Exploring Digital Embodiment in Wheelchair Dance with Generative AI

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ABSTRACT

In the era of blurring boundaries between technology and humans, the idea of posthumanism in the arts offers opportunities to overcome human natural limitations through the integration of artificial agents that can enhance performance and creativity. Within the field of dance, a variety of technologies have been utilized to amplify aspects such as training, artistic creation, live performance, and dance archives. Nonetheless, a largely unexplored territory exists—the application of emerging technology in the context of disability dance. This paper presents an ongoing project focused on gesture-controlled AI generation for wheelchair dance as a way to explore the complex relationship between dancers and their assistive devices. The system uniquely captures the dancer and wheelchair through body segmentation, then recombines them into a unified body. Subsequently, it extracts movement features based on the previously established framework for visualizing movement quality in wheelchair dance, generating images that enable a deeper understanding of the dance's expressive qualities. This innovative approach enhances the creative potential of wheelchair dance, empowering dancers to craft personalized visual narratives.

CCS CONCEPTS

• **Applied computing** → **Media arts**; • **Human-centered computing** → **Visualization toolkits**.

KEYWORDS

inclusive HCI, generative AI, disability art, movement visualization, gesture control

ACM Reference Format:
Yurui Xie, Giulia Barbareschi, Kai Kunze, and Masa Inakage. 2023. Exploring Digital Embodiment in Wheelchair Dance with Generative AI.

IoT 2023, November 07–10, 2023, Nagoya, Japan

ACM ISBN 979-8-4007-0854-1/23/11…$15.00
https://doi.org/10.1145/3627050.3631576

In *The International Conference on the Internet of Things (IoT 2023), November 07–10, 2023, Nagoya, Japan.* ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3627050.3631576

1 INTRODUCTION

The rapid development of technologies and tools that seem to alter or outright replace human functions has sparked a fear of integration with artificial technologies [11]. In searching for an alternative path from the idea of technology as a substitute for human ability, the concept of posthumanism centered on integration with technology as a way to disrupt the separate dichotomies of users vs artifacts, as well as the subversion of societal norms [5]. Within the disability community, and especially among disabled artists, there is often more awareness of this tension as assistive tools have been perceived both as potentially eclipsing the user's own identity and as a means to express it [1].

Experiments on posthumanism are frequently observable within the realm of dance. These endeavors encompass the utilization of visual design to extend the temporal-spatial capacities of the human body [2, 3, 13] or enhance the ephemeral dynamic of dance [10]. Dance, as an art form inherently rooted in human characteristics, serves as a medium for the transformation of implicit body schema into explicit embodiment.

Moreover, the visualization of dance transcends inherent physical limitations to facilitate extensive storytelling, aligning with the principles of posthumanism, wherein technology is harnessed to augment human attributes and re-negotiate the body itself [7]. Contemporary approaches to visualizing dance have delved into the augmentation of creativity [2], performance enhancement [4, 10], and training refinement[8]. Nevertheless, the exploration of dance visualization within the framework of posthumanism remains notably absent in the context of wheelchair dance, which is arguably more suited to it as a result of the natural integration between the human body of the dancer and the technological extension of the wheelchair.

In wheelchair dance, assistive tools can boost dancers' abilities but may also highlight their disability, possibly overshadowing their artistic identity [1]. Recent research has tackled this by visualizing expressive qualities in wheelchair dance, drawing from established movement methods to combat such stigma [13]. However, the solution by Xie et al 2023 [13] lacks adaptable visual narratives capturing the dynamic dancer-tool relationship that exists in wheelchair

dance. This research expands on the existing framework of movement quality visualization for wheelchair dance [13], integrating generative AI within the overarching posthumanist ideology to explore adaptive visualizations tailored specifically to wheelchair dance's identity.

2 RELATED WORKS

To examine the integration of posthumanism in dance visualization for disabled dancers and assistive technology, we conducted a literature review spanning three different domains: *Embodied*, *Incorporated*, and *Cybernetic*. We selected these domains to provide a structured framework for our investigation, allowing us to systematically analyze how disability dance and assistive technology intersect and evolve in these diverse dimensions. This structured approach informs our design considerations, focusing on the interaction between the disabled body and the wheelchair.

- *Embodied* In this research's context, *embodied* underscores the emphasis on our biological body and visualizing dance while maintaining a strong connection to our natural form. Such visualizations can be controlled by audiences' physiological feedback [10], participatory designed visual mapping [8], or dance trajectory generated avatar [2]. The focus is to enhance dancers' movement creation through varied design processes and visualizations. Sound-motion mapping has been employed for AI dance generation to bolster adaptability [12]. Yet, the potential of this approach remains unexplored in text-image generation and among disabled dancers.
- *Incorporeal* Under posthumanism the idea of *incorporeal* encompasses the existence beyond the limitation of the natural body, which transcends to a new form of being, such as a digital identity. Research that visualizes wheelchair dancers' expressive quality based on Laban Movement Analysis (LMA) for both wheelchair dancers and non has attempted to create a visual state of being that is not bounded by the specific characteristics of the body [9, 13]. These visualizations embody posthumanism's core principles by transcending physical limitations to digital narrative.
- *Cybernetic* This concept explores the idea that humans can merge with or become closely connected to technologies or machines, blurring the line between the human body and inhuman objects. In Oscar Schlemmer's *Bauhaustänze*, external tools such as costumes and geometrical poles were integrated to extend movement capacity towards the exterior space [3]. Although this is not digital visualization, the visual perception of costume and tools integrated *cybernetic* elements within the dance experience.

Dance visualization can derive from each mentioned category to practice the idea of posthumanism. Our research finds that while progress has been made in enhancing dance visualization, there remains a notable gap in developing adaptable visual narratives that fully represent the dynamic interaction between disabled dancers and their assistive tools. Since disability has its unique difference based on each case, it requires end-user adaptable visualization for wheeling dancers [13]. On the other hand, the positioning of wheelchairs in wheelchair dance visualization is yet to be examined and explored.

3 DESIGN DEVELOPMENT

3.1 Concept

This research focuses on integrating posthumanist approaches and adaptable visualization, categorizing posthumanism into three dimensions: the natural body, external body, and assisted body, corresponding to *embodied*, *incorporeal*, and *cybernetic*, drawing from the choreutics concept of the kinesphere within the dancer's body, the wheelchair, and their amalgamation.

Within adaptive visualization, we explore the dancer's control over the visualization process, referencing the systematic framework outlined in "Movement Quality Visualization for Wheelchair Dance" (Xie, 2023), utilizing extracted movement features to trigger visual content creation. Integrating AI generation enhances the dynamic and diverse visual language, elevating the visualization process and broadening the scope of visual expression.

3.2 Embodied, Incorporeal, and Cybernetic

The wheelchair dance movement is captured through video data input which facilitates both real-time and post-processing conditions. The video data is analyzed within the TouchDesigner platform, focusing on a four-second segment of movements. This analysis utilizes MediaPipe for the segmentation of predefined data within the original video content, including the body morphology. The aim is to identify three fundamental elements of the distinct and interconnected kinesphere:

- *Embodied* This category considers the dancer's own individual body. Machine learning directly segments the dancer's natural body from video input as the main target for *embodied* visualization (Figure 1).
- *Incorporeal* Wheelchair is considered as the *incoporeal* body. Segmentation of the wheelchair is not directly processed with machine learning. The system's post-processing masks previously segmented dancers' bodies on original video data to extract the wheelchair (Figure 1).
- *Cybernetic* The combination of dancer's body and wheelchair together makes *cybernetic* body. Uniting the previously extracted dancer's body and wheelchair, the system is able to present a visual amalgamation of two different bodies together.

Each individual piece of extracted visual data will function as the foundational input guiding the AI generation process, encompassing the distinct categories of *embodied*, *incorporeal*, and *cybernetic*.

3.3 Adaptive Control for Visualization

The AI generation from Stable Diffusion is accessed by connecting to an external application programming interface (API). The process of AI generation necessitates prompts to govern the visual output, and for the purpose of controlling visualization in this project, movement expression is employed to manipulate predefined prompt inputs. Xie's proposed solution [13] offers a method for handling extracted movement data grounded in LMA's Effort theory. LMA is an established movement analysis system, and its Effort theory examines movement quality into two opposite continuums from each motion factor [6]. Our proposed system uses extracted movement data from Effort theory's Weight and Time to

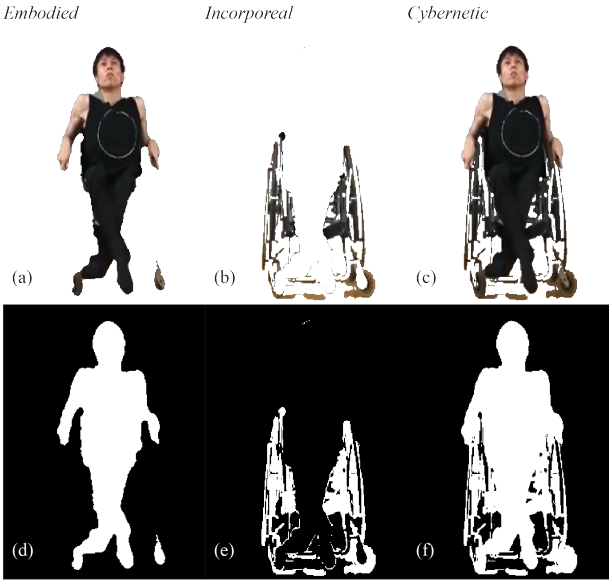

Figure 1: Body segmentation technique in three domains: (a, d) embodied, (b, e) incorporeal, and (c, f) cybernetic. (a-c) Original segmented video content. (d-f) Body and shape morphology.

Figure 2: Movement quality controlled AI generation: Weight quality of "light" and "strong" controls "bright" and "dark" prompts. Visualization generated from Sun Dance © Kenta Kambara

reconfigure movement data as the control factor to switch prompt input. The system demonstrates the capacity to employ existing solutions for motion-controlled to prompt input, thereby providing a platform for adaptive AI generation with integrated movement expressions.

3.3.1 Weight. In Effort theory, Weight signifies the force magnitude expressed by a dancer through body extension, encapsulating two qualities: "strong" and "light." As the body extends, Weight is perceived as "light," while the opposite denotes "strong". The current solution employs the identification of body extension by measuring the distance between the upper limbs and the nose to the constructed wheelchair center [13]. Our system calculates the average body extension values over a cumulative process, determining the points at which Weight is at its strongest or lightest, assigning two prompts to align with the maximum and minimum body extension values, and facilitating prompt input control based on the Weight quality of movements.

In the concept of *Incorporeal*, the system takes the extracted wheelchair as an image guide and generates visuals according to the preassigned prompts of "dark" and "bright" correspond to Weight's "strong" and "light" (Figure 2). Additionally, two constant prompts, "human body" and "dancehall", control the invariant visual condition.

3.3.2 Time. According to the LMA Effort theory, Time represents the duration of motion, incorporating the qualities of movement denoted as "sustained" and "sudden," with "sustained" relating to slower motion and "sudden" to faster motion. In Xie's proposed solution, Time is quantified by extracting the speed of upper limb motions [13]. Our system employs a parameter switch akin to the Weight attribute methodology to govern input prompts, categorizing motion as "sustained" or "sudden" depending on whether the input speed exceeds or falls below the average speed threshold.

The tested AI generation utilizes preassigned prompts of "geometric" and "organic" corresponding to "sustained" and "sudden" motions, as depicted in Figure 3. However, the generated content exhibited body deformation potentially stemming from the input video's characteristics and the dynamic nature of the movement sequence, necessitating further investigation. Conversely, the generation adheres to constant prompts of the "human body" and "dancehall," employing the extracted wheelchair as a guiding image.

3.4 Discussion

This study employs machine learning's body segmentation techniques to categorize wheelchair dance into the domains of *embodied*, *incorporeal*, and *cybernetic*, enabling exploration of the relationship between wheelchair movements and artistic identity, highlighting the potential for creative expression and reimagining the role of the wheelchair as an extension of the dancer's body or an independent dancing entity in performance contexts.

By incorporating an established artistic visualization solution, the system leverages AI-generated prompt inputs to enhance movement control, enabling personalized visualizations aligned with chosen LMA Effort qualities in wheelchair dance, thereby amplifying the system's adaptability and empowering artists to enrich the creative landscape of wheelchair dance. Future studies should

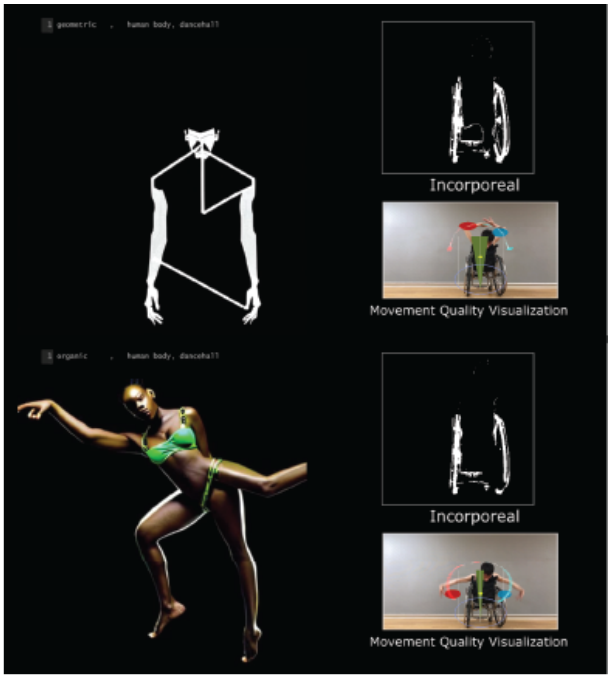

Figure 3: Movement quality controlled AI generation: Weight quality of "light" and "strong" controls "bright" and "dark" prompts. Visualization generated from Sun Dance © Kenta Kambara

consider categorizing prompts specifically in dance vocabulary and the incorporation with wheelchair dance vocabulary.

Despite the system's significant contribution to wheelchair dance, it is important to address existing technical constraints, including a latency range of two to five seconds attributed to cloud API stability, internet connectivity, and local processing capacity, alongside the necessity for a clean, high-contrast background for comprehensive body segmentation, emphasizing the need for solutions to prioritize end-user adaptability and real-time visualization quality within the framework of the LMA Effort theory.

3.5 Conclusion

This paper presents ongoing research at the intersection of posthumanism and adaptive visualization in wheelchair dance, categorizing the framework as *embodied*, *incorporeal*, and *cybernetic* to highlight the dynamic relationship between the dancer and the wheelchair, fostering artistic expression and embracing technology's potential to transcend physical limitations and diverse artistic identities.

Furthermore, the integration of AI-driven prompt generation, controlled by movement features based on LMA Effort theory, offers a flexible and adaptable means of artistic expression. Dancers can harness this technology to craft personalized visual narratives, amplifying their creative agency. However, it is crucial to address technical limitations such as processing latency and background requirements to ensure the practicality and real-time applicability of these innovative solutions.

This research paves the way for further exploration in the evolving field of wheelchair dance, highlighting the significance of user adaptability and personalized artistic expression, with future research focusing on enhancing prompt input, refining adaptive movement data extraction, minimizing generation latency, and engaging in user testing with wheelchair dancers, thus contributing to the ongoing discourse on the intersection of technology, artistic identity, and assistive tools within the realm of posthumanism and wheelchair dance.

ACKNOWLEDGMENTS

Thanks to all participants for sharing their time, expertise, and invaluable contributions, without which this work would not have been possible. This research is partially supported by Ericsson

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