

# Motion Capture Technology for Enhancing Live Dance Performances

## Introduction

In this research project, we present a novel approach that combines Virtual Reality (VR) with a motion capture (mocap) suit for live dance performances. Leveraging real-time motion capture technology, we can stream precise body movement data to a virtual character and project it behind the dancer in real-time. As a result, we create a captivating blend of Augmented Reality (AR) and Virtual Reality, producing an animated virtual shadow that follows along with the movements of a dancer as they perform.

## Motivation

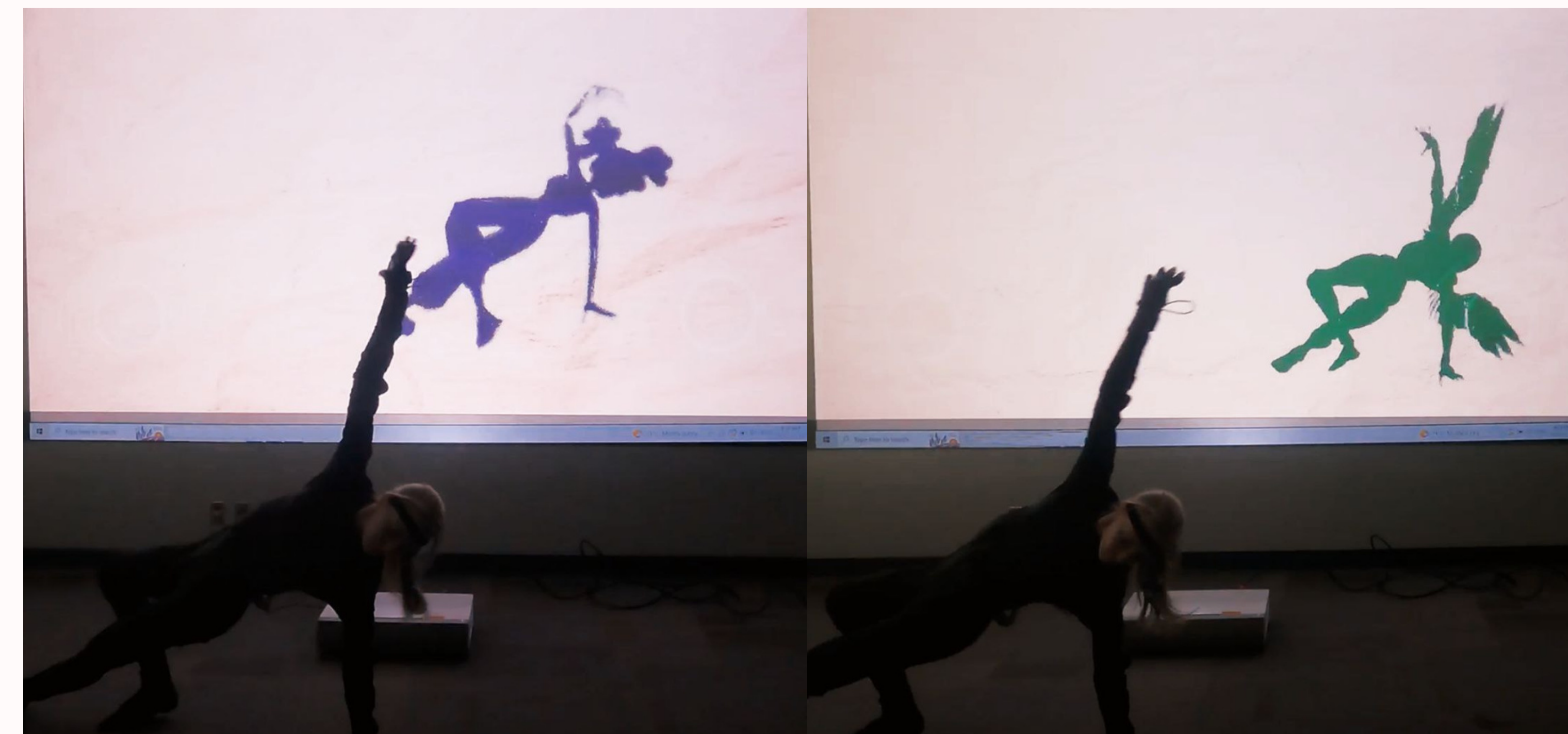
“Human shadows [can] be used as an ambient display” that transfers various emotions, such as excitement, joy, hope, sadness, etc., by manipulating its shape, colour and size [1]. We decided to use this capability in order to magnify an impression from a dance.

- **Performative:** The primary objective of this work is not to take all attention away from the dancer but to elevate their performance. With the existing delay on the character, we give an opportunity for the performer to create a bigger amplitude for the dance moves and help to fill in the stage if the act is solo. Styles like ballet or contemporary dance would mostly benefit. (Figure 1)
- **Practical:** While mostly for entertaining purposes, this technology can also be used as a learning tool to reflect on a dancer's posture and choreography [2]. Moreover, this capacity can become a reference for how multiple people dancing would look like, since the choreography can be recreated with just one person and multiple shadow characters. (Figure 3)
- **Instant Adaptation:** With this system a dancer has capability to improvise and/or freestyle during any phase of choreography. Even if a mistake happens, the dancer's shadow adjusts naturally, making errors less noticeable. Furthermore, from a technical perspective the need for post-production is eliminated.

All of the above can be done with just one mocap system.

## Implementation

This research was done using a Rokoko motion capture suit and Unreal Engine (UE) computer graphics program. Initially, we acquired a character whose silhouette would serve as the basis for our system. Then we imported this character into UE and developed an Animation Blueprint. By configuring nodes and retargeting the character's skeleton, we enabled real-time streaming from RokokoStudio to Unreal Engine. Since we did not need the actual character—just its shadow—we designed a new invisible material that still casts a shadow and applied the material instance to our character (Figure 2). Additionally, we implemented various features, such as the ability to change the colours of the shadow and the background, as well as alter the size of the character or the character itself. All of these features can be easily customized according to the user's preferences (Figure 1). We were able to set up our system and project a shadow on the wall behind the performer with an Optoma floor-based projector. This setup allowed us to seamlessly display the animated virtual shadow during the dance performance.



**Figure 1**  
Different characters doing the same movement



**Figure 2**  
Visible character vs. Silhouette Character  
Adapted from Xbot. Mixamo@  
<https://www.mixamo.com/#/?page=1&type=Character>  
Accessed Aug 2023

**Figure 3**  
Multiple Shadows  
Adapted from Michelle. Mixamo@  
<https://www.mixamo.com/#/?page=1&query=Michelle&type=Character>  
Accessed Aug 2023

- Projector at 30 hz (low) — disturbing drop in frames
- Projector at 60 hz (default) — noticeable drop in frames
- Projector at 120 hz (max) — much smoother image, but the delay becomes more visible

**Figure 4**  
Drop in Frames Visual Evaluation

Common-use AP to RokokoStudio	0.34 s
Isolated AP to RokokoStudio	0.27 s
Common-use AP to UnrealEngine	0.38 s
Isolated AP to UnrealEngine	0.33 s

**Figure 5**  
Delay Evaluation

## Discussion/Limitations

- The main aim of our work is to deliver a high-quality performance in real-time, avoiding post-production processes. While we successfully implemented our system, we experienced a noticeable drop in frames during the streaming process from PC to projector. To address that issue, we increased the refresh rate of the projector from 60hz to 120hz (Figure 4). That adjustment helped to improve the overall visual experience.
- Another problem was a visible delay between the actual and virtual movements. We set up our system on different Access Points (APs) and compared the delay between them (Figure 5). An isolated AP ensured consistent communication delays, rather than a common use AP that may be interrupted by other signals, so we achieved better results out of the isolated AP.

Despite implementing methods to enhance the original system, the delay remains the primary limitation for the real-time streaming of motion capture data. In the future, one potential avenue for improvement is to explore the possibility of setting up our system on a more powerful piece of hardware. Such an upgrade holds the promise of significantly reducing or even eliminating the delay, bringing us closer to achieving real-time motion capture streaming.

## Conclusion

In this work, we deliver a novel technique that uses real-time motion capture to support every stage of dance development—from the initial inception to the captivating final performance on stage (Video 1). With the virtual shadow, dancers gain invaluable insights into how the choreography appears with multiple performers, enabling them to reflect on the dance from a broader perspective (Video 2). Moreover, the interactive nature of the shadow allows dancers to improvise and engage with it as if the silhouette was a separate character, adding an exciting layer of creative possibilities to their performances (Video 3). Last but not least, our virtual shadow enriches the visual experience for the audience and extends the meaning of the dance beyond conventional body movements.

## Acknowledgements

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## References/Links

[1] Raudanjoki, Ö., Häkikä, J., Hurtig, K., & Colley, A. (2020). Perceptions of human shadow manipulation as an ambient display. Proceedings of the 9TH ACM International Symposium on Pervasive Displays, 71–77. <https://doi.org/10.1145/3393712.3395180>

[2] Tsampounaris, G., El Raheb, K., Katifori, V., & Ioannidis, Y. (2016). Exploring Visualizations in Real-time Motion Capture for Dance Education. Proceedings of the 20th Pan-Hellenic Conference on Informatics, 1–6. <https://doi.org/10.1145/3003733.3003811>

**Video 1** - Contemporary Dance with Angel Shadow  
**Video 2** - Pop Dance with Multiple Shadows  
**Video 3** - Interaction with Shadow