AI for Enhancing and Preserving Dance Cultural Heritage: a Case Study on Rudolf Nureyev's Costumes

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***Abstract*—This paper explores the concept of costume agency in dance heritage preservation, focusing on the case study of Rudolf Nureyev (1938-1993). It considers the multifaceted role of costumes in expressing tradition, character, and performance traits, highlighting their influence on movement and identity in dance. Nureyev's career serves as an ideal case study due to his meticulous attention to costume selection and the challenges posed in preserving and valorizing his legacy. The study employs Gaussian splatting models to reconstruct 3D models of costumes from 2D images, enabling a closer examination of their design and detail. Through this interdisciplinary approach, the paper underscores the significance of costumes in conveying narrative, aesthetic, and historical aspects of dance heritage, while also showcasing the potential of technology in enhancing preservation efforts.**

***Index Terms*—Costume agency, Dance heritage, Rudolf Nureyev, Preservation, 3D reconstruction.**

I. Introduction

The cultural heritage of dance is characterized by the coexistence of tangible and intangible objects, expressing a tradition rich in extremely varied documentary traces in terms of types, dating, and geographical location [1]. Preserving such heritage entails acknowledging its plurality, which involves adopting a comparative approach to analyzing all the sources [2]. Costumes play a central role in these efforts. They not only express the visual aspects of the choreography for which they were created and the characters they represent, but also, from a technical perspective, the specific performance traits of the associated dances, those of the dancers for whom they were designed, and those of individuals who have worn them over time. In essence, the costume is a 'speaking' object, possessing an 'agency' skillfully adept at conveying crucial narratives, vital for preserving a performative event.

The notion that costumes possess agency can be linked to the "material turn" [3] of the 1980s and, more specifically, to the insights gained from studies in archaeology, anthropology, and art history, which have focused on developing methodologies to investigate the relationship between humans and objects, and the role of objects in society, thus contributing to the advancement of Material Culture Studies (MCS) [4]. By incorporating insights from various disciplines, MCS provided a nuanced perspective on the social functions, symbolic meanings, and cultural implications of objects and artifacts [5]. This multidisciplinary approach enabled researchers to explore both macro-level societal structures and micro-level individual experiences, revealing that objects not only fulfill practical functions but also symbolize social affiliations, statuses, and personal identities [6] [7]. In this respect, studies in archaeology and anthropology have been important precisely because they have highlighted more clearly how objects play a role in conditioning action and even thought [8]. Just think, returning to costumes, about how a certain type of fabric or garment can influence the movement and sensations of those who wear them, and how this aspect, can significantly influence the course of a performance. In this regard, the past decade has witnessed a significant increase in Costume Studies, initiating discussions not only on costume construction but also on their influence in shaping performances [9]. This point is important to highlight a central aspect in defining the identity of this kind of asset, which combines strong aesthetic and narrative needs with an indispensable aspect related to functionality.

In the field of dance, in which the moving body plays a central role, one can well understand how central the reflection on theatrical costume is. Evidence of this is an ancient tradition of writings and theorizations. Just think of a seminal document in the development of theatrical dance, such as *Lettres sur la danse et sur les Ballets* (1760) by Jean Georges Noverre (1727-1810), and how with it the discourse on costumes practically goes hand in hand with that on dance styles. According to the *Lettres* costumes, indeed, should not only be aesthetically pleasing but also functional, allowing dancers to express their characters freely through movement [10]. Thus, each definition of the characteristics of the identified dance styles corresponds to a precise type of body and costume: the *sérieux* dancer is characterized by a statuesque and slender beauty and broad and elegant movements. A 'gracefulness' in costumes is represented by strong shapes, bows, and high

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plumes (Figure 1, *left*). The*demi-caractère* dancer is more dynamic and fast in movements, has clothing that allows greater mobility, less geometrically structured drapes, and brighter colors to emphasize the character (Figure 1, *right*) [11].

Strongly linked to bodies and their identity, dance offers a rich array of evidence on the ability of costumes to influence and condition movement. Just think, as an example, of the pioneering contribution of dancer Isadora Duncan (1877-1927) in opening up to a free mode of movement's expression and the role that soft and shoeless clothing played in these innovations (Figure 2) [12].

The concept of functionality thus arises, in the study of dance costumes, as characterized by a multifaceted dimension linked to poetics, execution techniques, and the aesthetics sought by both the performer and the choreographer. This point explains further the ability, which we previously defined as 'agency,' of the costume to 'tell' the specificities of the performer, the historical period in which he or she lives, together with his or her tastes and trends.

Considering a source like this in the analysis of Dance Heritage is indispensable. Doing so from a perspective that encompasses movement, volumes, and bodies, while also addressing the preservation and valorization of resources, presents a challenge to which the use of technology can offer intriguing insights.

Figure 1: From left to right, Maquette de Costume pour serieux (*Berger*); Maquette de Costume pour Demi-caractaire, by Louis René Boquet, ©Bibliothèque nationale de France.

II. Case Study: Rudolf Nureyev (1938-1993)

In this section, we detail our case study related to the public image of Rudolf Nureyev, examining the data correlated to him and the challenges raised by them.

A. Public Image

Rudolf Nureyev was a famous dancer and choreographer, whose performances, during the 1960s and 1980s, electrified audiences worldwide. Renowned for his technical skill and emotional depth, he rose to fame as a principal dancer with the Kirov Ballet in Leningrad. In 1961, after his defection to the West, he captured global attention and became a global phenomenon [13]. The widespread development of mass media between of the time accompanied the dissemination of his fame, characterized by strong attention not only to dance skills and on-stage presence but also to his public image as a member of the international jet set. Nureyev's media image is marked by this polarization: on one hand, the dance star with exceptional virtuosity and great abilities, and on the other, the style icon, his private life, attire, and gossip. These two aspects influenced his placement within the public imagination.

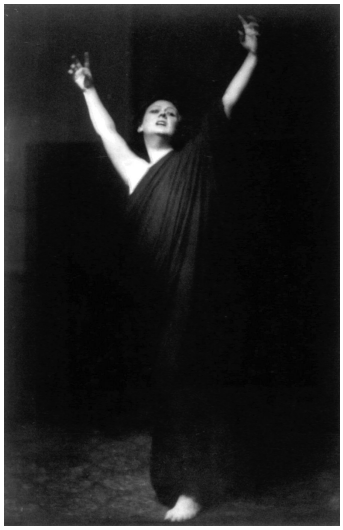

Figure 2: Isadora Duncan performing barefoot during her 1915–1918 American tour, ph. Arnold Genthe, ©Library of Congress.

B. Costumes and Fashion

Recognizing the significant power of his body in conveying artistry, Nureyev meticulously paid attention to costume selection throughout his career. Moments marked as "artist's whims," such as delaying the start of the final act of *Don Quixote* at the Kirov Theatre (because the trousers in the costume did not flatter his leg line), or systematically covering the streets of Paris upon his arrival in 1961 (in search of wigs and costumes) [14], actually reveal much about his artistic and aesthetic languages.

A comparative view of the costumes chosen for his choreographies, for example, shows recurring traits, such as a very short bodice, light-colored shoes, and tights to elongate the figure, wide openings at chest level to emphasize the face and bust proportions, rich decorations along the lines of force, and meticulous control over the final execution. The vision of the original sketches, in this regard, tells us much about the possibilities of intervention that he always reserved for himself [15]. To this it must be added that numerous newspaper articles present him not only as a skilled interpreter but also as a style

icon, frequently pairing these two aspects as shown in Figure 3.

The awareness and attention given to these aspects made Nureyev's public image highly recognizable and mediatized, capable of withstanding the test of time and influencing generations of dancers who adopted many of the aesthetic innovations he introduced. The same discourse naturally extends and reverberates within the broader public sphere and the general public. Just consider the work done to revive the "Nureyev style" by fashion houses, such as Etro [16] or Dior for their men's collections [17].

Figure 3: Rudolf Nureyev on the cover of "Observer" in 1976 (Paris, "Noureev Collection"/Press/1975-79, ©Centre national de la danse)

C. Challenges

Due to its comprehensive exploration of costume agency, Nureyev serves as an ideal case study. In narrating the dancer's legacy, the costume indeed plays a central role, albeit posing some difficulties to both the scholar and the user. These, to offer a synthesized view, can be attributed to two strongly interconnected categories:

- Preservation
- Valorization

The international nature of Nureyev's career has led to a strong dislocation of sources, scattered among museum institutions, theatrical archives, and private collections worldwide. The value of these objects, along with the fragility associated with costumes already heavily worn from intense use, requires the utmost care in preservation operations. In both cases, the accessibility of the heritage can only be affected by inevitable limitations, with repercussions in terms of valorization.

Masterful in this regard is the work of the Fondation Rudolf Noureev (RNF) and the Centre National du Costume de Scène in Moulins (CNCS), which have dedicated an entire exhibition section to the "Collection Noureev" [15] consisting of costumes, scene sketches, everyday clothing, personal items, and furniture from his Parisian apartment. The collection provides a tangible example of the full range of documentary resources necessary to activate costume agency: photographs, sketches, videos, but also newspaper articles, and texts revolving around the performances (programs, posters, etc.). Hence, in order to explore potential examples that ensure both preservation and valorization, we will review and apply in real cases those paradigms allowing the reconstruction of 3D objects from 2D images. The chosen primary sources are among the most widespread and ready-to-use for what concerns Nureyev: photographs featured in international print newspapers.

III. From 2D images to 3D objects

A. Related works

Transitioning from 2D images to 3D models involves various methods, which are listed below.

Among the most widespread approaches, we mention Structure-From-Motion (SfM) [18], which reconstructs 3D geometry from a series of 2D images by analyzing their relative positions and orientations. In particular, SfM methods first detect and match key points between pairs of images. The camera poses are estimated and 3D coordinates are triangulated by intersecting the rays back-projected from the cameras. Finally, they provide a dense 3D model with texture mapping. SfM is advantageous for its simplicity and ability to handle large datasets, however, it struggles with accuracy in complex scenes and requires considerable computational resources. Furthermore, multi-view stereo (MVS) [19] methods have been developed. Different from SfM, this class of methods estimates depth information by analyzing multiple images of the same scene. MVS offers improved accuracy compared to SfM, particularly in detailed environments, but it can be computationally intensive and sensitive to image quality and viewpoint variations. Photogrammetry is another widely used method for creating 3D models from 2D images. The process involves analyzing the geometric properties of images taken from different viewpoints to reconstruct the three-dimensional structure of objects or scenes. Photogrammetry (Ph) [20] offers advantages, such as scalability, as it can be applied to images captured from consumer-grade cameras or drones, and it provides detailed surface information. However, photogrammetry also has limitations, as it can be sensitive to factors like lighting conditions, camera calibration, and image quality, which may affect the accuracy of the resulting models. Additionally, it requires careful planning and processing to ensure reliable results, and capturing images from multiple viewpoints can be time-consuming. Gaussian splatting (GS) [21] is a technique commonly used in computer graphics and computer vision for rendering 3D scenes from 3D point cloud data. In Gaussian splatting, each point in the point cloud is represented as a Gaussian distribution centered at its position in 3D space. When rendering the scene, these Gaussian distributions are "splat" onto a 2D image plane, where they contribute to the pixel intensity based on their spatial extent and distance from the pixel. This process effectively blends the contributions of nearby points in the point cloud, resulting in smooth and continuous renderings. Gaussian splatting is particularly useful for visualizing dense point cloud data captured from sources like LiDAR sensors or depth cameras. So far, AI-based approaches have been used, for example, to assist SfM, MVS, GS or Photogrammetry approaches in solving tasks like

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feature extraction, matching, and reconstruction, leading to more accurate and efficient 3D model generation, which by leveraging AI can mitigate some of their traditional limitations and offer improved results across a range of applications. However, AI methods have been developed also to directly estimate 3D meshes. Pixel-aligned Implicit Function (PIFu) [22], employs a neural network architecture to predict a voxelized representation of the 3D object directly from the 2D input image. This method stands out for its ability to generate highly detailed and accurate 3D reconstructions even with one single image, capturing fine-grained surface details through pixel-aligned implicit functions. Moreover, Neural Radiance Fields (NERF) [23] are capable of representing scenes as continuous volumetric functions describing radiance at any given 3D point. By training a neural network to predict this function from 2D images and corresponding camera poses, NeRF achieves photorealistic reconstructions with high fidelity across viewpoints.

B. Application of Gaussian Splitting models

In Figure 4, we report three views of the reconstructed 3D model obtained by applying a Gaussian splitting model to the 2D image of the Double for the role of Basilio in *Don Quixote*. Despite being generated from a single 2D view, the 3D reconstruction exhibits sufficient accuracy and captures the main details. Furthermore, by restoring its three-dimensionality, the technology employed allowed for a 360° view of the object (rebuilt thanks to AI), thus enabling it to perform under conditions as close as possible to the original, intended for continuous motion viewing.

In addition, we crop from newspaper pages a hat and a doublet used by Nureyev and we provide 3D reconstructions from one image using a Gaussian splitting model. In Figure 5 and 6, we report the 2D crop and two views of the 3D objects, one related to the repertoire of stage costumes, the other to a fashion item.

Working from newspapers, in the case of Nureyev, is crucial. As we have mentioned, his figure has been heavily mediatized, making him highly present in this type of documentation. However, this choice also presents significant benefits for adding to a costume heritage that would otherwise be scarcely accessible because stored and sold at auctions or dispersed. In this way, it is possible to expand existing collections and, in cases where costumes are already allocated, contribute to describing the resource by adding dates of use, and performances, and tracing their media coverage.

IV. Conclusion

This contribution has highlighted the pivotal role of costumes in dance heritage, exemplified through the case study of Rudolf Nureyev. Costumes serve as dynamic agents, conveying narratives, aesthetic preferences, and historical contexts, while also influencing movement and performance. Nureyev's career exemplifies how meticulous attention to aspects related to costume contributed to the construction of the imagery associated with him and thus to the perpetuation of his artistic legacy. In Nureyev's case, this extends to the broader realm of clothing and fashion choices, which have greatly shaped his public image. However, the preservation and valorization of those items pose significant challenges: How is it possible to integrate the volumetric and dynamic dimensions of costumes designed for movement? How can their integrity be preserved without sacrificing communication with the audience? How can widely available sources be transformed into fonts of new information? Innovative approaches such as 3D reconstruction techniques offer a valid example to address these questions. By employing photogrammetry and Gaussian splatting models, this study demonstrates the potential of technology in enhancing preservation efforts and enabling closer examination of costume design and detail. Once reconstructed in 3D, these objects offer significant usability, overcoming the fragility associated with their uniqueness and value, enhancing comparative viewing of heritage assets, detailed examination, usability, and preservation. Appropriately processed digital objects also contribute to this effort. The interdisciplinary approach used in this study further sheds light on the intricate interplay between dance, costume, and technology, underscoring the importance of promoting dance heritage for future generations and doing so by collaborating with experts from different domains. Considering future investigations, we will adopt different neural rendering paradigms, including also neural radiance fields, and compare quantitatively and qualitatively the approximated 3D models, involving dance experts.

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Figure 4: Views of the 3D model of the Doublet for the role of Basilio in *Don Quixote*, 1979. Costume by Nicholas Georgiadis. ©CNCS / Photo Pascal Francois.

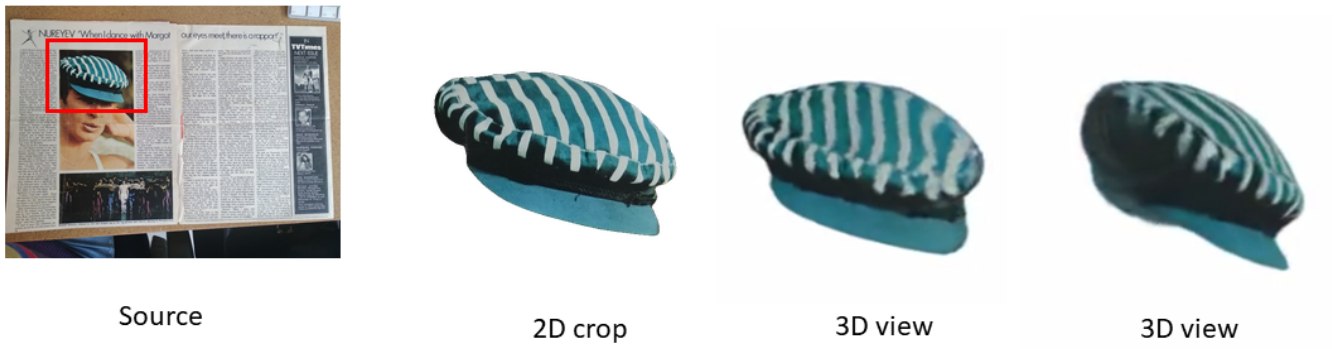

Figure 5: Views of the 3D model of a hat taken from a magazine (Paris, ”Noureev Collection”/Press/1972, ©Centre national de la danse).

Figure 6: Views of the 3D model of Nureyev's *Swan Lake* Doublet for ”The Muppet's Show”, starting from a photo on a magazine (Paris, ”Noureev Collection”/Press/1972, ©Centre national de la danse).

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