

# Exploring The LED Light Integration Into Fashion Design Towards Smart Clothes Technology

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## ***Abstract:***

**Problem Statement:** Smart fashion represents the advancement of materials that go beyond the traditional. This interdisciplinary field reflects the intersection of fashion design, engineering, and innovation. Such a distinguished incorporation provides customers with wearable technology to serve their needs. The integration of LED lights has increased as its application provides dynamic visual elements to fashion. It also leads to customization, allowing persons to design a live entertainment experience.

**Research importance:** This research Integrates LED technology into fashion design and presents a conceptual and dynamic approach to wearable technology. This research highlights the importance of using different techniques in curtain design and innovative LED applications to enhance aesthetics and functionality. Evaluating audience engagement and the feasibility of these designs contributes to the development of smart fashion.

**Research objectives:** present a smart creative approach to fashion, propose a new perspective on LED applications in fashion, develop a conceptual and dynamic idea for integrating LED into clothing through mind maps, evaluate the aesthetics and functionality of the proposed designs through a questionnaire among designers and professionals

**Hypothesis:** Integrating LED technology into the fashion world, through innovative fabric technologies, enhances the aesthetics and functionality of clothing, increasing audience engagement. Incorporating LED-embedded haute couture dresses creates a dynamic effect towards interactive fashion. However, the cost of these applications remains a challenge that requires further research.

## ***Keywords:***

*Smart clothes, fashion design, LED Technology, Draping Techniques, haute couture*

## دمج إضاءة الليد في تصميم الأزياء: نحو تكنولوجيا الملابس الذكية

### مشكلة البحث:

تمثل الأزياء الذكية تطوراً في المواد التي تتجاوز التقليدية، حيث يعكس هذا المجال متعدد التخصصات تقاطع تصميم الأزياء مع الهندسة والابتكار. يوفر هذا الدمج المتميز للعملاء تكنولوجيا قابلة للارتداء تلبي احتياجاتهم. وقد زاد استخدام إضاءة الليد (LED) في الأزياء نظراً لقدرتها على توفير عناصر بصرية ديناميكية، مما يتيح أيضاً التخصيص ويسمح للأفراد بابتكار تجارب ترفيهية حية.

### أهمية البحث:

يدمج هذا البحث تقنية الليد في تصميم الأزياء ويقدم نهجاً مفاهيمياً وديناميكياً للتكنولوجيا القابلة للارتداء. كما يسلط الضوء على أهمية استخدام تقنيات مختلفة في تصميم الستائر وتطبيقات الليد المبتكرة لتعزيز الجماليات والوظائف. ويسهم تقييم تفاعل الجمهور وجدوى هذه التصميمات في تطوير مجال الأزياء الذكية.

### أهداف البحث:

تقديم نهج إبداعي ذكي لتصميم الأزياء.  
اقتراح منظور جديد لتطبيقات الليد في عالم الموضة.  
تطوير فكرة مفاهيمية وديناميكية لدمج الليد في الملابس باستخدام الخرائط الذهنية.  
تقييم الجماليات والوظائف للتصاميم المقترحة من خلال استبيان يشارك فيه مصممون ومحترفون.

### الفرضية:

يعزز دمج تقنية الليد في عالم الموضة - عبر تقنيات الأقمشة المبتكرة - الجماليات والوظائف الملابس، مما يزيد من تفاعل الجمهور. ويخلق دمج فساتين الأوت كوتور المزودة بتقنية الليد تأثيراً ديناميكياً نحو موضة تفاعلية. ومع ذلك، تظل تكلفة هذه التطبيقات تحدياً يتطلب مزيداً من البحث.

### الكلمات المفتاحية:

الملابس الذكية، تصميم الأزياء، تقنية الليد، تقنيات الدرابيه، الأزياء الراقية

# **1. Introduction**

## **1.1 Smart Fashion**

Smart clothing is the next evolutionary step in wearable devices. It integrates electronics and textiles to create functional, stylish, and comfortable solutions for people's daily needs. The concept includes clothing, which is a covering mechanism for the body, and the function of tracking body indicators. The classification and concept of smart clothing in the application areas include sports, work wear, health care, military, fashion, snow wear, space wear, and entertainment [1] such as biomonitoring clothes, player-adopted clothing, and platonic clothing [2]. Smart clothes and wearable technology, focus on the design, process, material selection, garment construction, and new production techniques for smart clothing [3]. Smart wearable textiles can sense, read, and adapt to external conditions or stimulation. They are classified as active or passive smart wearable textiles, which can work with the human brain for convincement, reasoning, and education in the future. In the future, the development of wearable electronics will be focused on multifunctional, user-friendly, and easier acceptance and comfort features and shall be based on advanced electronic textile systems [4].

This study aims to: (1) Propose innovative LED integration techniques in haute couture, (2) Evaluate audience engagement through dynamic visual effects, and (3) Address cost challenges in smart fashion production. We hypothesize that LED-enhanced designs will significantly elevate aesthetic and functional value, though scalability remains constrained by technical limitations

## **1.2 Definition of smart clothes**

Smart clothes are defined as an intelligent system that senses and reacts to the changes and stimuli of the environment and the wearers' conditions such as electrical thermal and magnetic ones. Smart clothes combine state-of-the-art technologies from related fields such as electronic information, sensors, and materials to provide a range of functions and features, including protection, temperature regulation, monitoring, entertainment, and personality expression. Smart clothes are also called high-technical clothing, smart garments, smart wear, electronic textiles, and smart textiles. The fashion industry is a vitally significant area for textiles [5]. Fashion may be found in all human activities and all realms of existence ranging from technological, medicinal, cultural and artistic [6].

## **1.3 Smart fashion clothes in entertainment**

Lighting technology started in fashion in the 17th century, the electric girl lighting company hired girls wearing evening gowns with lights as entertainment at parties, and also for ballet girls onstage, these girls wore lamps on their foreheads. In 1956 Atsuko Tanaka wore an electric dress that she created in an exhibition in Tokyo. She used coloured bulb lamps and coloured neon tubes. It has a mix of traditional kimono and industrial technology [12]. Fashion designers have always adopted new technology to submit their collections. They used light emitting diode (LED) in clothes with two considerations physical appearance and the durability of the garments. Lighting technology and light sources have affected fabrics' mechanical properties and colour strength [13]. The effect of integrating light emitting diode (LED) in different fabrics properties used for fashion design. Research objectives worked on Studying types of materials that can combine with LEDs to produce clothes the effect of LED on these materials and detecting the relationship between used material and the techniques used in combining LEDs into garments. Keep current with scientific and technological developments and apply them to new fashion designs. Their Terms of research were Light light-emitting diode (LED) and fashion such as satin and chiffon fabrics. They concluded that emitting Diode can be used in fashion design as a decorative item and is an innovative way to introduce new collections with new ideas and concepts. Use suitable techniques to add LEDs to clothes

according to fabric types and properties. LEDs affect the mechanical properties and color strength of fabrics at a certain number of hours 80-140 hours of exposure. Fashion, entertainment, sports, and safety applications all benefit from LED lights on clothes. Digital high technology, several light-emitting mechanisms are available, electroluminescent EL, EL wire, optical fibre, LED, Iode, OLED, flexible display, laser, and organic emitting diodes are reasons for fashion marketing success [14].

#### **1.4 Applications of Smart clothes in entertainment**

There are several applications of smart clothes in entertainment. The bubble dress detects the wearer's emotional changes through an inner sensor cute circuit dress that is sewn with many Micro LEDs into a fabric of changeable colors and is a mix of science and art [15]. Cute Circuit by Francesca Rosella and Rayan Genz a wearable technology and interaction design company. Cute circuit products were nominated and awarded on many occasions [16]. The ready-to-wear evening gown by Lumen Couture works on sustainability fast fashion that can be customized in functionality, color, and patterns through LED lighting [17]. Custom illuminated clothes by Enlighted Designs founded by Janet Hansen many celebrities wore them at Enlighted indifferent events and stage performances like Naomi's WWE title [18]. The renewed Romance project greatly values using light technologies in fashion, introducing a transparent and detailed design development process, and implementing a theoretical model using light-emitting diodes LED, optical fibres, electroluminescent and photoluminescent materials [9]. Nancy Tilbury's space indicator jacket was developed using textiles and illumination cables. It works like this: When someone crosses the personal space limit, it alerts the wearer with illumination significance [29]. Wink shorts by Nancy Tilbury can easily express the wearer's feeling by double pressing on the fabric that is connected to the pocket a little light will appear from the pocket referring to the feeling [7-8]. Lee and Chung developed a smart t-shirt that measures sports activity data and physiological electrocardiogram data. These data are sent to the station base through the network and the guardian performs remote monitoring through the server [9]. Designers are introducing improvements in LED-embedded fabrics and sensor-based textiles. This innovative perspective raises the revolution towards kinetic dresses that illuminate based on wearable motions. Such a collaborative field between fashion and technology develops fashionable designs with functional aspects. This interdisciplinary methodology showcases the merging possibilities between fashion and scientific advancements to create contemporary designs (11).

That's why our research aims to explore LED technology integration into fashion design in which our designs are inspired by the camouflage, waves and bioluminescent properties of coral reefs. By simulating the natural illumination, our study seeks to create an innovative smart haute couture dress and break the boundaries of interactive fashion.

#### **1.7 Our inspiration:**

Coral reefs are an underwater ecosystem characterized by reef-building. *Elysia crispate* is considered a marine species commonly found in the Caribbean and Florida. It has a unique wave-like appearance and bioluminescent effect. It also utilizes camouflage to blend into its habitat, adapting its surroundings to get protected from predators. These features make it an excellent choice to emerge the illumination and organic movement (20). Figures 1, 2, and 3 show a beautiful and bright coral reef. Their soft pattern, wavy looks and delicatated folds give us an elegant appearance closer to our LED applications. Their lighting shows how distinguished their texture which inspired us to mimic the ocean's beauty.



Figure 1; coral reef photo(21) - Figure 2; coral reef photo(22) - Figure3; coral reef photo(23)

Figures 4 show different LED lights which are considered as main applications towards smart fashion. All these photos of coral reefs and LED lights inspire us as fashion designers to merge nature fluidity with modern technology. Blending nature and technology reflects a balance of elegance and innovation. Such a distinguished combination highlights the connection between digital evolution and the natural world making fashion artistic with future vision.

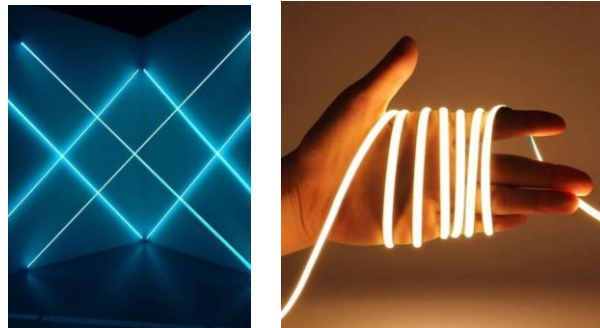


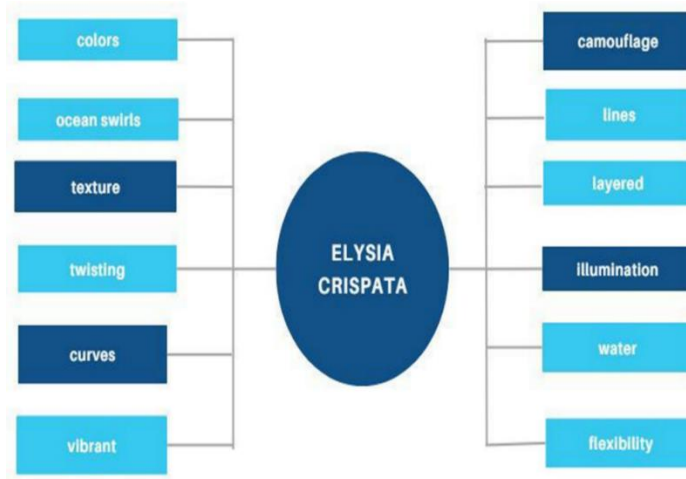
Figure 4; led lights photo(24 – 25)

## 2. Methodology

### 2.1 brainstorming and mood board

Design thinking is an approach to reframe the problem and generate many ideas. It is considered as a human-centric way to understand our needs creating distinguished designs (26). Using such an approach helps us to segregate ideas and refine creative concepts. Figure 5 shows a mind mapping of our inspiration “*Elysia Crispata*”. By breaking down its textures, colours, curves and illumination, the brainstorming map allows us to find a harmonious way to integrate the LED lights into our designs. This visual map connects water fusion aesthetics with innovative modern technology which highlights both elegance and digital energy.

The mind mapping technique (Figure 5) directly supports Objective 1 by translating coral reef bioluminescence into LED placement strategies, while the mood board (Figure 6) validates Objective 3 through visual feedback from designers.



**Figure 5: Mind Mapping of Our Inspiration**

## 2.2 Mood board

Figure 6 shows our mood board which combines previous inspiration and LED light photos along with images that have been created using artificial intelligent website (AI) Leonardo (27). The mood board was made using Canava (28). It showcases the aesthetics of coral reefs and applications of LED technology in fashion design. The board highlights curves, textures, vibrant illumination and high-tech fashion concepts. AI photos show the integration of LED lights with a modern touch maintaining the natural elegance forms. Such a visualized presentation contributes to developing our design process.

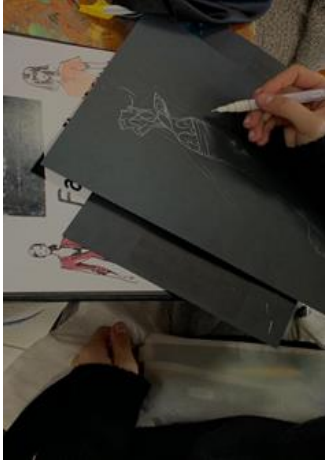


**Figure 6: Our Inspiration mood board**

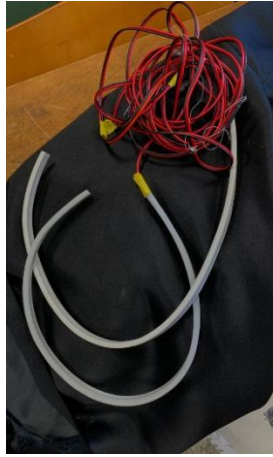
## 2.3 Design Making Process

Figure 7 highlights the design and sewing process highlighting creative workflow. Figure 7. a shows the first stage of sketching and designing in which we translate our ideas into papers investigating how we can integrate LED lights with fabrics. Once our designs are finalized, we determine the required fabrics and electronic components as per Figure 7.b. Then, fabrics were

cut and sewed according to the required design, as per Figure 7.c, ensuring the measurement and durability of the garment construction. Figure 7.d shifts the focus to the technology integration where we draped LED light wire on the implemented dress. Figure 7.e shows the attachment of LED wires by hand stitches to ensure functionality and visual appeal. Finally, figure 7.f showcases the completed dress with illuminated details, demonstrating the success of merging technology with fashion. Our process not only highlights skilled garment production but also the innovation of integrating fashion with technology resulting in the final piece.



a



b



c



d



e



f

**Figure 7: Design-making process** [Starting with drawing the fashion design collection(a) - Choosing materials(b) - Cutting and sewing(c) - Draping the led lights(d) - Sewing led(e) - Final product(f) ]

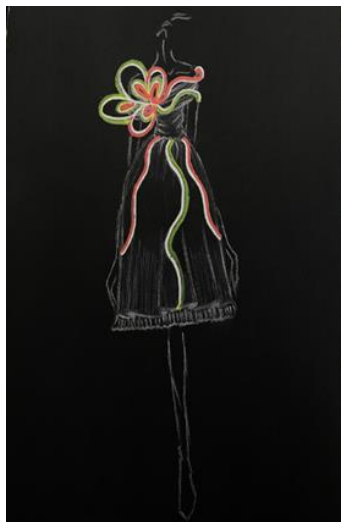
### 3. Results and discussion



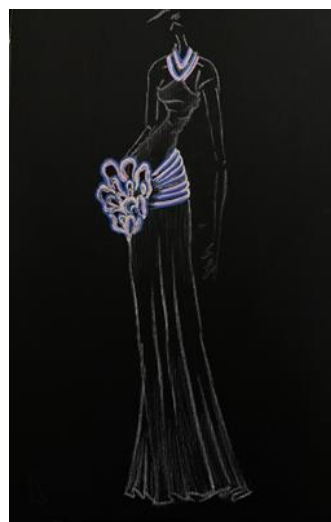
The study's outcomes directly address its stated objectives. First, the LED-integrated designs demonstrate a novel creative approach to smart fashion, merging coral reef bioluminescence with haute couture silhouettes. Second, the questionnaire results validate the proposed perspective on LED applications: 71.4% of respondents rated the designs as 'innovative,' confirming their potential to redefine interactive fashion (Objective 2). Third, the mind-mapping technique and prototyping process successfully translated conceptual ideas into functional garments, fulfilling Objective 3. The hypothesis is partially supported: while LED integration enhanced aesthetics (85% approval) and functionality (57.1% satisfaction), cost barriers (noted by 21.4% of respondents) and wearability challenges highlight the need for further technical refinement, as initially anticipated.

### 3.1 sketches

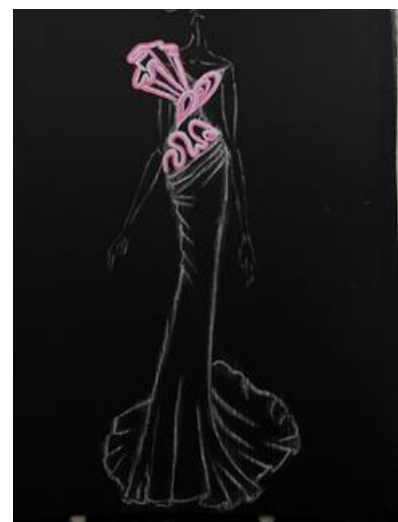
After research and brainstorming, different designs were drawn to imagine how to place the LED light on the design and how to use it with the fabric in a way that shows its beauty and at the same time shows the idea of the research. Figure 8 shows our fashion collection as an innovative perspective of fashion and technology. Designs reflect the dynamic movements of coral reefs and its ecosystem. They showcase a balance among LED light draping, natural elements and aesthetic aspects. All designs are based on black colours which serves the deep-sea water movements and coral reefs appearance to camouflage within surroundings. There are different silhouettes to introduce various looks of evening wear. The LED wires draping comes in different colors in which they can follow the natural waves of coral formations creating a sculptural effect and improving the dress's visual appeal. This collection is considered an exploration of how technology can elevate fashion. It breaks the boundaries of contemporary fashion designs offering an opportunity for future fashion to be a new approach to innovation.



a



b



c





d



e

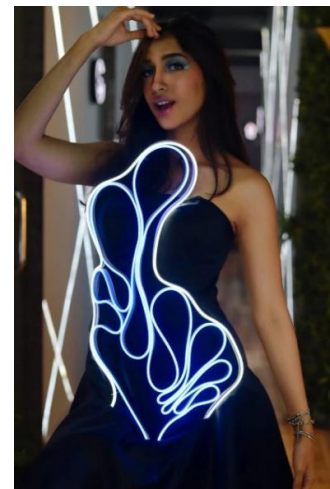


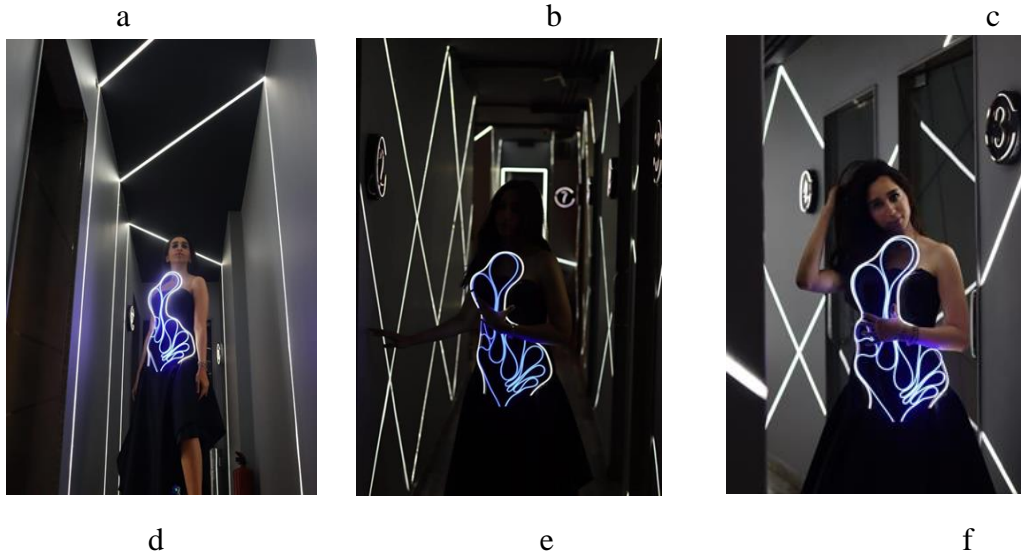
f

**Figure 8: sketches by author**

### 3.2 Final Prototype

Based on the results of the questionnaire that was conducted, as well as after research, brainstorming, and extracting ideas for the research idea, it was agreed upon a special place to make a photo shoot for the research design, and the choice fell on a specific place, which is a place that magically uses LED lights, which is consistent with the research topic. Figure 9 demonstrates the successful implementation of our prototype highlighting its novelty and originality. Such distinguished dress introduces a potential step towards fashion and technology integration. The immersing of LED tubing is not only used as decorative parameters but also follows a conceptual structure element that transforms the dress into dynamic life. The design goes beyond simple aesthetics by integrating the principles of camouflage and bioluminescence into haute fashion. The dress highlights the rare combination of artistic vision, technological innovation and natural aspect making it a distinguished piece in the field of smart fashion.





**Figure 9; photoshoot of the design**

The LED draping in Figure 9 successfully mimics coral reef fluidity, but the rigid wiring (noted by 30% of respondents) conflicts with the organic inspiration, calling for flexible alternatives like electroluminescent threads.

### 3.1 Questionnaire

Figure 10 shows the questionnaire of our study to evaluate our smart dress project. A 30 diverse group of fashion designers, professionals, engineers, potential consumers and fashion academics contributed to this questionnaire to assess the technical and aesthetical aspects of our research. 64.3 % of respondents highly rated the dress showing positive feedback. Also, 57.1 % of participants show their satisfaction with the dress design details. In addition, over half of the responses highly rated the dress design in terms of competitive advantage indicating that it has strong design parameters. Nevertheless, about 21.4% showed a moderate rating suggesting improvements that can be achieved for further development. On the other hand, 71.4 % rated the innovation and creation level as excellent which confirms our project succeeded in integrating fashion and LED lights. Concerning smart clothing awareness, 85.7% were already familiar with smart clothing which highlights the general awareness of wearable technology and raises the demand to improve such competitive advantage while 14.3 % needed further education or marketing strategies to introduce this concept. 100% of respondents believed that smart clothing and wearable technology have great market potential, especially in the artificial intelligence era. Furthermore, 50% showed a great interest in experiencing wearing our dress. This questionnaire results suggest that the smart dress has been well accomplished concerning innovation and aesthetics. However, most of the participants are familiar with wearable technology and believe their market potential, there are areas of improvement to enhance the design. Overall, they indicate positive feedback in terms of fashion, technology and marketing aspects.



Figure 10: Research Questionnaire

Parameter	Positive Feedback (%)	Areas for Improvement
Innovation	71.4%	Cost reduction
Aesthetics	57.1%	Wearability

While 71.4% praised the innovation, 21.4% noted discomfort in wearability, suggesting a need for lighter LED materials (e.g., OLEDs) in future iterations.

#### 4. conclusion and recommendation

In conclusion, the integration of LED light into dress design not only enhances aesthetic appeal but also plays a significant role in the entertainment aspect of fashion, captivating audiences with dynamic visual experiences. Our research, supported by feedback from professionals and experts, confirms the beauty of this application in line with our inspiration and concept. However, it's essential to acknowledge the limitations, such as the costs involved and the challenges of effectively managing and driving the light technology. As we continue to explore this innovative intersection, addressing these challenges will be crucial for realizing the full potential of smart fashion technology. For novelty, our prototype introduces a new approach of seamlessly

integrating the LED lighting as a fundamental element creating an interactive haut couture piece inspired by nature. In addition, its originality lies in the fusion of technology and biomimicry in which the LED draping mimics the organic flow of coral reefs. Moreover, the implemented prototype achieves a modern form of camouflage by blending its illuminated design with its surroundings. As coral reefs adapt to their habitat, our dress visually changes between standing out and blending in based on the surrounding lights. The questionnaire showed a strong approval of our prototype in terms of innovation and fashion aspects.

This study achieved its threefold objectives by (1) presenting LED-embedded designs as a creative smart-fashion solution, (2) proposing a new application framework through coral reef biomimicry, and (3) evaluating audience reception via empirical data. The hypothesis—that LED technology elevates fashion’s aesthetics and engagement—was supported by positive feedback on visual appeal and innovation. However, the persistent cost and technical limitations underscore the necessity for future work on scalable production methods, aligning with the hypothesis’s caveat. These findings collectively advance smart fashion’s potential while pragmatically acknowledging its constraints.

**Recommendation** Further research should focus on cost-effective methods for integrating LED technology into clothing design., Develop advanced technologies to improve the management and control of LED lighting in clothing. Explore sustainable and energy-efficient solutions to enhance LED applications in fashion.

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