Photogrammetry and 360° Virtual Tours: Differences, Relevance, and Future Possibilities

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***Abstract*—This paper examines the impact of technology integration in fashion retail, specifically focusing on virtual tours using 360° cameras and photogrammetry. Through case studies of Ralph Lauren and Dolce & Gabbana, it compares the strengths and limitations of each approach, emphasizing user experience and brand representation. While 360° tours offer accessibility, photogrammetry provides immersive experiences and detailed visualizations. The paper addresses challenges like content relevance and technological obsolescence, proposing strategies for innovation. It also discusses a project at the University of Bologna's VARLab for AEFFE s.p.a., exploring the future integration of virtual tours into transmedia storytelling. Additionally, the study investigates the role of VR in luxury fashion retail, emphasizing emotional impact and aesthetic engagement, presenting a preliminary report on immersive VR video design.**

***Index Terms*—Virtual tours; Fashion retail; Photogrammetry; Brand heritage; Immersive experiences.**

I. Introduction

In recent years, there is an abundance of studies that have explored the evolution of technology in fashion, dedicating particular attention to the retail context. The shopping experience has been defined as made by multiform sensory and informational solicitations [1] that aim to engage customers and enhance their overall satisfaction. However, confusion within the marketing and communications team has led to a proliferation of creations by brands using similar keywords without much differentiation [2], [3]. This has resulted in an abundance of "virtual tours", "showrooms", and "museums". Instead of providing an overview of these experiences, let's focus on understanding the differences between two types of virtual tours: those realized through a 360° camera and those realized through photogrammetry. For many years, 360° videos were more commonly used due to their ease of production. On the other hand, photogrammetry often yields better results in terms of accessibility and immersiveness [4]. These technologies are considered examples of Desktop Virtual Reality known for enhanced 3D visualization capabilities compared to Immersive Virtual Reality. The terminology surrounding virtual tours can be confusing; here it refers to a tour within a virtual reproduction representing an actual physical space with depth perception [5]–[7]. To provide further clarification on this choice – only two case studies will be examined corresponding with either 360° cameras or photogrammetry techniques allowing for greater insights into their respective strengths and limitations. We then focused on 360° cameras and video, and in general, Virtual Reality (VR) and Augmented Reality (AR) paradigms in fashion. Fashion functions as an interpreter of societal change, adeptly deciphering subtle cues and trends, and subsequently reintroducing them into the commercial forefront through a process of remixing and refinement. Nowadays, this perpetual cycle of interpretation and adaption is performed by adopting modern technologies [8].

VR has emerged as a pivotal tool in enhancing the online retail experience, bridging the gap between physical and digital realms [9]. The Metaverse [10] is an interconnected virtual universe that can transform the way individuals interact and transact within digital spaces, with VR serving as a gateway to this new frontier [11]. Defined as "the use of computer simulation that enables interaction with a virtual, three-dimensional, visual environment through digital representation" [12], VR transports users into digitally reconstructed worlds via Head-Mounted Displays (HMDs), creating a sense of presence and immersion [13]. Projections indicate a steep rise in VR headset adoption, with the majority of internet users projected to incorporate VR into their daily routines within the next decade [14]. Within the realm of retail, VR applications are rapidly evolving, offering novel avenues for consumer engagement and experiential marketing [15], [16]. By integrating exclusive content and VIP experiences inaccessible in the physical realm, VR further enhances the allure of luxury fashion brands [17]. It is within this dynamic landscape that the present study unfolds—a quest to explore the potential of immersive 360° VR videos in eliciting aesthetic experiences among users. As part of a broader research endeavor aimed at investigating and developing Extended Reality (XR) prototypes tailored for luxury fashion brands, this paper serves as a preliminary report detailing the design process of an immersive VR experience. By documenting the initial steps undertaken, the paper sets the stage for further exploration into the possibilities afforded by XR technologies within the realm of fashion retail with a focus on the emotional impact that XR experiences can provoke in the users. This manuscript will conclude with an ongoing project carried out within the Virtual and Augmented Reality

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Laboratory (VARLab) [18] of the University of Bologna for the luxury company AEFFE s.p.a. [19].

II. Case studies

In the following section, we present two case studies of prominent fashion brands, Ralph Lauren and Dolce & Gabbana, which leverage virtual experiences to engage customers and showcase their products.

A. Case Study 1: Ralph Lauren Virtual Experiences

The first brand to be mentioned is Ralph Lauren, a renowned fashion house founded in 1967. The brand is famous for its distinctive polo shirts, tailored suits, and an iconic logo featuring a polo player on horseback. With a focus on timeless designs, Ralph Lauren caters to a discerning clientele seeking refined and sophisticated attire. The brand's aesthetic seamlessly blends traditional Americana with high-end craftsmanship, creating an aspirational lifestyle and sense of prestige. Offering an extensive range of products including clothing, accessories, fragrances, and home furnishings, Ralph Lauren continues to shape the landscape of contemporary fashion and luxury lifestyle. Their webpage dedicated to virtual stores is not connected to their e-commerce shop and changes based on the audience. Generally, the virtual tours are defined "RL Virtual Experience" or "Virtual Flagship Store", see Figure 1 and Figure 2. Three distinct platforms that cater to different geographical markets were considered: the first targets a global audience, the second caters primarily to a US audience the third is directed towards the UK market, featuring stores in Milan and London. Each URL shares a common feature, the 888 House, providing an immersive and experimental space to display the collection, while the global URL emphasizes characteristics specific to the winter holidays, including in-store decorations, a gifts section, and Christmas background music.

Overall, such platforms exhibit characteristics tailored to enhance user engagement and navigational ease, integrating an audio component for realism. Utilizing a drag-around feature coupled with anchored arrows, users are afforded seamless movement throughout the virtual space, facilitating exploration of various sections within the store environment. Complementing this navigational aid, a map sign positioned on the right side of the interface serves as a helpful guide, elucidating the spatial layout and enabling users to discern different sections efficiently. Interactive elements were strategically positioned throughout the virtual environment, offering users the opportunity to delve deeper into showcased products [20], [21]. If these objects remain accessible online, they seamlessly redirect users to their corresponding pages for online shopping, complete with detailed product descriptions and prices [22]. In instances where online access is no longer available, users are seamlessly redirected to the main page, ensuring continuity of the browsing experience. Notably, within the preview of each object, pertinent details including price and descriptive information are prominently displayed, facilitating informed decision-making and enhancing user engagement with the

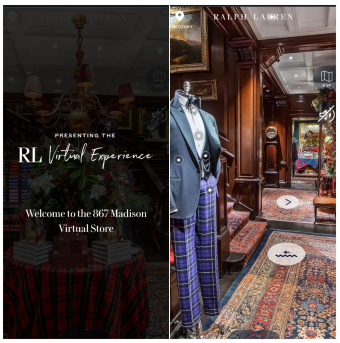

Fig. 1: RL virtual experience homepage and interiors of 867 Madison store.

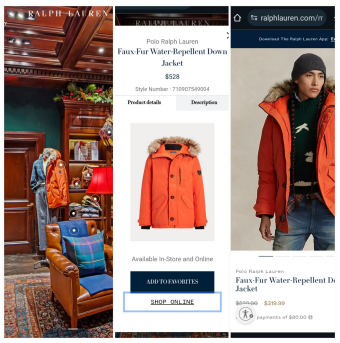

Fig. 2: Stills of RL 867 Madison Virtual Store showing a jacket on the mannequin, the information showing when clicked on it and in the e-commerce from left to right.

virtual store environment. In conclusion, these meticulously crafted virtual tours embody a multifaceted approach aimed at providing users with an immersive and informative shopping experience within the realm of Ralph Lauren's storied brand universe.

B. Case Study 2: Dolce & Gabbana Virtual Boutiques

The second case study is devoted to Dolce & Gabbana's choice of recreating their stores with photogrammetry. The Italian luxury fashion house was established in 1985 and embodies opulence and sensuality in its creations. Renowned for its bold and glamorous designs, the brand exudes a distinct Mediterranean flair infused with Italian heritage and craftsmanship. Dolce & Gabbana's virtual boutiques stand out as a hallmark of innovative online retailing, offering patrons a distinct and immersive experience via a dedicated website distinct from their e-commerce platform. Upon navigating the main menu, users are greeted with several options, from previews of upcoming virtual boutique unveilings to the convenience of booking appointments, accessing the Women's and Men's fashion shows for FW2022, utilizing the store locator, and revisiting past virtual boutiques. This designated section, defined as "Relive Virtual Boutiques," serves as a gateway to explore eleven distinct venues spanning the globe, including iconic locations, such as Venezia, Roma, Osaka, Chadstone, Shanghai, Paris, Miami, Las Vegas, Cannes, Seoul,

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Fig. 3: Dolce & Gabbana virtual boutiques of Venice (upper half) and Rome (bottone half) venues.

and Tokyo. Each venue offers a bespoke lens through which to perceive the brand's rich tapestry of identity and aesthetics, from the grandeur of historical European settings to the pulsating energy of urban metropolises, see Figure 3. While some of the more recent virtual venues may feature embedded links directing users to the e-commerce platform, it's noted that the functionality of these links may vary, with some potentially rendered inactive due to expiration. The presence or absence of such links in previous iterations remains a matter of uncertainty, hinting at the dynamic evolution of the virtual boutique landscape over time.

A cornerstone of the virtual boutique experience lies in its utilization of photogrammetry, enabling the meticulous mapping of spatial dimensions and textures that afford users a degree of freedom in navigation and exploration. This platform immerses users in a sensory journey through the heart of Dolce & Gabbana's design ethos. While certain venues like Venezia and Roma serve as showcases of the brand's Italian heritage, it's noteworthy that the most contemporary settings bear subtle yet unmistakable traces of this identity. Whether in the ornate flourishes adorning architectural details or the evocative styling of merchandise displays, these recurring elements serve to uphold a sense of continuity and coherence across the diverse array of virtual boutiques, ensuring a seamless brand experience for patrons worldwide [23].

III. Case Studies Analysis

An in-depth examination of the positive and negative attributes inherent in the utilization of both a 360° virtual tour and a photogrammetry virtual tour within the context of fashion showrooms illuminates various nuanced aspects. Despite their differences, these modalities share a common functionality in offering a dedicated section for booking appointments, thereby facilitating seamless customer interaction and engagement. Delving into the advantageous aspects, these virtual tours emerge as potent tools in shaping the multifaceted image of a brand, serving as dynamic contributors to its identity construction. By providing immersive experiences that transcend the confines of traditional retail environments, they afford consumers a novel and explorative mode of shopping, transcending geographical barriers and time constraints. Moreover, these tours offer a unique opportunity for customers to delve into the architectural intricacies of each showroom, with some establishments boasting more distinctive and culturally resonant designs than others. This architectural exploration not only enhances the overall shopping experience but also fosters a deeper appreciation for the brand's aesthetic diversity and heritage.

Despite notable advantages, virtual tours face challenges such as presenting static images of the past and requiring constant updates to remain relevant amid evolving consumer preferences. The rapid pace of technological advancement and ongoing experimentation render these tours susceptible to obsolescence, necessitating adaptation to maintain efficacy. Given their inception during the pandemic, there is a pressing need for virtual tours to evolve and align with brand missions. This entails significant investments in time and resources to ensure continued relevance in facilitating brand objectives. Addressing these challenges necessitates a proactive approach towards innovation and adaptation, wherein embracing emerging technologies and incorporating interactive features can enhance the immersive nature of these virtual tours, elevating the overall customer experience. By integrating dynamic content and personalized recommendations, fashion brands can ensure ongoing engagement and relevance, catering to the diverse preferences and tastes of modern consumers. Moreover, forging strategic partnerships with tech companies and leveraging data analytics can provide valuable insights into consumer behavior and preferences, guiding informed decision-making and content development efforts.

In this context, Photogrammetry and 360°-video technology stand as two distinct approaches for reconstructing a virtual 3D environment to create immersive experiences. While they consider different paradigms to achieve this goal, the strategic implementation of these technologies can significantly augment brand visibility and customer engagement in the competitive fashion retail landscape.

Photogrammetry utilizes 2D photographs to create detailed 3D models through specialized software like Agisoft Metashape, RealityCapture, or Pix4D, requiring precise photographic capture and good lighting. This method is ideal for sectors like virtual archaeology and civil engineering but can be complex and time-consuming. 360° video technology records panoramic videos for interactive viewing, offering a smoother visualization and cinematic experience suitable for virtual tours. Unlike photogrammetry, it requires less time and technical skills but lacks detailed 3D models. Both approaches have advantages in showcasing fashion showrooms and enhancing brand visibility, yet face challenges. By acknowledging limitations and embracing innovation, fashion brands can maximize the potential of virtual platforms in an evolving digital landscape.

IV. Adopting 360° videos to assess emotional drivers

Considering our previous considerations for 360° videos, we here proceed by crafting an exclusive and immersive

experience, aimed at democratizing access to rare and coveted items within the fashion realm, to cultivate a sense of personal connection between consumers and the products they admire, while simultaneously fostering a vibrant community around the brand. In contemporary fashion marketing, the useof brand ambassadors has become a prevalent strategy for launching and promoting new collections [24]. This phenomenon is particularly significant in today's digital age, where social media platforms serve as central hubs for fashion discourse and engagement [25]. To explore the potential of this approach, a low-cost prototype was conceived to facilitate initial experiments, with 360° videos. The prototype aimed to create a one-to-one immersive encounter wherein a dancer or performer, outfitted in a rare and iconic garment from a luxury brand, moves gracefully around a stationary camera which acts as the user's point of view. The prototype intentionally minimized direct interaction and verbal communication between the performer and the observer to focus on fostering a profound connection between the viewer and the attire itself. The captured 360° video was intentionally short and will be presented to a test group, allowing for an assessment of its practicality and its impact on users. Furthermore, in a bid to explore the dynamic interplay between reality and virtual reality, the prototype will be tested in the same physical environment where the 360° video was filmed. This approach will provide valuable insights into how users perceive and engage with the virtual representation of a physical space, further informing the development of future iterations of the project. By combining elements of experiential marketing, immersive technology, and brand storytelling, the project aims to pave the way for innovative approaches to consumer engagement within the fashion industry. Through experimentation and iteration, it seeks to uncover new opportunities for brands to connect with consumers on a deeper level.

V. METHOD

In the following section, we inspect the intricacies of measuring aesthetic emotions elicited by immersive 360° video experiences, detailing the process, methodologies, and expected outcomes of the research endeavor.

A. Making of the 360° video

The process of capturing 360° video with Insta360 cameras involves recording the video, transferring the files, and stitching, which is the process of combining different camera perspectives to create a seamless panoramic video. The video lasts 10 minutes based on the average attention span of users [26], [27], [28]. Here are the details of the process:

1) Recording and transferring the video: using an Insta360 camera to record the 360-degree video capturing images/videos from all directions simultaneously, recording the entire surrounding environment.
2) Stitching: after transferring the files to the processing device, the stitching process is required. The stitching process combines the different camera perspectives in the 360-degree camera to create a seamless panoramic video. Insta360 stitching software, whether integrated into the cameras or provided separately, analyzes images from different lenses and blends them to ensure a smooth transition between different views.
3) Editing: after stitching, you can make any necessary edits to the video using video editing software. This phase allows you to add effects, adjust colors and contrasts, add audio, and make other customizations to 360-video. In the case of our video, the tripod on which the Insta360 camera was always present in the frames. Therefore, a mask was applied to hide the tripod to reach a sense of realism to the experience.
4) Exporting the final video: once the stitching and the optional editing are complete, the final video is exported and uploaded into a structure for environmental images to be visualized with the headset.

In Figure 4, we report some screenshots taken from the 360° video produced in the described process.

Fig. 4: Screenshot taken from the produced 360° video.

B. Selection of target audience

Once the video production is complete, it will undergo evaluation by users spanning diverse age demographics and varying levels of digital literacy. The primary objective is to discern any potential influence of user age and familiarity with immersive technologies on their perception of the experience. Although the current trend of leveraging new technologies to appeal to younger consumer segments, it is imperative to ensure accessibility and usability for older generations as well. This is particularly significant considering the important presence of millennials and older individuals within the luxury market [29], [30], [31], [32]. The final sample size for user testing is estimated to comprise approximately 10 to 30 individuals, representing a broad spectrum of age groups. This number has been determined as a balance between the need to gather sufficient data from a diverse sample and the practical constraints of the evaluation phase. It is anticipated that this sample size will exceed 10, as previous research has indicated that a minimum of 10 testers is sufficient for identifying meaningful correlations across various parameters in interface design [33], [34], [35].

C. Measuring Aesthetic Emotions

The first objective is to evaluate the aesthetic experience of the user. Cognitive scientists have tried to implement direct and indirect measures for aesthetic emotional experience in

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experiments in empiric aesthetics. Given that making appropriate aesthetic judgments is not fixed but is modulated by daily behavioral habits [36], Mastandrea et al. reflected on the account of the relationship between aesthetic emotion and physical-psychological well-being [37]. The behavioral-qualitative investigation of aesthetic experiences focuses on the measurement of self-reported emotions. Others suggested an analysis of existing measures for aesthetic emotions within specific domains of artistic productions [20], [21], [38]. They developed the Aesthetic Emotions Scale (AESTHEMOS) structured around groups of emotions:

- **Prototypical aesthetic emotions like the feeling of beauty**: Being moved; Awe; Fascination;
- **Epistemic and emotions like interest**: Joy; Relaxation; Vitality; Negativity;

Hereby, I report a description of the survey that will be given to the sample users.

a) Aesthetic Emotions Scale (AESTHEMOS): The AESTHEMOS can be used to assess either the intensity of aesthetic emotions (e.g., for studying momentary aesthetic experience or the experience of a specific stimulus, such as a picture, poem, piece of music, or film scene) or the frequency of experiencing aesthetic emotions during a more prolonged aesthetic experience (e.g., for studying an event as a whole, such as an entire art exhibition, theater performance, or a walk through-nature).

In this proposal, the scale adopted matches exactly the AESTHEMOS introduced by Schidler et al. [38], assessing the intensity of all the emotional aforementioned constructs. In particular, each emotional construct is detailed in pairs of questions.

For the frequency version, the following modifications need to be made: (1) Rating instruction: How often did you feel this emotion? (2) Rating scale: A 5-point Likert Scale where 1 stands for never and 5 very often; (3) Instructions: Which emotional effect did the experience have on you? For each emotion listed below, please mark the response category that best matches your personal experience. Please only indicate how you felt. Do not characterize the emotions expressed in the experience if you did not feel them yourself.

D. Expected results and directions for further research

We expect to organize the testing sessions as follows. First of all, the users will be asked to fill a welcome form to declare their demographic data and their initial emotional state with a short Self-Assessment Manikin [39]. After that, they will be shown the immersive 360° video on a VR headset and they will be asked to answer the survey reported above in Table 1. Based on the questions of the AESTHEMOS scale, this study forecasts to have a starting impression of the emotional impact of an immersive 360° video with low human interaction on the viewer. Among other aims, we hope to understand whether there is a correlation between demographic data, digital literacy and the intensity of experienced emotions. This will lead to the development of further research, that can be implemented in several ways. For example, we could divide the sample users according to different age groups to better identify the correlation between age and VR experience. Or, we could develop other experiments to determine what sharpens the sensations felt during the test - i.e., the design of a digital twin or its motion, the interaction between user and digital twin, the computer-generated environment vs. the location of the experiment. However, considering that the survey must be filled moments after the experience, the result could be influenced by many external factors. For this reason, in the longer term, it is advisable to start experimenting with methodologies which - among others - evaluate emotional and affective reactions to stimuli by measuring, collecting and elaborating biometric data such as heartbeat, sweating, blood pressure or by finding ways to track the movement of the eyes - all elements that need to be monitored during the experience.

VI. Conclusion and further possibilities

As part of the PNRR project of Spoke 1, the authors and other colleagues have recently made a 360° virtual tour of the Moschino showroom in Via della Spiga in Milan. Moschino is one of AEFFE s.p.a.'s four brands, and the store had a well-designed and planned reopening in 2022 followed by another store opening in Rome. The new challenge embraced is to prototype a space that is less focused on being just a vitrine for e-commerce and more as part of an immersive narrative experience. To achieve this goal, two elements will be leading the experience: the store design and the window display. The newly designed stores, initially envisioned by former creative director Jeremy Scott, may undergo further evolution under potential new creative direction from Adrian Appiolaza, featuring elements reminiscent of Franco Moschino's bold and playful designs while paying homage to his studio through unique displays of precious accessories. Virtual tours capture specific moments featuring distinctive vitrine props from each collection over a time frame creating an engaging exploration connecting future retail window displays with implications extending into fashion studies through showcasing brand heritage. The ongoing objective is to integrate virtual tours into transmedia storytelling for enhanced visual retail communication and increased customer engagement with brand heritage.

To achieve such a goal, we will preliminarily gather comprehensive data regarding users' demographic profiles and validate their emotional states, and their responses to immersive 360° video experiences, aiming to elucidate the emotional impact of the VR environment through the utilization of the AESTHEMOS scale. This would set the stage for future research aimed at exploring factors influencing users' emotional responses, including age-related nuances, digital twin design, interaction dynamics, and environmental factors. Considering the latter, future research directions may incorporate methodologies such as biometric data capture to provide additional insights into users' emotional and affective reactions.

In conclusion, while the initial testing sessions offer valuable insights into users' immediate emotional experiences, future research endeavors will delve deeper into the intricate

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dynamics of emotional engagement within immersive environments, in particular, applied to the realm of luxury fashion retail.

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