function as a compelling and expressive co-performer in performance.

4.3 Protocol

The co-design session was structured as a single-day session consisting of multiple iterative and reflective phases. These phases were designed to elicit participants' imagined visualizations, embodied reactions, and emotional impressions of a drone-as-avatar. Activities were sequenced to gradually build a shared vocabulary of visual features, relational archetypes, and motion styles relevant to expressive interaction and performance.

ID	G	Y	S	A
P1	Ballet	13	F	25
P2	Hip-hop	9	M	19
P3	Contemporary Dance	7	F	21
Mean	—	9.67	—	21.67
Standard Deviation	—	3.06	—	3.06
Sex Ratio (M:F)	—	—	1:2	—

Table 4.1: Participant demographics and dance backgrounds. **ID** refers to anonymized participant codes, **G** is their specialized dance genre, **Y** denotes years of dance experience, **S** is sex, and **A** is age.

Drone Motion Vocabulary: To simulate expressive drone behavior, the proxy's movement was based on a spatial vocabulary adapted from the work of K. Dong et al. (2024), which outlined four key types of drone motion:

1. Circling motion in the X–Z plane
2. Diagonal zigzag motion
3. Vertical movement (Y-axis) with forward/backward translation (Z-axis)
4. Lateral side-to-side motion along the X-axis

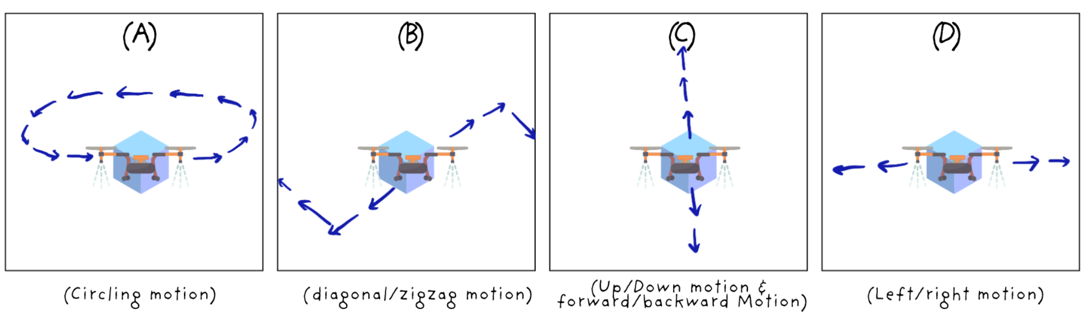

Figure 4.1: Drone-inspired motion patterns adapted from Dong et al. (2024)

These trajectories were used through the proxy during the performance to see how different types of movement could affect how participants felt and responded (see Figure 4.1). Instead of showing each pattern one by one, we combined the movements smoothly to make the interaction feel more natural and expressive. The sequence started with simple gestures like hovering and circling, moved into more complex ones like figure-eights and spirals, and ended with slower or retreating motions to show that the performance was finishing. By blending these paths, the avatar was able to show changes in mood and intention, which helped participants connect with it and respond through their own movements. Additionally, the box proxy was held and moved at varying heights, ranging from 0.5 to 1.8 meters above the ground, to more accurately simulate drone behavior, adapting the flight dynamics outlined in the work of K. Dong et al. (2024).

Ethical Considerations and Safeguards: Given the physically interactive nature of the co-design session, participant safety and ethical compliance were prioritized. Participation was voluntary, and individuals were informed of their right to withdraw at any point without penalty. All data were anonymized, with video recordings and written responses stored securely and accessed only by the research team.

The session was held in a safe, well-ventilated studio with appropriate lighting and flooring. Individuals with significant physical limitations were not invited to participate due to the movement-intensive nature of the activities.

Orientation: At the outset, participants received a detailed briefing on the study's aims, procedures, and safety guidelines. Verbal and written instructions were provided, along with a printed validation protocol and Informed Consent Form (see Appendix A). The orientation also included a safety protocol that defined spatial zones for participant and drone proxy movement. No formal pre-tests were conducted beyond initial screening for movement experience.

Co-design Phases: The co-design session is structured with five iterative and reflective phases. Each phase is deliberately structured around a sub-research question, aligning with the goal of addressing RO1. The phases progress from initial imagination to embodied interaction and reflection, allowing participants to gradually refine their perceptions of the drone avatar. This experiential design process ensured that each sub-research question was addressed through direct engagement and iterative insight.

Participants engaged in imaginative sketching, improvisation with a physical drone proxy, and open-ended discussion. They visualized how a performative drone avatar might appear and behave in different segments of a dance routine: pre-, during-, and post- dance. The box proxy served to simulate the presence of the drone, aiding in real-time interaction and co-presence.

The structure of the co-design session allowed the participants to revise their interpretations as they moved through sketching, dancing, and discussion 4.3. Each phase was designed to elicit specific feedback about the visual and behavioral characteristics of a potential drone avatar.

Phase 1 – Imagine, then Sketch: To address sub-research question 1, we asked participants first to visualize their ideal drone avatar across three segments of a performance: pre-dance, during dance, and post-dance. The structure and rationale behind these segments are detailed in Table 4.2. They were encouraged to think about how the drone might express emotion, presence, and transformation during each stage. Participants then sketched their envisioned avatars. Drawing quality was not assessed; instead, emphasis was placed on expressive intention and conceptual clarity (see Figure 4.2).

Figure 4.2: Re-imagine then Sketch phase of the co-design session

Phase 2 – Dancing with the Avatar: We simulate a mixed-reality performance without requiring live drone control to answer sub-research question 2. In this phase, a researcher manually held a lightweight box proxy with the participant's sketch attached to represent the drone avatar's scale, position, and presence (see Figure 4.3). Participants then performed improvised sequences across three structured segments of a dance routine, *Pre-Dance, During-Dance*, and *Post-Dance*, interacting with the proxy as if it were an expressive co-performer.

To constrain the spatial dynamics and encourage focused engagement, dancers were asked to remain within a 2x2x2 meter space, while the proxy moved outside this volume. This structure, adapted from K. Dong et al. (2024), reflected typical drone operation constraints while still allowing for meaningful proxemic variation and relational positioning. Following each sequence, participants were asked about the avatar's perceived emotional tone, expressive alignment, and its role as either a co-performer, guide, or passive object in performance.

Phase 3 – Re-imagine, then Sketch: After the dancing phase, participants revisited and revised their original avatar sketches; this is to answer sub-research question 3. The participants' changes reflected their new understanding of which visual and behavioral features resonated in interactions with the drone proxy.

For Phases 4-5, we sought to answer the sub-research question 4. In order to

Dance Segment	Description
Pre-Dance	The initial phase of the routine, just before full movement begins, marked by anticipation and preparation. This includes how the dancer orients themselves to the drone, and how the avatar's appearance (e.g., glow, posture, cues) signals readiness. This moment helps establish rapport and sets emotional expectations. Subtle design details in the avatar can shape the dancer's mindset, influencing perceived intent and trust (Fung et al., 2025; La Delfa et al., 2020; Van Oers & Cramer, 2022).
During-Dance	The main body of the performance where the dancer actively interacts with the drone-avatar. It includes moments of improvisation, synchronization, and divergence in movement. Here, the avatar's expressive visual behaviors and motion paths influence the dancer's spatial orientation, emotion, and creativity. Visual flow and temporal alignment are key design considerations (Kolesnikov et al., 2025; D. Dong & Wakkary, 2020).
Post-Dance	The final segment of the routine, often involving deceleration or closure. The drone-avatar may signal an ending through slowed movement, color shifts, or directional retreat. This phase captures emotional resolution—how the experience concludes and lingers in memory. Design of these transitions can evoke a sense of finality, relief, or reflection (Bohus & Horvitz, 2009; Lee & Park, 2023).

Table 4.2: Temporal Segments of the Dance Routine and Interaction Rationale

do this, we describe a two-phase approach where participants do a dance routine and then we invite them to a post-routine reflection.

Phase 4 – Uninterrupted Full Routine: To observe how the avatar's presence carried through an entire performance, participants danced a full routine with the avatar proxy without breaks. This allowed for holistic feedback on the avatar's consistency, expressivity, and impact on performance flow.

Phase 5 – Final Discussion: Participants reflected on their sketches, dancing experience, and relationship to the avatar. They articulated which design felt most natural, emotionally resonant, or disruptive. This closing conversation was key in identifying the features they believed would best support a performative drone avatar.

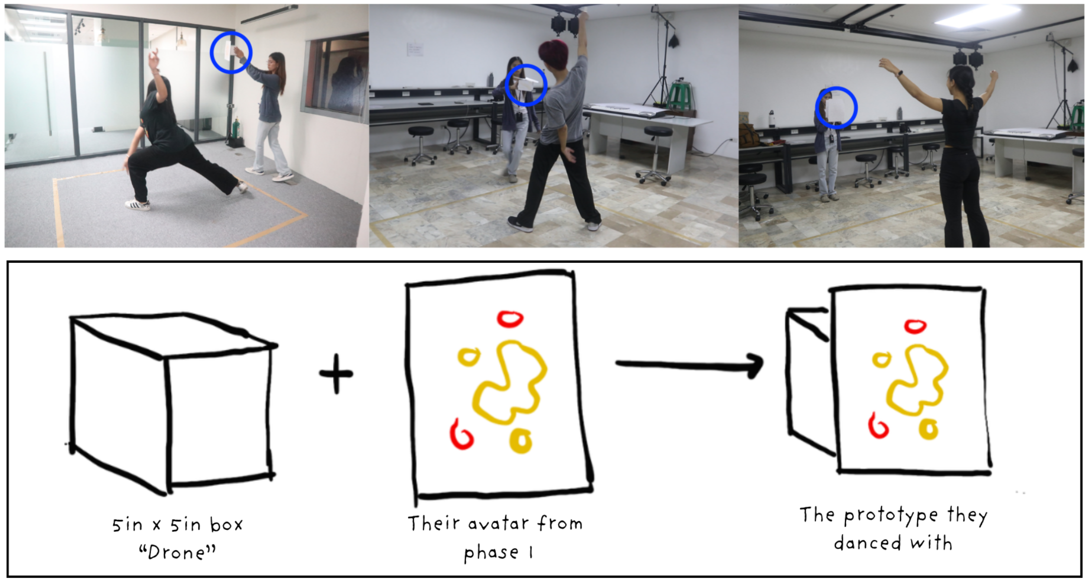

Figure 4.3: Dancing with the Avatar phase of the co-design session

Debriefing: Following each major activity, participants answered open-ended questions that explored their emotional responses, perceived connection with the drone, and reflections on the avatar's expressive qualities.

This structured yet open-ended approach not only created space for dancers to shape, critique, and emotionally engage with the idea of a drone avatar but also mapped directly onto the study's objectives. Their insights form the foundation of the themes presented in the next section.

4.4 Findings

This section presents key insights gathered from the co-design session and thematic analysis of participant responses, centering on the features most relevant to designing the augmented appearance of the drone. Through a combination of sketching, embodied interaction, and reflective interviews, participants articulated how they envisioned the drone's appearance, behavior, and presence in a performance context.

A total of six key themes emerged from the data: (1) Imagery and Visualization, (2) Avatar Behavior, (3) Influence on Dance, (4) User Perception, (5) Emotional Responses, and (6) Feedback and Suggestions. These themes were synthesized and visualized through a Sankey diagram (see Figure 4.4) to illustrate the progression of insights from raw feedback to high-level design implications.

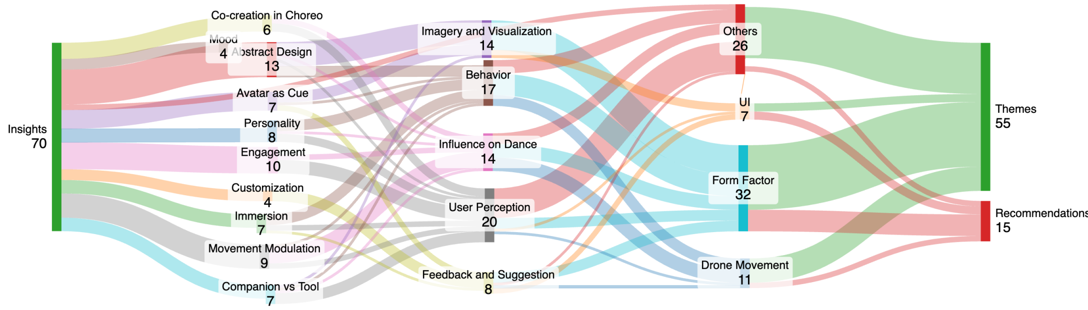

Figure 4.4: Sankey diagram showing thematic relationships from co-design session feedback.

4.4.1 Imagined drone avatar features

Preference for movement rather than shape

We observed participants having a preference for abstract shapes rather than more defined features such as fairies or animals. P1 described a form that resembled "*an abstract form with a core that radiates energy around it, resembling gas,*" emphasizing its dynamic and ephemeral quality (see Figure 4.5). P2 imagined the avatar as "*a something could change into wings, trails, or orbs,*" depending on the cue given by the user (Figure 4.6). P3 envisioned a floating orb with colorful gradients and visual cues like fireworks or smoke to signify moments of transition or climax (Figure 4.7). In these sketches, we can see that users prefer to see some more movement, and the form factor of the avatar does not really remain evident. Participants envision the drone as abstract and evolving, emphasizing fluid visual representations over literal or mechanical forms. There was a preference for soft, organic visuals, such as radiant cores, particles, or flowing gradients, that could shift in shape and color to reflect emotional tone and narrative progression.

These visual forms were not purely aesthetic choices but were seen as emotionally communicative, capable of amplifying mood, marking rhythm, or supporting narrative flow during improvisation. Rather than presenting the drone as a fixed object, participants imagined it as a dynamic visual entity that could "co-perform" by adapting its form in response to context and movement. The evolving visuals provided a kind of emotional choreography, helping dancers respond not just physically but emotionally to the avatar.

Overall, participants felt the need to see dynamic and moving features. This is why they preferred features that glow or particle effects that respond to light.

This suggests that having visuals that can morph, glow, and respond through light or particle effects is essential. These features helped the avatar appear more emotionally responsive and involved in the performance. In improvisational dance, this kind of visual adaptability supports co-located HDI by making the avatar feel like a live, expressive presence within the shared space.

This finding addresses the first sub-research question, which is about how humans imagine drone avatars by revealing a clear preference for abstract visual forms. Participants did not see the drone as a rigid or literal object but as an emotionally expressive entity that could shift its shape, glow, and emit particles in response to movement and context. This suggests that even before encountering the actual drone in performance, participants projected qualities of fluidity, ephemerality, and co-performativity onto the avatar, highlighting the importance of designing drone visuals that support an improvisational, emotionally resonant interaction.

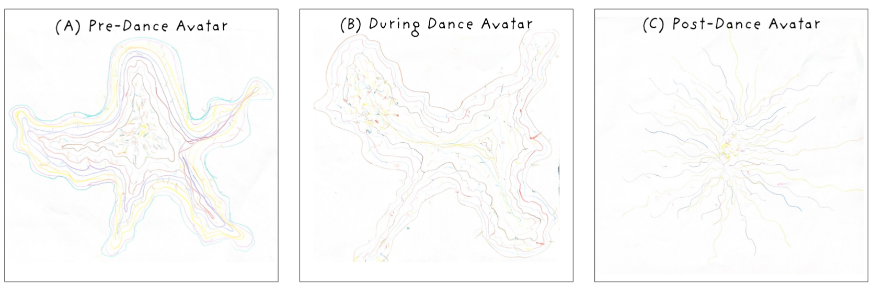

Figure 4.5: Participant 1's avatar sketches for Pre-Dance, During Dance, and Post-Dance phases.

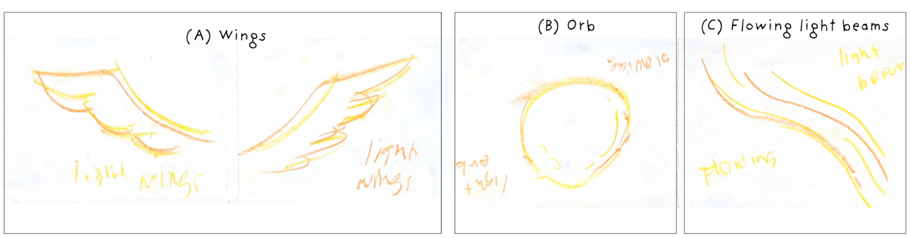

Figure 4.6: Participant 2's drawings of three distinct avatar forms: Wings, Light Orb, and Flowing Light Beam.

Avatar Behaviors induce emotions

Participants reported feeling emotional responses when looking at these augmented avatars and sketches. Even without direct control over the drone, participants perceived the avatar's augmented appearance as having intentional behavior. The way the visuals changed through pulsation, bursts, trails, or resizing was

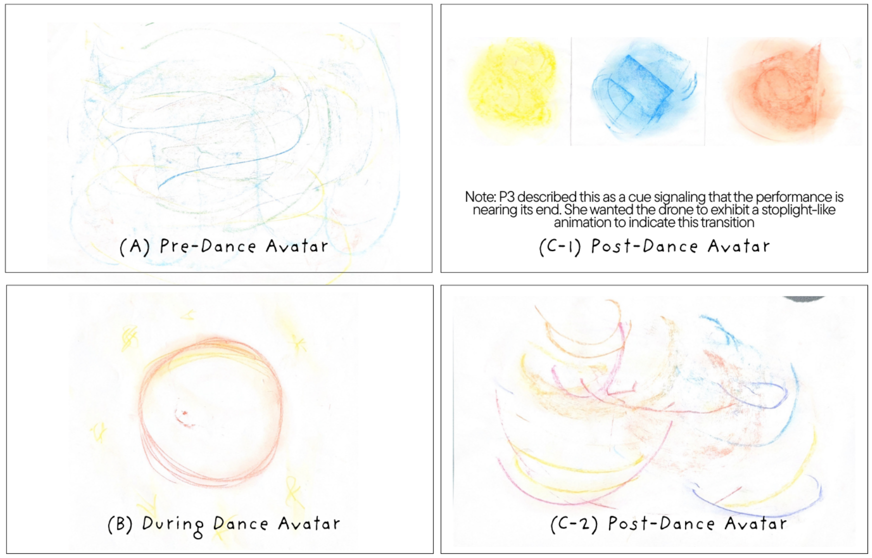

Figure 4.7: Participant 3's sketches representing Pre-Dance, During Dance, Pre-Post Transition, and Post-Dance avatars.

interpreted as meaningful and affective. This suggests that specific animations denote specific emotional nuances. P3 noted that the avatar "*required something from me,*" suggesting an inferred logic or inner state that participants responded to. P2 described the visual behavior as "*mood-dependent,*" reinforcing the sense that the avatar expressed emotion through its changes. Rather than being passive visuals, these transformations were read as communicative gestures.

This suggests that participants were not only reacting to the avatar's visuals, but also attributing emotional meaning to them. Transitions and visual pacing played a key role in shaping this experience; the way the avatar shifted its form over time helped establish rhythm, intention, and engagement. When designed thoughtfully, these visual cues gave dancers the sense that the avatar was co-creating the moment with them, even if the drone itself operated autonomously. Overall, this theme highlights how intentional visual behavior can support co-located HDI by fostering a stronger sense of presence and emotional connection.

This finding addresses sub-research question 2 by highlighting the way visual behaviors were interpreted as intentional and emotionally meaningful. Participants responded to the avatar's dynamic animations, such as pulsation, bursts, and trails, by attributing mood, intention, and even an inner state to the drone, which shaped how they engaged with it throughout the interaction. These perceptual cues demonstrate how carefully designed visual behaviors can transform an otherwise simple drone into an emotionally resonant co-performer, deepening the sense of presence and co-creation across phases of improvisational dance.

Dancing with Drones with Low-Fidelity Prototype influenced User Movement

These findings echo the results of K. Dong et al. (2024); however, participants noted some points on how these sketches' visuals may have changes on them. The avatar's appearance directly influenced how participants moved. Many noted that the drone's visual form and movement patterns shaped their decisions on gesture, scale, and tempo.

P1 shared that curved, flowing visuals *"encouraged fluidity,"* guiding them toward softer movement. P2 explained that the changing avatar helped them *"visualize interaction"* and inspired creative experimentation, though occasional unpredictability meant they had to *"adjust to it."* P3 said the avatar *"guided and shaped movement"* and helped reduce hesitation, making them feel more expressive.

These insights suggest that the avatar acted not only as a visual reference but also as a kinesthetic cue that supported improvisation. Its changing form offered direction and inspiration, creating a dialogue between movement and visual feedback. For some, the visuals helped structure gestures; for others, they sparked exploration or acted as a mirror to their expression. This shows how the avatar's features such as motion trails, scale changes, or visual rhythm, can actively influence the dance process. The theme highlights the avatar's potential to enhance co-located HDI by acting as an expressive, movement-shaping presence within the shared space.

This demonstrates how participants' imagined perceptions evolved after engaging in a simulated dance with the low-fidelity drone and its augmented avatar. Initially, the avatar was conceived primarily as a visual element, but through embodied interaction, participants discovered its direct impact on their movement choices, fluidity, and expressiveness. The dynamic visuals acted as kinesthetic prompts that structured, inspired, or mirrored their gestures, showing that the avatar was perceived not merely as a passive form but as an active partner in improvisation. This shift highlights the potential for drone avatars to transform from imagined visuals into co-creative agents that shape real-time human motion in a shared performance space.

4.4.2 User Perception and Experience

Emotional engagement shaped by visual behavior

Participants reported diverse emotional reactions to the drone's augmented appearance. These ranged from curiosity and playfulness to deeper senses of connection and inspiration. P1 described the experience as *"meeting a stranger,"* evoking a sense of curiosity and anticipation. P2 said it felt like *"a game,"* offering fun and spontaneity but limited emotional depth. P3, on the other hand, reflected that the drone added *"emotion to the movements and sparked my creativity,"* contributing to a sense of purpose during their performance.

These quotes reveal how participants emotionally engaged with the drone not because it looked human, but because of how it behaved visually over time. The use of timing, movement, and visual cues shaped how connected or inspired they felt. These emotional responses were not driven by anthropomorphism but by how the avatar appeared to behave in time; its perceived presence, timing, and responsiveness through visual design.

This suggests that specific design features, such as visual rhythms, expressive cues, and symbolic shapes, can help build emotional resonance. The theme points to a broader implication: when designed thoughtfully, visual augmentation can create emotionally engaging experiences that support co-located HDI and deepen the performer's sense of connection during improvisation.

This finding answers how humans perceive a low-fidelity co-located drone augmented with an avatar during various distinct phases of interaction by showing that emotional engagement was shaped not by static visuals but by the avatar's dynamic behavior. Participants described feelings ranging from curiosity and playfulness to deeper inspiration, all arising from how the drone's visuals moved and changed over time. This suggests that well-designed visual behaviors, such as rhythm, pacing, and symbolic form shifts, can evoke meaningful emotional responses, enhancing the sense of presence and shared improvisation between human and drone throughout the interaction.

Flexible perceptions of the Avatar

These finding extend current understandings of human-drone interaction by highlighting the range of roles and relationship with the drone and the user. while prior work often positions the drone as either tool or partner, participants in this co-design session revealed more fluid and flexible interpretations.

Participants described varying relationships with the avatar. Some perceived it as a tool or visual aid, while others framed it as a co-performer or companion. P1 and P2 saw it more as a guide or visual aid; P2 commented that the dynamic was "*mostly one-sided,*" requiring them to adapt. However, P3 framed the avatar as a "*companion,*" saying it felt "*constructed and alive*" and even supported their choreography process.

These differences in perception reveal that the avatar's visual qualities, behavioral pacing, and responsiveness support multiple modes of interpretation. For some, it provided direction or inspiration; for others, it became an expressive partner. The fluidity of this relationship enabled dancers to shift between functional and emotional roles during improvisation.

These insights suggest that avatars designed for co-located human-drone interaction should support flexible user roles. Key features such as distinct visual states, smooth transitions, and adaptive timing foster more personalized interpretations and allow users to assign meaning that fits their expressive needs. The theme underscores how perceived partnership in MR performance is not fixed, but dynamically constructed through visual behavior, context, and personal engagement.

This finding addresses how humans perceive a low-fidelity co-located drone augmented with an avatar during various distinct phases of interaction, while also showing how their initial expectations can shift through embodied engagement. The flexible ways participants described the avatar, as a tool, guide, co-performer, or companion, highlight how perception evolves dynamically in response to visual qualities, behavior, and context. Some found the avatar mostly directional or supportive, while others experienced it as an expressive, almost alive partner that shaped their choreography. This fluidity shows that users' imagined roles for the drone before dancing were often expanded or redefined through direct interaction. Overall, the insight suggests that co-located drone avatars should be designed to support multiple interpretations that can adapt across moments of improvisation, reinforcing both moment-to-moment perception and the transformative impact of actual experience.

Participant feedback for enhancing co-performance

These insights build on earlier themes by addressing how users envision improving future co-performance with the avatar. Rather than seeing the avatar as static, participants expressed a desire for dynamic and personalized interactions that respond to individual expression and creative goals.

Participants offered practical suggestions related to customization and feedback. Several expressed interest in being able to adapt the avatar's appearance according to their personal style or the performance's tone. This includes features like adjustable color schemes, visual intensity, or behavior presets. They also noted the importance of feedback: subtle visual signals, such as pulses, glow, or micro-movements were valued as indications that the drone was *"listening"* or *"responding"* to them. These ambient cues enhanced their sense of connection.

These suggestions reveal the significance of two interrelated design directions: (1) a user interface that enables expressive customization, and (2) visual feedback mechanisms that maintain a sense of continuity and presence throughout the interaction. Together, these features support a more fluid and emotionally attuned human-drone relationship, essential for co-located improvisational settings.

This finding bridges how humans perceive the drone avatar during interaction and how their perceptions evolve after direct experience. Participants' feedback highlights that co-performance is not only shaped by what the avatar currently offers, but also by what they realize it could do better, supporting dynamic, personalized, and responsive behaviors. Their suggestions for adjustable visuals and subtle feedback signals reflect lessons learned during improvisation, showing that participants' imagined expectations expanded into more nuanced ideas about emotional connection and presence. This insight underscores that co-located HDI design should accommodate both real-time expressiveness and user-driven adaptation, ensuring that the avatar can continue to feel alive and co-creative across distinct phases of interaction and beyond.

4.4.3 Supporting improvisation through minimal user interface cues

While the primary focus remained on the avatar's visual presence, participants occasionally discussed how minimal interface features could support their improvisational process. These references highlight a subtle but important desire for clarity and control, even within an otherwise autonomous system.

Participants proposed lightweight UI elements that would not interrupt performance flow but could guide interaction. P1 suggested a simple pre-performance mode selection, allowing dancers to *"set the emotion or intensity"* of the avatar to align with their expressive intent. P2 proposed a minimal UI overlay or wrist-based projection showing the avatar's current visual mode, *"just to avoid guessing,"* which would help reduce uncertainty during live improvisation.

Rather than seeking full control, participants wanted just enough feedback or customization to feel attuned to the avatar's logic. This theme emphasizes that even in improvisational or semi-autonomous contexts, low-friction UI design plays a role in supporting creative agency and flow.

This finding contributes to the second sub-research question by revealing how participants perceived the augmented drone during different phases of interaction. Specifically, their suggestions for minimal interface cues indicate that their perception was not solely visual or reactive, but also entailed a desire for subtle guidance and real-time interpretability, especially during improvisational segments.

4.4.4 Observed Behavioral Patterns During Routine

To complement participants' verbal reflections and sketches, we documented visible behaviors throughout the full routine with the drone proxy. We created a timeline where each session was segmented into labeled intervals corresponding to specific phases of the dance routine. These intervals are denoted as A1–A3 for the pre-dance phase, B1–B17 for the during-dance phase, C1 for the post-dance phase, and D1 for the finale pose. Each segment represents a 10-second window, allowing for tracking of the different behavioral categories to be observed.

All participants used the same soundtrack, which ensured a consistent tempo, emotional tone, and structure for each dance session. The selected song was Only One by nck, an emotionally neutral track with subtle rhythmic shifts that supported both fluid and expressive movement exploration.

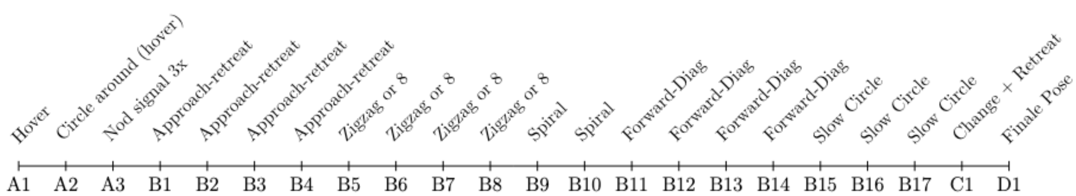

Figure 4.8: Timeline of drone movement across the performance.

Figure 4.8 illustrates the drone's pre-programmed path and movement across the different intervals of the routine. As the drone consistently followed the same sequence in every session, this timeline serves as a useful reference for comparing how each participant responded to identical movements.

To support this analysis, we developed a **Mapping of Movement Motifs** (see Table 4.3) that connects each drone behavior to an intended relational or emotional theme and expressive archetype. This mapping was instrumental in structuring how participants were invited to reflect on drone behavior in relation to human movement, intention, and co-presence. It also informed the choreography of the drone across the timeline and the interpretation of participant responses.

The analysis focused on four key behavioral categories observed throughout the performance. These included attention to the drone, emotional expression,

Drone Movement Motif	Emotional Theme	Expressive Archetype
Pre-Dance (Initiation and Attention)		
Approach and hover	Curiosity, initiation	Gather, Invite
Nod signal	Acknowledgment, affirmation	Signal, Mirror
Circle around	Inspection, playfulness	Play, Trap
During-Dance (Interaction and Play)		
Approach–retreat	Tension, uncertainty	Trap, Test
Zigzag or figure eight	Play, provocation	Play, Mirror
Spiral	Transformation, connection	Mirror, Journey
Diagonal	Directionality, subtle guidance	Lead, Gesture
Slow circle	Calmness, observation	Support, Observe
Post-Dance (Resolution and Exit)		
Change and retreat	Disruption, ambiguity	Retreat, Test
Land	Closure, resolution	Support, Farewell

Table 4.3: Mapping of MR. Drone movement motifs to relational themes and expressive archetypes based on (Madill et al., 2025)

body orientation, and arm movements. For each interval, we recorded the most prominent behavior displayed by the participant in each category.

Specifically, we first monitored whether participants were looking at the drone, as this served as a proxy for attention and engagement with the avatar. Second, we examined their emotional expression, which allowed us to trace the emotional trajectory of each dancer during the routine. Third, we observed whether participants oriented their bodies toward the drone, interpreting this as a potential sign of openness, trust, or receptivity to the avatar's presence. Lastly, arm movements were tracked to identify recurring patterns and the types of motions executed during the performance.

This finding addresses the fourth sub-research question by offering direct behavioral evidence of how participants perceived and interacted with the augmented drone during an uninterrupted dance routine. The timeline-based behavioral mapping, combined with the consistent drone choreography, enabled a structured analysis of participants' engagement, emotional response, and physical alignment with the drone throughout the full routine. These observed patterns reveal how the drone's presence influenced dancers' sustained interaction, attention, and movement dynamics across an uninterrupted performance timeline.

4.4.5 Comparative Temporal Patterns Across Timeline

After analyzing the behavioral data across participants, a distinct pattern in their interactions with the "drone" was revealed throughout the performance timeline. The comparison centered on their levels of engagement, emotional expression, and responsiveness to drone movement signals.

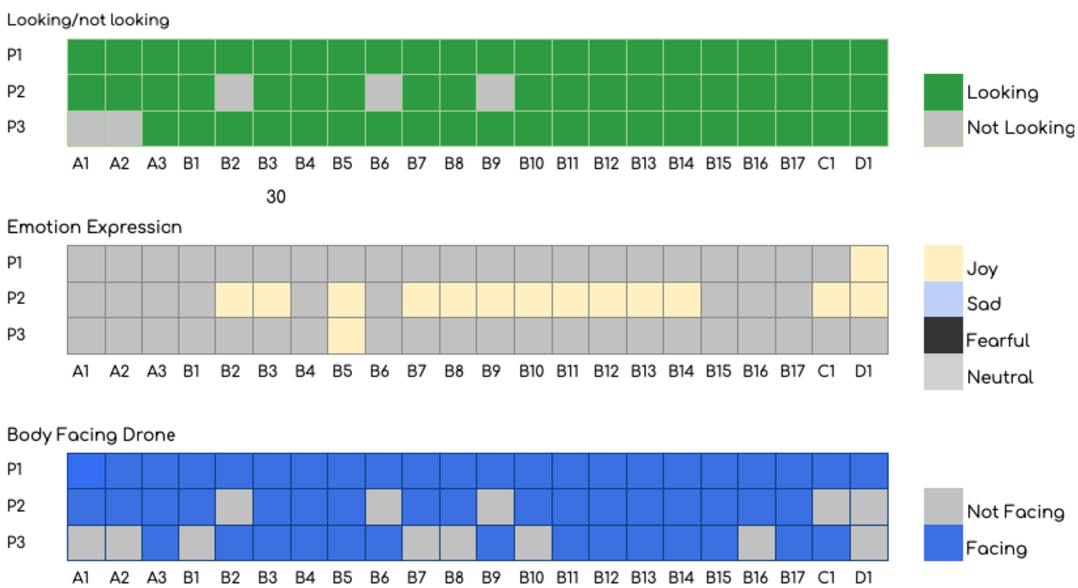

Figure 4.9: Composite heatmap visualizing participant engagement throughout the interaction. The top panel shows gaze direction and attention intensity over time, the middle panel maps the perceived emotional tone of the performance, and the bottom panel displays body orientation relative to the drone.

As shown in Figure 4.9, P1 demonstrated consistent visual engagement, maintaining eye contact with the drone throughout the dance. P2 also showed high engagement, though brief moments of visual disengagement (*not looking*) occurred around the B2, B6, and B9 marks, possibly indicating moments of personal adjustment, as P2 stated, "*Its movement sometimes distracted me because I felt I had to adjust to it rather than it adjusting to me, making it hard to connect espe-*

cially for my social dance style." P3, in contrast, began with two "not looking" instances in the pre-dance phase but maintained full engagement afterward.

Emotional engagement, visualized in Figure 4.9, also varied. P1 remained neutral for most of the dance, with joy emerging only in the final pose. P2 showed the most emotional changes, shifting from neutral to joy at the beginning of the session, briefly returning to neutral, and ending with a joyful emotion. P3 expressed predominantly neutral expressions, with a brief moment of joy around the B5 mark.

In terms of physical orientation, Figure 4.9 reveals that P1 consistently faced the drone, which indicated openness and attentiveness. As P1 shared, "*It felt a bit weird and like a process of discovering, cautious and unsure, like walking on eggshells,*" yet also noted, "*The movement helped make the experience feel more engaging.*" Contrary to P1, P2 and P3's orientation fluctuated, frequently alternating between facing and not facing the drone, particularly in the latter half. This reflected both an interested and questioning approach. As P2 stated, "*The changing shapes of the drone, which I couldn't predict, influenced my movements and made me think creatively about how to interact with it.*" Similarly, P3 added, "*It made me feel like I need to do something. It makes me think of a choreo[graphy], and I feel like I have to do something with the avatar.*"

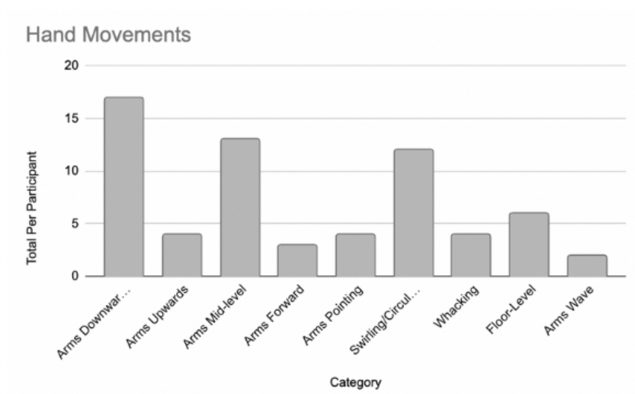

Figure 4.10: Bar chart showing frequency of hand movements of all the participants.

The drone's movement elicited different physical orientations and emotional reactions, with participants expressing tension, creativity, and joy in response to its unpredictable behavior which contributes to sub-research question 2.

As shown in Figure 4.10, arm movement patterns varied across participants. However, when observing all participants collectively, the Arm Downwards movement emerged as the most dominant. P1 exhibited a gradual increase in movement, beginning with arms down and progressing to expressive, swaying, and arm-level directed gestures. This progression suggests a responsive build-up in relation to the drone's movement, as reflected in their statement: "*There are times when it feels like the drone is leading.*" In contrast, P2 demonstrated the greatest variety of arm movements, including swirling, whacking, and pointing. These indicated a highly reactive style that aligned closely with the drone's behavior. Unlike P2's dynamic escalation, P3 maintained a consistent, flowing style, incorporating circular, zigzag, and wave-like motions that followed a choreographic rhythm.

Each participant responded to the drone in a different way, although they all experienced the same drone movements. These movements revealed how each participant interpreted the drone's role in the interaction: a) P1 aligned with the drone, b) P2 reacted dynamically to it, and c) P3 treated it as a choreographic prompt. The autonomous movement of the drone evoked different responses, which specifically depend on the participant's personal style, intent, and perception.

These insights offered a clearer understanding of how each participant connected or interacted with the "drone." Their unique ways of engaging, whether by closely following the drone's movements or exploring freely, played an important role in shaping the overall interaction experience.

This addresses the fourth sub-research question by providing a comparative view of how each participant responded to the same uninterrupted drone routine across time. By mapping their gaze, emotional expression, body orientation, and arm movements across the timeline, the analysis captures how the avatar was perceived as a co-performer throughout the performance. It reveals how personal dance styles, interpretive frameworks, and levels of engagement shaped the evolving relationship between human and drone, thus highlighting the diversity in how the avatar was experienced across an uninterrupted, co-located interaction.

4.5 Discussion and Design Recommendations

This session was structured around our three key research objectives, which combine the elements of interaction design, embodied movement, and MR. The following considerations for designing the drone's augmented appearance were drawn from a detailed analysis of participant responses and behaviors across each phase, guided by our objectives.

Use Abstract Visuals: Favor glowing, particle-based, and morphing forms over literal representations to support expressive ambiguity and creative interpretation.

As seen in P1's drawing (see Figure 4.5), the avatar was described as "*abstract form with a core that radiates energy around it, resembling gas*" felt more evocative than a fixed shape. P2 added, "*it could turn into wings, orbs, or something that flows,*" highlighting a preference for non-static and symbolic visuals, as also reflected in their drawing (see Figure 4.6). These abstract visuals appeared to sustain attention *(looking/not looking)* throughout the dance, having their arm movements also aligned with these changing visuals, with P1 noting that the design kept them visually engaged from start to finish. Similarly, both P2 and P3 maintained consistent visual attention for most of the session, suggesting that such dynamic representations effectively held their focus. This sustained attention not only reflected engagement but also seemed to inform their physical responses, particularly in choosing arm-based movements, such as prominent downward gestures, that aligned with the avatar's expressive cues. This ambiguity mirrors the openness of improvisational dance. By avoiding literal forms or imagery, the avatar supported an aesthetic where dancers actively co-construct its meaning in motion. This engagement was not just visual but somatic, bridging perception and movement.

Visual Behavior Matters: Design transitions and motion implies emotional states or internal logic. P3 reflected, "*It felt like it required something from me, it wasn't random,*" suggesting that subtle, consistent logic in visual changes can simulate intention. Similarly, P2 mentioned, "*its movements felt mood-based,*" reinforcing the value of affective visual dynamics. These qualities not only shaped emotional perception, but also played a key role in maintaining attention and making them more creative in engaging their body. Although no explicit emotional labels were assigned to the avatar, participants interpreted its behavior and responded accordingly, evident in their choices to pause, mirror, or initiate new gestures. This interpretive response to the avatar's visual behavior shows that the dancers formed a sense of relationship with it, treating it as something that could influence the emotional tone of the interaction. All participants have been observed looking at the avatar throughout the entire dance, indicating a high level of sustained visual engagement driven by the expressive behavior of the avatar (as seen in Figure 4.9). These findings highlight that emotional resonance can emerge without anthropomorphic cues. Instead, dancers responded to perceived intentionality conveyed through consistency and subtle variation in movement. Such design enables open emotional interpretation and supports a deeper sense of connection during co-performance.

Support Improvisation: Embed dynamic patterns (e.g., bursts, curves, pace changes) that encourage movement exploration without overwhelming the user. P1 noted that the avatar's "*curved paths encouraged me to move more fluidly,*" while P2 emphasized that changes in the avatar "*made me want to experiment,* *but not too much.*" These statements, along with the frequency patterns observed in both arm and drone movements, demonstrated how the avatar's behaviors, ranging from nodding signals and forward-led paths to zigzag and spiral motions, elicited spontaneous, expressive gestures from participants, such as swaying, whacking, and pointing. As shown in Figure 4.10, participants frequently employed circular movements, downward gestures, and mid-level arm positions, indicating active, full-body engagement. This aligns with the drone's varied movement dynamics (see Figure 4.8). It did not dictate what to do but offered rhythmic and spatial suggestions. This balance between structure and freedom allowed the participants to maintain their control while still being creatively pushed.

Emotional Resonance Through Design: Aim for visuals that can evoke curiosity, joy, or focus without relying on anthropomorphism. P1 described the experience as "*like meeting a stranger, it was unfamiliar but engaging.*" P3 shared that the avatar "*sparked my creativity*" and made the dance "*feel purposeful and alive,*" showing how visual design can generate emotional depth through abstraction alone. To support this, the participants mostly displayed neutral expressions with occasional moments of joy as seen in Figure 4.9. Their emotional responses to the design suggests that they experienced the avatar as calm, focused, and exploratory, than being highly emotional, distracting, and playful. The findings suggest that while the avatar primarily encouraged focused and reflective interaction, moments of increased movement complexity and perceived connection helped foster joy and engagement.

Minimal Interface, Maximum Clarity: Provide light-touch UI elements (e.g., mode indicators, emotion presets) to guide dancers when needed. P2 mentioned wanting "*some gentle indication of what the avatar's mood was or what it was doing,*" suggesting subtle visual cues could enhance confidence without breaking immersion (seen in Figure 4.6).

Customization Options: Allow dancers to influence or personalize the avatar's visual themes based on mood, rehearsal needs, or style of dance. P3 expressed interest in avatars that could "*change colors depending on my mood or the music,*" while P2 noted, as seen in Figure 4.6, "*I'd like to choose what it starts as, like a base form I'm comfortable with.*"

These insights collectively inform the continued development of augmented drone systems for performative and rehearsal contexts.

4.5.1 Summary

These findings offer a set of design recommendations grounded in participant feedback and observed engagement during the co-design session. First, abstract and dynamic abstract visuals, such as glowing, morphing forms, were shown to support expressive ambiguity and sustain participants' attention throughout the routine. Second, movement transitions that conveyed emotion or internal logic encouraged participants to perceive the avatar as intentional and responsive. Third, dynamic but not overwhelming motion patterns supported improvisation, prompting full-body engagement and spontaneous movement.

Participants also reported emotionally resonant experiences, marked more by curiosity and focus than by high-intensity emotions, demonstrating the effectiveness of non-anthropomorphic design. In addition, subtle interface cues and customization options were identified as ways to enhance user confidence and creative control without disrupting immersion.

The co-creative session revealed how dancers perceived, interpreted, and responded to the drone's presence as an expressive agent rather than a mere machine. Their reflections emphasized a desire for dynamic, abstract visuals, subtle feedback cues, and improvisation-friendly movement patterns. These insights directly informed the development of MR. Drone, a mixed reality (MR) system designed to embody the qualities participants valued most. By integrating visual feedback, choreographed drone behavior, and real-time MR interaction, the system aims to realize the concept of the drone as a responsive co-performer.

Chapter 5

MR. Drone Design and Implementation

Building directly on the insights from the co-design session (see Chapter 4), MR. Drone is a performative, mixed reality (MR)-enhanced drone system developed to embody the qualities participants valued most: expressiveness, subtle guidance, and improvisation support. Participants emphasized the need for a presence that could inspire movement without overwhelming it, leading to a design that integrates real-time spatial cues and visually responsive feedback.

Rather than serving a purely functional or utility-based role, MR. Drone operates as a co-performer. Its visual augmentation and choreographed behavior enable it to express agency, rhythm, and emotional tone. The performative concept was shaped by dancers' reflections and sketches, which consistently highlighted glowing orbs, flowing particles, and nuanced feedback as core features of an engaging avatar.

5.1 MR. Drone Architecture

This section describes the architectural design of MR. Drone. The system integrates a DJI Tello EDU drone, a Meta Quest headset running Unity, and a laptop executing the Python scripts. The drone follows pre-programmed flight paths, while Unity renders the avatar in real time based on the drone's live coordinates sent through a local Wi-Fi UDP connection, ensuring precise alignment between physical and virtual layers. The interaction unfolds in three segments: pre-dance, during-dance, and post-dance, each marked by coordinated transitions in both drone behavior and avatar visualization. Together, these components create a seamless, performative MR experience grounded in timing, motion, and visual feedback. The entire interaction flow and communication between software and hardware components are illustrated in Figure 5.1.

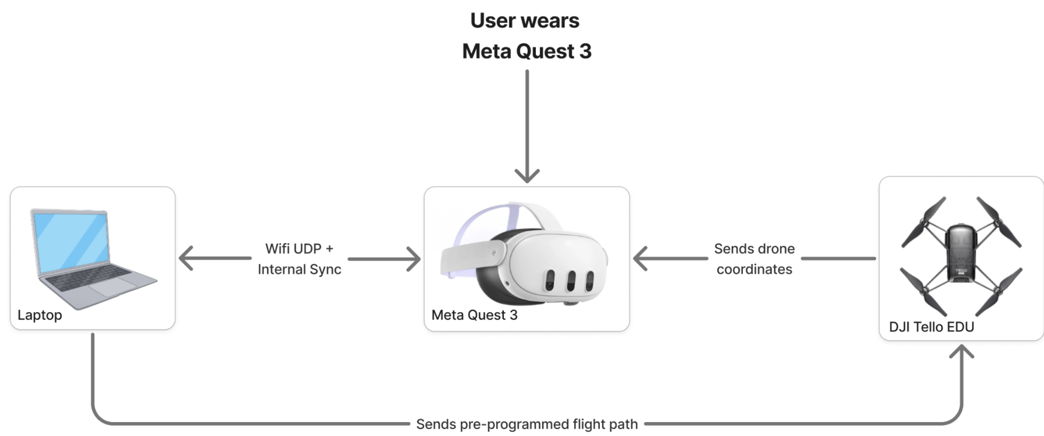

Figure 5.1: System architecture showing the relationship between the Meta Quest headset, Unity visuals, control device, and the Tello EDU drone.

5.2 Tech Stack Overview

To develop and integrate the MR. Drone, a modular tech stack was assembled, balancing programmability, safety, and mixed reality capabilities. This section outlines the core hardware and software components used to prototype the system and evaluate initial implementation strategies.

Drone: The DJI Tello EDU serves as the designated physical platform. It is a lightweight, programmable mini drone widely adopted in educational and research settings, offering compatibility with Mission Pads, visual markers used for spatial localization and command triggering. These features enable precise, responsive movement within bounded indoor environments.

Control: Drone commands are executed via Python 3 using DJI's Tello SDK. This setup allows for real-time scripting of autonomous behaviors such as takeoff, rotation, and landing, as well as sensor data retrieval. It also supports synchronization with the virtual drone avatar in Unity.

Mixed Reality: Unity 2022.3.60f1 serves as the core development platform for building the MR environment. The system uses OpenXR and the XR Interaction

Toolkit to enable cross-platform compatibility and interaction within virtual and augmented spaces. The Meta Quest headset renders the MR visuals, allowing users to view the drone avatar in real-time, accurately overlaid onto the physical performance space.

Design Tools: Figma is used for interface wireframing and user flow mapping, while Blender is utilized for 3D modeling and animation of the drone avatar.

Communication: The system communicates with the drone using UDP (User Datagram Protocol) over a local Wi-Fi network, allowing for fast, low-latency transmission of movement commands. These same commands are mirrored in Unity to drive the MR avatar, ensuring consistent physical-virtual synchronization.

5.3 Schematic of the Performance Space and Safety Zones

The performance environment for the MR. Drone system is defined by a 2x2x2 meter bounded space. This scale was selected to balance safe drone operation with the expressive range of motion required in improvisational dance. The space is designed to simulate a controlled setting where both digital and physical elements co-exist.

At the center of this cube is the performer, who can move freely within an approximately 1-meter movement zone. This area supports expressive full-body motion while minimizing the risk of contact with the drone. The size of this movement zone aligns with what is known as the "personal zone" (0.46 m to 1.22 m), as defined by Hall et al. (1968), a framework commonly used in human–robot and human–drone interaction studies.

During the routine, the drone may occasionally enter parts of the personal zone for brief moments but is programmed not to enter the "intimate zone," defined as the area from the performer's body up to 0.46 meters. This zone is kept clear at all times as a no-fly area to ensure safety.

To reinforce spatial boundaries and support safe distancing, mixed reality overlays are rendered through the Meta Quest headset. These visual cues provide real-time spatial guidance for the performer. The zones are defined as follows (see Figure 5.2):

1. **Red zones** represent strictly restricted airspace. These are areas where drones are not permitted to fly for safety purposes.

2. **Dotted red overlays** span from 0.46 m to 0.76 m away from the dancer and mark the close phase of the personal zone. This zone requires heightened caution.

3. **Yellow lines**, located 0.76 m away from the dancer, indicate the transition into the far phase of the personal zone. This area is still within the movement-aware boundary but offers greater flexibility for drone movement.

The drone's typical flight patterns, such as spirals, lateral, and figure-eights, occur outside of the dancer's movement zone. To support structured interaction, the mission pad for takeoff and landing is placed just outside the dancer's movement radius. This ensures that critical drone operations (takeoff and landing) are conducted in a low-risk zone, away from expressive bodily movement.

The vertical dimension of the cube is also critical. The drone typically operates at heights between 0.5 to 1.8 meters above the ground, avoiding both the floor and head-level space. This vertical margin ensures the drone remains visible in the performer's lower and mid-field view within the Meta Quest headset while minimizing physical risk. See Figure 5.3.

5.4 Interaction Walkthrough

The walkthrough is divided into two layers: (1) the performer's experience through the Meta Quest headset and (2) the drone's physical behavior in the space. These operate in tandem to simulate co-presence and emotional expression.

5.4.1 Dancer Walkthrough in Meta Quest

The interaction sequence is as follows and is visually illustrated in Figures 5.4–5.6:

1. **System Setup and Initialization:** The performer wears the Meta Quest headset while the drone remains on the mission pad. The physical drone is visible in the environment but not shown in the headset view as the virtual avatar is anchored above the pad, visible only in MR (Figure 5.4 - I-II).

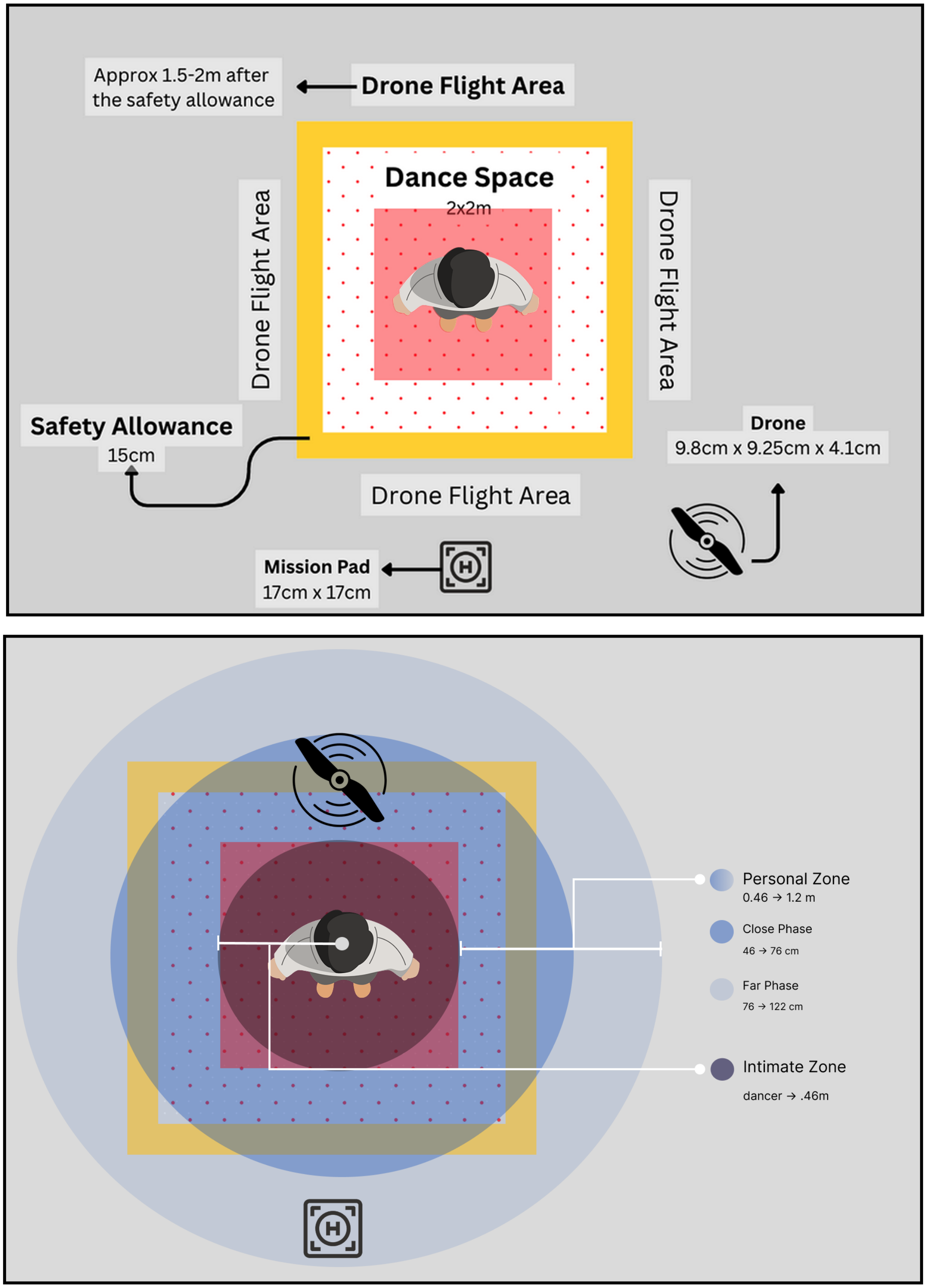

Figure 5.2: Top-down schematic of the 2×2 m MR. Drone performance space, showing flight zones, safety boundaries, and proxemic layers based on (Hall et al., 1968).

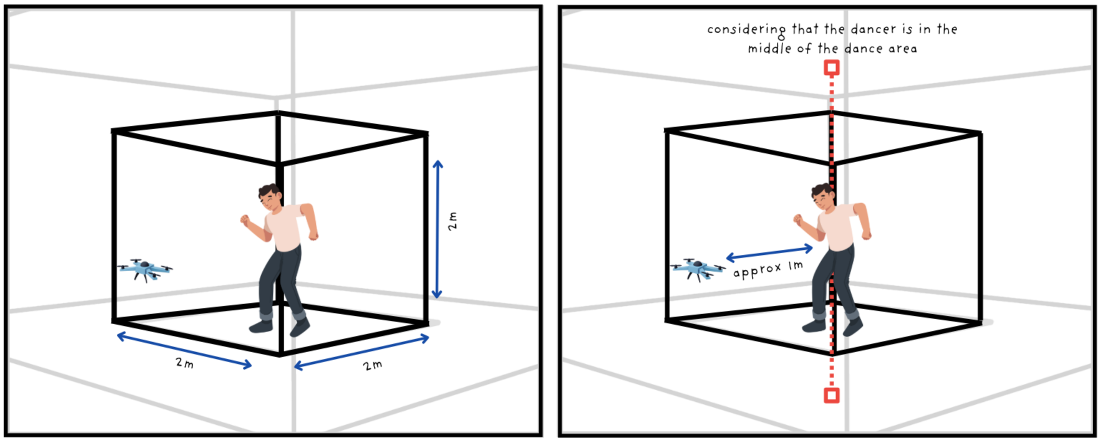

Figure 5.3: 3D side view of performance space showing safe vertical drone range and clearance from the dancer.

2. **Avatar Spawn and Environment Cues:** The Unity application activates, spawning the glowing avatar above the mission pad. Ambient sound and cues such as boundary outlines appear in the 2x2x2 meter interaction space, signaling the beginning of the session (Figure 5.4 - III-V).

3. **Flight Synchronization:** As the drone lifts off, the avatar becomes more animated. Trails become more pronounced, and color shifts begin to reflect drone phase changes (Figure 5.5 - VI-XIII).

4. **Performance Sequence:** The avatar mirrors the drone's physical movements with expressive visual behaviors, shimmering, glowing, and pulsing with changes in rhythm.

5. **Final Interaction Phase:** As the drone descends, the avatar dims, fragments, and fades, subtly reminding of the end of the interaction. The environment resets to idle, awaiting a new session (Figure 5.6 - XIV-XVI).

This MR layer enhances embodied improvisation without overwhelming the dancer with visual clutter. The user is guided gently through motion, timing, and mood via the avatar's evolving form.

5.4.2 Drone Behavior Walkthrough and Flight Path

While the MR interface operates visually, the drone performs a choreographed motion path based on scripted commands. The semi-autonomous UAV takes off, performs expressive flight patterns, and lands back safely on its mission pad.

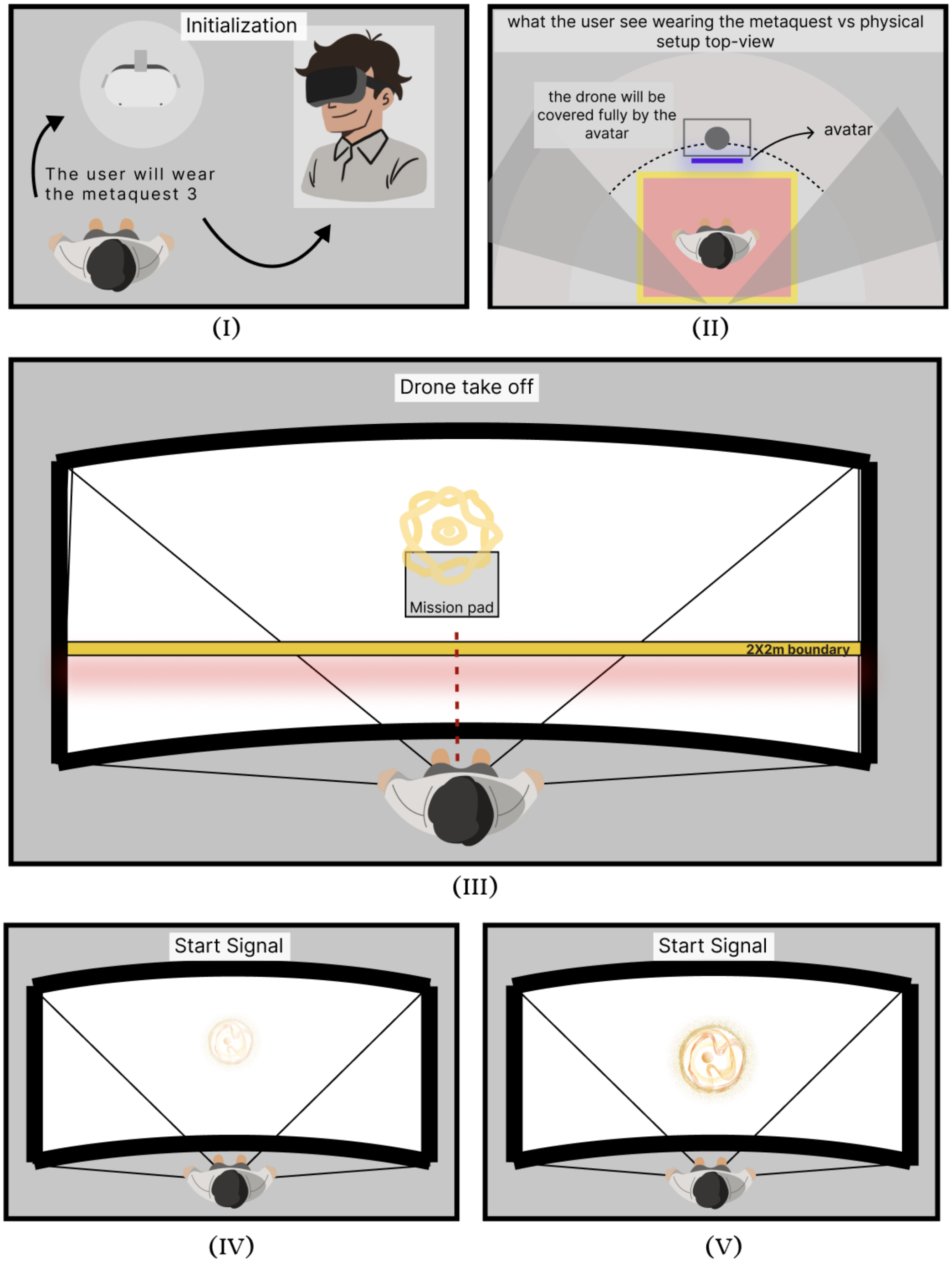

Figure 5.4: MR. Drone Storyboard (Part 1): Avatar spawning and ambient interaction cues at initialization.

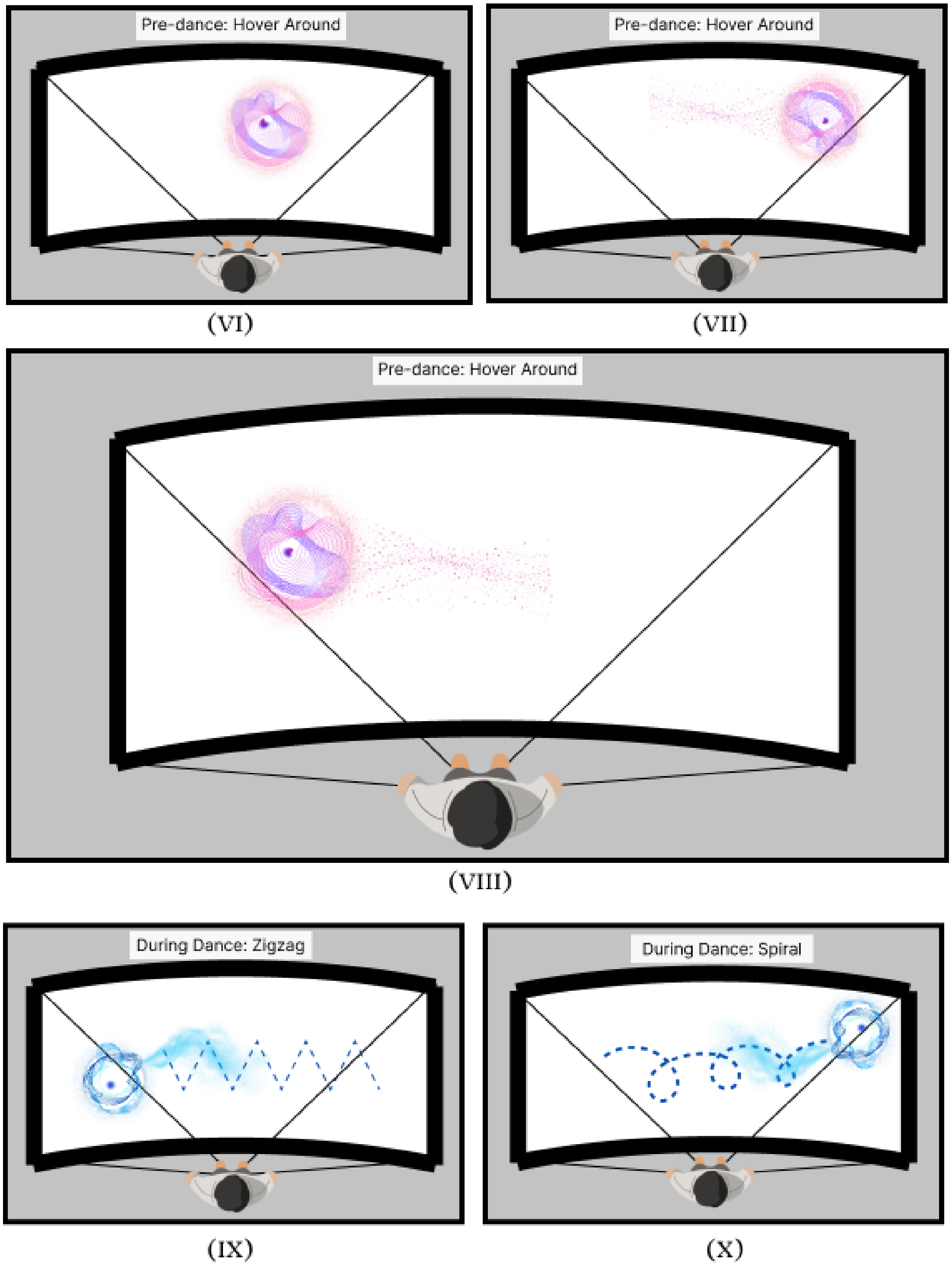

Figure 5.5: MR. Drone Storyboard (Part 2): Avatar starts hovering and synchronizes with drone flight.

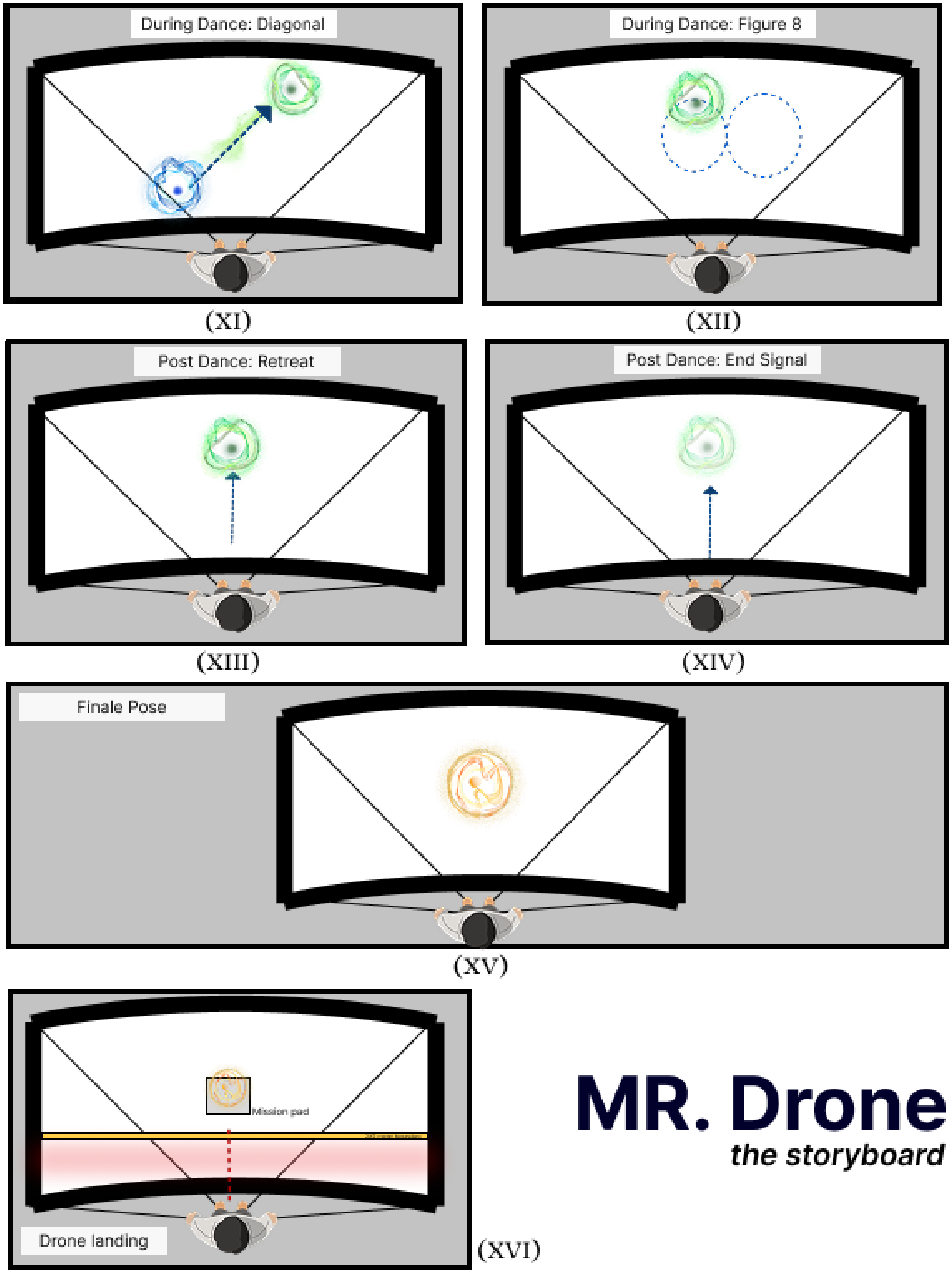

Figure 5.6: MR. Drone Storyboard (Part 3): Avatar closure gesture and drone prepares to land.

The flight phases include:

1. **Introductory Phase:** The semi-autonomous UAV ascends and hovers, establishing its presence without overwhelming the space (see Figure 5.7 - I).
2. **Interaction Phase:** It will then execute lateral and vertical patterns such as spirals, figure-eights, and orbiting arcs. These gestures are designed to embody affective tone and rhythmic variation (see Figures 5.7 and 5.8 - II: A-G).
3. **Landing Phase:** The semi-autonomous UAV then goes back to where the mission pad is, hover, and gradually descends to land, marking the end of the sequence. This final gesture aligns with the avatar's visual fade-out (see Figure 5.8 - III: A-B).

The overall sequence of flight paths of the semi-autonomous UAV is visualized in Figures 5.7 and 5.8, highlighting how each movement segment contributes to the performance's narrative.

Although the drone is not reactive in real time, its scripted behavior is designed to simulate responsiveness. When experienced in tandem with the MR layer, this creates a compelling sense of presence and improvisational potential, central to the MR. Drone's performative goals.

5.5 Tested Modules and Current POC of Tracking

At the current stage, the MR. Drone system has not yet integrated an operational drone due to timing and integration constraints. Initially, the project aimed to build a custom programmable drone platform. However, during the thesis panel evaluation, concerns were raised regarding the safety and compliance of a non-commercial drone. In response to the panel's feedback, specifically the recommendation to use a production-certified drone to ensure alignment with existing safety standards, the team decided to adopt the DJI Tello EDU. While the drone is not yet integrated into the prototype at this stage, it has been selected as the target drone platform for future implementation in THESIS 2. Early experimentation focused on exploring various methods to align the drone's movement with its MR avatar.

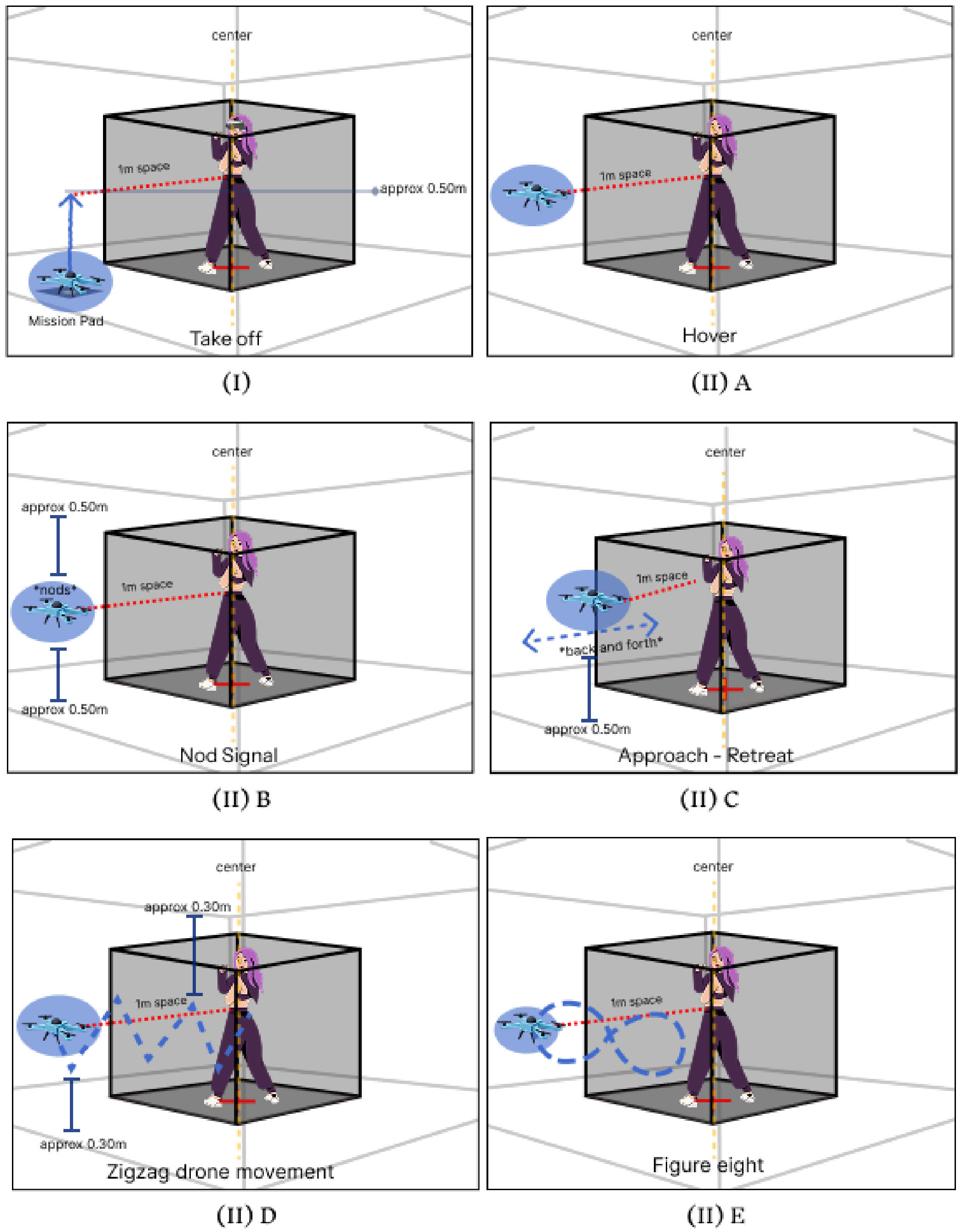

Figure 5.7: Drone Behavior Timeline (Part 1): Drone movements during introductory and interaction phases.

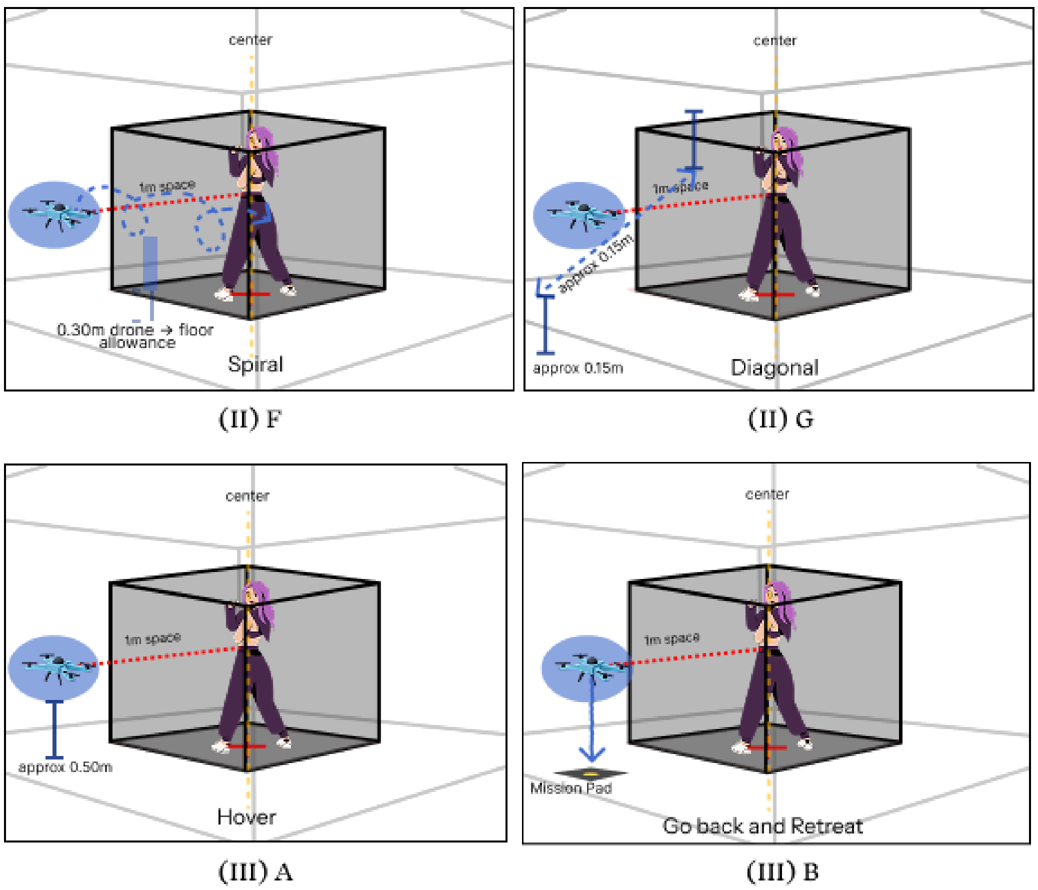

Figure 5.8: Drone Behavior Timeline (Part 2): Closing sequence and landing gestures in sync with avatar fade-out.

Initially, we tested image marker tracking as a way to anchor the avatar in space. In this setup, a mobile device running the Unity application used AR-Foundation to detect a visual marker attached to the drone. Once detected, an avatar would spawn and remain anchored to that marker. However, testing the prototype revealed instability and latency problems during flight; frequent camera shake and motion blur caused the marker to lose tracking, resulting in the avatar becoming detached or floating incorrectly. This issue is illustrated in Figure 5.9.

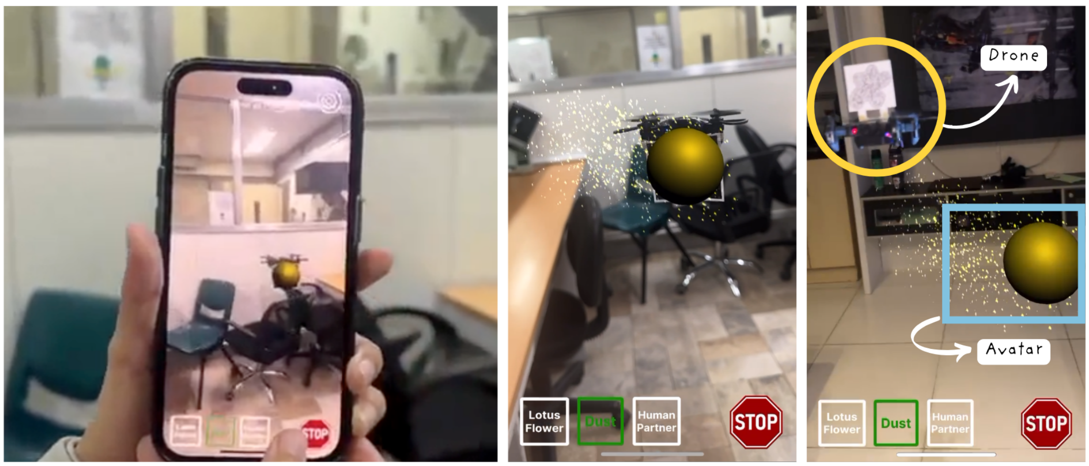

Figure 5.9: Early AR prototype using image tracking. The avatar loses spatial alignment during flight due to unstable marker detection.

To address this limitation, we transitioned to an alternative approach: sending real-time coordinates directly from the drone (or proxy) to the Unity application via local Wi-Fi. This setup eliminates the need for continuous camera tracking. A proof-of-concept of tracking was built using an ESP32 board equipped with a Neo6M GPS module, an MPU6050 IMU sensor for orientation, and an OLED screen for on-board debugging (Figure 5.10).

Using this sensor data, the Unity application receives and visualizes the avatar at the transmitted coordinates, validating the system's ability to spatially align virtual content without reliance on visual markers. Figure 5.11 shows the GameObject successfully spawning and tracking in AR space, as visualized on a mobile device.

This tested setup provides a foundation for future integration with the DJI Tello EDU drone, which is expected to supply its own positional data via SDK-based commands or onboard sensors in the next phase of development.

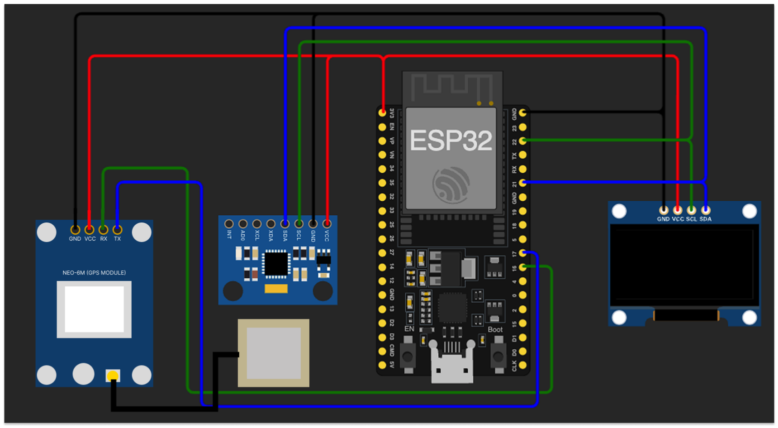

Figure 5.10: ESP32 sensor board setup for real-time tracking and transmission.

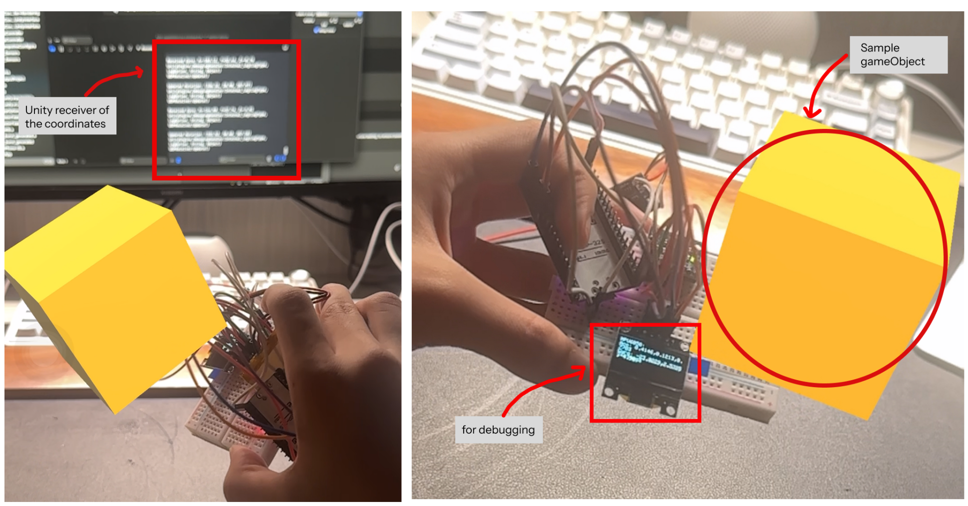

Figure 5.11: Avatar spawning in AR space using a mobile device. The GameObject appears anchored to the transmitted coordinates, verifying successful spatial alignment in Unity's AR environment.

Chapter 6

User Evaluation

6.1 Method

This study integrates and extends methodological approaches by K. Dong et al. (2024) and Madill et al. (2025) to evaluate how a visually augmented drone can function as a performative avatar in an improvisational dance setting. From K. Dong et al. (2024), we adopt the use of semi-autonomous UAV movement motifs and structured observation of embodied interactions in a bounded performance space. From Madill et al. (2025), we draw inspiration from drama-based affective evaluation, narrative interpretation, and archetype matching to capture emotional and relational responses to expressive movement. By combining these frameworks, the study embraces both spatial-temporal behavioral analysis and subjective feedback to assess the perceptual and emotional impact of mixed-reality augmentation in performance contexts.

A central focus of this study is co-located human-drone interaction, where both the human performer and the semi-autonomous UAV share the same physical performance space. This setup enables real-time, embodied interaction, where the drone's expressive motion and the participant's interpretation unfold together within a 2x2x2 meter environment as discussed in Section 5.3. Mixed-reality (MR) overlays are used to investigate how visual augmentation transforms the perceived character, agency, and emotional expression of the UAV.

6.1.1 Conditions and Variables

This evaluation explores how an augmented drone is perceived as a performative avatar in an improvisational dance context. The study adopts a within-subjects design, where each participant experiences both a Drone-only and an MR. Drone condition.

The experimental conditions are defined as follows:

1. **Drone-only Condition:** The participant interacts with a physical semi-autonomous UAV executing expressive movement motifs without any augmented visuals.
2. **MR. Drone Condition:** Participants wear a Meta Quest headset to view synchronized virtual overlays, e.g., trails, glows, or avatars, mapped onto the drone's position.

The independent variable is the presence or absence of MR visual augmentation. This allows us to evaluate how such augmentation affects user experience and perception in co-located interaction scenarios.

The dependent variables include perceived cognitive load, emotional response, perceived expressiveness, anthropomorphism, immersion, usability, and social engagement. These are measured through a combination of standardized instruments, affective models, and behavioral observation.

To assess affective response, we adopt a discrete-label version of Russell (1980)'s Circumplex Model of Affect. Rather than using a continuous grid, participants choose from five emotional labels: Delighted, Relaxed, Neutral, Bored, and Angry, each representing a specific valence-arousal combination. This approach, adapted from Madill et al. (2025), which supports the evaluation of emotional resonance and engagement based on the drone's behavior.

6.1.2 Participant Recruitment

Twenty participants will be recruited based on their background in improvisational or contemporary dance, ensuring they possess the embodied experience necessary for open-ended and expressive movement. Participants must be between 18 and 35 years old to align with the typical age range of active dancers in this genre. All participants must have a minimum of two years of formal training or equivalent experience in improvisational or contemporary dance, which may include professional practice, academic coursework, or membership in a dance troupe or collective.

To ensure safety, participants must be in good general health and have no physical injuries or conditions that would interfere with light, floor-based movement. Normal or corrected-to-normal vision and hearing are also required. Individuals with a history of photosensitive epilepsy, vertigo, chronic motion sickness, or other neurological conditions that may be aggravated by head-mounted displays or moving visual stimuli will be excluded from the study. Due to the nature of the MR visuals and the proximity of a flying drone, individuals with anxiety or strong discomfort around drones or fast-moving visual effects will also not be eligible to participate. Pregnant individuals will be advised not to participate as a precautionary measure.

Participants must also be willing to engage in immersive mixed reality experiences using a Meta Quest headset and consent to interactions with a small drone operating in close physical range. Prior experience with drones or MR technology is not required, but participants will be screened for familiarity to ensure a balanced sample. A pre-study screening form will be administered to gather demographic information, confirm eligibility, and identify any relevant health concerns. This ensures that all participants can safely and comfortably engage in the evaluation process.

6.1.3 Protocol and Hypotheses

The protocol adapts methods from (Madill et al., 2025), (Cui, Choi, & Walker, 2023), and (K. Dong et al., 2024), combining expressive robot movement evaluation with performative improvisation. It is designed to assess the impact of MR augmentations in drones as co-performers in improvisational dance. See Table 6.1 for reference. The evaluation procedure consists of the following phases:

1. **Pre-study Debriefing:** Participants are briefed on the study's objectives and procedures, screened for contraindications (e.g., motion sickness, light sensitivity), and asked to sign a consent form. Safety guidelines related to the semi-autonomous UAV will be emphasized.

2. **Interaction Trials:** Each participant will complete two sessions involving co-located interaction with the semi-autonomous UAV: one in the Drone-only condition and one in the MR. Drone condition. The order of these conditions will be counterbalanced to control for order effects. After each session, participants will complete a series of standardized questionnaires

to assess workload, usability, perception, and affect. These instruments include the NASA-TLX, Godspeed Questionnaire, UEQ-S, MREQ, SSQ, and the Circumplex Model of Affect. The Mixed Reality Experience Questionnaire (MREQ) and the Simulator Sickness Questionnaire (SSQ) are only administered during the MR. Drone session, as they measure responses specific to mixed-reality interaction and potential visual discomfort. This is followed by a semi-structured interview where participants reflect on their experience across both conditions.

3. **Post-study Debriefing:** After both sessions, participants will proceed to a final interview and debriefing phase to conclude the evaluation.

Hypotheses

Grounded in prior studies and informed by the structure of the evaluation procedure (see Table 6.1), the following hypotheses were formulated to guide the assessment of how mixed-reality (MR) augmentation influences user experience in drone-mediated performance. Each hypothesis targets a specific aspect of interaction, ranging from cognitive effort to affective and social responses, across the two experimental conditions.

1. H_0**:** Participants will report lower cognitive load in the MR. Drone condition compared to the Drone-only condition.
2. H_1**:** Participants will perceive the MR. Drone as more anthropomorphic, expressive, and socially engaging.
3. H_2**:** Participants will report higher immersion and presence in the MR. condition.
4. H_3**:** Participants will demonstrate greater engagement and stimulation in the MR. condition.
5. H_4**:** Affective responses will show distinct valence-arousal patterns in the MR. condition, reflecting higher emotional resonance.

6.1.4 Metrics

To evaluate participant responses across both the Drone-only and MR. Drone conditions, the study employs a mixed-methods framework combining quantitative, qualitative, and observational measures.

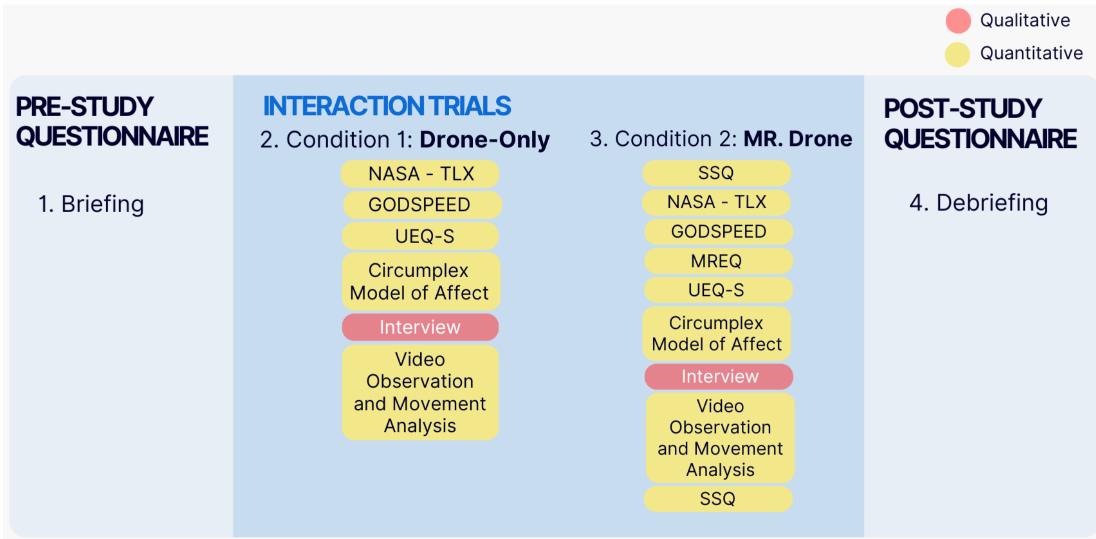

Figure 6.1: User evaluation procedure diagram.

Quantitative metrics are gathered through a series of validated instruments. The NASA Task Load Index (NASA-TLX) measures participants' perceived subjective cognitive load. The Godspeed Questionnaire assesses perceptions of the drone's animacy, likability, and intentionality, providing insights into how participants anthropomorphize the semi-autonomous UAV. Usability and user engagement are measured using the User Experience Questionnaire - Short version (UEQ-S), while subjective immersion, system responsiveness, and the naturalness of interaction in the MR environment are evaluated through the Mixed Reality Experience Questionnaire (MREQ). To monitor any physical discomfort, especially in the MR. Drone condition, the Simulator Sickness Questionnaire (SSQ) is administered both before and after the session. Emotional responses to the drone's behavior are classified using a discrete-label adaptation of the Circumplex Model of Affect, helping to identify affective resonance through valence-arousal categorization.

Qualitative metrics are derived from participants' narrative responses and interview reflections. These include brief written interpretations of each movement motif, a short narrative summary describing the full sequence of drone actions, and insights gathered from the post-study semi-structured interviews. These data points provide a deeper understanding of how participants emotionally and cognitively made sense of the drone's movements in both conditions.

Observational metrics are extracted from video recordings of each session. These include analysis of body language, spatial positioning, and movement patterns during co-located human-drone interaction. By comparing participant behavior across both the Drone-only and MR. Drone conditions, the study assesses impact of MR augmentations in drones as co-performers in improvisational dance.

To examine differences across conditions, data from standardized instruments, including NASA-TLX, Godspeed Questionnaire, UEQ-S, Circumplex Model of Affect, video observations, and semi-structured interviews, will be compared across both the Drone-only and MR. Drone conditions. These comparisons will use both descriptive (e.g., mean, standard deviation) and inferential statistics (e.g., paired t-tests or non-parametric equivalents), depending on data distribution and scale type.

Participants will report their individual subjective ratings using the Mixed Reality Experience Questionnaire (MREQ), which contains 33 items rated on a 7-point scale and is used only in the MR. Drone condition. This instrument evaluates dimensions such as immersion, interaction, and system responsiveness. Only descriptive statistics, including means and standard deviations for each dimension, will be reported. To examine the consistency of participants' ratings, Cohen's Kappa will be calculated to assess inter-rater agreement. Following the benchmark from Tran, Song, Jeong, and Kim (2024), Kappa values above 0.7 will be interpreted as indicating acceptable reliability. Additionally, specific subcomponents of the MR experience, such as presence and interaction, will be examined using the approach described in Schwind, Knierim, Haas, and Henze (2019).

The Simulator Sickness Questionnaire (SSQ) is also administered only in the MR. Drone condition, both before and after the trial. Pre- and post-test scores will be compared to assess changes in simulator sickness symptoms. These difference scores will be analyzed using a two-tailed paired t-test, and effect sizes (Cohen's d) will be reported. Interpretation of these results will follow established SSQ threshold guidelines, as described in Kennedy, Lane, Berbaum, and Lilienthal (1993), to determine whether the MR visual augmentation induced any discomfort or disorientation.

Appendix A

Research Ethics Documents

The following documents were submitted for ethical review and approval:

- Research Ethics Review Form
- General Research Ethics Checklist
- Specific Checklist A: Human Participants
- Workshop Protocol
- Experts Agreement Form
- Questionnaire and Interview Script

A.1 Research Ethics Review Form

RESEARCH / PROJECT ETHICS REVIEW FORM
For Thesis / Capstone / Dissertation Proposals
(*ver.Oct2024c*)

Names of Student Researcher(s):
CANAYON, Roger T.
DELOS REYES, Carl Justin B.
MARUCOT, Hermoine
PANGAN, Yumi Ann S.

Research/Thesis/Capstone Title: Mr. Drone: Performers' Perception Towards Augmented Drone Avatars

College: College of Computer Studies

Department: Department of Software Technology

Course: THS1 to THS3

Expected Duration of the Project: from: May 2025 to: April 2026

PROTOCOL:
(*To be filled up by proponents; Use the Ethics Checklists as guides in determining areas for ethical concern/consideration. Attach and properly reference the accomplished ethics checklists and supporting documents.)*

		Reference Document (include page number)
Target participants	The study will invite 3–4 professional or trained dancers/movement artists per workshop. Participants must have prior experience performing a dance routine on stage or participating in a dance competition; however, the number of years of experience will not be a determining factor. Participation is open to individuals between the ages of 18 and 30, regardless of sex, however we will do our best to recruit a balanced sample for our sample. Participants will be recruited through convenience and purposive sampling via the researchers' networks in the local performance and design communities. All participants will be asked to complete a screening questionnaire. Informed Consent Forms will be distributed to participants prior to the study, clearly outlining the study's purpose, procedures, risks, benefits, and their rights, including the option to withdraw at any time.	Checklist A - Research Ethics Checklist for Investigations involving Human Participants (Page 3)

Data to be used / collected	a. Insights collected from the workshop - Purpose: To gather participants' feedback and insights through dancing, sketching, discussion, and reflection to inform the design of XR-augmented drone form factors. b. Post-Dance Interviews - Purpose: will gather participants' reflections on their experience with the XR-augmented drone. - Variables: Expressiveness, comfort, engagement, emotional response, visual perception, feedback c. Video Observation and Analysis - Purpose: the dance sessions will capture dancer-drone interactions. This includes spatial positioning, movement dynamics, adaptation behaviors, and visible emotional responses such as hesitation or engagement. - Variables: Movement patterns, spatial interaction, adaptation behavior, hesitation, gaze, body language d. User surveys and Self-Assessments - The study will use several standardized questionnaires to evaluate the user experience: ● Questionnaires: ○ Godspeed: will assess how participants perceive the drone in terms of expressiveness, likeability, intelligence, and safety. This will help determine how well the drone functions as a performative avatar. ○ User Experience Questionnaire (UEQ): will measure the overall enjoyment, stimulation, and aesthetic appeal of the XR experience. This gives insight into how engaging and pleasant the interaction felt. ○ Movement Rating Questionnaire (MRQ): a simplified version of MRQ will be adapted to capture perceptions of the drone's movement quality, such as	Checklist A - Research Ethics Checklist for Investigations involving Human Participants (Page 1) [MR Drone] Questionnaire and Script (Page 3-19)

	smoothness and expressiveness during the performance. ○ Simulator Sickness Questionnaire (SSQ): will be used to assess any discomfort caused by the XR headset, including symptoms like nausea, dizziness, or eye strain. These tools will provide a comprehensive understanding of the participants' comfort, engagement, and perception of the XR-augmented drone system.	
Brief procedure	- THS1: Feature Identification Participants will be invited to join workshops involving guided improvisation, discussions, and feedback sessions to identify features relevant to designing the drone's augmented appearance. - THS3: User Studies Participants will perform improvisational dance routines with the augmented drone while wearing a Meta Quest 3 headset. Video recordings, surveys, and interviews will be used to evaluate engagement, expressiveness, and the impact of XR augmentation.	Checklist A - Research Ethics Checklist for Investigations involving Human Participants (Page 1)
Potential risks	- Physical Risk: Participants may be exposed to minor physical hazards due to the drone's propellers or unexpected flight behavior, especially during indoor operation. These risks may occur during rehearsals or user studies (THS2 and THS3), particularly when the drone is in motion close to participants. - Cognitive Visual Strain: Extended use of XR headsets may lead to discomfort, motion sickness, or cognitive overload. These issues are most likely during the improvisational sessions (THS3) involving head-mounted displays (HMDs). - Data Privacy Risk: Video recordings and survey responses may include identifiable information. References:	N/A

	Safa, A., Haddadin, S., & Shah, J. A. (2021). *Safety and Trust for Human-Robot Interaction: A Survey on Design Frameworks and Research Challenges*. arXiv preprint arXiv:2108.12770. Deloitte. (2020). *Drone risk assessment: Managing emerging risks of unmanned aerial systems*. Retrieved from https://www2.deloitte.com/us/en/pages/public-sector/articles/drone-risk-assessment.html Cacace, J., Finzi, A., Lippiello, V., Siciliano, B., & Staffa, M. (2019). *Human–Drone Interaction: Haptic Feedback and User Trust in Drone Swarm Control*. IEEE Access, 7, 102097–102111. https://doi.org/10.1109/ACCESS.2019.2930406	
Applicable Terms of Use or Licensing Agreement of Data, Models and/or Tools	The system will primarily use original assets and open-source tools. All visual overlays, XR elements, and drone movement patterns will be custom-developed for the study. For the XR implementation, Unity and AR Foundation will be used under their respective standard licenses, which allow non-commercial academic research use. No copyrighted music will be used during system development or evaluation. If background audio is needed for guided improvisation, royalty-free music will be sourced from platforms such as Free Music Archive (FMA) or Pixabay Music, which provide tracks under Creative Commons licenses. All audio used will be properly credited as per the license terms, and no commercial music will be included unless explicitly permitted by the license holder. If third-party models or graphics are used for prototyping visual overlays (e.g., avatar models, particle effects), these will be sourced from Unity Asset Store or Sketchfab under assets marked as royalty-free for academic or non-commercial use. Documentation of license agreements and permissions will be maintained in the project folder for transparency and audit.	
Steps to safeguard the participants and/or data	To protect participants from identified risks, the following safeguards will be implemented:	N/A

	- Pilot Study: Before formal sessions, a trial run will be conducted with research staff to verify drone flight paths, XR system stability, and safety protocols. This ensures all equipment functions correctly and potential hazards are identified and mitigated. - Collision Risk and Physical Injury: Participants will receive a safety orientation explaining drone flight zones and safe distances. The drone will have propeller guards and operate within a predefined, controlled space. A trained operator will supervise all sessions and can immediately stop the drone if necessary. Emergency procedures will be in place. - Dizziness and Motion Sickness: XR sessions will be limited to short durations with regular breaks to minimize discomfort. The Simulator Sickness Questionnaire (SSQ) will be used to monitor symptoms. Participants can pause or stop at any time. Clear instructions on headset use will be provided during orientation. - Cognitive Overload: Tasks will be structured with clear, simple instructions and gradual complexity. Participants will be briefed beforehand to set expectations and reduce stress. Post-session surveys will assess cognitive load for ongoing adjustments. - Participants will sign informed consent forms detailing data collection and use. All personal information will be anonymized during data processing to protect individual privacy. Data, including video recordings and survey responses, will be stored securely on encrypted drives accessible only to the research team. These safeguards align with best practices from drone safety and XR research to ensure participant well-being and data protection.	
Other concerns and considerations	- Sessions will take place in a clean, well-ventilated space. Headsets and controllers will be adjusted to ensure participant comfort. At this time, the study will not be able to accommodate	N/A

	individuals with physical limitations due to the movement requirements of the activity. - Bias and Representation: Participants with diverse dance and movement backgrounds will be recruited to reduce bias and improve the generalizability of results. - Transparency and Consent: Participants will receive clear, written, and verbal explanations of the study, risks, and benefits. Informed consent will be obtained before participation. - Environmental Control: Lighting and sound conditions will be optimized for XR tracking and comfort. Floor space will be cleared to prevent tripping hazards.	

PANEL'S ASSESSMENT/COMMENTS:

The group has addressed major ethical concerns. The group is commended for taking extra consideration of the safety of the dancer participants especially while being immersed in the virtual space and while interacting with the drones.

The group is asked to provide additional detail on the drone setup and how it is currently passing existing safety standards (hint: if product is sold in production then it most likely is safe for personal use).

PANEL'S DECISION:

✓ € **Approved** (*Proponent/s may proceed with the study/data collection*)

€ **Modifications Required** (*Proponent/s should address ethical issues, follow the panel's recommendations for required modifications, and resubmit Ethics Review Form for approval before proceeding with the study or before starting with data collection*)

€ **For Full Review** (*Proponent/s should submit the proposal to the University Research Ethics Review Committee (RERC) and obtain a research ethics clearance before proceeding with the study or before starting with data collection*)

JUSTIFICATION:

____
____
____

Jordan Aiko Deja

Name and Signature of Adviser/Mentor

Date: 04 June 2025

Christian Terrence Esguerra

Name and Signature of Panel Member

Ryan Austin Fernandez

Name and Signature of Panel Member

Date:	 ______________________________ **Name and Signature of Panel Member** **Date:**	**Date:**	June 7, 2025

Appendix A

Revision/s (*Highlighted as Yellow):*

Target participants	THS-1: Co-design Session: - The workshop session will invite 3–4 professional or trained dancers/movement artists per workshop. Participants must have prior experience performing a dance routine on stage or participating in a dance competition; however, the number of years of experience will not be a determining factor. While prior experience with augmented reality (AR) or virtual reality (VR) is not required, familiarity with these technologies is considered beneficial. Participation is open to individuals between the ages of 18 and 30, regardless of sex, however we will do our best to recruit a balanced sample for our sample. Participants will be recruited through convenience and purposive sampling via the researchers' networks in the local performance and design communities. All participants will be asked to complete a screening questionnaire. Informed Consent Forms will be distributed to participants prior to the study, clearly outlining the study's purpose, procedures, risks, benefits, and their rights, including the option to withdraw at any time. THS3: User Study - The study will invite 20 participants who are dancers, aged between 18 and 35, to align with the typical age range of active performers in this genre. All participants must have at least two years of formal training or equivalent experience in improvisational or contemporary dance, whether through stage performance, professional practice, or membership in a dance troupe. To ensure safety and compatibility with the study's requirements, participants must be in good general health, with no injuries or conditions that could interfere	Checklist A - Research Ethics Checklist for Investigations involving Human Participants (Page 3) Manuscript - Section 3.6, Pp. 19-20 Manuscript - Section 4.2, P. 23 Manuscript - Subsection 6.1.2, Pp. 59-60

		with light, floor-based movement. Normal or corrected-to-normal vision and hearing are required. Individuals with a history of photosensitive epilepsy, vertigo, chronic motion sickness, or other neurological conditions that may be triggered by head-mounted displays or moving visual stimuli will be excluded. Individuals with anxiety or strong discomfort around drones or fast-moving visuals, as well as pregnant individuals, will also not be eligible. Participants must be willing to engage in immersive mixed reality (MR) experiences using a Meta Quest headset and interact with a small drone operating in close proximity. Prior exposure to AR, VR, or drone technology is not required but will be recorded during screening to ensure a balanced representation of familiarity levels. Recruitment will be conducted through convenience sampling, leveraging the researchers’ networks within local performance and design communities. All participants will undergo a screening process to confirm eligibility, assess health considerations, and document demographic background. Informed Consent Forms will be provided prior to participation, outlining the study’s purpose, procedures, potential risks and benefits, and the right to withdraw at any time.	

Appendix B

Revision/s (*Highlighted as Yellow):*

Data to be used / collected	Chapter 4 a. Insights collected from the workshop - Purpose: To gather participants' feedback and insights through dancing, sketching, discussion, and reflection to inform the design of XR-augmented drone form factors. Chapter 6 **A. <u>Quantitative Measures:</u>** - purpose: To capture measurable aspects of user experience, workload, immersion, and affective response through standardized questionnaires. 1. The **NASA Task Load Index (NASA-TLX)** will be used to assess participants' perceived subjective cognitive load across six dimensions, including mental demand, effort, and frustration. This will help determine how mentally demanding the interaction with the drone system is. 2. The **Godspeed Questionnaire** will measure participants' perceptions of the drone's animacy, likability, safety, and intelligence. This allows us to assess whether the drone is perceived as an expressive or intentional agent in performance contexts. 3. To evaluate general usability and user satisfaction, the **User Experience Questionnaire – Short Version (UEQ-S)** will be used. It captures both pragmatic and hedonic aspects of the interaction, including how stimulating and enjoyable the experience was. Participants in the MR. Drone condition will also complete 4. the **Mixed Reality Experience Questionnaire (MREQ)**, which focuses on immersion, presence, and responsiveness in MR environments. Ratings from this questionnaire will be analyzed descriptively, and **Cohen's Kappa** will be applied to examine inter-rater agreement among participants. This provides insights into whether participants share a	Checklist A - Research Ethics Checklist for Investigations involving Human Participants (Page 1) Manuscript - Section 4.4, Pp. 22-23 Manuscript - Subsection 6.1.4, P. 61

	consistent perception of the MR experience. 5. To monitor any physical discomfort caused by the headset or visuals, the **Simulator Sickness Questionnaire (SSQ)** will be administered before and after the MR trial, evaluating symptoms such as nausea, eye strain, and dizziness. The difference in scores will indicate any onset of simulator sickness due to MR exposure. 6. the **Circumplex Model of Affect**, adapted using discrete labels, will be used to classify emotional responses along valence (positive-negative) and arousal (calm-excited) dimensions. **B. <u>Qualitative Measures</u>** - will focus on participants' personal reflections and interpretations. After each session, 1. **semi-structured interviews** will be conducted to explore how participants perceived the drone's expressiveness, emotional behavior, and role in the dance. Participants will also describe how comfortable and engaged they felt, and offer suggestions for improving the system. 2. In addition to verbal interviews, participants will write short **narrative reflections** after each performance motif. These will include emotional labels, descriptive feedback, and interpretations of the drone's behavior, supporting a deeper understanding of user perception beyond numerical scores. **C. <u>Observational Measures</u>** 1. **Video and audio recordings** of each dance session. These videos will be analyzed to identify patterns in movement, body language, and interaction between dancer and drone. Specific variables include spatial positioning, adaptation behaviors, pauses or hesitations, gaze direction, and how the dancer reacts to changes in the drone's visuals. These observational data provide an embodied understanding of	

	how users responded to the drone's behavior in real time.	

Appendix C

Revision/s (*Highlighted as Yellow):*

Brief procedure	- THS1: Feature Identification Participants will be invited to join workshops involving guided improvisation, discussions, and feedback sessions to identify features relevant to designing the drone's augmented appearance. - THS3: User Studies Participants will undergo three phases: pre-study, interaction trials, and post-study. In the pre-study phase, they will be briefed, screened, and asked to give informed consent. During the trials, each participant will experience both a Drone-only and an MR Drone condition, with the order counterbalanced. After each session, they will complete standardized questionnaires and participate in a short interview. Their movement and interaction will be video and audio recorded for observation. In the post-study phase, they will take part in a final interview and debriefing.	Checklist A - Research Ethics Checklist for Investigations involving Human Participants (Page 1) Manuscript - Chapter 6, Pp. 58-61

Appendix D
Revision/s (*Highlighted as Yellow):*

Potential risks	- Physical Risk: Participants may be exposed to minor physical hazards due to the drone's propellers or unexpected flight behavior, especially during indoor operation. These risks may occur during pilot study or user studies (THS2 and THS3), particularly when the drone is in motion close to participants. Notably, the study by Dong et al. (2024), which involved dancing with drones, did not report any incidents or physical risks, suggesting that such activities can be conducted safely with appropriate precautions. - Cognitive Visual Strain: Prolonged use of XR headsets during improvisational sessions (THS3) may lead to temporary discomfort, including motion sensitivity, eye strain, or cognitive fatigue. Since the study involves active movement and head-mounted displays, participants may experience sensory overload. Those with heightened sensitivity to light, sound, or spatial stimuli may also be at risk of discomfort due to the drone's illuminated visual augmentations and occasional close-range motion. Special caution will be taken for individuals with a history of photosensitive epilepsy or related neurological conditions, as they may be more susceptible to adverse reactions. - Data Privacy Risk: Video recordings and survey responses may include identifiable information. References: Safa et al. (2021), Dong et al. (2024), Deloitte (2020), Cacace et al. (2019)	N/A

Appendix E

Revision/s (*Highlighted as Yellow):*

Steps to safeguard the participants and/or data	To protect participants from identified risks, the following safeguards will be implemented: - Screening: The participants will undergo a screening process where they will be asked if they have any medical conditions or sensitivities that could be affected by close drone interaction and usage of the mixed reality system, such as photosensitive epilepsy or related conditions. This step ensures the safety of all participants and helps determine their suitability for engaging in sessions that involve moving drones and augmentation. - Pilot Study: Before formal sessions, a trial run will be conducted with research staff to verify drone flight paths, XR system stability, and safety protocols. This ensures all equipment functions correctly and potential hazards are identified and mitigated. - Autonomous Drone Operation: The drones will follow a pre-programmed, autonomous flight path, not manual remote control. This ensures consistent and predictable movement. Flight paths will be tested in advance during pilot trials to verify safety and reliability. - Safe Distance and Spatial Boundaries: Based on prior drone studies (e.g., Dong et al., 2022), a minimum distance of 2 meters will be maintained between participants and the drone within a clearly bounded indoor arena (2 m × 2 m × 2 m). The flight area will be visually marked using floor tape and mixed reality overlays. Participants will be instructed not to cross into the drone's active flight zone during operation. While the drone may briefly enter the performer's personal zone (approximately 1 meter radius) to support expressive interaction, it will be strictly programmed to avoid the intimate zone (within 0.46 m of the body) to ensure physical safety. Takeoff and landing will occur from a mission pad positioned outside the dancer's movement	N/A Section 5.4, Pp.47-49 Section 5.3, P. 46

	radius, minimizing risk and maintaining a controlled and safe interaction environment. - Collision Risk and Physical Injury: Participants will receive a safety orientation explaining drone flight zones and safe distances. The drone will have propeller guards and operate within a predefined, controlled space. A trained operator will supervise all sessions and can immediately stop the drone if necessary. Emergency procedures will be in place. - To minimize the risk of dizziness or motion sickness during XR sessions, interactions will be limited to short durations with regular breaks between trials. Participants will be advised to pause or withdraw at any point if they feel discomfort. Orientation will include clear, guided instructions on safe headset use and expectations for the experience. Any signs of discomfort will be addressed immediately by pausing the session and providing assistance if needed. - Tasks will be structured with clear, simple instructions and gradual complexity. Participants will be briefed beforehand to set expectations and reduce stress. Post-session surveys will assess cognitive load for ongoing adjustments. - Participants will sign informed consent forms detailing data collection and use. All personal information will be anonymized during data processing to protect individual privacy. Data, including video recordings and survey responses, will be stored securely on encrypted drives accessible only to the research team. These safeguards align with best practices from drone safety and XR research to ensure participant well-being and data protection.	

A.2 General Research Ethics Checklist

DE LA SALLE UNIVERSITY
General Research Ethics Checklist

This checklist is to ensure that the research conducted by the faculty members and students of De La Salle University is carried out according to the guiding principles outlined in the Code of Research Ethics of the University. The investigator is advised to refer to the <u>De La Salle University Code of Research Ethics and Guide to Responsible Conduct of Research</u> before completing this checklist. Statements pertinent to ethical issues in research should be addressed below. The checklist will help the researcher/s and advisers/readers/evaluators determine whether procedures should be undertaken during the course of the research to maintain ethical standards. The University's <u>Guide to the Responsible Conduct of Research</u> provides details on these appropriate procedures.

Researcher Details	
Students	CANAYON, Roger T. DELOS REYES, Carl Justin B. MARUCOT, Hermoine PANGAN, Yumi Ann S.
Thesis Adviser	DEJA, Jordan Aiko P.
Department/College	Department of Software Technology / College of Computer Studies
Proposed Title of the Research	MR. Drone: Performers' Perception Towards Augmented Drone Avatars
Term(s) and academic year in which research project is to be undertaken	Term 3 of AY 24-25 to Term 2 of AY 25-26

This checklist must be completed AFTER the **De La Salle University Code of Ethics** ***has been read and BEFORE gathering data.***

Questions	Yes	No
1. Does your research involve human participants (this includes new data gathered or using pre-existing data)? If your answer is **yes**, please answer **Checklist A (Human Participants).** **Please specify if the kind of research you will be conducting falls under any of the following Human Participants sub-categories:**	✔	
1.A. Will you be conducting Action Research in an existing business, company, or school? If your answer is **yes**, please answer **Checklist F (Action Research).**		✔

1.B. Does your research involve online communities (this includes culling data from social media platforms, online forums and blogs)? If your answer is **yes**, please answer **Checklist G (Internet Research).**		✔
1.C. Does your research involve human participants who are situated in a community and may necessitate permission to acquire access to them? If your answer is **yes**, please answer **Checklist H (Community Research).**		✔
2. Will your research make use of documents which are not in the public domain and, thus, require permission for use from the custodian of such documents? **If YES, please provide certification that permission from the custodian of the data was sought and granted.**		✔
3. Will your research make use of secondary data (e.g., surveys, inventories, plans, official documents, etc.) from an institution, organization, or agency, which are not in the public domain and, thus, require permission for use from the custodian of such documents? **If YES, please provide certification that permission to use the data was sought from the institution, organization, or agency and approval was granted.**		✔
4. Does your research involve animals (non-human subjects)? If your answer is **yes**, please answer **Checklist B (Animal Subjects).**		✔
5. Does your research involve Wildlife? If your answer is **yes**, please answer **Checklist C (Wildlife)**.		✔
6. Does your research involve microorganisms that are infectious, disease causing or harmful to health? If your answer is **yes**, please answer **Checklist D (Infectious Agents).**		✔
7. Does your research involve toxic/chemicals/ substances/materials? If your answer is **yes**, please answer **Checklist E (Toxic Agents).**		✔

Research with Ethical Issues to address:

If you have a YES answer to any of the above categories, you will be required to complete a detailed checklist for that particular category. A YES answer does not mean the disapproval of your research proposal. By providing you with a more detailed checklist, we ensure that the ethical concerns are identified so these can be addressed in adherence to the University Code of Ethics.

Declaration of Conflict of Interest

[✔] 1. I do not have a conflict of interest in any form (personal, financial, proprietary, or professional) with the sponsor/grant-giving organization, the study, the co-investigators/personnel, or the site.

[ ] 2. I do have a conflict of interest, specifically:

[ ] A. I have a personal/family or professional interest in the results of the study (family members who are co-proponents or personnel in the study, membership in relevant professional associations/organizations).
Please describe the personal/family or professional interest:

[ ] B. I have proprietary interest vested in this proposal (with the intent to apply for a patent, trademark, copyright, or license)
Please describe proprietary interest:

[ ] C. I have significant financial interest vested in this proposal (remuneration that exceeds P250,000.00 each year or equity interest in the form of stock, stock options or other ownership interests).
Please describe financial interest:

A.3 Checklist A - Human Participants

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A.4 Workshop Protocol and Appendices

Workshop Protocol for Dancers

Section 1: Information about this research

Background and Purpose of the Study

We are Computer Science students from DLSU developing an Augmented Reality Interactive Space that explores how drone augmentation can influence performers' perception during improvisational dance. This study aims to evaluate the impact of augmented drones on a dancer's spatial and perceptual experience. This two-day group workshop is designed to gather insights from dancers to inform the visual and aesthetic development of the drone's augmented appearance. As a collaborative session, it will focus on identifying key visual elements and design directions that support expressive and interactive performance within a mixed-reality environment. Your collective input will serve as a vital foundation for the avatar designer, ensuring that the final visual representation is rooted in performer-centered perspectives.

Type of Research Intervention and Participant Selection

This study involves a design-oriented workshop where participants will contribute to the visual and conceptual development of the drone's augmented appearance within a mixed-reality performance setting. The intervention primarily consists of guided questionnaires and sketching sessions focused on aesthetic and expressive design elements.

You have been invited to participate in this workshop due to your expertise as a dancer and your insight into movement and performance. Participants were selected based on their prior experience performing a dance routine on stage or participating in a dance competition, however, the number of years of experience will not be a determining factor. While prior experience with augmented reality (AR) or virtual reality (VR) is not required, familiarity with these technologies is considered beneficial, as it can inform creative insights on enhancing interactive and expressive systems through visual augmentation.

Scope of Avatar Creation and Artistic Input

By participating in this thesis project, you agree to allow the use of your intellectual property in the following ways:

1. Your avatar designs and artistic contributions may be digitally incorporated into the MR. Drone project for the purpose of testing and evaluation within the mixed-reality performance space.
2. Your designs will be analyzed to assess how well they integrate into the MR. Drone system, particularly in terms of aesthetic alignment and effectiveness in augmenting performer expression.
3. The designs and artwork will be used solely within the context of this thesis project, including the application itself, feedback sessions, and the research paper. The results may be shared through the De La Salle University repository, with appropriate credit attributed to you.

Your materials will be used solely within the context of this thesis project, including the application proper, memory retention tests, and the paper itself. The thesis may be shared through the De La Salle University repository, with appropriate credit attributed to you.

Rights and Ownership

By consenting to participate, you confirm that you retain full ownership and copyright over your artistic materials and designs. This consent form does not transfer any rights or ownership of your materials to the research group or any associated institution. You retain the right to request removal of your materials at any time during the study.

Voluntary Participation

Your participation in this research is entirely voluntary. You can withdraw from the study at any point without providing any reasons for doing so.

Procedure

The procedure for this workshop is as follows:

1. Background Information (Pre-workshop): We will collect some demographic information to help determine your suitability for this study. This may include questions about your dance experience, including participation in competitions and familiarity with different dance genres. If any question makes you uncomfortable, you are free to skip it.

2. Informed Consent (Pre-workshop): You will be provided with the Informed Consent Form (ICF), which you must digitally sign before proceeding. You will be given the opportunity to ask any questions or seek clarification about the study.

Once informed consent is signed, we will send the necessary details regarding the scheduling of the workshop. Your participation in this study will take at most 3 hours for each session, and it is divided into 5 Phases for the first session and 4 Phases for the second session. Please note that this is a group workshop.

There are two sessions to allow for a more focused and structured process. The first session will primarily involve sketching the avatar and include an interactive activity to simulate dancing with it. The second session will focus more on discussing and refining the appearance of the avatar. This is essential because the sketched avatar will be placed into an XR environment, and we want to ensure it aligns closely with your vision and expectations before doing so.

We recommend a three-day interval between the two workshops to allow time for processing the initial outputs and preparing the XR version of the avatar for the second session.

Session 1:

3. Phase 1a: Imagine, then Sketch (40 mins)
    a. We will go through a typical dance routine divided into three parts: before the dance, during the dance, and after the dance. For each stage, imagine what your dancing partner, your avatar, might look like. What does their appearance, presence, or gestures look like throughout the routine?
    b. We will then ask you to sketch your avatar, but there's no need to worry about your drawing skills; what matters is your vision and idea. Focus on how the avatar might support or enhance the emotional and physical experience of dancing.
4. Phase 2a: Dancing with the Avatar (10-15 mins)
    a. We will try to replicate how our prototype works. In the actual setup, the dancer would wear a Meta Quest 3s headset and dance with an augmented drone that projects the avatar. Since we are only simulating it for now, one of our team members will hold a box with the approximate size of the actual drone and act as if it's the drone. We will attach your avatar drawings, so it looks like you are dancing with your imagined partner.
    b. We will also be asking questions every now and then to ask about your thoughts, feelings, and experiences dancing with the avatar.
5. Phase 3a: Re-imagine, then Sketch
    a. Based on your experiences and insights from Phases 1 and 2, we will invite you to revisit and reimagine your avatar design. This is an

opportunity to refine and improve your sketch or description, incorporating any new ideas or feelings that emerged while dancing with the simulated avatar.
   b. Take your time to express how your vision has evolved and make any adjustments that feel right.
6. Phase 4a: Final Discussion (20-30 mins)
   a. We will talk about how the avatars looked and how it felt to dance with them. Then, choose the design of the avatar that felt the most natural to dance with, the one that seems friendly, easy to connect with, and not too overwhelming or intimidating.

Session 2:

7. Phase 1b: Discussion of the Prototype Avatar (40 mins)
   a. We will begin by presenting a digital prototype of your avatar, based on the sketches and feedback gathered from Day 1. You will be asked to share your thoughts on how well the prototype captures your intended design, including its appearance, movement style, and emotional presence. This is also a space for open feedback on what aspects feel accurate or misaligned, and what changes you'd like to see before engaging with it in motion.
8. Phase 2b: Dance with the Prototype Avatar (20 mins)
   a. Next, you will dance with the XR-based prototype of your avatar. This time, instead of a sketch attached to a box, you will interact with the digital version of your imagined partner through an iPad. The iPad will be your avatar, giving you a sense of how it might look and move in an actual XR environment.
9. Phase 3b: Experience Discussion (30 mins)
   a. After dancing with it, we will reflect and discuss how the interaction with the initial prototype avatar feels. We will ask to describe their response, ease or difficulty of connecting with the avatar, and any other particular features or gestures that either helped or hindered the experience.
10. Phase 4b: Final Discussion (20 mins)
    a. To close the session, we will conduct a final discussion focusing on the overall evolution of your avatar. You will be asked to reflect on how your perception of the avatar changed from sketch to XR prototype, and which version felt most natural or emotionally resonant.

To help document and analyze your feedback, the sessions will be audio recorded. This is required for accurate transcription and analysis. Additionally, video recording may be conducted to observe movement and non-verbal interaction during activities like dancing or sketching.

You may opt out of video recording at any time, but audio recording is necessary for participation. All recordings will be securely stored, anonymized in reports, and used solely for this thesis project.

Risks and Benefits

There are no reasonably foreseeable risks, discomforts, or disadvantages connected to your participation. However, if you feel uncomfortable with any aspect of the study, you may withdraw at any time. There will be no direct financial benefit to you, but your artistic contributions will play a significant role in shaping the MR. Drone system, helping to create more engaging and effective visual representations for performers. As a token of appreciation, light refreshments and snacks will be provided during the session to support your comfort and participation.

Confidentiality

We will not share your personal information with anyone outside of the research group. Your real name will be removed from all publications and outputs. Any information about you will be marked by a participant ID instead of your name. Only members of the research group will have access to personally identifiable data, and all the information will be securely stored and destroyed when it is no longer needed.

Processing and Storing Your Data

Your artistic materials and designs will be stored securely for the purpose of analysis. Only authorized personnel will have access to the stored data. Any materials that are identifiable will be anonymized before being analyzed. Data that could identify you will be destroyed after 3 years from the first publication of the research. The data will be stored on secure platforms with limited access, and anonymized versions of the materials may be shared for academic purposes, including presentations, publications, and future research. Your materials will only be used in alignment with the scope outlined in this consent form.

Data Breach

In case of a data breach, the person responsible for data protection will be informed by the responsible researcher. Together, they will undertake all steps necessary to minimize any negative consequences. You will receive a notification about the nature of the Data Breach, the information lost, and the actions taken as soon as possible.

Your rights

You have the right to access your personal data, to correct it, to erase it, to restrict its processing, the right to data portability, and the right to object to it in accordance with Articles 15-22 of the General Data Protection Regulation (GDPR). However, the right of erasure does not apply when the processing is necessary for the purposes of archiving that is in public interest, as well as the purposes of statistical analysis and scientific or historical research. You can also withdraw your consent to process your personal data at any time according to GDPR Article 6(1) and Article 9(2) without any consequences. Upon request, your local supervisory authority will provide you with information on exercising your rights according to Article 57(e) GDPR.

Usage of your data

Processed data will be used in research publications, for education purposes and for future research. The use will not be limited to the research group. Third parties will be able to access and process the anonymized data deposited on a private Google Drive repository. As a participant, you can receive a summary of the results upon request.

Section 2: Certificate of Consent

Please read the ten statements below and tick the blanks to confirm your agreement:

____ I have read all sections in this information sheet.

____ I have been given the opportunity to ask questions about the project.

____ I agree to maintain confidentiality of the information discussed in the focus group.

____ I understand my participation is voluntary, and I can withdraw at any time.

____ I understand my words may be quoted in publications and other research outputs.

____ I understand my real name will be removed from all publications and outputs.

____ I understand my personal data will be kept securely and available only to authorized personnel.

____ I understand that anonymized research data will be archived and may be used by third parties.

____ I assign the copyright I hold to the content generated in this activity to the affiliated organizations involved.

____ I understand that audio recordings are required and will be used only for research purposes.

____ I consent to being recorded on video during the workshop and will be used only for research purposes.

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it, and any questions I have asked have been answered to my satisfaction. I consent voluntarily to be a participant in this study.

______________________	______________________	______________
Print name of participant	Signature of participant	Date

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered appropriately and to the best of my ability. I confirm that the individual has not been coerced into giving consent and that consent has been given freely and voluntarily. A digital copy of this certificate of consent has been provided to the participant.

______________________	______________________	______________
Researcher taking the consent	Signature of researcher	Date

De La Salle University
College of Computer Studies

CONSENT TO PARTICIPATE IN THE THESIS PROJECT "MR. Drone"

We are inviting you to participate in the thesis project entitled MR. Drone: Performers' Perception Towards Augmented Drone Avatars. This project is conducted by senior BS Computer Science students at De La Salle University, Roger Canayon, Carl Justin De los Reyes, Hermoine Marucot, and Yumi Ann Pangan, as part of their undergraduate thesis requirement under the supervision of Mr. Jordan Aiko P. Deja.

Your expertise and contributions are vital to this project. As a resource participant, you will be responsible for:

- Evaluating and identifying the most suitable form factor for the avatar.
- Sharing insights and reflections based on your experience interacting with a stand-in object that represents the drone during the dance simulation.
- Offering creative input on how the avatar's presence, movement, and form can enhance emotional connection and artistic expression in performance.

A. INTRODUCTION/PURPOSE

MR. Drone explores how augmented and mixed reality technologies, combined with aerial drones, can create embodied, expressive avatars that support performers in shifting perceptions of drones within a dance context. By integrating insights from dancers, this study investigates how their feedback can help transform the drone's traditionally mechanical and authoritative presence into something more approachable, comfortable, and enticing to dance with.

B. SCOPE OF CONTRIBUTION USE

By participating in this thesis project, you agree to allow the use of your contributions, including insights, verbal feedback, and sketches, in the following ways:

1. Your contributions may be interpreted, modified, or adapted to align with the creative and technical needs of the MR. Drone avatar system and mixed reality (MR) environment.

2. Your input may be used in the development, testing, and presentation of the MR. Drone system, including performance simulations and video documentation.

3. You will be credited by name in all academic outputs, demo videos, and published materials related to the MR. Drone thesis, unless you request to remain anonymous.

4. Upon submission, ownership and intellectual property (IP) rights of all contributions, including conceptual ideas, movement-based input, and performance-related suggestions, will be transferred to the MR. Drone thesis group. The group will retain the exclusive rights to use, adapt, and distribute these materials in support of the project.

C. RIGHTS AND OWNERSHIP

By consenting to this agreement, you acknowledge and agree that the intellectual property (IP) of all sketches, design feedback, recommendations, and insights established for this project will be owned by the *MR. Drone* thesis group. You understand that this ownership includes the rights to use, adapt, and distribute the materials as the group deems fit.

To support your participation, light refreshments and snacks will be provided during the activity as a token of appreciation for your time and involvement.

D. POTENTIAL BENEFIT TO SUBJECTS AND/OR TO SOCIETY

Your participation contributes to innovative research at the intersection of art, technology, and performance. By supporting the creation of expressive drone avatars, you are helping shape future research on embodied interactions and engaging MR experiences. Your contribution may also be featured in exhibitions, demo reels, or future publications with proper credit.

We, the undersigned, confirm that (please tick the appropriate boxes):

TAKING PART IN THIS PROJECT	
We have read and understood the information about the research provided in the above Information Sheet.	☑
We voluntarily agree to allow the use of my contributions, including lesson protocols, tasks, and Sibelius files, in the project.	☑
USE OF THE INFORMATION WE PROVIDE FOR THIS AND FUTURE STUDIES	
The procedures regarding rights and credits have been clearly explained to me.	☑
We agree that the data I provide be archived by the researchers.	☑
We are allowing other researchers to have access to the data collected from this study if they agree to preserve the confidentiality of the data and to the terms specified in this form.	☑
DEADLINE AGREEMENT	
We acknowledge and agree to submit all final deliverables (lesson protocols and Sibelius files) by the **[Date]** deadline.	☑

De La Salle University
College of Computer Studies

PARTICIPANT:

Name and Signature of Participant	Date

RESEARCHER:

Name and Signature of Researcher	Date

Workshop Setup

This study is designed as a one-on-one workshop. To capture your expressions, movements, and insights during the different phases, the session will be recorded using cameras placed in the room.

The workshop will involve only the participant and the research team, and it will take place in a space arranged to allow for free movement and safe interaction with the box representing the drone-avatar. The room will be set up to ensure there is enough space for all activities to be conducted comfortably.

Moderator: Zach

Facilitator: Rog, Yuan, and Ju

Miscellaneous

Settings:

- Venue: GK401
- Powerpoint for guide of the workshop: Workshop PPT

Materials/Tech Needed in Workshop:

- Consent form
- 3 Medium Sized Box as drone to imagine, glue for the mimic prototype
- Name Tag, Tape, Bond paper, coloring materials, pens, & pencils for sketching
- Snacks and water
- Speaker for music & cameras/phones for recording

Workshop Script [Day 1]

Rog will show Slide 1

Part 1: Brief Orientation/Introduction:

Rog will show Slide 2

Hello, I'm **Hermione**. Thank you for participating in this study.

Before everything else, we'd like to discuss first the context of our study, or what we're trying to do. While drones have been used in performances, they often feel mechanical, intimidating, or impersonal. We're exploring how we can use augmentation. Through digital overlays, avatars, and expressive forms, to make drones feel more like dance partners than just flying machines.

The purpose of today's workshop is to help us explore and identify drone-avatar form factors that feel most natural, supportive, and engaging for dancers and choreographers like you.

By the end of this workshop, we hope to gather valuable observations and reflections that will inform the next steps of our research and thesis project. Please note that your participation is entirely voluntary. You may skip any question that makes you uncomfortable, and you are free to withdraw at any point during the session.

There are no right or wrong answers here, we're simply interested in how you work, what you feel would support you, and your insights on how we can shape or alter your perception of drones in the context of dance performance. Feel free to express any thoughts or ideas throughout the session.

This is a one-on-one workshop and will take approximately **3 hours**, divided into **five phases**. We will also be recording parts of the session to document your expressions and feedback, with cameras positioned to capture your movements and reactions in each phase. Only the research team will have access to this data.

Rog will show Slide 3

Informed Consent and Materials
Before we begin, we'll be handing out the consent forms. Kindly read them carefully and sign them. If you have any concerns, please do not hesitate to let us know.

****Yuan will hand out the following: Informed Consent forms & Materials: Pens, coloring materials, Bond Paper****

Ju will start recording once the participant submitted the consent form to Yuan

Rog will show Slide 4

Part 2: Phase 1a: Imagine, then sketch

MEMBERS' NOTES
Materials Needed: Paper & Ballpen **Workshop Structure:** 1. Ask the participant to sit in a monoblock. 2. Place a box in front of the dancer/choreographer. 3. Ask them to imagine what they would like the drone to portray in the context of a dance performance (different parts are as follows: pre-dance, during-dance, & post-dance). 4. Give the paper & ballpen to the participant.

   a. Allow them to sketch based on their imaginations
   b. Ask a series of questions & give some guidance if they can not think of anything
5. Repeat starting Step 3 for each part of the dance.

Workshop Script:

Now that you've completed the consent form and have a clearer understanding of our study, we'd like to start with a preliminary question:

Are you familiar with the idea of drones being used in dance or performance settings?

- **If yes:** As a dancer, how do you imagine drones being used in a performance? What kind of role do you think they could play, and how might dancers feel when interacting with them?
- **If no:** In recent years, drones have been introduced as potential dance partners or expressive elements in performances. What are your initial thoughts on this concept? Does it make you curious? If you were to dance with a drone, how do you imagine that experience would feel?

Thank you for sharing.

To begin, we want to reiterate the goal of this workshop: to shift how drones are perceived—from mechanical or authoritative devices to expressive and calming presences. With your insight as a performer, we're exploring how a drone's form and behavior can be augmented to feel more like a responsive, engaging dance partner—an avatar that supports and complements movement in a performance.

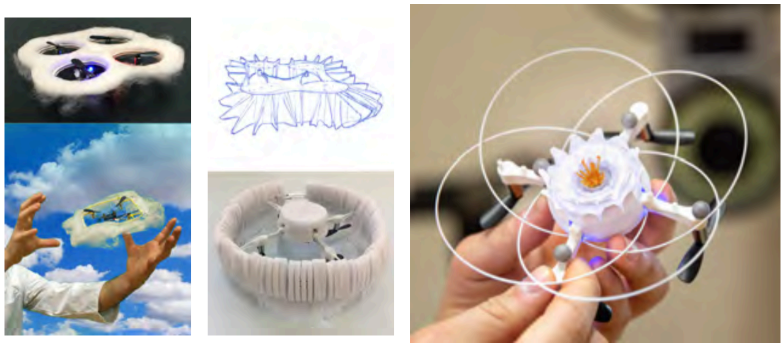
Let's now move into our first phase, which focuses on the **Pre-Dance** experience.

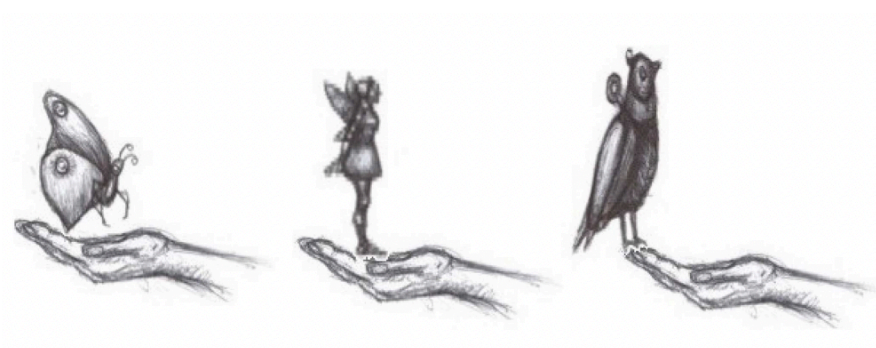
To start, take a look at the box in front of you. Let's imagine that this box represents your dance partner, like a drone you're about to perform or freestyle with.

I. **Pre-Dance scenario:**

   [Q1] Before the dance begins, what would you like this drone to express or communicate? Or How do you want to see the drone?

   a. Does it have a face? Is it a figure, like a fairy, a mask, a shadow, or something abstract?
      - [Show figure] We've got a few examples here that might help you picture what the drone could look like.





[Add POC Video]

b. Now, please sketch or describe what you're imagining. Don't worry about your drawing skills; what matters is your vision and idea.

Hand out the paper and pen

Take your time, and feel free to think about how its appearance would look before dancing.

Members will take down notes on how they are conceptualizing/imagining

Rog will show Slide 6

Now, let’s move on to the next scenario**.** Imagine the drone starts flying and starts interacting with you as you dance.

II. **During Dance Scenario:**

[Q2] As it begins to move with you, does the way you imagined it earlier, during the pre-dance phase, remain the same? Has its appearance changed?

a. Does it still have a face, or take the form of a fairy, or something else?
b. We’d love for you to draw again or describe how your imagined avatar has changed or remained the same, now that it’s actively dancing with you.

Hand out another paper and pen

Again, don’t worry about how well you draw; what’s important is capturing your idea and experience.

Members will take down notes on how they are conceptualizing/imagining

Rog will show Slide 7

Now, to our last scenario on this phase**,** imagine that you have just danced with a drone.

Hand out another paper and pen

III. **Post Dance Scenario:**

[Q3] How do you imagine the drone's appearance as the dance is about to end?

a. Does it give you a signal that the performance is about to end? If so, what does the signal look like?
b. Does it look almost the same as the previous phases, or will there be some changes in its appearance?

[Q4] How about after it has ended?

a. Does the drone appear to be sitting? Standing still

Researchers’ insights/inputs on the participant’s drawing

Rog will show Slide 8

Part 3: Phase 2a: Dancing with the Avatar

MEMBERS’ NOTES

Workshop Structure:

1. Participants will be encouraged to dance improvisationally
2. A member now moves the box in front of the dancer as if it were dancing with the participant.
3. While dancing, different faces will be attached to the box.
4. Ask questions and gain insights from their experience to determine how they feel about doing this
5. Repeat the process to compare different avatar experiences.

Workshop Script:

Now that we've imagined and sketched your ideal drone-avatar, we're going to simulate what it might feel like to dance with it.

In our actual setup, we use a Meta Quest 3 headset to show a digital avatar projected by the drone during live performances. For now, we'll simulate this experience using pasted drawings on the box to approximate how you might perceive different forms of avatars.

Carl, acting as the drone, will hold a box about the size of the real drone. We'll paste your sketches onto the box and move it around you, mimicking how a flying avatar might move in space.

You'll be guided through three movement phases: **Pre-Dance, During-Dance, and Post-Dance.** We'll also play music to help you get into the mood. You don't need to perform anything fancy, just move in a way that feels natural. Focus on how you feel interacting with your imagined avatar.

Rog will show Slide 9

I. **Pre-Dance (12 seconds)**

This phase is about building presence and awareness.

Dancer Prompt:

Here are the things to keep in mind:

1. Start from stillness.
2. Acknowledge the avatar's presence, nod, lift a hand, shift your weight.
3. Mirror the avatar's slow circular path or follow it with your eyes and torso.
4. Focus on breathing and move slowly, in sync with its motion.

Are you ready?

*****Plays Music*****

Drone Prompt:

*****CLAP cues will be used to transition Carl's movements.*****

Holds the Box with the pre-dance sketch

1. Hover 1-1.5 meters away at chest level for 3 seconds.

*****CLAP*****

2. Circle slowly around the dancer in gentle vertical arcs for 7 seconds.

*****CLAP*****

3. Hover in front, nodding motion to signal readiness (2 seconds)

*****Pause the music after 12 seconds and begin asking questions*****

Get the Box with the during dance sketch

With that, here are some questions for you:

[Q5] How did it feel to interact with this avatar? *note: make sure that theyre focused on the appearance of the avatar not the movement the dron*
[Q6] Did its movement support or distract you?
[Q7] Did it feel like a real partner or something else? Why?
[Q8] Would you change anything about this avatar?

Moving on to our next part

Rog will show Slide 10

II. During-Dance (*0:13-2:20/127 Seconds*)

In this part, the drone becomes more animated. It follows, weaves, or leads you.

Dancer Prompt:

Here are the things to keep in mind:

1. Interact dynamically - reach, spin, duck, stretch.
2. Explore levels - stand tall, bend low, reach up.
3. Respond to proximity - pull away when it's close, follow when it retreats.
4. Take turns leading and following.

Are you ready?

*****Plays Music*****

Drone Prompt:

*****CLAP cues will be used to transition Carl's movements.*****

1. Approach and retreat within half a meter (Music Cue: 0:13–0:27)

*****CLAP*****

2. Dynamic zigzag or figure-8 path (Music Cue: 0:27–0:46**)**

*****CLAP*****

3. Spiral or curved paths (Music Cue: 0:46–1:20**)**

*****CLAP*****

4. Forward -led movement and diagonally (Music Cue: 1:20 - 1:50**)**

*****CLAP*****

5. Slowing circular movent (Music Cue: 1:50–2:20**)**

*****CLAP*****

*****Pause the music after 12 seconds and begin asking questions*****

Get the Box with the post-dance sketch

*****Resumes*****

With that, here are some questions for you:

[Q9] How did this version of the avatar feel different from the last?
[Q10] Did its design or motion impact how you moved or felt?
[Q11] What adjustments would make it feel more natural?

Rog will show Slide 11

III. Post-Dance (26 seconds/*2:21-2:47*)

This part is for closure and reflection.

Dancer Prompt:

Here are the things to keep in mind:

1. Slow down.

2. Add a gesture of closure: bow, look back, or a letting-go motion.

Are you ready?

*****Plays Music*****

Drone Prompt

1. Slowly retreat to a neutral distance
2. Hover still or drift back to a "stage wing" area

*****Pause the music after 12 seconds and begin asking questions*****

*****Resumes*****

With that, here are some questions for you:

[Q13] How did you feel at the end of the dance?
[Q14] Did this feel like how you usually feel after finishing a real dance?
[Q15] Did the interaction feel natural to you?

Thank you for that. This concludes our Phase 2 of the session. Now we'll give you 5 minutes to have some water, snacks, use the restroom, and take a breather. We'll return shortly for our final discussion phase."

This concludes our interactive dance phase. Moving on to the final discussion to reflect on the full experience.

Rog will show Slide 12

Next, we'll let you watch the recording of your interaction with the drone. This will help you reflect on the overall experience before we move on to the next phase..

Part 4: Phase 3a: Re-Imagine, then Sketch

MEMBERS' NOTES

Materials Needed: Paper & Ballpen
Workshop Structure:
1. Ask the participant to sit in a monoblock.
2. Place a box in front of the dancer/choreographer.
3. Ask them to imagine what they would like the drone to portray in the context of a dance performance (different parts are as follows: pre-dance, during-dance, & post-dance).
4. Give the paper & ballpen to the participant.
   a. Allow them to sketch based on their imaginations
   b. Ask a series of questions & give some guidance if they can not think of anything

5. Repeat starting Step 3 for each part of the dance.

Workshop Script:
Now that you have imagined the drone from phase 1 and experience dancing with it on phase 2, similar to phase 1 we will be asking you to re-imagine and take a look at the box in front of you. Let's re-imagine that this box represents your dance partner, like a drone you're about to perform or freestyle with.

IV. Pre-Dance scenario:

[Q16] Before the dance begins, again, what do you envision this drone is portraying? Or How do you want to see the drone?

a. Does it have a face? Is it a figure, like a fairy, a mask, a shadow, or something abstract?
b. We'd love for you to sketch or describe what you're imagining. Don't worry about your drawing skills; what matters is your vision and idea.

Hand out the paper and pen

Take your time, and feel free to think about how its appearance would be before dancing.

Members will take down notes on how they are conceptualizing/imagining

Now, let's move on to the next scenario**.** Same scenario to earlier, Imagine the drone starts flying and starts interacting with you as you dance

V. During Dance Scenario:

[Q17] As it begins to move with you, does the way you imagined it earlier, during the pre-dance phase, remain the same? Has its appearance or behavior changed?

a. Does it still have a face, or take the form of a fairy, or something else?
b. We'd love for you to draw again or describe how your imagined avatar has changed or remained the same, now that it's actively dancing with you.

Hand out another paper and pen

Again, don't worry about how well you draw; what's important is capturing your idea and experience.

Members will take down notes on how they are conceptualizing/imagining

Now, to our last scenario on this phase, imagine that you have just danced with a drone

Hand out another paper and pen

VI. Post Dance Scenario:

[Q18] How do you imagine the drone's appearance as the dance is about to end?

a. Does it give you a signal that the performance is about to end? If so, what does the signal look like?
b. Does it look almost the same as the previous phases, or will there be some changes in its appearance?

[Q19] How about after it has ended?

b. Does the drone appear to be sitting? Standing still?

Part 5: Phase 4a: Final Discussion

MEMBERS' NOTES
Workshop Structure: 1. Reflect on the overall experience, how the avatar looked, and how it felt to dance with it. 2. Ask the participant to evaluate the avatars and choose which ones felt the most natural to dance with. 3. Identify the key traits that made the interaction feel more natural or supportive. 4. Discuss any final changes they'd want to make.

Workshop Script

Thank you for participating in our workshop! Before we come to an end, we'd love to hear your overall reflections. After imagining, sketching, and dancing with the prototype, what are your thoughts on how the drone's appearance affects your performance?

Let's talk about what stood out the most to you:

[Q20] Looking back at your new designs and your experience dancing with them and seeing other dancers dance with them, which avatar felt the most natural or expressive to interact with?

a. When we say "natural," what traits come to mind?
    - Was it friendly? Easy to connect with? Not too overwhelming or intimidating?

b. Is this the version you would prefer dancing with in the future? Why?

[Q21] Did any version of your avatar before re-imagining and re-sketching feel off or not quite right?

a. Did it feel like the avatar had a personality or intention?
b. Was there anything about its appearance that made you feel uncomfortable, confused, or distracted?
c. Did the size interfere with your focus or rhythm?
d. What specific changes, such as adding a face, emotions, or color, might make it feel more natural or enjoyable to dance with?

[Q22] How did the presence of a "partner" as the avatar you have drawn influence your dancing?

a. Does it give you the feeling of having a real partner?
b. Were there moments where you followed its lead or treated it like a real dance partner?
c. Did you feel more expressive, more cautious, or more confident while dancing with it?

[Q23] What was it like to dance with your imagined avatar overall?

a. Did anything feel awkward, unclear, or surprising during the interaction? *(If the participant doesn't specify, prompt them to elaborate: e.g., "Was there a moment when you didn't know how to respond to it?" or "Did the avatar ever surprise you?")*

[Q24] Did interacting with this avatar influence your creative process in any way?

a. Did it inspire new movements or ideas?

[Q25] How does your re-imagined avatar feel compared to your first version?

a. Do you feel the avatar now expresses a clearer personality or intention?
b. What changes did you make to the avatar's appearance or behavior? Why?
c. Does the updated avatar feel more comfortable or engaging to dance with?
d. How does the size, color, or added details affect your focus and rhythm during the dance?
e. Overall, how has your perception of the avatar evolved through this process (Before & After of Phase 1 & 2)?

Rog will show Slide 13

Part 6: Wrap-Up

Thank you so much for your active participation today. We deeply appreciate all the insights and creativity you brought into this space. Your feedback is incredibly valuable as we continue shaping MR.Drone into a real, expressive tool for dancers and performers.

We'll follow up with you soon regarding your compensation. If you have any additional thoughts or suggestions after today, feel free to email or message us.

Rog will show Slide 14

Show Emails screen

You can take a picture or take note of our emails

Before we officially end, do you have any questions for us or anything you'd like to add?

END RECORDING

Rog will show Slide 15

Workshop Script [Day 2]

Phases:

1. Welcome Back + Recap
2. Dancing with the High-Fidelity Avatar (iPad display)
3. Immediate Participant Reflection
4. Group Discussion & Recommendations

Part 1: Intro & Avatar discussion

Hi again! Welcome back and thank you so much for joining us for Day 2 of this workshop. Before we begin, just a quick reminder: as noted in the consent form you signed on Day 1, our sessions are being recorded for research purposes. This session will also be recorded.

May we confirm that you're still okay with being recorded today?

START RECORDING

Last time, we explored your creative ideas and sketched how you imagined your ideal drone-avatar across different stages of a dance performance, before, during, and after the dance. You danced with a low-fidelity prototype where we used a box and drawings to simulate interaction.

Based on what you shared, we've now created a high-fidelity prototype that more closely represents what you envisioned. This version includes improved visuals, more refined animations, and interactions that reflect your input.

Today, we'll guide you through another dance session. This time with the enhanced prototype and we'll ask you to reflect on how it felt, what changed for you, and how we can improve further.

Briefly go over the flow of today's session (slide visuals + short agenda recap):

1. Discussion of the prototype avatar
2. Dancing with the High-Fidelity Avatar
3. Open Discussion and Reflection
4. Feedback and Recommendations

We'll start by showing you the digital prototype we built from your design sketches and notes from Day 1.

[add discussion here based on the findings in day 1]

As you observe the avatar:

[Q1] How well does this prototype reflect your vision?

a. Does the prototype bring your idea to life in a way you expected or differently?
b. Which specific features do you recognize from your original design?
c. What feels aligned and what feels different?

[Q2] Does the appearance feel accurate to what you imagined?
a. Do any parts feel flat, too rigid, or overly animated?
b. How would you describe the personality or "presence" of this avatar? Does it match your intent?

[Q3] Does the avatar's appearance match something you could imagine dancing with in a real performance?
a. Does it look accurate enough for you to feel comfortable dancing alongside it?

[Q4] Are there any features that feel off, or aspects you'd like changed before engaging with it in motion?
a. Do the proportions, colors, or any features affect how inviting or comfortable it feels to dance with?
b. Are there any visual distractions or elements that make you hesitant to move naturally or freely?

Feel free to comment freely, we're here to listen.

(After this conversation, proceed to dancing.)

Part 2: Dancing with the High-Fidelity Avatar (10–15 minutes)

MEMBERS' NOTES
This session focuses on letting the dancer interact with the high-fidelity prototype via iPad, guided by music, drone cues, and facilitator prompts.

Now, we invite you to dance with the digital prototype via this iPad. Unlike the first meeting, where you danced with sketches attached to a box, you'll now interact with a digital representation of your imagined partner.

Let the avatar guide, inspire, or simply accompany your movement. There's no pressure to follow any choreography. Just move freely, and notice how its appearance and behavior shape your experience.

I. **Pre-Dance (12 seconds)**

This phase is about building presence and awareness.

Dancer Prompt:

Here are the things to keep in mind:

1. Start from stillness.
2. Acknowledge the avatar's presence, nod, lift a hand, shift your weight.
3. Mirror the avatar's slow circular path or follow it with your eyes and torso.
4. Focus on breathing and move slowly, in sync with its motion.

Are you ready?

Plays [Music]

Drone Prompt:

CLAP cues will be used to transition Carl's movements.

Holds the iPad with the high-fidelity prototype

1. Hover 1-1.5 meters away at chest level for 4 seconds.

CLAP

2. Circle slowly around the dancer in gentle vertical arcs for 6 seconds.

CLAP

3. Hover in front, nodding motion to signal readiness (2 seconds)

Pause the music after 12 seconds and begin asking questions

Get the iPad with the during dance sketch

Moving on to our next part

II. During-Dance (*0:13-2:20/127 Seconds*)

In this part, the drone becomes more animated. It follows, weaves, or leads you.

Dancer Prompt:

Here are the things to keep in mind:

1. Interact dynamically - reach, spin, duck, stretch.
2. Explore levels - stand tall, bend low, reach up.
3. Respond to proximity - pull away when it's close, follow when it retreats.
4. Take turns leading and following.

Are you ready?

Plays [Music]

Drone Prompt:

CLAP cues will be used to transition Carl's movements.

1. Approach and retreat within half a meter (Music Cue: 0:13–0:27)

CLAP

2. Dynamic zigzag or figure-8 path (Music Cue: 0:27–0:46**)**

CLAP

3. Spiral or curved paths (Music Cue: 0:46–1:20**)**

CLAP

4. Forward -led movement (Music Cue: 1:20 - 1:50**)**

CLAP

5. Slowing circular movent (Music Cue: 1:50–2:20**)**

CLAP

Pause the music after 12 seconds

Get the iPad with the post-dance sketch

Resumes

Now we'll move on to Post Dance.

III. Post-Dance (26 seconds/*2:21-2:47*)

This part is for closure and reflection.

Dancer Prompt:

Here are the things to keep in mind:

1. Slow down.
2. Add a gesture of closure: bow, look back, or a letting-go motion.

Are you ready?

Plays Music

Drone Prompt

1. Slowly retreat to a neutral distance
2. Hover still or drift back to a "stage wing" area

Pause the music after 12 seconds and begin asking questions

Resumes

Thank you for that. This concludes our Phase 2 of the session. Now we'll give you 5 minutes to have some water, snacks, use the restroom, and take a breather. We'll return shortly for our final discussion phase."

This concludes our interactive dance phase. Moving on to the discussion to reflect on the full experience.

Part 3: Experience Discussion

Thank you! Now that you've danced with the high-fidelity version of the avatar, let's talk a bit about how it felt.

[Q1] How did it feel to dance with this more polished avatar compared to your previous sketches?

a. Was the experience more immersive or less? Why?

[Q2] Did the avatar's design feel emotionally expressive or more mechanical?

a. When were you able to feel it expressing something? Can you describe it?
b. If it felt mechanical, what might help it feel more relaxed or relatable?

[Q3] Was there any specific movement or visual element that resonated with you or distracted you?

a. Was this tied to a particular change in visuals or just a shift in music?
b. How did this element influence your movement or focus?

[Q4] Did you feel supported, challenged, or inspired by this version of the drone avatar?

a. In what ways did the avatar affect your confidence or creativity in movement?
b. Does it feel like guiding or asking something of you?

[Q5] If we were to use this in a real performance, what would you want changed or improved?

a. Would you prioritize changes to appearance or movement?

[Q6] How did the avatar's size and shape affect how you interacted with it?

a. Did its proportions make you feel more open and creative or cautious and restrained?
b. Were there moments where you adjusted your body or spacing because of how large or small it felt?

Part 4: Recommendations and Final Insights
We'd love to hear any additional thoughts now that you've experienced both the low-fidelity and high-fidelity versions.

[Q7] What would make the avatar feel more alive or emotionally resonant to you?
  a. Do you think sound, shifts in colors, or lights could enhance its presence (*for the better)*?

[Q8] Did anything surprise you during today's session?
  a. Was the movement or behavior of the avatar different from what you expected?
  b. Did you respond to it differently than what you imagined?
  c. Were there any emotional or physical scenarios that caught you off guard?

[Q9] Were there any disconnects between what you imagined yesterday and what you saw today?
  a. Which parts felt misaligned: appearance, behavior, or energy?
  b. Was anything lost in translation from sketch to screen?
  c. How did those differences affect how you danced with it?

[Q10] How might this avatar influence your creative process or performance if used regularly?
  a. Do you see it as a partner, a mirror, or an extension of yourself?
  b. Would it be able to help with expression, storytelling, or improvisation in your work?

[Q11] If you could direct your own drone-avatar design team, what would your top priorities be?
  a. What qualities would you emphasize: emotion, movement, visuals, interaction?
  b. Would you prioritize aesthetics, functionality, or responsiveness first?
  c. What would you tell your team to avoid at all costs?

Wrap-Up

Again, thank you so much for your active participation today. Thank you again for your time, energy, and imagination. Your insights are incredibly valuable to us as we continue developing this project. We hope this workshop was not only helpful for our research but also inspired new ideas for your own dance practice.

Also as previously discussed, We'll follow up with you soon regarding your compensation. If you have any additional thoughts or suggestions after today, feel free to email or message us.

*****Show Emails screen*****

You can take a picture or take note of our emails

Before we officially end, do you have any questions for us or anything you'd like to add?

*****END RECORDING*****

Appendix B

Questionnaires

B.1 NASA-TLX Questionnaire

Figure 8.6

NASA Task Load Index

Hart and Staveland's NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales.

Name	Task	Date

Mental Demand — How mentally demanding was the task?

Very Low — Very High

Physical Demand — How physically demanding was the task?

Very Low — Very High

Temporal Demand — How hurried or rushed was the pace of the task?

Very Low — Very High

Performance — How successful were you in accomplishing what you were asked to do?

Perfect — Failure

Effort — How hard did you have to work to accomplish your level of performance?

Very Low — Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed wereyou?

Very Low — Very High

B.2 User Engagement Questionnaire (UEQ)

Items of the short version of the User Experience Questionnaire (UEQ)

This document lists the items and their order for all the available languages of the UEQ.

English version

obstructive	o o o o o o o	supportive
complicated	o o o o o o o	easy
inefficient	o o o o o o o	efficient
confusing	o o o o o o o	clear
boring	o o o o o o o	exciting
not interesting	o o o o o o o	interesting
conventional	o o o o o o o	inventive
usual	o o o o o o o	leading edge

B.3 Godspeed Questionnaire Series

Bartneck, C. (2023). Godspeed Questionnaire Series: Translations and Usage. In C. U. Krägeloh, O. N. Medvedev, & M. Alyami (Eds.), International Handbook of Behavioral Health Assessment (pp. 1-35). Springer. https://doi.org/10.1007/978-3-030-89738-3_24-1

English

Translated by: Christoph Bartneck
Publication: https://doi.org/10.1007/s12369-008-0001-3
Instructions: Please rate your impression of the robot on these scales:

Anthropomorphism

Fake	1	2	3	4	5	Natural
Machinelike	1	2	3	4	5	Humanlike
Unconscious	1	2	3	4	5	Conscious
Artificial	1	2	3	4	5	Lifelike
Moving rigidly	1	2	3	4	5	Moving elegantly

Animacy

Dead	1	2	3	4	5	Alive
Stagnant	1	2	3	4	5	Lively
Mechanical	1	2	3	4	5	Organic
Artificial	1	2	3	4	5	Lifelike
Inert	1	2	3	4	5	Interactive
Apathetic	1	2	3	4	5	Responsive

Likeability

Dislike	1	2	3	4	5	Like
Unfriendly	1	2	3	4	5	Friendly
Unkind	1	2	3	4	5	Kind
Unpleasant	1	2	3	4	5	Pleasant
Awful	1	2	3	4	5	Nice

Perceived Intelligence

Incompetent	1	2	3	4	5	Competent
Ignorant	1	2	3	4	5	Knowledgeable
Irresponsible	1	2	3	4	5	Responsible
Unintelligent	1	2	3	4	5	Intelligent
Foolish	1	2	3	4	5	Sensible

Perceived Safety

Anxious	1	2	3	4	5	Relaxed
Calm	1	2	3	4	5	Agitated
Still	1	2	3	4	5	Surprised

Fig. 1 English (original)

B.4 Mixed Reality Questionnaire (MRQ)

Table 1: MREQ questionnaire items

No	Relation	Item(s)
1	P(RE)	There was a real world environment.
2	P(VE)	There was a virtual environment.
3	P(RO)	There were real objects.
4	P(VO)	There were virtual objects.
5	P(RA)	There were other (real) [agents].
6	P(VA)	There were virtual representations of other [agents].
7	P(Usr)	I could recognize myself in the environment.
8	Usr-VE	I felt I was part of the [virtual environment].
9	Usr-RE	I felt I was part of the [real environment].
10	Usr-RO	The [real objects] and I were in the same environment. (I felt I could have touched the [real objects])
11	Usr-VO	The [virtual objects] and I were in the same environment. (I felt I could have touched the [virtual objects])
12	Usr-RA	[Other agents] and I were in the same room.
13	Usr-VA	The [other virtually presented agents] and I were in the same environment.
14	VO-VE	The [virtual objects] belonged to the [virtual environment].
15	VO-RE	The [virtual objects] belonged to the [real environment].
16	VO-RO	I could not distinguish between [real objects] and [virtual objects].
17	VO-VO	The [virtual objects] were part of the same space.
18	VO-RA	[Agents] in the environment were in the same space as the [virtual objects]
19	VO-VA	Virtual [agents] were in the same space as the [virtual objects]
20	VE-RO	The [real objects] belonged to the [virtual environment].
21	VE-RA	The [agents] belonged to the virtual environment.
22	VE-VA	The virtually presented [agents] belonged to the [virtual environment].
23	VE-RE	[Virtual and real environments] formed one, common space.
24	VE-VE	The virtual environments presented belonged to each other.
25	RE-RO	The [real objects] belonged to the [real environment].
26	RE-RA	The [agents] were in the real environment.
27	RE-VA	The [virtually presented agents] belonged to the real environment.
28	RO-RO	The [real objects] belonged to each other
29	RO-RA	The [agents] and [real objects] were in the same environment. (The [agents] could have touched the real objects.)
30	RO-VA	The [virtually presented agents] and [real objects] were in the same environment. (The [virtually presented agents] could have touched the real objects.)
31	RA-RA	The [other agents] could have communicated with each other.
32	RA-VA	The [other agents] could have communicated with the [virtually presented ones].
33	VA-VA	The [other virtually presented agents] could have communicated with each other.

End of Technical Report.

B.5 Simulator Sickness Questionnaire (SSQ)

Walter, Hannah; Li, Ruixuan; Munafo, Justin; Curry, Christopher; Peterson, Nicolette; Stoffregen, Thomas. (2019). APAL Coupling Study 2019. Retrieved from the Data Repository for the University of Minnesota, https://doi.org/10.13020/XAMG-CS69.

The Simulator Sickness Questionnaire

Subject _______

SSQ- X

Are you motion sick now? Circle YES or NO

If you are sick, when did you first notice the symptoms? Time: _________ Date:______

Circle how much each symptom below is affecting you now.
0 = "not at all" 1 = "mild" 2 = "moderate" 3 = "severe"

1. General discomfort	0	1	2	3
2. Fatigue	0	1	2	3
3. Headache	0	1	2	3
4. Eyestrain	0	1	2	3
5. Difficulty focusing	0	1	2	3
6. Increased salivation	0	1	2	3
7. Sweating	0	1	2	3
8. Nausea	0	1	2	3
9. Difficulty concentrating	0	1	2	3
10. Fullness of head	0	1	2	3
11. Blurred vision	0	1	2	3
12. Dizziness (eyes open)	0	1	2	3
13. Dizziness (eyes closed)	0	1	2	3
14. Vertigo*	0	1	2	3
15. Stomach awareness**	0	1	2	3
16. Burping	0	1	2	3

*Vertigo is experienced as loss of orientation with respect to vertical upright

Walter, Hannah; Li, Ruixuan; Munafo, Justin; Curry, Christopher; Peterson, Nicolette; Stoffregen, Thomas. (2019). APAL Coupling Study 2019. Retrieved from the Data Repository for the University of Minnesota, https://doi.org/10.13020/XAMG-CS69.

**Stomach awareness is usually used to indicate a feeling of discomfort that is just short of nausea.

Appendix C

Turnitin Similarity Report

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