DESIGN AND SMART TEXTILE MATERIALS

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ABSTRACT
This research discusses smart textiles and their implications in the design process. The aim is to equip designers with an understanding of the significant potential properties of smart textiles and inspire them to integrate these materials into the design process. The sensory, adaptive, responsive, and multifunctional qualities of smart textiles open a multidisciplinary scope of use that offers many alternatives in numerous industries, including construction, fashion, healthcare, sports, and automotive. Research and development for new and smart materials cross scientific boundaries, entering design territories and enhancing the quality of life and our environment. These textiles are created by integrating material properties with embedded technology to deliver aesthetically pleasing innovative functional qualities. However, the practices associated with the two disciplines of conventional textile design and advanced technology embedding often vary. Designers currently working with conventional textiles may be able to solve problems by utilizing smart materials and revisiting their design techniques to embrace the unique characteristics of the smart materials. The research findings suggest that designers should pursue appropriate approaches and contribute their productive skills and material expertise to utilize the smart textile design effectively.
Keywords: textile design, smart textiles, smart textile design.

1 INTRODUCTION

Materials that can sense and react to the surrounding environment have been labeled "smart." Advances in new and smart material design have reached new heights. Designers embed computational programmability in conventional materials like textiles to develop innovative material that is both functional and expressive [1], [2]. The influx of new approaches to designing with new and smart materials presents a wide range of opportunities [3]. However, the ways in which designers will utilize these materials have not been defined, as the possibilities for design expand in conjunction with the development of new and smart materials. How will designers embrace these new, smart materials and create designs that incorporate their unique qualities and support their interactions with humans and the environment? This question calls for a new understanding of these materials to facilitate their incorporation into innovative designs.

Smart textiles can react and adapt to stimuli sensed from the environment. Stimulus and response can involve various interactions, such as those based on magnetic, electrical, or thermal energy [4]. Smart textiles constitute a relatively new textile field that can produce new applications, such as wearable technology and technical textiles, by integrating design and technology [5]. Smart textiles are divided into two categories of smartness: passive and active. Passive smart textiles, viewed as the first generation of smart textiles, have functionality beyond the level offered by traditional textiles, while active smart textiles can adapt by changing their functionality due to a user action or in reaction to changes in the surrounding environment. These textiles may, for example, change shape or may store and regulate energy. While passive smart textiles typically depend on their structure to function, active smart textiles use some form of energy that can support sensors and actuators. The sensors and actuators allow the smart fabric to sense numerous stimuli from the surrounding environment and interpret and process this variety of inputs according to the surrounding environment [5]. The role of textile designers who have deep material

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exploration experience and knowledge becomes vital to creating innovative forms of interactions between the designed object and its user [6].

2 LITERATURE REVIEW

Research work in the field of innovative smart textile applications is growing as scholars seek to discover the prospects presented by manipulating textiles down to the nanoscale for producing new and smart functionality, resulting in integrated intelligent systems that can wirelessly sense and communicate. Such systems offer a multifaceted set of design, material, and manufacturing challenges. This literature review highlights some of these challenges.

Textiles are characterized by being flexible and can be easily formed over objects. New textiles that are electrically conductive have been created for stretchy electronic structures that can be curved or shaped around curved shapes [7]. Stylios and Chen [8] introduced a smart textile product called Psychotextiles after studying the relationship between brain waves and design. Using electroencephalograms (EEGs), characteristics of patterns that impact specific emotions emerged, which were then designed into four pairs of smart, pattern-changing textiles for examination. They then developed a new thermochromic procedure to enable the construction of innovative yarns that can switch from one pattern into another when knitted into jacquard patterned textiles. This procedure was essential in achieving Psychotextiles [8].

Malm et al. [9] discussed conductive structures in which micron-size metal flakes of silver-coated copper were used as conductors in woven textiles, and the fabric's flexural stiffness was examined for performance, reliability, and durability. The authors discussed measuring and optimizing the electrical resistance and mechanical properties of different textile sensors. In another study, Stöhr et al. [10] tackled the concept of a thermal textile, which is based on a textile arrangement that shows temporal and spatial thermal contrast and can be applied in thermal communication applications.

In a publication detailing their research, Lis Arias et al. [11] discussed uncontrolled active molecules in the spraying of textiles and defined polymers that protect active components that permit the regulation of drug dosages, with encouraging results for clothes and in-home use, thereby developing bio-functional textiles. Vojtech et al. [12] addressed the problem of identifying a surface area that supports the improved functioning of electrically conductive polymer-based textiles. The researchers employed an electrochemical process to determine the resistance between two electrodes to compare surface areas of textile. ECG measurement and motion tracking were accomplished by developing a new hybrid soft textile electrode [12]. Furthermore, An and Stylios [13] reported that systematic measurements demonstrated that this hybrid textile electrode was capable of recording ECGs and motion signals synchronously, possibly providing a life-changing approach to constant health monitoring. Moradi et al. [14] suggested a solution of connecting e-textiles using embroidery; they researched the ways in which signal propagate control may be accomplished, enabling customized electromagnetic characteristics, such as filtering for wearable electronics. Moreover, energy generation was addressed through textile-based dye-sensitized solar cells in two studies – one by Juhász and Juhász Junger [15] and one by Juhász Junger et al. [16]. Juhász and Juhász Junger [15] were concerned with understanding the physical processes in the cell and optimizing them, while Juhász Junger et al. [16] introduced electro spun polyacrylonitrile nanofiber mats coated with a conductive polymer as collar cells.

With the fast growth of the Internet of things (IoT), which is affecting our lives, the way we work, our homes, and our communications, electromagnetic shielding is important, as it guards against emissions of electromagnetic frequencies as a health protective measure and to prevent possible hack attacks. Neruda and Vojtech [17] argued that smart textiles with their high flexibility and formability are well-suited to help address this issue.

3 A CALL FOR NEW MATERIAL UNDERSTANDING IN DESIGN

The designer's role calls for involvement in discovering new potentials for materials rather than only relying on known techniques to create product applications [18], [19]. Possible material designs are created through the collaborative interactions of individuals, processes, and the environment in general [20]. Smart materials have specific qualities that change and adapt over time and that can affect our experiences and the ways in which we interact with products [21]. Indeed, materials can be active and adaptive in various ways. In this context, adaptive is defined as material expressions in which distinctive qualities of computational materials adapt and react through interactions [22].

Adaptive as an approach for the expressive and performance characteristics of material-driven design offers exceptional prospects in design practice and research [23]. It enables an arena for designing emerging materials that involve the fields of biology, computation, and design [24]. How can designers utilize a textile, for instance, if they believe that it is adaptive to different situations in the surrounding environment? What are possible design solutions for situations in which an expected adaptive textile behavior may possibly evolve? As responses to such complex questions may not be forthright, changes in mindset and in approaches to dealing with smart materials towards more non-linear and open designs and use cases is needed.

3.1 Designing with smart textiles

In the case of dynamic textile surface patterns, the aesthetic manifestations and the functions can be joined together, unlike traditional static textile surface patterns, the aesthetic manifestation of which does not actively contribute to the function. The integration of information technology with textiles expands the possibilities for new use cases in which information supplies the building blocks for the surface pattern and vice versa, that is, the surface pattern functions as a textile interface that can, for example, display information [25]. Craftmanship in textile design is important to revive the interaction with the material to reinforce textile representations both functionally and aesthetically [26]. Materials are full of suggestions for their use if approached non-aggressively and the designer is receptive to new and innovative ideas. They provide a source of endless stimulation and inspire us in a most unexpected way [27], [28].

It is important to work directly with a material to be capable of developing it, as there is an important change in the articulation of textiles and how they may behave in conjunction with integrating information technology aspects and applications into the textile industry [29]. Some examples of experimental work with developing prototypes that merge new materials, textiles, and electronics are included in projects described in "E-broidery: Design and Fabrication of Textile-based Computing" [30]. For example, textiles have been used to display information, generate heat, and light up when dark [31], [32].

A textile surface pattern that reveals different aesthetic manifestations over time is called a dynamic textile surface pattern. An example is a surface pattern that appears to be striped initially then changes to appear checkered a moment later [33]. This demonstrates a type of textile surface pattern that needs to be designed differently than traditional textile surface patterns, which maintain the same state constantly, are designed [34].

The experience of designing a textile surface using materials that are capable of changing their appearance over time compared to designing a static textile surface pattern differs for the designer [35].

Apart from the design prospects, another challenge is the possible need to integrate electronic components. Consequently, textile designers and electronic engineers must collaborate on how to structure textiles that sense and react to different situations in the surrounding environment [36]. However, certain restrictions in the fields of textiles and electronics may conflict, e.g., the products of one are expected to be washable, while products from the other are negatively affected by water.

Moreover, challenges exist for producing electronic conductive yarn on an industrial level; arguably the most important is presented by the global economy, which principally encourages standardization, low prices, and production scale in industrial operations [37]. For example, when using hand looms, the weft builds the textile by turning the yarn at the edges and maintaining an uninterrupted construction of the woven structure. However, industrial weaving machines regularly cut the yarn at the edges, producing a textile that contains individual pieces of yarn that produce the textile structure, causing one cut length for each piece inlaid, which restricts the possible use of the traditional industrial weaving machines to integrate electronics at the weaving stage. Therefore, it is easier to work such smart materials in a hand loom upon starting the research for innovative smart textile materials [38].

Some techniques other than weaving are suitable for integrating electronics with textiles; still, significant limitations exist to the possible applications. A new approach to viewing textiles from an alternate perspective as a new modern craft will play an essential role in developing the potential of this new field of textiles. The limitations lie beyond the traditional questions of where and when a product will be made available and how long it will continue as a trend [39]. Time should be a crucial design variable in developing dynamic textile surface patterns. The time variable relates to spatial and temporal settings and can be characterized and developed considering the following factors: stimuli that initiate change, time, and duration of change, and finally, location where changes show. These considerations have to be considered when it comes to design methodology, materials, and techniques [40].

4 CONCLUSION

In an ever-evolving design arena, design research work that explores the understanding of new practices, such as how new potentials are detected during the production process in design practices that utilize smart materials, are critical [20]. The aim is to urge designers to work directly with smart textile materials during design development to extend their knowledge of various ways to design with smart textile materials and seek a better understanding of the great potentials of smart textiles. This article also discussed designing dynamic textile patterns [34].

In today's design environment, designers should work beyond the systematic traditional methods of the design process, in which the conceptualization of ideas comes first and then the concepts are translated into forms, functions, and materials represented subsequently in the design process [41], [42]. While new materials and technologies offer a wide range of potential innovate design solutions, designers need to pursue appropriate approaches and identify tools to work with new materials that are characterized by being changing or responsive to the surrounding environment.

Studying the advances in the smart textile research enhances our knowledge and allows us to identify relevant challenges, such as washability and user safety, two vital factors that need to be addressed. A change of culture is needed to support textiles with electrical embedded components. However, the textile supply chain is not ready to incorporate rapid change; moreover, designers and engineers need to collaborate. After all, we have an exhausted textile industry that is supplying products criticized for harming the environment, when intact prospects are available for the industry provided that smart textiles converse with traditional textiles to reach innovative applications that respond to contemporary needs.

Finally, the author calls for an experiential approach to designing smart materials and to developing the methods for designing with and for new materials, an experience that is fostered by smart materials that require new ways of thinking and designing.

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