



Article

Unlocking the Potential of Artificial Intelligence in Fashion Design and E-Commerce Applications: The Case of Midjourney

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Abstract: The fashion industry has shown increasing interest in applying artificial intelligence (AI), yet there is a significant gap in exploring the potential of emerging diffusion-modeling-based AI image-generation systems for fashion design and commerce. Therefore, this study aims to assess the effectiveness of Midjourney, one such AI system, in both fashion design and related commerce applications. We employed the action research approach with the Functional, Expressive, and Aesthetic (FEA) Consumer Needs Model as the theoretical framework. Our research comprised three stages: refining an initial idea into well-defined textual design concepts, facilitating concept development, and validating the preceding observations and reflections by creating a new line of hemp-based products that were evaluated by targeted consumers through an online survey. Findings reveal that this AI tool can assist fashion designers in creating both visually expressive attire and ready-to-wear products, meeting defined design criteria and consumer needs. Midjourney shows promise in streamlining the fashion design process by enhancing ideation and optimizing design details. Potential e-commercial applications of such AI systems were proposed, benefiting physical and digital fashion businesses. It is noted that, to date, the major limitations of using Midjourney encompass its restriction to only facilitating early fashion design stages and necessitating substantial involvement from designers.



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1. Introduction

Artificial intelligence (AI), a computational system imitating human cognitive functions, shows immense potential in executing intricate tasks like data analysis, object recognition, and image processing, facilitating autonomous and collaborative problem solving [1,2]. Its wide-ranging applications include natural language processing, autonomous vehicles, and visual image synthesis, with expectations for continued growth [1]. The influence of AI applications quickly extends into the textile and apparel industry, manifesting in various aspects including big data analysis in the supply chain, sewing robots, personalizing advertisements, color trend forecasting, and supporting apparel design systems [3–9].

Since 2021, AI text-to-image generators utilizing deep machine learning and diffusion modeling have garnered substantial attention from scholars and practitioners, prompting research and discourse on their potential applications [10–12]. In 2022, an emerging artist who utilized Midjourney, an AI-powered image-generation program based on diffusion modeling, received an award at the prestigious Colorado State Fair's art competition [13]. This recognition has spurred further exploration among artists and designers into the capabilities of such AI systems in image generation from initial ideas or inspirations. Several emerging diffusion-modeling-based AI text-to-image generation platforms, including Disco Diffusion, Midjourney, Stable Diffusion, and DALL-E 2, have garnered considerable attention within the practical and academic communities. Among these platforms, Midjourney

stands out for its remarkable advancements, positioning it as an exceptional tool for designers and artists in their creative processes. For instance, in the study conducted by Lyu, Wang [11], Midjourney was selected by a panel of aesthetics experts as the preferred AI tool for generating experimental paintings, underscoring its efficacy and relevance in an artistic context. Additionally, Jaruga-Rozdolska [2] highlighted the potential of Midjourney in architectural design, while Ruskov [14] demonstrated its favorable assistance in generating illustrations depicting fairy-tale themes. However, there remains a significant research gap regarding the utilization of advanced diffusion-modeling-based AI image-generation systems, such as Midjourney, in fashion design and related commerce applications.

Fashion design is pivotal in driving innovation within the fashion industry [4,15]. While fashion designers infuse their unique preferences, methodologies, and practices into the design process, it typically unfolds through four fundamental stages: concept generation, design development, prototyping, and solution [16,17]. Concept generation marks the inception of design ideas, commencing with initial concepts that gradually evolve into tangible design propositions through research and experimental exploration [17]. Design development encompasses the meticulous refinement of specific design concepts, considering factors such as silhouette, construction, fabric, and aesthetics [16]. Prototyping involves transforming design details into three-dimensional representations, while the solution stage involves realizing design requirements, including craftsmanship, quality, and finishing [17]. Moreover, the stages of concept generation and design development significantly influence the trajectory of the fashion design process, guiding subsequent steps like production, presentation, and promotion, ultimately determining the design's market success [17,18]. Despite its importance, the ideation stage presents challenges due to its inherent ambiguity, context specificity, and close ties to individual designers' philosophies and creative understanding [15,18].

The introduction of diffusion-modeling-based AI text-to-image generators holds promise for revolutionizing the concept generation and development processes within fashion design. These advanced AI systems possess the capability to rapidly generate diverse and unique digital images based on input keywords, textual descriptions, photographs, or specific parameters [10,11]. This functionality empowers designers to access a wide array of visual references, facilitating rapid digital experimentation and addressing complex design objectives, thereby expediting the fashion design process [2,10]. Consequently, there is a pressing need for empirical investigation into the practical utilization of such AI-powered text-to-image generators in the field of fashion design.

The Functional, Expressive, and Aesthetic (FEA) Consumer Needs Model, introduced by Lamb and Kallal [19], has gained wide acceptance and validation among scholars in the apparel design field. Serving as a comprehensive conceptual framework, it enables the design of various fashion products, catering to both functional and fashion-forward aspects [20]. Central to the model is its capacity to help designers systematically assess the design process, refine design criteria, and address challenges to meet target consumers' needs and preferences [20]. Hence, in this study, the FEA model served as the theoretical foundation to guide the design process and suggest potential commercial opportunities.

The action research approach is renowned for its utility in generating practical knowledge and fostering innovation across diverse domains such as software engineering and education [21–23]. It has gained prominence in accelerating technological advancements within both academic and industrial realms [21–23]. In particular, this methodology engages researchers in real-world settings to explore the advantages, practical challenges, and potential solutions of emerging technologies, yielding authentic and actionable insights for their application and refinement [24]. Accordingly, we adopted the action research approach to observe and reflect on the integration of emerging AI image-generation systems in fashion design. To address the research gap and consider the aforementioned factors, this study aims to employ the action research method and the FEA Consumer Needs Model as the theoretical framework to examine how AI text-to-image generators based on diffusion modeling could support the concept generation and development processes of fashion design.

while exploring associated commerce potentials. Specifically, this study seeks to explore and investigate the potential of AI in fashion design using Midjourney as a specific case.

The research objectives are fourfold. Firstly, this study endeavors to examine the role and potential impact of Midjourney within the concept generation process of fashion design, with a specific focus on its ability to facilitate the transformation of an initial idea into detailed fashion design concepts. Secondly, we intend to delve into the capabilities of Midjourney in further developing the fashion design concept by refining input prompts including keywords, texts, images, and other specialized parameters. Thirdly, this research encompasses an examination of the constraints related to the application of Midjourney, within the realm of fashion design. Lastly, by scrutinizing the functionalities of Midjourney in the fashion design workflow, we aim to delineate potential commercial avenues associated with this AI tool.

Our research findings demonstrate the capabilities and constraints of Midjourney within the fashion design process. This AI tool aids fashion designers in concept generation and design development, enabling the creation of visually expressive attire and ready-to-wear products that meet design criteria and consumer needs. Additionally, such AI systems hold promise for e-commerce applications, benefiting both physical and digital fashion enterprises. However, the effective application of Midjourney remains in the early fashion design stages and requires substantial involvement from designers.

To the best of our knowledge, this study represents a pioneering endeavor to investigate the efficacy of employing an emerging diffusion-model-based AI tool in facilitating fashion design. This research contributes significantly to fashion design practice by harnessing the potential of such AI text-to-image generation systems and providing valuable implications and practical guidance to fashion designers and industry professionals. Moreover, this research imparts notable theoretical contributions by enriching the existing knowledge body on AI-driven image-generation systems, fashion design, the FEA Consumer Needs Model, and action research.

2. Literature Review

2.1. AI Image-Generation System

In recent years, significant advancements have been made in the domain of image synthesis based on AI technology [7,11]. The emergence of generative adversarial networks (GANs) and variational autoencoders (VAEs) has paved the way for generating high-quality images [25]. An increasing body of research has unveiled the potential of AI-driven image-generation tools in supporting various aspects of fashion design, such as assisting digital fashion sketches and automatically mapping 2D garment images onto human figures [5]. Among these tools, GAN-based AI image-generation systems have garnered intensive attention and investigation within the fashion industry [4,5,8]. To simplify, GAN-based image generators are AI-driven systems that facilitate image-to-image translation [4]. These systems utilize an image database as input to produce a collection of new images that exhibit similarities with, yet possess distinct characteristics from, the original resources [5].

More recently, the advanced technique of text-to-image generative artificial intelligence (GAI) based on diffusion modeling has gained popularity for its astonishing ability to swiftly create appealing, high-resolution, and varying styles of images in response to human natural language prompts [11,25]. This advancement has sparked intensive scholarly discussion and application in diverse fields, such as within the realms of art creation, graphic design, illustration, and architectural design [2,10,11,14].

The operational mechanism of diffusion modeling in AI image-generation systems encompasses three fundamental steps [11]. Initially, the system utilizes input prompts such as keywords or textual descriptions to retrieve relevant images from the Internet or a predetermined dataset. Subsequently, random noise is added to obscure the selected image information, creating variations. Finally, a denoising diffusion process is employed to produce novel images that align with the provided prompts. It is noteworthy that repeating identical input prompts will not yield the same results, as the program randomly

selects matching images from the database each time, meanwhile introducing further variability [2]. Therefore, it is assumed that each image produced by such AI systems is distinctive and original.

Nevertheless, previous studies have disclosed that adjusting prompts to achieve desired results is quite challenging, as even slight modifications can lead to significant variations in the output [2,11]. In response to this issue, the concept of prompt engineering has emerged, which refers to refining input prompts to effectively attain satisfactory outputs [14,26]. Specifically investigating how to use diffusion-modeling-based AI text-to-image systems to create digital art, Oppenlaender [26] conducted a three-month ethnographic study within the online community and identified six categories of prompt modifiers utilized by practitioners: subject terms, style modifiers, image prompts, quality boosters, repetition, and magic terms. While existing research on prompt engineering offers practical implications for leveraging such AI text-to-image generators, it is important to recognize that different domains may have distinct focuses and methods for refining prompts to achieve the desired outcomes.

2.2. Midjourney

Established in 2022 by an independent research lab led by David Holz, Midjourney attained profitability in the same year [1]. As a text-to-image generator based on the diffusion model, Midjourney is currently available in open beta and can be accessed through Discord [1,11]. Through utilizing the /imagine command and inputting prompts, such as keywords and specific parameters, this AI-driven image system produces four preliminary digital images that align with the provided data [2]. Subsequently, users have the option to utilize the image variation function, allowing them to acquire numerous diverse output images based on the same prompts, or adjust the input prompts to yield a greater variety of distinct visual outcomes [2,11]. Midjourney's exceptional performance in producing high-quality and visually captivating results has garnered wide recognition both within academic research and among practitioners [2,11,12].

Thus far, the academic literature has offered scant attention to exploring the utilization of Midjourney in fashion design and its potential commercial applications. To our knowledge, only one conference paper has investigated the impact of Midjourney on footwear design creativity and feasibility [27]. However, this particular investigation employed only 17 simple prompts for generating fashion images and did not explore the optimization of input prompts for desired outcomes [27]. Consequently, the full potential of this AI-driven image generator remains untapped in both the design process and the associated commercial dimensions within this research context.

In the context of art and design creation, certain potentials and limitations of Midjourney can be identified and summarized from the existing literature. First, Midjourney demonstrates its capacity to generate a wide range of digital images across various categories and styles [11,12]. For example, users can achieve high-quality results by inputting specific styles like vintage or referencing renowned artists such as Andy Warhol. Second, this system is adept at managing complex prompts involving textual, visual, and parameter inputs [2]. Third, Midjourney could serve as a tool for inspiration generation by rapidly presenting visual alternatives [10]. Fourth, this AI tool also demonstrates proficiency in capturing intricate details and managing scenes with multiple characters or objects [14]. However, two major limitations have been identified: the absence of an automatic image-editing function and the challenge associated with handling and refining input prompts [2,11].

2.3. The EFA Consumer Needs Model

The Functional, Expressive, and Aesthetic (FEA) Consumer Needs Model, initially introduced by Lamb and Kallal [19], offers a comprehensive framework for guiding the design of diverse apparel items [20]. The focal point of the FEA model is the interpretation and fulfillment of user needs and usage considerations, making it imperative as

a fundamental guide for design work aiming at achieving commercial success [19]. The functional facet of this model addresses consumers' sought-after utility, encompassing elements such as protection, fit, and comfort [28]. Expressive considerations delve into the communicative, symbolic, and emotional aspects of dress in various contexts, as attire can convey a spectrum of messages between wearers and observers [20,29]. The aesthetic dimension arises from the human inclination for beauty within cultural standards [20]. These functional, expressive, and aesthetic dimensions interplay, allowing for modifications tailored to specific design challenges and catering to the diverse needs and desires of consumers [20]. While the existing literature has suggested additional dimensions beyond the fundamental three, such as adaptability [30], structure [31], and emotion [32], these can be viewed as components inherently existing within the FEA model; for instance, the emotional dimension aligns with the expressive criteria of this model [20].

The FEA model's strength lies in its inherent comprehensiveness and flexibility, making it applicable to diverse design conditions, various product types, and different consumer segments [20]. This model encourages designers to adopt a holistic and creative approach, integrating consumer needs and design considerations into the design process [20,33]. It prompts designers to establish and refine design criteria and systematically evaluate each stage of the fashion design process within various cultural contexts [20]. Moreover, the FEA model's underlying structure assists designers in managing conflicting needs when designing user-centered products [20]. While the FEA model offers flexibility across different design environments, it is the responsibility of designers or researchers to investigate and define the criteria essential for meeting consumer needs, whether at an individual or market-specific level [20].

3. Research Method

In this study, we employed an action research approach to investigate the effectiveness of Midjourney's applications in fashion design, particularly in concept generation and design development processes. Action research is a participatory approach aimed at understanding and addressing practical issues related to emerging technologies or tools [24]. It emphasizes purposeful learning, practical application, observational analysis, and reflective thinking [23]. Moreover, the action research process is characterized by its iterative and cyclical nature, involving four fundamental stages: planning, execution, observation, and reflection [22]. Through this iterative process, researchers can refine their actions and achieve their intended objectives [22,23]. Thus, employing the action research approach is pertinent to our study context.

Midjourney was selected as the primary instrument for investigating the potential impact of AI on fashion design. To ensure the effectiveness and efficiency of this action research project, a comprehensive learning process preceded its implementation. This involved studying the operational instructions available on Midjourney's official website (<https://www.midjourney.com>, accessed on 1 July 2023) and actively engaging in related online communities to observe effective utilization strategies employed by other users. To achieve the research objectives, this research followed a three-stage action research process. We began our research by designing a line of expressive dresses that posed greater challenges in concept generation and design development. We then transitioned to the category of ready-to-wear clothing and accessories for validation purposes. The design criteria were initially formed based on the FEA Consumer Needs Model but were adjusted to align with our research objectives and the characteristics of the AI tool's outcomes. As a result, there are variations in design criteria between the initial phases and the validation stage.

Given that the design outcomes generated within Midjourney are limited to digital images, during the first two stages, the functional aspect of design criteria focused on the depiction of structure, craftsmanship, and fabric. The expressive criterion aimed to assess whether the outcome effectively conveys symbolic meaning, while the aesthetic gauge emphasized visual appeal and the allure of fashion. The first stage of our research

concentrated on investigating the impact of Midjourney on the concept-generation process of fashion design. Specifically, we aimed to observe and understand how this AI-based image generator could refine the initial concept of “a female fashion dress representing the symbolic meaning of rebirth” into well-defined textual design concepts.

Moving to the second stage, our primary objective was to explore how Midjourney could facilitate the design development process. This involved analyzing and visualizing detailed textual descriptions derived from the preceding ideation phase. Midjourney’s ability to rapidly produce high-fidelity digital images [2,11,12] allowed us to evaluate and refine fashion concepts simultaneously. Positive outcomes from the evaluation guided further development, while negative feedback prompted the generation of additional variants or prompt revision. The central focus of this stage was to explore effective prompt refinement strategies to attain desired outcomes, involving a thorough examination of available prompt types and content.

In the third stage, our objective was to validate the observations and reflections from the previous phases by exploring Midjourney’s potential to generate hemp-based fashion products. This idea stemmed from the significant potential of hemp-based fabrics within the fashion industry, particularly in response to the increasing demand for sustainability. Despite the legalization of hemp production in the United States under the 2018 farm bill, hemp-based fabrics have yet to see widespread adoption in the fashion sector [34]. However, hemp fiber stands out as one of the most environmentally sustainable natural fibers due to its various ecological benefits during cultivation, including biodiversity promotion, soil protection, minimal need for herbicides or pesticides, and significant carbon capture [34,35]. Textiles derived from hemp fiber offer wearers numerous benefits, including a conducive environment for physiological comfort, positive contribution to skin health due to their antioxidant, antibacterial, and anti-UV radiation properties, and exceptional durability [36]. Given these considerations, we sought to investigate whether Midjourney could generate various categories of ready-to-wear hemp fashion products that meet design criteria and consumer needs, including casual attire for both genders and handbags. Thus, drawing upon the FEA Consumer Needs Model, we integrated the generation of diverse product types into the functional design criteria and adjusted the expressive criterion to focus on consumers’ enjoyment of wearing hemp fashion garments in this phase of action research.

It is essential to highlight that throughout the stages of the action research process, we adopted an iterative and spiral approach. In the initial stage, 272 digital images were generated to facilitate the concept generation of fashion design. During the design development phase, a collection of 244 images was created. In the third stage of action research, approximately 151 fashion images were generated as outcomes. This dynamic and iterative methodology enabled the continuous refinement and further development of ideas and design concepts, facilitating a comprehensive exploration and evaluation of the utilization of Midjourney. In addition to exploring the potential benefits of Midjourney in inspiring ideation and facilitating the development of fashion design, we also dedicated effort to observing and summarizing the related boundaries and limitations of its utilization at all three stages. This approach ensured a thorough analysis of its capabilities and constraints.

4. Observations and Reflections

4.1. Concept Generation Process

Through iterative action research, our study revealed the significant potential of Midjourney in enhancing the efficiency of concept generation in fashion design. This AI image generator rapidly translates basic ideas into detailed design concepts, covering symbolic meaning, style, color, fabric, silhouette, and craftsmanship. However, researchers must actively guide the process. Collaborating with Midjourney, we developed two satisfactory textual descriptions of fashion concepts based on initial keywords. A visual depiction of an effective concept generation workflow in Midjourney is presented in Figure 1.

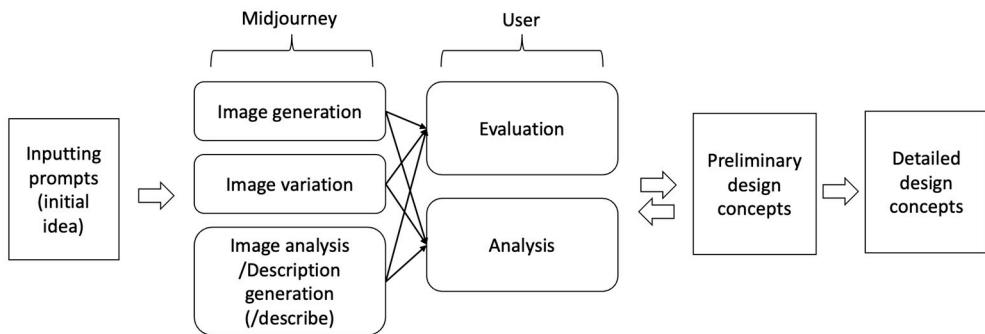


Figure 1. Concept generation workflow within Midjourney.

The image-generation function (`/imagine`) is fundamental to Midjourney's application, swiftly producing four initial digital images upon inputting keywords. Image-generation speed varies based on two models: the fast model, quicker yet costlier, and the relaxed model, slower and less expensive. In fashion design concept generation, Midjourney's image variation function plays a crucial role, generating four additional unique images each use, aiding in amassing a diverse visual repository for creative inspiration. However, assessing numerous images and deciding which elements to incorporate pose challenges, highlighting the need for the FEA Consumer Needs Model to establish design criteria. Nonetheless, this approach requires certain thresholds such as an appreciation for aesthetics and a knowledge base in fashion design. Consequently, the adoption of AI-powered image generators like Midjourney can expedite the concept generation process of fashion design, but it may not be universally suited for all users. It proves particularly advantageous for well-trained fashion designers who can effectively navigate and extract value from its capabilities.

The "`/describe`" function in Midjourney significantly aids the ideation phase of fashion design by thoroughly analyzing specified images and generating concise textual descriptions highlighting key attributes like subject matter, style, and coloration. This function produces diverse descriptions upon repeated use, enabling designers to obtain multiple distinct textual descriptions of the same image. Two examples utilizing the "`/describe`" command, along with corresponding images and textual descriptions generated by Midjourney, are illustrated in Figure 2 to illustrate its effectiveness.

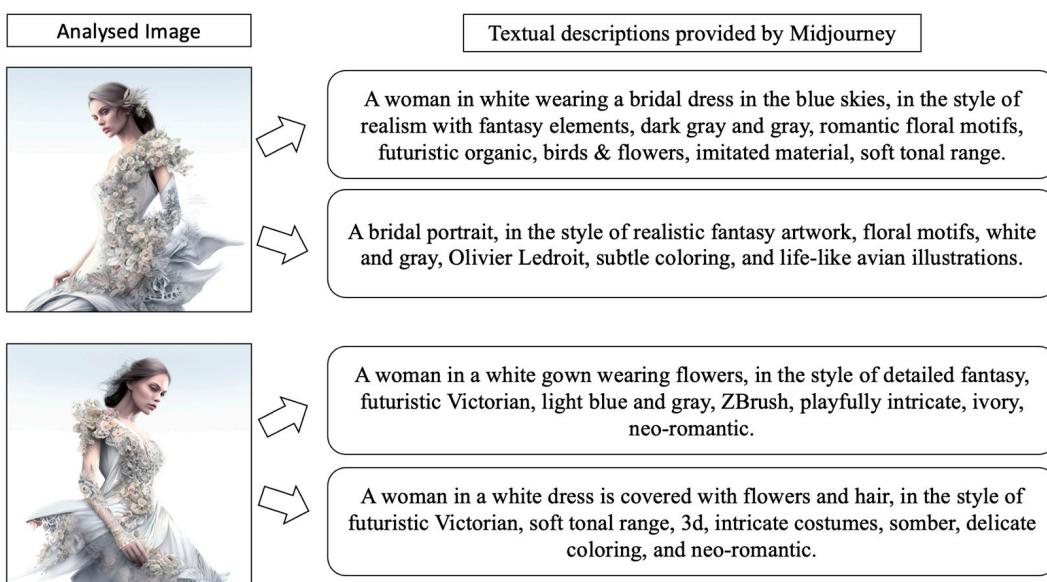


Figure 2. Examples of employing the `/describe` function in Midjourney.

Through iterative action research, it has become evident that utilizing the image-generation and variation functions, combined with the analytical capability of the “/describe” command, efficiently transforms initial concepts into detailed textual descriptions of fashion design concepts. Starting with the input of two primary keywords to generate visual references, a selective analysis was subsequently conducted on several output images deemed comparatively satisfactory by leveraging the capabilities of the “/describe” function. Similar to content analysis, all generated textual descriptions were meticulously reviewed and grouped based on similar keywords. Additionally, keywords resonating with our inspirations were identified, thus fortifying the foundation of our creative process. Ultimately, this investigative process yielded the culmination of two distinct preliminary design concepts: one inspired by the phoenix’s symbolism of rebirth and rejuvenation, and the other representing the transformative process of a butterfly emerging from its cocoon.

The initial keywords were refined to create concise descriptions aligning with two preliminary design concepts. Subsequent iterative image generation and variation formed the basis for crafting detailed design concepts based on predefined functional, expressive, and aesthetic criteria. The first design concept entails a feminine dress, inspired by the mythical phoenix. Its aesthetic composition features gracefully flowing lines accentuated by a vibrant color palette dominated by red and orange hues. The dress is characterized by a cinched waistline adorned with intricate embroidery, while layers of diaphanous fabric and a delicate trailing extension enhance its composition. The second design concept centers on a female dress symbolizing transformative processes. Constructed from superimposed iridescent fabrics, the dress captures the essence of the metamorphosis. The structured bodice features lines or angles, evoking a sense of resolute transformation, while the skirt gradually fans out into supple, billowing layers, resembling a butterfly gracefully emerging from its cocoon. This accentuates the essence of rebirth and renewed splendor. Notably, the use of the “/describe” command aids in both ideation and prompt refinement in the design process, offering valuable recommendations to designers. However, it is crucial to point out that designers must actively engage in the intricate task of evaluating, analyzing, and scrutinizing output images and the textual descriptions generated by Midjourney. For instance, a description in Figure 2 references the name of a French comic book artist, Olivier Ledroit. If designers are not familiar with this artist, further research is required to ensure a comprehensive understanding.

4.2. Design Development Process

During the fashion design development stage, Midjourney has demonstrated exceptional performance with the high involvement of researchers. This AI-powered system exhibits remarkable speed in generating digital images based on detailed textual prompts outlining two specific design concepts. Our observation indicated that using this system’s fast model produced around 12 digital images in less than 60 s. This speed exceeds that of existing design software, highlighting the significant impact of AI image-generation systems, as emphasized in recent research [1,2,10].

When we provided Midjourney with specific and detailed textual descriptions of design concepts, the resulting digital images exceeded our expectations. Midjourney adeptly generated both fashion design sketches and photorealistic effects, with a significant portion of the outcomes displaying visually pleasing aesthetics and high quality, aligning with previous research [2,11]. Over half of the outcomes effectively conveyed the symbolic meaning of “rebirth”. Researchers could readily identify intricate design details in digital fashion images, including coloration, silhouette, fabric choices, and craftsmanship. Overall, these AI-generated fashion design images effectively met predetermined design criteria encompassing functional, expressive, and aesthetic considerations.

Our study reveals a novel insight: providing clear and detailed textual prompts is essential for achieving desired image outcomes in fashion design using Midjourney. Furthermore, Midjourney’s ability to produce high-quality digital images at a rapid pace enables designers to quickly experiment with different design details and gain a com-

hensive understanding of fashion design concepts. Figures 3 and 4 showcase some of the satisfying digital image results generated by Midjourney for the two fashion design concepts.



Figure 3. Satisfactory fashion images generated by Midjourney based on Concept 1.



Figure 4. Desired fashion images generated by Midjourney based on Concept 2.

Furthermore, Midjourney exhibits remarkable proficiency in handling intricate prompts. Firstly, it demonstrates logical analysis capabilities similar to the cognitive functions of the human brain, as it comprehends and responds to disordered input keywords, aligning with prior research findings [2]. In our iterative action research, we explored strategies to enhance input prompts, initially starting with basic keywords and gradually incorporating more details and specific parameters. Our observations revealed that well-structured and detailed textual prompts along with specific parameters yield more satisfactory digital image outcomes within Midjourney.

Secondly, Midjourney maintains a certain degree of consistency among output digital images based on the input image prompt, effectively mitigating the inherent randomness associated with this AI tool. Three methods are available for employing image prompts in Midjourney. The primary approach involves the image variation function, which generates four distinct images with a degree of similarity based on a specific image output. Designers

can also upload an image from their computers to Midjourney Discord and incorporate the link of this uploaded image into the input prompts. Notably, Midjourney cannot generate output images solely based on a single input image, but, rather, relies on the combination of the image link and textual prompts. Furthermore, the image weight parameter (`--iw`) allows for the adjustment of the relative importance of the image and text components within a prompt. A higher image weight parameter value indicates a greater emphasis on the image prompt, enhancing its influence on the final output. Despite its inability to process image prompts alone, the `/blend` command enables the handling of multiple image inputs without textual descriptions. Based on our observations and reflections, combining the text and image prompts with a higher image weight parameter value leads to more consistent and desired image outcomes within Midjourney, as illustrated in Figure 4.

Thirdly, Midjourney offers an array of parameters that influence image generation, significantly augmenting the potential to achieve desired outcomes. For instance, the aspect ratio parameter (`-aspect`) allows for the adjustment of image aspect ratios to options like 2:2 or 3:4. The chaos parameter (`--chaos`) impacts the degree of variation manifested in image results, with higher values yielding more unexpected and unconventional generations. Multiple parameters can be appended to each prompt, consistently positioned at the end. In our action research conducted within Midjourney, we identified three relevant parameters in fashion design. The image weight parameter determines the weight of the image prompt relative to the textual prompt. The seed parameter (`--seed`) is crucial for generating images with consistent characteristics, allowing for specific image specifications. By employing this parameter, a higher level of similarity among image outcomes can be obtained. The tile parameter (`--tile`) generates images that can be tiled seamlessly to form patterns. In summary, harnessing the embedded parameters of Midjourney holds high significance in refining input prompts and yielding more desirable image outcomes, thereby facilitating the fashion design process.

Undoubtedly, Midjourney proves highly valuable in expediting concept generation and development of fashion design by generating high-quality design images that can meet functional, expressive, and aesthetic consumer needs. Nevertheless, our iterative action research has brought to light several evident limitations. First, the accuracy of fashion image outcomes cannot be guaranteed by Midjourney. For instance, it struggles to generate digital images precisely aligned with the fabric and silhouette descriptions provided as input. Second, while a certain degree of similarity among outputs can be achieved using specific parameters, attaining a high level of consistency remains challenging. Third, Midjourney cannot consistently provide fashion images from different angles as requested in the input prompts. For example, the requested back view of the fashion design may not be obtained. Fourth, Midjourney cannot automatically edit the details of the output images, necessitating manual adjustments using other design software to fine-tune the design specifics. This discovery is in line with previous research [2,10]. Last, achieving satisfactory results with Midjourney relies heavily on designers' expertise and engagement, including refining input prompts and evaluating outputs. Overall, considering these limitations, it appears that AI image-to-text generation systems like Midjourney may effectively support only the early stages of fashion design at present.

5. Validation: Hemp-Derived Fashion Product Design

During this stage, we employed the initial keywords "fashion design" and "hemp-derived fabric" coupled with three distinct types of fashion products as the initial textual prompts. Employing an iterative approach akin to previous stages, we conducted digital experiments within each product category. Consistent with our previous observations, this AI image generator provided extensive inspiration and high-quality visuals, expediting fashion design processes. Significantly, during this stage, Midjourney demonstrated remarkable proficiency in generating diverse types of fashion products based on hemp-derived materials. This suggests that AI image-generation systems employing diffusion modeling can aid fashion designers in both haute couture creations characterized by exclusivity and artistic

flair, as well as in designing everyday apparel. While Midjourney performed adequately in embodying hemp-derived fabric, achieving satisfactory results necessitated numerous experiments and the input of detailed textual descriptions, such as “using a united textile made from hemp 50%, cotton 20%, and silk 30%”. Furthermore, substantial engagement and interaction from researchers were still required at this stage. This involved continuous evaluations and decision making concerning design image outputs, presenting a notable challenge. To summarize, this stage of action research corroborated observations from prior stages, highlighting both advantages and limitations. Examples of satisfactory design images from Midjourney are illustrated in Figures 5 and 6.



Figure 5. Examples of casual wear for both males and females generated within Midjourney.



Figure 6. Examples of handbags generated within Midjourney.

In this stage, to further validate our action research findings, we conducted an online survey to assess the alignment of Midjourney-generated fashion design images in Figures 5 and 6 with the needs and preferences of young consumers. Our convenience sample comprised 174 college students from a U.S. university. We aimed to evaluate participants' attitudes and perceptions regarding functional, expressive, and aesthetic aspects of

this set of Midjourney-generated fashion design images. The three indicator variables were measured on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree). Additionally, we explored the influence of consumer perceptions on their overall attitudes. Single-item scales were developed to assess three dimensions of perceptions (functional, expressive, and aesthetic), grounded in the FEA Consumer Needs Model. A 10-item scale measuring consumer attitude on a 7-point semantic scale was adapted from Spears and Singh [37]. Table 1 lists all measures and items, and Table 2 provides a summary of survey participants' demographic information.

Table 1. Construct measures and items.

Construct	Item	Reference
Overall attitude (ATT)	Unappealing.....Appealing. Unlikable.....Likable. Bad.....Good. Unpleasant.....Pleasant. Unfavorable.....Favorable. Not practical.....Practical. Boring.....Fun. Ordinary.....Prestigious. Budget.....Luxury. Negative.....Positive.	Spears and Singh [37]
Functional perception (F)	Hemp fashion products can perform excellently regarding functional attributes, such as fit, construction, workmanship, durability, ease of care, and comfort.	Developed by researchers
Expressive perception (E)	Wearing hemp fashion is fun.	Developed by researchers
Aesthetic perception (A)	Hemp fashion products can stand out regarding aesthetic attributes such as appearance, color, pattern, and styling.	Developed by researchers

Table 2. Participants' demographic characteristics.

Characteristic	Items	n	%
Age	18–24	171	98.3
	25–34	2	1.1
	35–44	1	0.6
Gender	Male	25	14.4
	Female	148	85.1
	Prefer not to say	1	0.6
Race	White or Caucasian	118	67.8
	Black or African American	39	22.4
	American Indian/Native American	1	0.6
	Asian	12	6.9
	Other	4	2.3
Past purchase experience	No purchase experience	149	85.6
	Have purchase experience	25	14.4
Total		174	100

Notes: n, frequency; %, percent.

Descriptive statistics results showed that the mean values of all four variables, including attitude and the three perceptions, were 5.00 or higher (see Table 3), indicating

an overall positive assessment by participants. Attitude received the highest mean score (5.78), followed by aesthetic perception (5.27), functional perception (5.05), and expressive perception (5.00). These results indicate that Midjourney-generated fashion design images show the potential to satisfy consumers' needs and preferences, particularly regarding aesthetics. These results are consistent with our observations and reflections from previous action research.

Table 3. Descriptive statistics of constructs.

Construct	N	Minimum	Maximum	Mean	Std. Deviation
Overall attitude (ATT)	174	1	7	5.78	1.05
Functional perception (F)	174	1	7	5.05	1.38
Aesthetic perception (A)	174	1	7	5.27	1.28
Expressive perception (E)	174	1	7	5.00	1.42

Notes: N, the sample number; Std. deviation, standardized deviation.

To further validate consumers' assessments of this set of Midjourney-generated fashion design images, we conducted multiple regression analysis after a series of assumption tests, which included assessing independence, normality, linearity, homoscedasticity, non-collinearity, and the absence of influential outliers. The assumption test results showed that all statistical assumptions of multiple regression were met, with no issues identified. The multiple regression analysis revealed a statistically significant effect of the combination of the three perceptions on overall attitude, $F(3, 170) = 37.86, p < 0.001$. The R^2 value indicated that these perceptions account for almost 40% of the variation in attitude. Functional perception ($\beta = 0.31, t = 3.72, p < 0.001$) and expressive perception ($\beta = 0.28, t = 3.83, p < 0.001$) positively influence overall attitude (see Figure 7). This suggests that Midjourney-generated fashion design images can provide consumers with functional and expressive details, encompassing aspects like fabric embodiment, structural details, and craftsmanship, as well as the conveyance of meaning and emotion. These visual elements have the potential to satisfy consumer needs and influence their overall assessments.

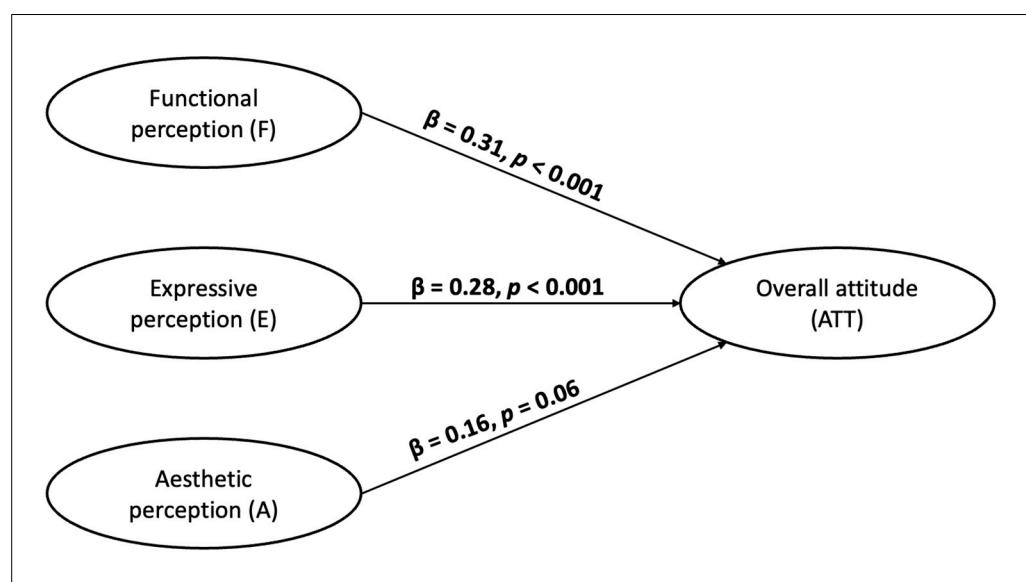


Figure 7. Results of multiple regression test. Notes: β , standardized coefficients beta; p , p -value at the alpha level of 0.05.

The statistical analysis also revealed that aesthetic perception ($\beta = 0.16, t = 1.89, p = 0.06$) did not influence attitude. This suggests that participants prioritized functional and expressive aspects over aesthetics when evaluating hemp fashion products based on

these images. This emphasis could stem from the fact that the images of casual wear and handbags in Figures 5 and 6 depict ready-to-wear products without striking visual effects. However, it is important to note that this result does not imply that Midjourney-generated fashion design images cannot meet aesthetic preferences, as the mean value of aesthetic perception surpassed both functional and expressive perceptions. Overall, these findings confirm the observations from the action research.

6. E-Commerce Implications

Our action research observations, confirmed by validation, affirm that the AI image-generation system, Midjourney, excels in producing expressive and aesthetically pleasing garment design concepts, ranging from haute couture to ready-to-wear fashion products. These AI-generated outcomes consistently meet predefined design criteria established upon the EFA Consumer Needs Model, effectively satisfying consumers' needs and preferences. Consequently, such AI tools hold potential benefits for both fashion brands and consumers.

In the contemporary fashion landscape, there are two principal commerce systems: the traditional fashion industry and the purely digital fashion economy that operates without physical production and consumption [6,38,39]. Whether designing physical or digital fashion, designers can integrate AI-powered text-to-image generators into their creative process for inspiration and digital experiments. Additionally, these AI tools can enhance the efficiency and effectiveness of in-house design team communication by rapidly producing high-quality fashion images that capture various details, including fabric texture, craftsmanship, color schemes, structural elements, and symbolic connotations.

AI image-generation systems have emerged as crucial tools for conventional fashion businesses, providing an innovative and efficient means of digitalizing the design process and enhancing communication with consumers. These systems accelerate design processes, stimulate creativity, save resources and costs, and shorten product development cycles. By quickly producing detailed images, such AI tools facilitate effective communication between designers and consumers, fostering collaboration, offering personalized solutions, and enriching consumer engagement and experiences.

It is noteworthy that these AI-driven image generators are particularly suitable for digital fashion commerce, showcasing adeptness in producing diverse artistic styles, including those with striking digital visual effects. As a result, such AI tools empower fashion brands and designers to achieve greater design freedom, foster creativity, and swiftly generate visually captivating digital fashion, surpassing the constraints associated with physical fashion production and consumption, such as materials, gender, and size limitations.

In recent years, there has been a noticeable increase in displaying fashion visuals on social media platforms, where individuals are seen wearing digital attire instead of physical clothing, reflecting a growing trend in digital fashion consumption [6]. Moreover, advancements in AI technology enable seamless and direct outfitting of images or videos [40,41]. Individuals can substitute physical attire with digital fashion garments in photos or videos through AI applications [40]. Therefore, advanced AI-powered image-generation systems aid fashion brands in offering consumers a comprehensive digital fashion consumption service, from the customization of digital garments to virtual try-ons. In summary, fashion practitioners can leverage advanced diffusion-modeling-based AI image-generation systems to capitalize on e-commerce opportunities, achieving commercial success in serving the traditional textile and apparel industry and enhancing the digital fashion economy.

7. Conclusions, Limitations, and Future Research

This study delved into the exploration, examination, and validation of the utilization and impact of Midjourney on the domain of fashion design. Our iterative action research reveals Midjourney's potential in the processes of fashion design concept generation and development. Significantly, based on our observations, reflections, and validation, it is revealed that this AI tool can assist fashion designers in creating both visually appealing

and expressive attire and ready-to-wear products, aligning with defined design criteria and meeting consumer functional, expressive, and aesthetic needs.

The AI image generator, Midjourney, significantly accelerates the ideation process in fashion design by swiftly translating initial ideas into detailed textual design concepts. This finding provides valuable insights for fashion designers utilizing AI-based image tools. During concept generation, researchers, acting as design directors, collaborate with Midjourney, making informed decisions through professional evaluation and analysis. Moreover, our research highlights the impressive performance of Midjourney in fashion design development. It efficiently conducts digital experiments and produces high-quality fashion images containing intricate design elements, facilitating the advancement of design concepts. In the design development phase, researchers take on the role of design curators, responsible for evaluating, selecting, and excluding fashion image outcomes based on specific design concepts and criteria. While AI-powered image generators present distinct advantages, it is crucial to acknowledge their limitations and technical constraints in fashion design applications. Currently, these AI tools primarily aid in the initial phases of fashion design, relying on designers' expertise and active participation for effective utilization.

This study employed the action research approach and the Functional, Expressive, and Aesthetic (FEA) Consumer Needs Model as the theoretical framework to investigate the potential of emerging diffusion-modeling-based AI image generators in the fashion design process. Related e-commerce ventures were also explored and proposed. By doing so, this contributes to enriching existing knowledge and offers actionable insights into the application of these AI tools within the fashion domain.

However, this study has several limitations that may enlighten future study directions. First, the use of a convenience sample in the statistical validation stage may somewhat limit the generalizability of the findings. Thus, future studies can increase sample size and collect data based on national-based consumer panels to further validate the findings regarding AI-assisted fashion design. Second, our examination focused solely on one prominent AI image generator, Midjourney. Future research endeavors could explore and compare different AI tools to assess their impact on fashion design and associated e-commerce scenarios. Third, we did not focus on investigating the ethical implications of integrating AI tools into fashion design, but it is crucial to balance technological progress with ethical concerns and emphasize transparency in AI-driven creativity to prevent misleading practices. Currently, the main ethical challenges in using AI image-generation tools center on two aspects: avoiding copyrighted design materials in AI training data and ensuring legal and fair protection of intellectual property in AI-assisted creative design [42]. We recommend future research to thoroughly scrutinize these ethical concerns and explore potential solutions. Nevertheless, AI-based text-to-image systems hold great potential to be integrated into the creative workflows of fashion designers and contribute to both physical and digital fashion businesses.

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