Case Report

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CO-DESIGNING FASHION WITH AI IN THE PHYGITAL SCENARIO

Co-design de moda com IA no cenário phygital

ABSTRACT

For several years, the fashion industry has been grappling with an exponential technological and digital transformation, revolutionising the way ideas are conceived, designed, produced, communicated and sold. Artificial intelligence, integrated in fashion design, gives rise to new scenarios and acts of cultural and social construction in which human creativity and technology merge into new co-creative and collaborative approaches. Through the analysis of two significant case studies, Robbie Barrat and Anna Yang, this contribution aims to investigate the methodologies and practices through which this emerging phenomenon modifies the fashion design process and the skills of the professionals involved. The analysis provides insight into the ways in which archives can be transformed into datasets and the process of human-technology collaboration in fashion design.

KEYWORDS

Artificial intelligence; Co-design; Fashion archives; Phygital.

RESUMO

A indústria da moda tem lidado com uma transformação tecnológica e digital exponencial há vários anos, revolucionando a forma como as ideias são concebidas, projectadas, produzidas, comunicadas e vendidas. A inteligência artificial, integrada no design de moda, dá origem a novos cenários e actos de construção cultural e social em que a criatividade humana e a tecnologia se fundem em novas abordagens co-criativas e colaborativas. Através da análise de dois estudos de caso significativos, Robbie Barrat e Anna Yang, este contributo pretende investigar as metodologias e práticas através das quais este fenómeno emergente modifica o processo de design de moda e as competências dos profissionais envolvidos. A análise fornece uma visão sobre as formas como os arquivos podem ser transformados em conjuntos de dados e sobre o processo de colaboração humano-tecnológica no design de moda.

PALAVRAS-CHAVE

Inteligência artificial; Co-design; Arquivos de moda; Phygital.

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1. INTRODUCTION

In 2022 Calvin Wong, professor in fashion at the Hong Kong Polytechnic University, presented AiDA, a device that enables fashion design through AI, allowing users to upload mood boards, color palettes, sketches, or complete patterns and generate new products. The process leads to a close integration of technology and humans, between algorithmic design and human knowledge. On one hand, fashion designers have the opportunity to accelerate the creative process and quickly obtain a large quantity of ideas and images from which to select the most convincing ones. On the other hand, the idea takes shape that even those who are not fashion designers can develop a fashion project and generate clothing and accessories by providing simple textual or visual inputs.

Fashion and technology have always been deeply intertwined, with a succession of technical, formal, and material innovations that allow us to view the history of fashion as a history of technology (Quinn, 2002, p. 3). In investigations of past and present technological changes, the focus is not solely on the diffusion and use of technical artifacts, but also on the acts of social and cultural construction that are intrinsically linked to the context and environment in which these artifacts manifest themselves. Throughout history, humanity has experienced technological change, but only rarely has technology radically transformed the social and political structure of society (Kissinger, Schmidt & Huttenlocher, 2021). As emphasized by Aant Elzinga, professor of Theory of Science, "technological change goes hand in hand with social reordering and cultural reinforcement or dissolution" (Elzinga, 1998).

Technological development in fashion design produces both material and immaterial impacts that range from the micro to the macro scale, from the human body to the territory. These innovations have multiple implications, including the reconfiguration of design and production processes, the redesign of manufacturing spaces, the relationship with territories and production districts, gender issues (Schroeder, 2016), and the redefinition of fashion timelines (Evans & Vaccari, 2020). However, more than other fields, fashion has turned technological innovations into elements of fracture that have generated opposition and different ideas of style, society, and the world: for example, the increasingly evident clashes that have emerged since the end of the 20th century between craftsmanship and industrial production; between handmade and machine-made; between unique pieces and mass production; between fast and slow fashion; between local and global; between analog and digital. These concepts are often considered in opposition and not integrated into a more nuanced panorama. These fractures appear even more pronounced today, in a moment of transition towards the so-called *Industry 5.0*, in which the relationships between humans, technology, artificial intelligence (AI), cloud, and generative design appear complex and difficult to decipher. AI is entering, more or less consciously, many aspects of daily life, ushering in a silent revolution that involves everyone. In fashion, significant changes are shaping the ways we think, design, produce, sell, and communicate.

One aspect that remains relatively unexplored is the application of artificial intelligence in the fashion design process and its impacts on the role and skills of the fashion designer. This contribution aims to begin to bridge this gap. In particular, through the theoretical perspective of the posthuman, it will highlight the possibility that AI becomes a co-designer, an entity to collaborate with, to exchange ideas and visual references, to share texts and archive images, and to generate shapes, volumes, and textures.

From a methodological point of view, the contribution defines a theoretical framework by analysing the existing literature that relates the concepts of posthuman, co-design and archives as data for fashion. The research was conducted by entering the following keywords on Google Scholar: artificial intelligence, co-design, fashion archives, and phygital, showing how this aspect of fashion is still little explored and consequently necessitating a critical analysis on the topic of the contribution. Subsequently, two representative case studies of two different ways of integrating AI in fashion design were selected: Robbie Barrat, investigated as an example of fashion archives as dataset, and Anna Yang, as examples of co-design between human and AI. The analysis conducted also highlighted how many dynamics are transversal

and how there are areas of overlap between the case studies examined. This demonstrates the inherent complexity of the various design acts and further conceptualises the significant role of AI in fashion design.

2. STATE OF THE ART

The fashion sector has undergone numerous transformations over the centuries, shaped by various industrial revolutions, culminating in the most recent one in which the use of new technologies has led to a gradual convergence between physical and digital spaces (Bertola & Teunissen, 2018). The emerging cyber-physical system of fashion involves the use of digital tools, experimentation with algorithms, and neural networks. These changes expand and complicate the role of the fashion designer, who must develop a shared language with other disciplinary knowledge, enhance technical skills, and interact with new software and algorithms. Additionally, the idea that technology allows non-designers and even machines to enter the field of fashion design opens up the possibility of deprofessionalizing the role of the fashion designer. In the current framework, where digital technology is radically transforming the systems of consumption and production of goods, services, and content, this speculation gains greater relevance. This is because, on one hand, the use of digital tools and strategies enables new modes of fashion production and expression; on the other hand, technology, by intervening in design dynamics, offers the possibility to optimize and transfer operations traditionally carried out in an analog manner into the digital realm. The topic of digital transformation has been a part of the debate surrounding the social aspects of fashion for several years, highlighting the need to investigate and analyze emerging forms of change. Literature suggests that fashion transformation is intrinsically linked to the evolution of both individual preferences and social contexts (Pezzini & Terracciano, 2021). Fashion is a "continuous change of styles" (Wilson, 2003, p. 3), but it is also "a structural disposition to accept innovation", as König emphasized (1988, p. 13, in Segre Reinach, 2010). The future, with its different implications, is shaping the ongoing debate about contemporary fashion (Smith et al., 2017), increasingly aware of being in a transitional moment (Irwin, 2015). The dichotomy between physical and digital, subject to continuous technological innovations that break down the dividing walls of the two meanings, thus lands in new territories of experimentation where everything merges into a single concept: *phygital*. The word *phygital* is a combination of 'physical' and 'digital', describing the complex interaction between physical spaces and digital technologies and the synergistic experience that combines the potential of both worlds. We find ourselves living in new, augmented spaces that represent a clear extension of our senses and allow individuals to inhabit new realities in unprecedented, fully immersive experiences that revolutionize the fashion universe (Vaccari, Franzo & Tonucci, 2020).

As far back as the 1960s, Marshall McLuhan had predicted that, thanks to technology, humanity would extend its central nervous system, surpassing the limitations of space and time, leading individuals to a new phase of their evolution in which consciousness is technologically simulated and knowledge is collectively shared (McLuhan, 1964). It is evident that today technology extends and expands most human actions into new digital scenarios and environments, allowing for significant changes in the values of many individual activities, including design, organization, and management. With the advent of digital media, our sensory systems have also expanded into space, and at the same time, the nature of space has transformed into a global dimension. This perspective, which considers media as extensions of our human senses – including the possibilities of technological simulation of consciousness – offers new perspectives in the field of fashion, especially as it becomes increasingly smart and interactive (Barile & Sugiyama, 2020). This suggests that, when a technological and cultural process rapidly expands and reaches a peak of intensification, it then transforms into something opposite to what it initially was, contaminating and blending into new phygital scenarios where the physical becomes digital, and the digital becomes physical. Fashion, in its continuous tension between the cultural and industrial system (Kawamura, 2018), constitutes an ideal testing ground for analyzing the

integration of Artificial Intelligence in this *phygital* and immersive space. Currently, literature addresses the topic of AI in fashion almost exclusively from the perspective of marketing, the sales experience, and user experience (Goti et al., 2023; Silvestri, 2020). There is an increasing number of examples of AI applications on e-commerce websites, which suggest products or services to users based on their preferences and buying habits.

While some of the literature explores the use of AI in the fashion system as a tool serving humans – consumers – and their needs (Iannilli & Spagnoli, 2021), other perspectives highlight the limitations of this anthropocentric view. In particular, reflections on the concepts of the posthuman (Braidotti, 2019) and cyborg (Haraway, 2016), introduced in fashion design by Anneke Smelik (2018), Natalia Särmäkari, and Annamari Vänskä (2022), together question the need to abandon an anthropocentric perspective and look beyond the human to seek new alliances with other living and non-living beings, including technology. This perspective allows for overcoming the dichotomies between the human and the non-human, avoiding placing the fashion designer and artificial intelligence in a state of conflict and opening up the possibility of collaboration.

An important aspect of the ongoing phenomenon – still underexplored by current literature and the subject of this contribution – is the role of AI in the fashion design and ideation phases, interpretable as an entity that co-creates and collaborates with the fashion designer. We are witnessing a radical transformation of languages in which it becomes necessary to understand how they can be managed and interconnected. The growing use of AI and digital automation tools in fashion design, which is becoming increasingly algorithmic and generative, exponentially alters this discipline, co-evolving in parallel with technological, social, and cultural changes. The generative design process is therefore examined as an iterative and collaborative process where, starting from an initial goal, the fashion designer defines variables and constraints. These are formalized through inputs capable of guiding the process of a given algorithm, which processes input data a very large number of times, yielding various types of outputs for the fashion designer (Nachtigall, 2021). Consequently, it is the designer, from a collaborative perspective, who analyzes and experiments with the calculation results, modifying the starting inputs if they do not conform to the designated goal. The iterative and cyclical nature of operations defines the process, which can be regenerated infinitely until a product that meets the desired requirements is achieved. Artificial intelligence is based on the analysis and interpretation of significantly complex data to generate predictions and create text and images based on the same data. According to Gloria Maria Cappelletti, creative director of RED-EYE, the first magazine dedicated to the links between fashion, artificial intelligence, and the metaverse, harnessing the potential of AI to design products based solely on consumer-related data, their searches, and purchasing experiences represents a potential drawback in this new scenario. There is a risk of producing collections that reflect the taste of a global market, preventing young fashion designers or independent brands that lack the resources to adopt new technologies from progressing (Vaccari & Franzo, 2022, p. 62). In parallel, according to her analysis, creativity should be promoted and supported, freeing itself from consumer demands, as in fashion, the most significant moments have occurred when designers have radically challenged the system, breaking the rules dictated by the demands of the moment.

3. CASE STUDIES

Starting from this framework, we will analyze two case studies in which AI has been integrated into the fashion design process, with the aim of conceptualizing two phenomena: the transformation of a fashion brand's archive into a dataset that AI can reprocess to generate new outputs in line with the previous aesthetic, and the development of co-design processes in which fashion designers, non-designers, and artificial intelligence collaborate to generate new ideas and products. The first approach is investigated through the work of Robbie Barrat, through the concepts imagined for Balenciaga and the collection developed by the artist in collaboration with Acne

Studio; the second through the work of Anna Yang, fashion designer of the Annakiki brand. Robbie Barrat is an artist and graphic designer who uses artificial intelligence as both a tool and a medium. In 2018, as a personal project, Barrat used AI to generate images of a hypothetical collection for Balenciaga. He incorporated and utilized images extracted from extensive online documentation of the brand, including lookbooks, catalogs, and marketing campaigns, to train the pix2pix neural network. Using a GAN (Generative Adversarial Network), Barrat was able to closely examine the machine learning process, identifying the selected images within the latent space of the GAN, which can be informally thought of as an abstract space where synthetic images are generated before being transformed into visually perceivable images on the display. By analyzing the GAN's learning process and accessing the latent space, Barrat selected synthetic images with specific characteristics or visual styles, using them for further analysis as well as for artistic and design purposes. The final result of the procedure was a series of images that contained representations of models with physical anomalies or unusual clothing and color combinations that deviated from the brand's style. From the analysis of the images, it is evident that the network lacks any contextual awareness of the functional aspects of clothing. This is reflected in high shoulders and necks, pants with bulky bags attached to the leg, jeans and sweaters grouped into a single piece; accessories, such as bracelets, often appear as fragments of fabric held in the model's hand; belts and bags merge into the models' legs (Fig. 01).

Fig. 1
Robbie Barrat, A look from a hypothetical Balenciaga collection created with AI, 2018.

Even more significant for the investigation is a second project developed by Barrat: the collaboration with the fashion brand Acne Studios, culminating in the Fall/Winter 2020 men's collection. Unlike the previously analyzed case, here the exploration of artificial intelligence's potential did not limit itself to the concept and 2D visualization phase of ideas but continued with the physical production of garments generated by AI. Within a neural network – trained by Barrat not to learn according to the classical fashion standards – thousands of looks from the brand's archives were input. The outputs returned by the neural network were unconventional fashion images where it is possible to identify defects caused by algorithm misinterpretations. Faithfully utilizing the renderings obtained through artificial intelligence, creative director Jonny Johansson then physically reproduced the selected outfits, retaining the same errors caused by the neural network in the garments produced (Fig. 02).
Examples include a perforated shirt resulting from glitches generated by the low-quality rendering engine, a buttonless polo, distorted and warped snake-skin prints, unique curved openings in the front and bottom of the presented coats, a direct consequence of the algorithm's malfunction in processing clothing edges, and wrinkled or frayed fabrics (Fig. 03).

Figs. 2 & 3
(Left) Acne Studio, Fall/Winter 2020 men's collection, collaboration with Robbie Barrat and AI, 2020. The physical garment reproduces the glitches and the errors of the digital garment obtained with AI. (Right) Acne Studio, Fall/Winter 2020 men's collection, collaboration with Robbie Barrat and AI, 2020. The physical garment reproduces the glitches and the errors of the digital garment obtained with AI.

The second case study analysed in this contribution, focused more specifically on the dynamics of co-design that are activated, is the work of Chinese fashion designer Anna Yang, founder and creative director of the Annakiki brand. In 2019 she co-designed a fashion collection with AI using a smartphone and a mobile app. A particular process was adopted that leverages the dual neural processing unit (NPU) found in smartphones from the Asian brand Huawei. Artificial intelligence was trained by providing a dataset of 30,000 images representing the most relevant fashion shows of the last hundred years and a specific set of photographs of Annakiki's latest collections. Subsequently, the Fashion Flair app was used to involve the brand's customers in the design process, further expanding the co-design process. An image gallery was generated by AI and indexed to respond to the application of four user-set filters: colors, shape, length, texture; each user could choose the desired parameters and select images proposed by the app's gallery, one for each filter; AI generated outputs in line with the user's preferences (Fig. 04).

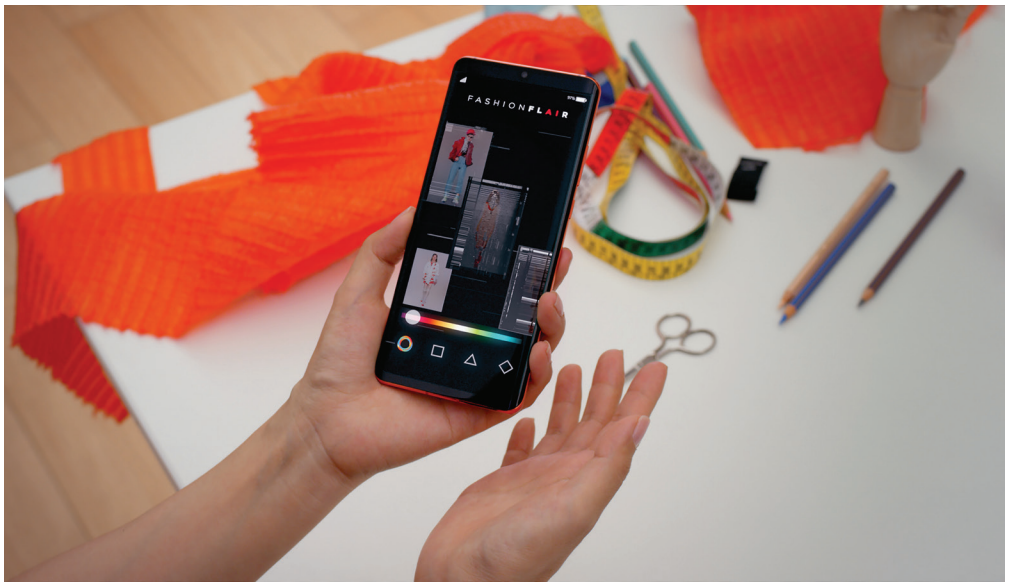

Fig. 4
Annakiki, Co-designing with Fashion Flair AI app, 2019.

The fashion designer entered the design process only at the end of this phase, selecting the images obtained from the collaboration between AI and customers and further adapting them to the brand's style. The result of this process manifested itself in May 2019 with the Annakiki collection for Huawei, consisting of twenty outfits presented in a fashion show and sold in stores.

4. FINDINGS

The analysis of the case studies described in the previous section shows how the integration of artificial intelligence in fashion design is significantly redefining the methods and processes of the fashion system. In particular, by analysing the project in which Robbie Barrat realizes hypothetical concepts for Balenciaga, we are able to more clearly conceptualize the design changes taking place. In the traditional ideation phase, fashion designers use sketches, drawings, and prototypes as tools to construct external representations of their design concepts. Barrat's work demonstrates how the integration of artificial intelligence into this initial phase of the design process revolutionizes and accelerates the process, allowing for immediate comparison between the idea and its representation, and expanding the designer's creativity. This acceleration of ideation processes gives rise to the concept of 'ultra-fast fashion'. The aforementioned definition is not related to the issue of excessive and rapid material production of clothing and fashion accessories, but rather to the speed of immaterial production that artificial intelligence models have in generating an infinite quantity of images in very short timeframes.
From the collaboration between the artist and the Acne Studio brand, it emerges in more detail how in this phygital territory the methodologies of fashion design evolve and hybridise, manifesting new forms of reverse design (Vaccari, 2012, p. 89). The creative process, in fact, arrives almost instantaneously at a photographic visualisation of how the final product should appear and, through work on materials, modeling, fit, and details, reconstructs the garment in every detail. Furthermore, the analysis of Robbie Barrat's work on fashion archives as sources of data for the project allows us to theorise how fashion is created and worn using data as materials. The act of making specifically does not translate, in the analyzed case, only as a performative act, but also as a creative act involving the construction and transformation of meaning (Sanders & Stappers, 2014), the result of mixing and hybridising with various knowledge, disciplines and artefacts. Starting from data, which can thus be considered as the metaphorical DNA of the products designed by the artist, another reflection brings out their close connection with fashion design in terms of ephemerality. Fashion is ephemeral

as data itself is ephemeral, showing on the one hand how fashion designers have quickly learnt to manipulate the transitory nature of fashion by orchestrating its trends, and on the other hand how data and fashion influence each other. This is because it is evident how data science is able to tell us something about fashion and how fashion history is able to tell us something about data science. This case study demonstrates how, through the use of artificial intelligence, it is possible to combine the physical and digital environments, reactivating archival materials, reinterpreting the brand's heritage, expressing a new form of creativity, and materializing it through technical and manual skills. Fashion is configured both in its physical and digital dimension in a continuous wave motion capable of generating new futures.

From the analysis of the second case study, Anna Yang with her Annakiki collection in collaboration with Huawei, the alteration of design processes with the integration of AI and the close interdependence between technology and humans becomes more evident. In particular, in this case, the project arises from a close relationship between fashion designers, artificial intelligence, the brand's archive, the history of fashion, and customers. Through the app, users and their preferences actively participate in the ideation process, providing moodboard and concept indications to the design team and, notably, to AI. The fashion designer therefore finds himself interacting not only with bodies, but also with the mind, the senses, and thought, living in a world of non-things (Han, 2023). At the same time, new collaborative relationships emerge, established not only through the use of new technologies, but also through the acquisition of new knowledge and synergies in a transdisciplinary and co-design perspective in which the fashion designer is transformed into an increasingly hybrid figure, hybridised by the metamorphoses of time. The designer is transformed from Human to 'Human+' (Ranzo & Scarpitti, 2023), not to be understood as an empowered figure, but as a figure capable of going beyond any existing anthropological type. Generative systems offer, as analyzed in Anna Yang's work, a real paradigm shift (Kuhn, 1996) in design practice, in the design process and in the material expression of the process. This shift affects the interpretation that designers can give to artefacts and the actions that manipulate them (McCormak et al., 2004), effectively shifting the focus from individual objects and components to a holistic and collaborative view that interprets artefacts as systems and processes composed of interacting parts.

5. CONCLUSIONS

The development of new technologies and Artificial Intelligence is profoundly altering the fashion system as a whole. The awareness of being in a transitional phase leads to a reconsideration of previous logic and the professions involved. But, above all, it requires the formulation of new questions, and not simply new answers to the same questions of past decades. The question arises to what extent artificial intelligence and the data processed by it influence the meaning and perception of a garment, whether methods such as co-design or participatory design empower and alter the role of the fashion designer, and how AI transforms fashion design.

As highlighted in this contribution, the design process is inevitably redefined due to the unprecedented relationships between humans and technology. The proliferation of AI systems, as explored, impacts both design theory and practice. The relationship between the design process and technology now transcends the purely functional level to enter the realm of the existential. Through the analyzed case studies, it has become apparent how the creative processes are changing, what role archives and history can play, and how designers, non-designers, customers, technology, and the material and immaterial dimensions can collaborate. AI integrated into fashion design, in fact, transforms the fashion project into an iterative flow based on reactive feedback where processes are influenced not only by the use of data as new design tools but also by the artefacts themselves which, once selected and prototyped, could feed the artificial intelligence algorithms in order to obtain new variants

of the same, in a perpetual cycle that is difficult to stop. It becomes, therefore, essential to bring back to the centre of the debate the role of the fashion designer who becomes essential in the project to manage the generative flow.
It is evident that the acceleration of processes and idea visualization through AI allows for resource optimization and a reduction in experimentation and material consumption, facilitating more sustainable approaches. One of the main implications of this evolving landscape is the possibility for new professionals, both human and non-human, to be involved in fashion design. Just like human fashion designers, computers can be legitimized and authorized for fashion design. However, this occurs through input provided by humans, allowing them to guide the workflow. At the same time, machine designers may take on new roles as designers, employing innovative approaches to meet the needs and desires of people. However, although artificial intelligence can produce many formal, aesthetic and content implications, the generative approach applied to fashion design has constructed an induced aesthetic that could homogenize artifacts both from a formal and design point of view. There is a chaotic proliferation among various entities that refer without any logical, conceptual and functional connection to fashion products of difficult interpretative key complicating the role of the fashion designer. The designer, in fact, finds himself in an additional effort of physically reworking the random outputs generated through automatisms by a software that iterates a series of operations without any understanding or knowledge of the discipline of fashion design. This is strongly manifested in both case studies investigated in which, on the one hand, significant flaws in the construction and structure of the models explicitly emerge and, on the other hand, the need to intervene in the outcome of the generations by redesigning their silhouettes.

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