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Co-designing with the archive: a new way of interacting with fashion design heritage

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The rise of digitally interactive archives has introduced new opportunities for more proactive interactions with historical fashion collections. This paper explores how contemporary fashion archives are evolving, focusing on their current framework of interaction and how these could be further enhanced through the integration of advanced digital technologies, such as extended reality (XR), which includes virtual (VR) and augmented reality (AR), and artificial intelligence (AI), considering machine learning (ML) as well. Given the structured, heterogeneous and richly labeled nature of fashion archives - garments images, dates, labelled details, digital twins and inspirational material - they are particularly well-suited for integrating emerging technologies, such as XR and AI systems, and for exploring new roles in the user-archive interaction. This possible shift has been investigated through the analysis of a workshop, where fashion and interaction design students explored how interactive technologies can serve as a vehicle for novel ways of engaging with the fashion cultural heritage of a given fashion designer, leading to highlighting the potential for a more proactive role of archives in fashion design. The findings lead us to propose a possible new framework where fashion interactive archives act not only as repositories but as proactive co-creators, enabling a more dynamic dialogue between the user and the archive.

KEYWORDS

co-design with archive, fashion heritage, user archive interaction, digital archive role, fashion collection data

Introduction

The digital transformation and technological advancements have profoundly impacted the fashion industry, influencing not only communication, marketing, and production but also the cultural and educational dimensions of fashion (Nobile et al., 2021). Archives, particularly fashion ones, play a fundamental role in fashion-related education and innovation by preserving the rich heritage of the industry and by rebuilding the archive's fashion designer know-how (Martin and Vacca, 2018). With the rapid progress of technology, archives across all domains have increasingly embraced digitization, leading to new ways in which technology can shape their function and

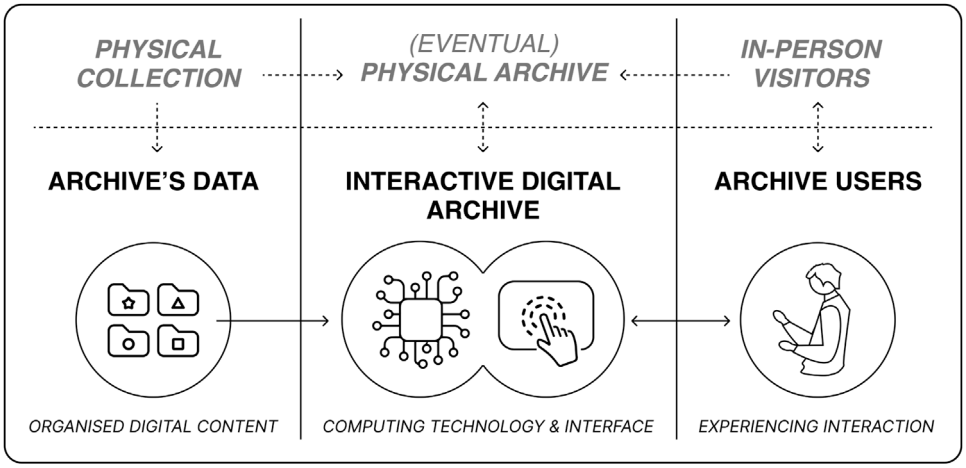

FIGURE 1
Interactive archives allow users to interact with their digitized content.

accessibility. New digital interactive technologies could preserve, revive, valorize fashion cultural heritage and transmit it to the users by encoding their data, information, and knowledge encoding (Casciani and Vandi, 2022), also following the idea of safeguarding the intangible cultural heritage through digitization (Alivizatou-Barakou et al., 2017). Clarified further, fashion design's interactive archives allow users to interact with the digitized content of the archive, thus its embedded heritage (Figure 1). The digitized content, often coming from a physical collection or more generally repository of material, can eventually be accessed both inside and outside the physical archive, that remains the place in which original physical items are preserved and accessed (Deegan and Tanner, 2006).

In this technical context, fashion digital archives occupy a crucial position where technological innovation can harness their data's unique characteristics to unlock new possibilities. No longer confined to static repositories of historical data (Opgenhaffen, 2022), these interactive archives can be transformed into dynamic platforms, and integrate technology enabling a more proactive engagement and exploration for visitors (Mantzou et al., 2023). Recently, in the conclusions of the paper "Dealing with Objects, Dealing with Data. The Role of the Archive in Curating and Disseminating Fashion Culture through Digital Technologies," Vandi reflects that machines can assume the role of a partner in how to interpret archival data and ultimately suggest that a possible research trajectory could involve exploring new possible roles of archives by reflecting on the potential of collaborative robotics in co-creative practices (Vandi, 2023).

Therefore, the paper explores the integration of interactive technologies in enhancing the engagement and accessibility of digitally interactive archives related to fashion heritage; by reflecting on which ways technological advancements are transforming not only the preservation, but also the more proactive role that fashion archives can assume in the user-archive interaction.

Structure and methodology

The first part–Sections *New interactive technologies and digital archives*, *Interacting with fashion digital archives: the actual framework* and *Artificial Intelligence and Fashion archives' data potential* - of the study will focus on exploring, through an exploratory literature review (Paré et al., 2015), the increasing "proactivity" of archives of different domains, exploring how technology can enable in presence and online visitors by integrating, for example, AI systems and engage them even more through immersive technologies, such as extended reality (XR), using digitized content or "digital twin" 3D models. These technologies allow people to engage with a wide array of diverse archival content in multi-modal and personalized ways. Therefore, we tried to represent this modern dynamic by visualizing the current framework, thus focusing on interactive archives of fashion designers and their fruition. Subsequently, we propose exploring new possible functionalities of such archives and highlight how the unique characteristics of fashion archives' data make them particularly well-suited to harness the potential of advanced interactive technologies, such as AI systems, which are considered powerful user-enablers. When combined with advanced interfaces, these technologies can empower a broader range of in-person and "online" visitors - especially creatives like fashion designers - by facilitating deeper, more creative engagement with archival materials. In doing so, we hypothesize that fashion archives could evolve from passive repositories to collaborators in more creative process.

The second part of the paper – Sections *"Exploring new ways of engaging fashion cultural heritage": a workshop* and *The workshop resulting approaches* – will introduce a workshop conducted with MSc Design students, which aimed at exploring new possible roles of fashion digital archives. The workshop encouraged students to investigate how emerging technologies might redefine these interactions. The findings were qualitatively analyzed and clustered them thematically (Clarke and Braun, 2017) to conceptualize new roles for technology within fashion archives, particularly through the lens of ML and other advanced technologies. These sections outline the approach taken during the workshop and based on the outcome of the workshop; it reflects on the potential new roles that these archives could adopt.

Drawing on the state-of-the-art analysis from the first part and reflecting on how the approaches and insights gained from the workshop presented in the second part, in Section *A co-creative dialogue with the archive: a new framework* we propose a revised version of the framework that captures a potentially more proactive role that fashion archives could assume in the future.

It is important to clarify our use of terminology: while we will use the term "AI" throughout this paper for its broader recognition and alignment with common references to recent technological advancements, in most cases, the more precise term would be Machine Learning (ML). These are the foundational algorithmic approaches driving AI innovations, and they are the widely spread basic algorithmic approaches behind the recent transformative changes seen in contemporary products and services (Dove et al., 2017; Zhang et al., 2022). Similarly, we will use the overarching term "XR" – extended reality–to group together the different immersive technologies of virtual reality (VR), augmented reality (AR), and mixed reality (MR). For the sake of the study we will reflect just in general about the inherent ability of all three to be able to create interaction spaces that straddle the virtual and the physical.

To align with the scope of the study and workshop, our focus is limited to fashion designer's archives intended as comprehensive repositories dedicated to the work of a single creative individual, which can vary in terms of production, but present common traits and materials, presenting not only signature garments, but also some among accessories, jewelries, bags and shoes. These archives typically include both physical collections and digitized content, encompassing assets such as dated artefacts photographs, digitized sketches, item replicas, and inspirational images used by the designer. This specific archival nature will be further defined at the beginning of chapter 3, where we elaborate on the characteristics and potential of such archives. Consequently, our focus explicitly excludes other type of museums and purely documentary archives that do not share these attributes.

Finally, In the paper, we refer to three main figures as part of the system. The first is the (archives's) "fashion designer," who created the design pieces documented and valorized in the fashion archive and to whom the archival spaces are also dedicated. Based on the workshop participants' investigations, we identify two types of "archive users" who explore and interact with the digital archive. Finally, we defined a broader category of "visitor-users," which includes anyone who interacts with and enjoys the archive, such as fashion enthusiasts, kids, or curious visitors to the physical archive. Secondly, we define a subcategory of "visitors-users," that is people who consult and interact with the archive but are also creators of fashion-related content themselves and may possibly leverage their interactive experience in their own creative process; for example, they may be fashion designers or design students or artists or stylists and similar. This last specification aims to prevent misunderstandings between the fashion designer whose repertoire is kept by the archive and those external fashion designers who visit and interact with the archive as users, who will be classified among the "creative users." At present, for the sake of the study, archivists, archive curators, and, in general, people related to archival design are not considered in the reflection even though we acknowledge their important role within the system.

New interactive technologies and digital archives

Recent technologies have transformed the way users interact with historical archives, offering immersive experiences and detailed insights into cultural, material, and historical contexts (Martin and Vacca, 2018). By digitizing artifacts, institutions can safeguard fragile materials while expanding access to a wider audience, overcoming geographical and physical barriers (Rocamora, 2012). In a certain sense, new interactive technologies, such as extended reality and artificial intelligence systems, are changing the role of technology, and possibly the role of interactive archival systems.

On the one side, immersive XR technologies can overlay historical data information onto physical spaces, allowing users to experience "the past" *in situ*. For example, The Royal Ontario Museum (ROM) launched an XR application-based exhibit where visitors can interact with digital reconstructions of ancient artifacts and explore reconstructions of ancient building, with the idea of bridging the gap between the physical museum exhibits and the digital world and enhancing users' understanding of historical events (Pedersen et al., 2017). Similarly, the "Streetmuseum" app by the Museum of London uses XR to superimpose historical images over present-day locations, providing a window into the past (Panciroli et al., 2018). Therefore, we could imagine a future where digital archives themselves become adaptive and generative, suggesting new development possibilities by dynamically overlaying their content onto our current projects. By leveraging technologies like AR combined with

intelligent systems, these archives could eventually analyze the data within it and propose innovative, context-aware solutions or designs, offering a seamless integration of historical insight with contemporary development.

On the other hand, emerging advanced technology, such as AI algorithms, can now analyze vast amounts of archival data to uncover patterns and insights that were previously inaccessible. Tools like Transkribus use ML models to automate the transcription of handwritten documents, significantly aiding historians and researchers (Kahle et al., 2017). Additionally, in several domains, AI algorithms, particularly machine learning and deep neural networks (DNNs), have shown significant potential in analyzing and classifying artifacts as well as historical texts and images (Assael et al., 2022; Bickler, 2021). Also here, if we dare fantasize, we could imagine future where we actively dialogue with the past through digitized content of archives, using AI systems to "interrogate" historical data and gain real-time feedback on our current work. This interaction would allow us not only to write new narratives but also to continuously validate and refine our designs or definitions.

In this technological era, digital archives accordingly are no longer just static repositories. They are becoming more and more dynamic "spaces" that inspire and assist users (Opgenhaffen, 2022). This transformation is evident in various innovative projects where digital archives are used not only for preservation but also for education and as creative endeavors. For instance, the "Europeana" project provides access to millions of digitized items from European museums, galleries, libraries, and archives, fostering a deeper connection between users and historical content (Concordia et al., 2010). The "Digital Public Library of America" similarly aggregates content from libraries, archives, and museums across the United States, making it globally accessible (Karadkar et al., 2016).

These transformations showcase the fast-changing role of technology itself, which is also becoming increasingly proactive and can even assume the identity of a design partner in the creative process (Lopes et al., 2023; Verganti, 2009). Accordingly, modern technology could transform future archives, reinforcing the idea that they serve as a bridge between the past, present, and future by enabling even more contemporary interpretations and applications of historical data. This shift not only could foster a deeper connection between users and content but also enhance the accessibility and usability of archives. By integrating interactive technologies, archives can evolve into "alive," educational, and inspirational resources that actively contribute to the cultural and historical discourse, eventually playing a part in new creative processes.

For example, the "Smithsonian Institution's Digitization Program" has digitized almost two thousand of the museum's objects, making them freely available for download, 3D printing, virtual reality experiences, and other interactive applications through an online repository in order to preserve the models' cultural heritage (Coyle, 2018; Hollinger et al., 2013). This not only preserves the artifacts but also allows for innovative educational uses, such as virtual field trips and interactive exhibits. This "digitally open" approach to content management is also available to designers who can exploit such 3D models as well as contribute to the archive by sending their own work.

For these reasons, integrating interactive technologies into digital archives represents a significant shift in how historical data of diverse nature is preserved, accessed, and utilized. These technologies not only protect and disseminate cultural heritage, but also potentially transforms the learning and creative processes, bridging the gap between past and present and opening new avenues for exploration and understanding.

Interacting with fashion digital archives: the actual framework

In the modern technological landscape, fashion heritage archives possess unique characteristics that make them ideal for innovative forms of interaction in the digital sphere (Clark et al., 2014). This is due to the fact that this type of archives includes a diverse and vast amount of garment images–also taken at catwalks - and digital representations from collections, as well as samples of materials or sketches, and different types of sources of inspiration for the designer, both in terms of physical artifacts and references from different cultures and places. In general, a fashion designer's archive contains latent fashion concepts capturing styles, events, and environments that are shaped by design elements such as color, material, and silhouette (Sorger and Udale, 2017). All these elements, when digitalized in an archive, allow the rebuilding and preservation of a fashion designer's know-how (Martin and Vacca, 2018), reflecting values, style, and creative process, invaluable aspects for understanding the historical context and inspiring new designs. For instance, the designer's sketches could eventually provide insights into their conceptual thinking and design evolution, while material samples offer a tactile sense of the fabrics and textures used in different periods or geo-labelled information about the archive's fashion designer life and lifestyle could offer insights to other cultures' references that have influenced the ideation processes. Therefore, we can observe that fashion repositories have become more accessible and interactive, allowing users to engage with them in multi-modal and dynamic ways thanks to the integration of advanced technologies, that can foster a different learning and explorative culture where the user creates personal meaning from interacting with archives' content less passively (Martin et al., 2016).

As seen before, archive users can now select from different content typologies - ranging from garments collections to sketches, videos, and interviews–providing a multidimensional

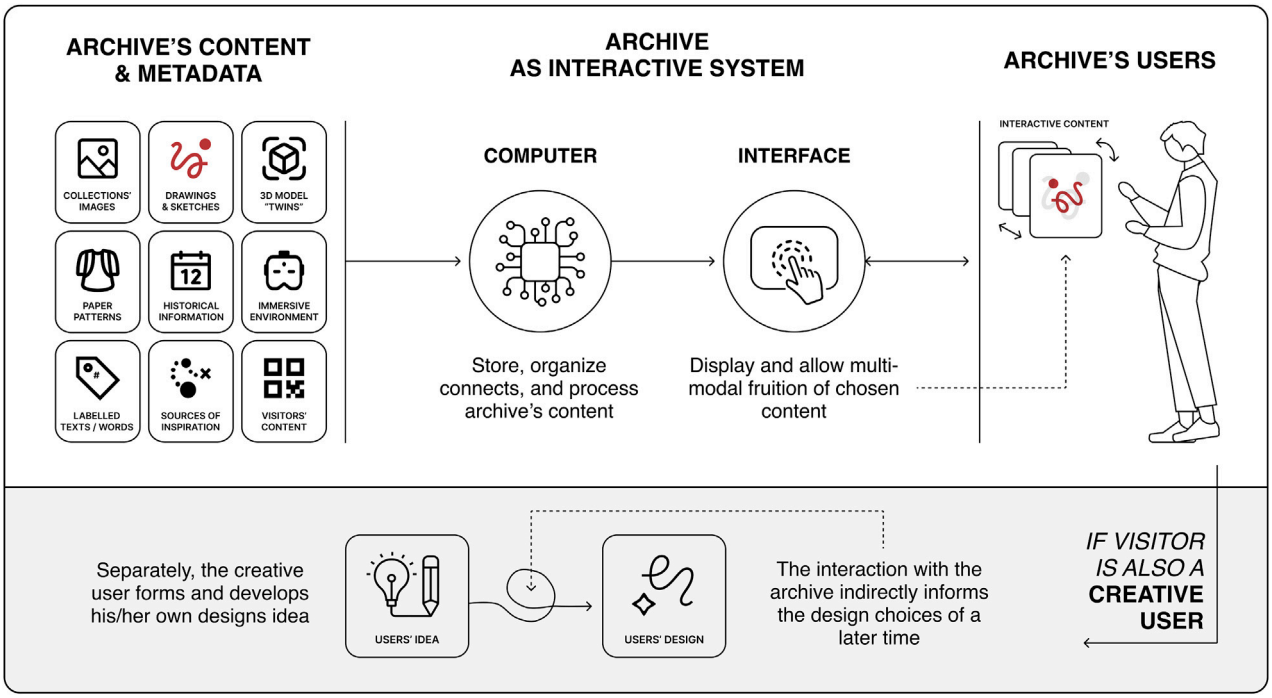

FIGURE 2
The role of technology and interfaces in interacting with fashion digital archives–Current framework.

view of fashion history and know-how related to a designer. Most of these digital platforms allow users to navigate through a designer's work chronologically, thematically, or by specific garment features, offering a more immersive and detailed exploration. This capability is invaluable for gaining a deeper understanding of a fashion designer's evolution, creative process, and production over time. By interacting with fashion archives in this way, scholars, enthusiasts, and even creatives themselves can retrace the legacy, influences, and innovations of key figures in fashion history.

As anticipated, in this work we investigate the relationship advancement of digital technologies–computing and interface wise–in order to describe the potential future roles of the interactive archive in the interaction between user and cultural heritage. However, to the best of our knowledge the literature does not propose a framework describing the relationship between user and interactive archives' heritage, highlighting the role enabled by its technology and interface. Some related works focus primarily on different aspects such as the properties of technologies in processing data (Patel et al., 2004), or the overall management or data integration for cultural heritage documentation (Ning et al., 2011) the technology behind organizing and querying cultural heritage archives for users (De Mooij et al., 2022), or–differently–on the potential role and trajectories related to curating and disseminating knowledge based on levels of digitization and dematerialization (Vandi, 2023).

Therefore, by building on the role that nowadays fashion digital archives mostly have as interactive system and by synthesizing insights from current archive examples presented above, we describe the modern dynamic that captures the interplay between user, archive and embedded heritage through the following framework representation (Figure 2).

If we focus on the big picture and try to define these dynamics better, we can briefly outline the main user experience, which represents the general interaction between users and the archive and the resulting outcomes, as well as the archive's technical functionality, which describes the interconnection between the archive and the technology, both in relation to the overall framework.

User experience: The main current use of fashion digital archives typically involves visitor-users engaging with the content–in presence and through digital platforms - in a deep and detailed yet efficient manner. Users can rapidly explore related materials and gain a thorough understanding of any specific item within the archive, facilitated by the integration of multimedia and metadata associated with it, This can enhance their ability to trace the history, context, and significance of each item, thus creating a rich narrative and learning experience (Andò et al., 2023; Hall, 2017). This approach allows for a

more dynamic interaction with the archives, fostering deeper engagement with the fashion heritage beyond simple observation.

Technical functionality: On the technological side, digital archives are designed to process, organize, and display "interactively browsable" content. These systems enable interaction and navigation by integrating various metadata standards and advanced search capabilities, allowing users to explore content closely and correlate related data quickly. The role of technology is then to make it easier for users to explore in depth the content and discover connections across the archive (Carbajal and Caswell, 2021).

Combining fruition and technological functioning, we can observe that these platforms are designed involving technology to facilitate seamless navigation, allowing users to closely examine fashion artefacts and quickly correlate related data, and enhance both accessibility and user experience. With the prospects of AI systems integration and XR development in the context of fashion archives and artefacts, we can assume that it will be possible to design for always more rich interaction and facilitate more powerful and heterogeneous ways of navigating digital content.

To conclude, in the close future archives will serve as the context to develop fashion innovation trajectories by favoring the redefinition existing cultural expressions and the visualization of future cultural patterns for the field (Vandi, 2023). Accordingly, we can also reflect on the implications of this interaction when a creative user - such as other fashion designers–is using the archive for research or as source of inspiration for new design processes. Creatives often consult digital repositories as a valuable resource to inspire and inform their personal design choices. Often, this kind of users explore these collections to draw new ideas or to incorporate historical references and visual elements into their fashion-related work (Smith, 2018). Moreover, modern intelligent systems and advanced computing are becoming more and more important in providing alternatives and variety of stimuli to support the designer's idea generation strategy (Yang and Cheng, 2020). This process may even involve "borrowing" or reinterpreting elements as designers use archives to enrich their creative practice and develop unique expressions rooted in past trends and aesthetics preserved in a fashion archive. In relation to this last point, as outlined better in Section *The workshop resulting approaches*, while we recognize the importance of reflecting on authorship-related issues, this study does not directly address this theme as part of its limitations.

Implication to creatives' design process: Now, creatives - and fashion designers typically - use digital archives as a source of inspiration, exploring vast collections to gather ideas and insights. After browsing, they step away from the archive to a separate space where they work and reinterpret the elements they found, developing their own design process. This two-step process allows them to transform inspirations and learnings from the past into new creative expressions in their own original designs yet informed by the interaction with the archive.

Artificial Intelligence and fashion archives' data potential

Using the previous paragraph as a starting point and reflecting on the fast advancement of the fashion industry in this technological era (Bertola and Teunissen, 2018), we advance our reflection with the idea of exploring how interactive technologies and new user interfaces could potentially change also how these digital archives are intended, for example, through the integration of AI systems. Novel opportunities for rich engagement with digital and physical materials and large data sets are made possible by large-scale interactive displays, embedded sensing and actuation or smart materials, eventually combined with artificial intelligence among the others (Elmqvist, 2023). Accordingly, we can investigate novel technological opportunities for engaging with archives' diverse fashion heritage elements.

The rich, categorized, and visually detailed nature of fashion designers' portfolios and collections (Kiper, 2014; Sorger and Udale, 2017) is often reflected in their digital archives. This vast array of systematically organized images from collections over time containing various versions of garments, digitalized paper patterns, along with detailed labels such as material types, colors, and time-related keywords, provides an ideal foundation in terms of quality and quantity of data for training and leveraging modern technologies like artificial intelligence (Ng, 2018). In fact, well-labeled and structured datasets allow these algorithms to learn patterns, leading to better generalization and generation capabilities (Goodfellow et al., 2016). In these cases, of abundance of training data, AI-enabled technologies recently started to function almost as collaborators in the creative process for designers, facilitating idea development through text and image generation, among other methods (Figoli et al., 2022; Tholander and Jonsson, 2023). Thus, imagining applying these technologies to process fashion archives' data, we can hypothesize that these digital collections could be somehow harnessed to support visitors-users exploration as well as play a role in the definition and generation of new fashion-related content itself.

Among the key resources in digital fashion archives we have digital twins of garments - 3D model replicas - that can be enhanced and further explored through extended reality technologies (Vandi, 2023). This immersive approach not only allows for a deeper exploration of garment details, such as texture, movement, and fit, but also open up possibilities for virtual try-ons and zero-impact garment development. An example of this is The Fabricant, a company that pushes the boundaries by proposing a more sustainable "digital-only" fashion (Ellen MacArthur Foundation, 2021).

On the other hand, the extensive visual content in archives - including collection images, catwalks' photographs, and digital 3D replicas - can be combined with material samples, cultural references that inspired the creative process, and digitized sketches. This create a comprehensive resource repository for emerging fashion designers and, more broadly, for creatives within the field. Fashion archives not only chronicle the progression of fashion over time but also function as vital repositories of inspiration and technical expertise. These collections house detailed records of garment construction techniques, fabric innovations, and design processes, making them invaluable educational resources for contemporary designers, scholars, and artisans (Cognini and Vacca, 2022). For example, the Europeana Fashion is a publicly accessible digital archive with digitized collection of haute couture, fashion garments and everyday clothing of major historical significance, making it accessible and interactive for users, thereby preserving the socio-cultural history of the region through clothing (Suls, 2017). This archive also features tools and services aimed at integrating user generated content that will enrich and complement the standard metadata descriptions, engaging the European fashion community in museums, universities and in the private sector.

Moreover, alongside visualizing future cultural patterns for the fashion field (Vandi, 2023), the integration of artificial intelligence within digital fashion archives would favor the analysis of fashion styles and the forecasting of future trends (Chang et al., 2021). This technological synergy not only aids in the preservation of fashion heritage but also in its continuous evolution, making it a dynamic tool for contemporary designers. The Chronicle Archive of Tokyo Street Fashion, for instance, uses machine learning to identify fashion trend patterns, demonstrating the potential of digital archives to uncover new perspectives and promote an understanding of societal and cultural trends through fashion (Takahashi et al., 2020).

More recently, several scholars have explored how artificial intelligence can be exploited to support the design of new garments starting from designers' collections (Kouslis et al., 2024). According to them, AI can be proactively harnessed in garment design by leveraging intelligent design platforms, such as those based on GPT-like technology, to innovate upon existing collections. These platforms facilitate data processing and model training, which enhances the creative possibilities available to designers (Wang and Zhao, 2024). By integrating AI tools into the fashion design process, as highlighted in research on AI-based clothing design methodologies, designers can effectively navigate challenges such as design fixation, allowing for more dynamic ideation and evaluation (An and Park, 2023). Additionally, the application of machine learning techniques enables the generation of new fashion styles, enhancing the synergy between AI capabilities and designer creativity. This collaborative approach not only streamlines the design process but also fosters a more expansive exploration of styles and trends, leading to the creation of unique and forward-thinking garments.

A really relevant case study demonstrating how artificial intelligence can be used to process fashion designers' collections data to proactively affect the fashion design process and help a designer "draw" and shape the concept is Amber Jae Slooen's experiment discussed in the study "'Just hit a button!' - fashion 4.0 designers as cyborgs, experimenting and designing with generative algorithms" (Särmäkari and Vänskä, 2022). Slooen explored the possibility of using a fashion designer collection's images and picture and merge them to have a draft for possible new garments design by using AI algorithms to process the data. She started playing with the algorithms which asked her to guess between real images of garments and those created by the AI system till the difference was minimal. Stunned by the results she decided to use the result of this back-and-forth interaction with the system as an inspiration for her outfits in terms of color, material and shape; effectively co-designing and defining the garments with the platform.

Lastly, even in market application, machine learning combined with big amount of categorized and labelled outfits has led to the creation of several data-driven fashion applications that allow users to express their desires in natural language just as they would to a real stylist and produce tailored item recommendations for their fashion needs (Vaccaro et al., 2016). Differently, platforms like Altr use AI algorithms to enable brands to digitize and showcase their archives, offering interactive 3D views and virtual try-ons, which enhance user engagement and provide valuable insights into consumer interactions by leveraging data analytics to gain insights into how younger and global demographics interact with brands' archives, fostering connections with the community and promoting data-driven innovation (Altr Labs Ltd, 2023).

From all these assumptions, we can assume fashion digital archives possess the perfect nature in terms of content to be exploited as advisors to fashion designers, students or curious, reinforcing the idea that archival fashion collections - aggregators of this plurality of diverse data - make the archive interaction a "knowledge-generating process" when interconnected with proper technology and interface (Vandi and Vacca, 2023).

We can then summaries that fashion digital archives offer a rich, interactive, and comprehensive resource that preserves historical context and the collections' intrinsic style and values, but also, they could inspire new designs and integrate advanced technologies to enhance user engagement. These archives are not just repositories of the past but can be dynamic tools that bridge the gap between historical knowledge and contemporary innovation. More specifically, by analyzing historical patterns and comparing them with contemporary developments, technologies like AI systems could provide us some directories and guidance, making the past an active collaborator in shaping the future.

"Exploring new ways of engaging fashion cultural heritage": a workshop

Having perceived the potential of digital fashion archives in relation to new technologies and Interaction design as an approach, we decided to conduct a workshop, engaging fashion and interaction design students in exploring how interactive technologies can serve as a vehicle for novel ways of engaging with the fashion cultural heritage. The scope of the workshop was to explore the development of the topic according to students and highlight possible roles of digital archives.

Therefore, in the Summer of 2024, at Politecnico di Milano university we organized a one-week design workshop course. In total, 54 design students from different countries enrolled in the university's MSc programs Digital & Interaction Design (46 participants), Design for the Fashion System (7 participants) or other (1 participant), participated in the workshop. The participants also had different BA educational backgrounds: 19 graduated in Industrial Product Design, 12 in Digital Media and/or Communication Design, 9 in Architecture, 7 in Fashion Design, 2 in Interior Design and 5 in other disciplines. The 54 participants were divided into 14 groups of four and each group focused on one out of two design project directions listed in the following.

The workshop was structured as follows. Prior to the workshop, the design students were given a guided tour of a fashion designer's physical archive and an introduction to the physical archive and the digital archive's content in order to clearly understand values, design principles, know-how, history and cultural influences of the archive's fashion designer, as well as some preparatory readings. At the start of the design workshop, archive employees responsible for the digitalization process of the archive also presented the nature of its digital content–for example, by showing some digital twins - and the potentiality of it. In the following 5 days, the students worked full time on design proposals and were assisted by the authors through process and concept reviews of their work. On the final day, the participants presented their design proposals to the archives' responsible people through an oral presentation, a poster exhibition and an experiential prototype.

To get started with their projects, as anticipated, students were given the design brief to conceptualize a new technological way to utilize and interact with the fashion heritage within a fashion designer's archive, along with two possible project directions that were provided:

- Exploring how interactive technologies can broaden ways of engaging with the place and materials in the archive to support engagement with cultural heritage and through designing for "socio-spatial interaction" (Krogh et al., 2017).
- Exploring possible roles for digital technologies in broadening participation in fashion making (Bertola and Teunissen, 2018), where the archive serves as a FabLab in which users actively create/explore inspired by the designers' principle.

We asked the students to approach the brief with the idea that the digital archive "possesses" an exploitable know-how of the archive's fashion designer, as well as his principles and values to be respected and eventually incorporated while making use of the knowledge gained from interacting with the archive.

In the workshop, students were guided to follow a participatory design approach to the development of their interactive digital archive's concept. This means that they were asked to involve potential but specific users of the archives, such as fellow students, fashion enthusiasts, other designers, and even extreme users, such as children, to better inform their projects and help envision the alternative roles of archival technologies as previously discussed. They were required to draw upon participatory design approaches to engage with representative users as part of their process.

The expected outcomes of the workshop included scenarios and experience prototypes that conceptualized these new roles for fashion archives enabled by advanced digital technologies. To structure their work, we provided students with a specific format for their final deliverables, which included the following elements:

- A *hero shot image* illustrating the core concept,
- A *step-by-step scenario visualization*, communicating the user-archive interaction flow, which most often took the form of storytelling images or video,
- A *concept scenario definition*, including: a description of the concept, a definition of the target users, and the kind of sensory interactive experience enabled by the design,
- A *description of their design process*, detailing: which users they involved, how they engaged them, and what they learned from the process.

This information was to be presented in the form of a printed poster, accompanied by a 3-minute video, an experiential prototype and a week after the workshop also a reflective written report.

For the purposes of this study, we focused exclusively on qualitatively analyzing the final concepts of interactive archival systems presented at the end of the workshop course, which outlined the target users and the envisioned user experience. All authors collaborated around scoping and planning the workshop and subsequently, two of the authors collaboratively clustered and analyzed the resulting design cases and identified patterns in the design work which are crystallized in roles/approaches of the archive identified in the following. Additionally, due to intellectual property agreements, at the moment we are unable

to disclose the students' work in its entirety. This includes sharing images, project titles, or providing more detailed descriptions of the single projects, as doing so would potentially compromise the confidentiality and ownership rights associated with their creative contribution. In order to analyze the potential future roles of the archive, it is the resulting patterns of roles of the archive that emerge out of the material, which is the key result.

The workshop resulting approaches

By analyzing the students' concepts, some common approaches to the potential future roles of the archive are identified. Based on conducting the workshop and analyzing the resulting 14 projects, by the authors comprehensively identify five main approaches to designing interactive systems and therefore envisioning new archives' roles, without necessarily defining or classifying them in terms of innovation. Each approach, merging different groups' work, is subsequently defined by (i) a summary of students' practical scenarios merging their final concept definitions, (ii) the corresponding role of technology and (iii) few practical examples from different domain identified by the authors to make the approach to interactive archives and the concept scenarios more relatable.

Archive helps user shape new fashion ideas, enriching and inspiring new creative design

In this category of scenarios resulting from the workshops, students envisioned an archive that clusters and processes digitized sketches and images of garment collections, guiding users through a process of exploration and (re)creation of new fashion pieces. In an iterative process, the users shape their fashion design idea responsively guided by the principles, techniques, and style of the original designer. Through displays or, in some cases, VR application that supports drawing-and-cutting-kind-of interaction, the users start designing and receive suggestions on shapes, colors and materials selected by the archive, showing where the advice comes from using its collection material, and helping users to craft designs that are both original and informed by the archive's know-how.

Regarding the corresponding role, as an interactive system the archive would take on the role of simultaneously creating or modifying content with the user, enriching and inspiring their new creative designs. The archive would be a step-by-step guide in the user's creative exploration and creation of a fashion-related item, without claiming to define a finished product, but developing a rough piece that follows the archives' embedded know-how and principles. The archive can also simply act as a guide and conduct to a specific item contained in the archive based on users' creative input.

Looking at similar external examples, in recent years several AI-enabled tools that help creatives into defining their design concepts based on big and organized quantity of images and sketches emerged. Among those we can find Scrying-Pen that suggest simultaneously how to continue a sketch properly by guessing what the user wants to draw (Matuschak, 2018), SketchImage.AI that can add color and material to architectural design sketches (SketchImage, 2024), Sketch-to-Image that convert simple drawings into dynamic images offering a wide range of imaging possibilities (Clipdrop, 2024) and - why not–Image-to-Paint systems that modify image according to a selected painter style (OpenArt, 2024). Following this first approach, some workshop participants envisioned applications in which the archive guides the user's sketches or propose color and material to be applied to a drawing, based on the fashion designer's embedded principles and know-how, thus indirectly learning from him.

As later deepened in Section *Study limitation and future work*, ethical concerns related to intellectual property and data usage in AI systems were not addressed in the workshop, as they fell outside its scope. However, it is crucial to recognize that such issues will require further investigation. Future archive designers must ensure the responsible use of archival systems by integrating mechanisms that uphold the values and principles of fashion designers while ensuring appropriate credit is given when relevant in future developments.

Informing new creative processes by tentatively retracing the designer's one

In the scenarios of the workshop projects within this second strand, the archive allows both expert and non-expert fashion enthusiasts to explore the designer's creative process, from initial inspiration to final garment or accessory design, through large-scale interactive displays. Users can engage with the archive by retracing the designer's process step-by-step, actively learning how each phase leads to the next and ultimately reaching the final information they wanted to reach. Thanks to specific AI algorithms, the archive could also offer multiple personalized pathways, for example, working on different sources of inspiration and eventually suggest potential design guidelines when asked to, assisting and informing users in their own future creative processes.

Reflecting on the archival role, here the interactive archive acts as a design or creative process "advisor," which guides users in retracing and reviving the fashion designer process and indirectly enriches their personal ones. Here, Integrated technology helps clustering materials and establish relationships between data, this highlights connection in terms of creative process and eventually allow for the navigation of it through multiple paths. A responsive interface should support users in learning how the designer moved from, for example, a

cultural reference to the garment concept. Eventually, always according to the archives' embedded values and know-how, it provides suggestions to improve the user's creative process, by responding to user's question on his own creative process, of course if coherent and consistent.

Looking at external case studies, similarly the project "Mona Lisa: Beyond the Glass" implemented such approach to give a different role to the archive. This VR application uses the latest scientific research on Leonardo da Vinci, his creative processes and his painting techniques, to guide the user through the whole creative process of the famous painting starting from inspiration, exploring preliminary drawing, to final painting (Louvre, 2021). In this way, the digital-visitor can retrace the creative steps. Similarly, as presented in the scenario, some workshop's participants envisioned an application that invites people to actively interact with the different inspiration material, sketches and painting, making him or her really empathize with the archive's fashion designer.

User and archive co-constructing new narratives and pathways linking various material

In this approach and concept scenarios summary, thanks to displaced interfaces in the physical archive - such as simple QR code to be scanned or more complex displays - or through specific digital platforms, users can navigate single contents and "collect them" to build new narratives and collection based on their personal interpretation and correlation between different data typologies. Thus, becoming "co-creators" of the archive. By collecting traces of this archival bricolage or physical visit, thanks to eventual AI clustering algorithms, it would also be possible to construct new collections-related content that could be combined with the archive's one to create new narratives accessible to non-expert visitors.

In this third case of potential archival role, archive and user both assume the one of "co-developers" of new archival content for future users, sort of curating a small part of the archive's narration regulated by the archives' heritage. The technology here enables users in creating new personal narratives and pathways by interacting with the material. The archive interface should allow for bringing together different kinds of archival material in the same interactive, even fully digital, place and enable the user in describing the connection among chosen items.

An example of such approach is the Rijksstudio. It is a digital initiative, launched by the Rijksmuseum in Amsterdam, which allows users to explore the museum's collection online, select and remix images of artworks, and create their own collections and path, based on a personal interpretation (Rijksmuseum, 2024). By allowing users to engage directly with art through creation, the Rijksmuseum simplified the relationship between archival material and personal expression and found new artistic correlations, useful for both visitors and the museum. Similarly for fashion archives, few workshop participants reflected on the possibility of bringing together different archive pieces and provide their own personal thoughts about the selection or, extremely, on the possibility that the physical and digital archive could keep track of user's selection activities to discover new path.

A second demonstration of this approach was the thought-provoking interactive experience "Energy: fueling the future" by the Science Museum of London where children aged 7–14 were invited to contribute to the physical exhibition by sharing their thoughts on how energy could shape the future through some interactive displays (Science Museum London, 2018). The curators' idea of having a dialogue between subsequent young visitors was to transform a technically complex topic into a participatory simplified discussion, making it easier for non-experts to connect with and understand the exhibition's content. Even in the case of interacting with fashion heritage, participants also explored the possibility of involving visitors towards a more relatable fruition by non-experts, obviously without trivializing the content.

Enriching cultural heritage, history and background with external current information

Regarding this is group of scenarios, students envisioned that users start exploring the archive form the materials that were mostly related to the life and memories of fashion designers as well as digital resources and physical artefacts from other places and cultures that have been relevant inspirational references to get started from the beginning. Then, thanks to large responsive displays and either physical or virtual object manipulation, users can interactively explore all the connected archive contents "one after the other" until they reach the final items by keeping a stronger focus on specific aspects such as material provenience and historical attachment, thus highlighting even more the temporal and socio-cultural influences and impacts on the final design. Combining the archive embedded information, such as production techniques and cultural references ones, with external sources' data retrieved and processed by, for example, AI algorithms, the users are involved in a more sensitizing experience that helps them address contemporary socio-cultural challenges through the fashion lens. For example, while discovering techniques or materials from a different country and how they were applied to a garment, the user is also exposed to content related to external issues such as the environmental pollution caused by the fashion industry or our consumptions, eventually leveraging on designer's good practices in relation to the topic, for example, on his or her hypothetical good practices of reusing textile material.

Here, the role of the interactive system would be that of data scavenger and aggregator that finds themed correlations between archives' content with external online data to enrich the archival navigation, especially by integrating, addressing and raising awareness about current issues or topics particularly close to the designer's principle and values. Leveraging the designer's related material, the archive should act as an intelligent browser where the user can confirm correlations or add more significant ones, therefore enriching the archives' cultural heritage with modern perspectives. User generated content has always been integrated in interactive archives and repositories as precious resource to increase the value of knowledge content (Sciascio et al., 2019; Shan et al., 2020), but thanks to new advance technologies we can now envision new enabled systems being constantly trained by users in looking for new correlations, thanks to the content generated through the interactive collaboration in.

A similar example from another domain is Tellart's "Dinner in 2050" immersive installation (TellArt, 2023). Using a game approach, users stand together around a table, speak their favorite meal into a microphone and an AI model identifies the top ingredients in their meal with the highest carbon footprint and then generates a more-sustainable future version of this dish–where lamb is, for example, swapped for grasshoppers - with an informative description. Guests learn how their meal can impact water and energy use, carbon emissions and biodiversity, and improve their nutrition. The goal here was to "inspire optimism and agency to drive positive change." Translating this approach to garment-related data, some participants worked on the possibility of using digital archives' contents - from cultural inspirations to garments production - combined with news and information from outside to produce more sensitizing experiences.

As noted in the study's limitations, students speculated when defining their concepts and were not required to explore ethical implications in depth. However, it is essential to recognize that such conceptual scenarios are not without potential ethical concerns in contemporary contexts. For instance, in relation to this group of concept scenarios, it would be important to ensure that users are made aware of issues such as the exploitation of cultural contributions. A revised approach could offer an alternative perspective on the attribution and ethical use of creative inspiration.

Immersive collaborative dialogues experiences facilitated by the physical and digital archive

In this last group of scenarios implementing advanced technology in archives, users can collaborate in exploring the archives' content thanks to immersive–VR or AR - experiences or through big interactive displays, alongside eventually creating immersive inspirational environments outside the archive for a larger and more diverse audience. Starting from one piece of the physical or digital collection, users define new connections between material and contribute giving their interpretation, or even design something new with other visitors. Engaging in discussion with others, users can share new, diverse perspectives on the archive's fashion heritage beyond physical place limitations.

Regarding the archival role, lastly, the technology-enabled archive assumes the role of both *provocateur* and facilitator of discussions that include people from different places by displaying its content in relation to modern changing debates happening "outside." The technology should be able to process the content and pose questions to stimulate users' discussion and collaborative interaction around the archive material. Technology, in this case, has the role of bringing together people who can access the material in person as well as people remotely thanks to immersive solutions, allowing multiple user interactions at the same time.

An explicative external case study of such an approach is SCAD Art Museum's entrance installation which gathers users around a big responsive display, highlighting specific exhibitions or collections' objects and making them interactive elements. This immersive installation aims to foster interaction between users, creating a collaborative atmosphere that sets a welcoming social tone. Visitors gather around the table to view and exchange a series of "cards" that dynamically present information about the museum exhibitions and collections (Pentagram, 2012). Similarly, some workshop participants envisioned an application to involve people, even remotely and asynchronously, through the collaborative exploration of archives' metadata and physical content.

In conclusion, through analyzing the workshop results and participants' contributions, we can envision fashion archives taking on various interactive roles: (i) a partner in enriching and inspiring creative product; (ii) a design process advisors which guides users in retracing the fashion designer process and enrich their personal one; (iii) an archive co-developer of archive content that enables users in creating new personal narratives and pathways; (iv) an information aggregator that correlates and reprocesses its content with external data to address and raise awareness about current issues, and finally (v) a provocateur and facilitator of discussions that immersively includes people from different places through its content.

A co-creative dialogue with the archive: a new framework

Building on the previous chapters' foundational assumptions and on the analysis of the workshop's results, the paper introduces an new framework that reimagines the digital archives' role, which have historically been underutilized

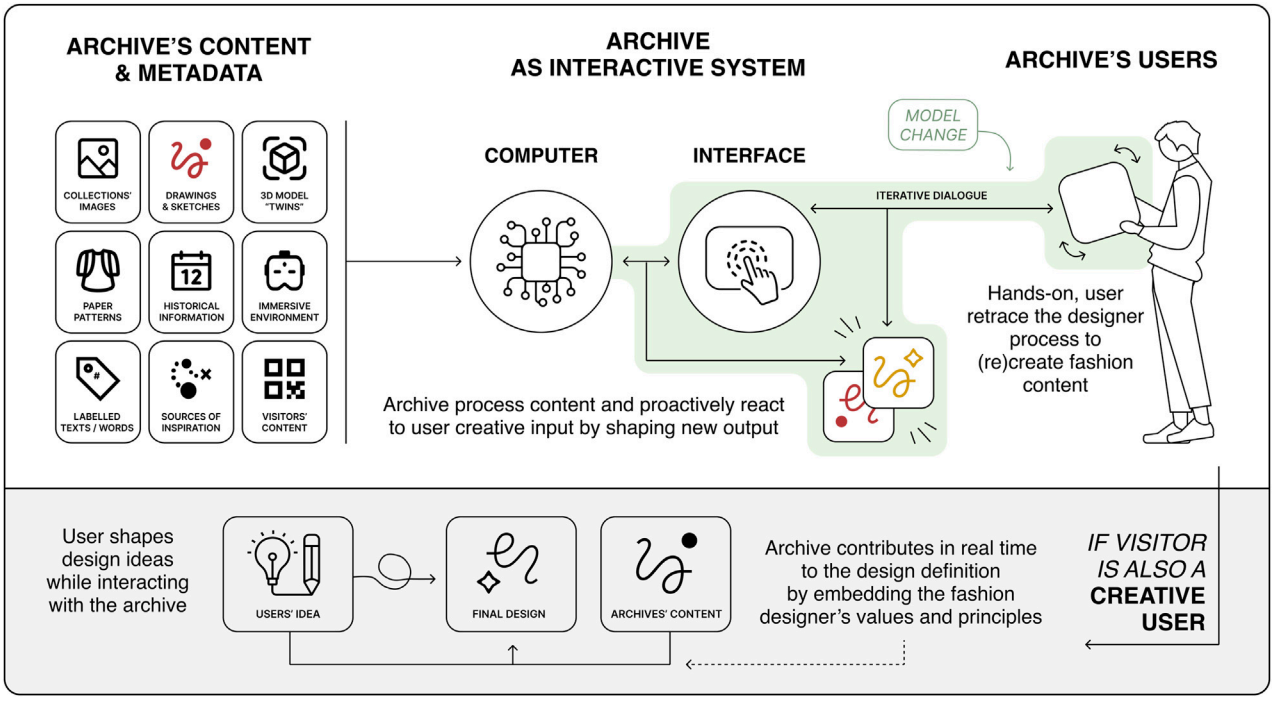

FIGURE 3
The role of technology in interacting with fashion digital archives–Revised framework.

considering their potential (Giannachi, 2016), transforming them from interactive repositories of digital content into dynamic co-designing partners for creatives and non-creatives who seek fashion archives to support their work in the field. This model envisions a future where users actively engage in co-creating designs and dialogical exchanges, leveraging the extensive historical visual and textual data housed within a fashion designer's archive, also following the suggestions by Vandi on the potential exploration of more collaborative archival roles (Vandi, 2023).

As demonstrated through examples in the previous chapter, earlier technologies primarily facilitated the navigation of archives and their vast datasets by leveraging digital tools to retrace processes and extract content or insights. Based on the results of the workshop, we are now envisioning new modes of interaction with fashion digital archives, driven by advanced technologies as AI systems. Building on the previously presented framework, we propose a new one that redefines the roles of both the user and the archive. In this revised version, users not only explore but also actively engage with the archive, which, in turn, responds proactively, creating a collaborative dynamic (Figure 3). This approach envisions a shift in the way users interact with fashion archives by empowering them with greater agency, while also transforming the archive's function beyond exploration and navigation.

To better describe this second revised framework we defined, it is useful to dwell on aspects related to users' experience and fruition, as well as the role of archival technology, especially in its interface.

User experience: In terms of user experience, visitors both remotely and in presence are invited to engage with the digital archives in a more proactive manner, transforming their interaction from passive exploration to active co-creation. Alongside navigating through the archive, users now interact with its content in three main ways. (i) First, users can actively manipulate and reshape the existing content within the archive, exploring relationships between different items and archives' domain in a "playful" and exploratory manner. This first interaction allows them to create new narratives or patterns by modifying how the archive's elements connect with one another, fostering a dynamic and creative engagement with the archival data while learning the designer process. (ii) Secondly, users can also initiate the remake of an existing digitized content or the "creation" of new fashion content in line with the archive. In this case, the archive acts as an interactive guide, helping through responsive displays. These may be digital online interfaces or interactive physical displays within a fashion designer's archive. As the user shape her ideas, the archive responds by suggesting relevant materials, connections, or by proposing practical directions, facilitating a collaborative design

process between the user and the archive. (iii) Finally, the user could explore the content of the archive, also in collaboration with other visitors in different places, in relation to different data on current relevant topics coming from external sources. This kind of exploration could both serve as a stimulus to raise awareness of specific topics of interest in the archive and as an initiator of discussions among visitors starting from the content of the archive, perhaps tracking and preserving the results of this interaction involving externally integrated information. In all these three experiences, the user should perceive the archive as a partner in the exploration, conversation, learning, and creative process.

Technical functionality: In this new tentative framework, technology goes beyond simply organizing and processing content. Through the possible implementation of AI algorithms combined with interactive displays, it should "play" with its data and proactively react to users' interactions. The archival system would possibly act as a representative of the fashion designer's by adaptively bring his or her principles, values, and expertise according to users' inputs. Assisting also the user in either the designer's creative process or exploring new content creation by following it, the technology should guarantee a smooth and satisfying interaction. In general, integrating AI-enabled technologies combined with interactive interfaces gives agency, brings the user more at the center of the actions–in terms of control of the interaction - of the user-system interaction (Shneiderman, 2020; Q. Yang et al., 2019), thus requiring more proactivity to the user as well and excellent stability and responsiveness to the technology.

As previously investigated for the actual framework, considering the previous chapter's reflections on AI-related implication to creative processes, also here we can reflect on implications to creatives' processes when they interact with the fashion archive in such scenario, especially in the case they approach it looking for support or inspiration sources to inform own design choices or get started with a new creative project.

Implication to creatives' design process: Starting from the idea of creating something from scratch and "co-designing" with the archive in a physical place or remotely, within this framework, the archive enables creatives in modifying, editing, playing with or leveraging the archives' content to form new fashion design concept or even just rough ideas. Creatives interact with the material and metadata through responsive archives' displays or platform, even remotely, in a more dialogical way. Therefore, they could use these co-creative outputs as intermediate steps for their own design development. Framing it in more practical terms, it would be like brainstorming, researching, and designing with the fashion archive or the fashion designer at their side, and sometimes they also slightly modify the user idea according to "their" knowledge and embedded heritage. In this case, emerging technologies as AI systems act as the tool allowing and facilitating this smooth exchange with the archive and indirectly the fashion designer.

For instance, a young fashion designer working on a new collection could utilize the archive to delve into traditional garment construction techniques or historical color palettes. By integrating these elements with contemporary trends, the designer can create unique pieces that honor and incorporate the foundational principles embedded in the archive by actively collaborating with it. The proposed framework not only enhances the utility of digital archives but also fosters a symbiotic relationship between historical data and modern design practices. This approach underscores the potential of digital archives to serve as active participants in the design process, thereby enriching the creative output and ensuring that the legacy of historical designs is preserved and respected through contemporary reinterpretations.

Conclusion

Our study began with an exploration of digital archives across various domains, highlighting the new opportunities that technological advancements bring to the field. Reflecting on technical aspects, such as the metadata characteristics unique to archives, we identified that fashion archives possess distinct properties - both in terms of their content and potential to redefine user-archive interactions - enabling more proactive experiences. The workshop conducted with students from diverse design backgrounds allowed us to explore practical scenarios where the archive assumes a more interactive and proactive role, emerging from a speculative design exercise based on a real case study. This exploration ultimately informed the final framework we developed.

It is important to emphasize that our proposed framework is not intended to replace or critique the other existing models, which are the result of valuable innovations. Instead, our aim is to explore a potential trajectory for digital fashion archives, especially as they increasingly integrate emerging technologies, such as AI systems and interactive displays. Additional archival roles could be explored as well, as this framework is informed both by our workshops and by our interpretation of the current state of digital archives and interactive technology.

To conclude, we believe that a new user-archive collaborative process could be facilitated by advanced algorithms capable of analyzing and adapting archival content in response to user interactions. These technologies enable tailored suggestions that align with the user's mental model, while also preserving the heritage and values embedded in the designers' original work. However, any advancement in this direction must prioritize a user-friendly interface that accommodates diverse users, ensuring accessibility to those engaging with emerging

computational methods and functional innovations (Jaillant and Aske, 2023).

Study Limitation and Future Work

Acknowledging the limitations of this study and the need for future research, we must note some limitation, especially those arising from the definition and organization of the workshop.

Firstly, students' did not have the time to deepen and explore problematics related to the concept of authorship or data crediting in the development of their ideas, especially when speculating about the integration of AI systems, even though we are aware that is a relevant concern in several fields from law (Selvadurai and Matulionyte, 2020) to human-computer interaction (Samuelson, 2020) and social sciences (Miernicki and Ng, 2021). The implications of this framework on ethical and authorship-related issues have not yet been explored, as out of the scope of this theoretical investigation. Regardless, we recognize the significance of these concerns, particularly the need to respect the identity, values, and principles of both the fashion designer and the archive. In our opinion, this can be a key requirement to be incorporated into future design processes, especially if the content is related to the creative output of a single (fashion) designer. For example, in future application following the proposed framework it may be necessary to limit the field of action of user and provide clarifying information on how archival data is processed. Ensuring that proper credit is always given to the fashion designer and safeguarding the integrity of the archive's content from misuse or exploitation will be a crucial responsibility for the designers and developers of such archival systems. Likely, given the short weekly duration of the workshop, students were not required to explore or anticipate potential ethical implications unless they were directly relevant to their projects or speculative scenarios. However, we recognize the importance of addressing these considerations in future refinements and developments of possible applications.

Although most students engaged with the archive's users, visitors, and stakeholders and developed prototypes, the structure of the weekly workshop did not allow for follow-up testing of their ideas and prototypes. However, this remains an area for future exploration. While all students produced visual content to support their envisioned projects, the flexible nature of the delivery requirements - such as those related to prototypes - combined with our stronger focus on how students conceptualized and described the archive's role, contributed to the choice of not to insert images and detailed project description, which are available upon request.

Additionally, as noted at the beginning the study, this study was conducted in two distinct phases. The first phase was informed by literature review and analysis of select case studies, while the second phase related to the workshop was analyzed based on our qualitative interpretation of its results. This approach introduces certain limitations due to the contextualization of the workshop, which centered on a practical case study of an archive dedicated to a specific fashion designer, as well as the singularity of participants involved and therefore the subjectivity of their final projects. Nevertheless, the final framework presented in Section *A co-creative dialogue with the archive: a new framework* is primarily informed by the literature review discussed in the first part of the publication, with the workshop serving primarily to validate and refine the proposed direction.

Finally, to further validate and confirm the potential of interactive archives in the realm of fashion heritage, it would be beneficial to develop prototype applications starting from existing digital archives in the field in the future. These prototypes could be used to test the various approaches derived from the concept scenarios synthesized from the workshop results. Furthermore, a deeper exploration of the potential differences and opportunities among various digital databases - each shaped by the specific characteristics of their respective institutions - would be valuable. In this study, students referenced real-world examples of digital fashion designer archives, each with its own unique attributes. Further investigation in this area could help refine the proposed model, making it more adaptable to different database structures and institutional contexts.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

We affirm that no student's personal information has been collected or used in this study. No project material is presented singularly as submitted; rather, we present our interpretation of the design approach to establish the role of digital archives. Furthermore, we acknowledge that students conducted interviews to inform their project decisions. These interviews are mentioned in the text solely to describe their activities in a general manner. This study has not included or analyzed any direct data from these interviews. Our study approach aligns with ethical research practices, ensuring the privacy and confidentiality of all individuals involved.

Author contributions

Conceptualization, NB, MP, PK, and DS; methodology, NB, MP, and PK.; software, NB; validation, MP, PK, and DS; formal analysis, NB and MP; investigation, NB and MP; resources, NB, MP, PK, and DS; data curation, NB; writing—original draft preparation, NB and MP; writing—review and editing, PK and DS; visualization,

NB; supervision, NB and MP; project administration, MP and DS; funding acquisition, NB, MP, PK, and DS. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that Generative AI was used in the creation of this manuscript. Not being native English speakers, ChatGPT was adopted for sentence reformulation and syntax improvement, as well as for simple English spell-checking. We would like to remark that NO results or hypotheses advanced through the entire publication were the result of the use of a system that integrates (Generative) AI. In using it, the authors were careful to exclude all concluding sentences formulated by the AI system.

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