ADVANCED TEXTILES MANUFACTURING INDUSTRY
Learning unit 1
Lesson 1

Definition and evolution of smart textiles

HACKTEX

Innovative smart textiles & entrepreneurship

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Content

Introduction

This lesson (LU1.1) about *Definition and evolution of smart textiles* is enclosed in the Learning Unit 1, which corresponds to *Introduction to smart textiles.*

Definition of the term "smart textiles". Its classification in subgroups such as passive, active or intelligent textiles will be described. Milestones in smart textiles will be analysed in order to determine their importance in the passage of time and difficulties for design and commercialisation will be mentioned.

1. Definition of smart textiles

According to Granch Berhe Tseghai et al. 2020, garments have been beyond any doubt one of the biggest necessitates of the human being. In the earliest years, textile was oriented toward apparel and over the years expanded to domestic purposes. Further use of textiles was specific applications such as canvas for sailing, coverings, protective clothing, etc., which were exploited to functional and high-performancee applications.

Smart textiles due to specific environmental conditions including mechanical, magnetic, thermal, electrical, or chemical, become sensitive and reactive [1]. The idiom of “smart” textiles or “intelligent” textiles or even “wearable electronic” textiles, are ordinarily used vice versa. The term “smart textile” may refer to either a “smart textile material” or a “smart textile system”. The definition is determined only by the context. Smart (intelligent) textile materials are functional textile materials actively interacting with their environment, i.e., responding or adapting to changes in the environment and smart (intelligent) textile system are textile system exhibiting an intended and exploitable response as a reaction either to changes in its surroundings/environment or to an external signal/input [2]. For instance, Steele et al. developed a bionic bra using electro-material sensors and artificial muscle technology to detect the increase in breast motion and then respond with increased breast support to improve active living [3].

Smart textiles integrate a high level of intelligence and can be classified into three subgroups: passive, active, and very active or intelligent smart textiles [4]. They can be made by incorporating electronic materials, conductive polymers, encapsulated phase change materials, shape memory polymers and materials, and other electronic sensors and communication equipment. As Dadi 2010 studied, these materials interact according to their designed feature with the stimuli in their environment [5]. As an example of a very active smart textile, the first generation of wearable motherboards—which has sensors integrated inside garments that can detect injury and health information of the wearer and transmit such information remotely to a hospital—has already been developed [6].

2. Evolution of smart textiles

The basic materials needed to construct e-textiles, conductive threads and fabrics exist for over 1000 years. More specific, artisans have been wrapping fine metal foils, most often gold and silver, around fabric threads for many years [7]. At the end of the 19th century, as people developed and grew accustomed to electric appliances, designers and engineers began to combine electricity with clothing and jewellery—developing a series of illuminated and motorized necklaces, hats, broaches and costumes [8,9]

People have been investigating medical applications of electricity in clothing such as corsets and belts as early as the 1850 s,12 but the scientific community only became interested in wearable electronic applications (specifically wearable computing) fairly recently. The first wearable computer was developed in 1955 by Edward Thorpe and Claude Shannon [14].

In 1968, the Museum of Contemporary Craft in New York City organized a groundbreaking exhibition called Body Covering that focused on the interaction between technology and clothing. The show included among others astronauts' space suits along with clothing that could inflate and deflate light up, and heat and cool themselves [10]. More specifically we must mention that in this collection was the work of Diana Dew, a designer who designed a line of electronic fashion, including electroluminescent party dresses and belts that could sound alarm sirens [8].

In 1985, an inventor named Harry Wainwright (www. hleewainwright.com) designed the first total animated sweatshirt consisting of fiber optics, LEDs, and a microprocessor to control individual frames of animation resulting in a full-color cartoon on the surface of clothing. [11]

Wainwright continued with the invention of the first machine in 1995 enabling fiber optics to be machined into fabrics, the process needed for manufacturing enough for mass markets. In parallel, he hired a German machine designer named Herbert Selbach, from Selbach Machinery to produce the first CNC machine in the world which was able to automatically incorporate fiber optics into any flexible material (www.usneedle.com) in 1997. [11]

MIT staff purchased many fully animated jackets for their researchers to wear at their demonstrations in 1999 to bring attention to their "Wearable Computer" research. [11]

Wainwright was invited to speak at the Textile and Colorists Conference in Melbourne, Australia on June 5th, 2012 where he was requested to present his fabric creations that change color by using any smartphone, indicate callers on mobile phones without a digital display, and with use of WIFI secure the protection of purses and personal items from theft. [11]

In the mid-1990s a group of MIT researchers with Steve Mann, Thad Starner, and Sandy Pentland as leaders began to develop what they called wearable computers. These devices consisted of traditional computer hardware attached to and carried on the body. [12,13]

In response to technical, social, and design challenges faced by these researchers, another team of MIT, which consists of Maggie Orth and Rehmi Post, started to research how such devices could be more gracefully integrated into clothing and other soft substrates. [12,13]

At the same time, Maggie Orth and Rehmi Post explored integrating digital electronics with conductive fabrics and created a method for embroidering electronic circuits [12,13]

3. Difficulties in smart textiles design

In this part, we will refer to some of these challenges smart textile designers face. To understand all the difficulties that the researchers who want to create smart textiles face, we have to take into consideration some of the requirements textile circuits need to fulfill. The convenience and washability of the smart textile should not be affected by the presence of the circuits, i.e., at the same time it should be rough enough to survive being used daily . Circuits need power chargers with light weight and having also high capacity to ensure independent operation for many hours (or more depending on the targeted end-user application). Smart textiles launch in the market need to meet the requirements of both textile and electronics sections. These criteria can often be very strict and also controversial. Below some of the important challenges we deal with smart textile creation:

• **Mechanical properties**: If we compare to flexible display applications that are going to be rolled around cylinders with diameters of a few cm, smart textile fibers are under high tensile and rolled in much smaller cylinders than 1 mm. The grade of tensile strain that e-fibers are under has to do with the textile structure but also with the position of the body at which the textile circuit is placed. Textile fibers for shirts and jackets close to the upper neck receive high levels of pressure. The use of simulants of textiles has shown that the stress in a shirt for example can be up to 20% at the shoulder blades.

• **Washability:** Latest smart textiles that launch in the market such as the ICDþ textile coat designed by Phillips and Levi needed the person who wear to take out all electronic components (including wiring) before cleaning. Lately, smart textile creators (such as the Eleksen textile keyboard trusted waterproof packaging to protect sensitive electronics from being destroying during washing.

• **Power supplies**: The majority of smart textiles are charged by classic rechargeable batteries, but these are large and bulky and not possible to incorporate totally into the textile structure. It is a strong motivation to create alternative wearable and lightweight power generation and storage devices. Examples include flexible or elastic batteries, supercapacitors and solar cells, and energy harvesting devices such as thermal and piezo generators. Unfortunately, none of these devices reach the levels of traditional batteries as far as storage and maximum current value are concerned. It is imperative to proceed with research to upgrade the performance of these textile-compatible power supplies for smart textile applications in the future.

• **Product development and commercialization**: The insecure contributions from the electronic and clothing fields lead to incompletely integrated applications. The electronics section still has a main role in the design of a product, and consequently, the main research efforts focus on solving technical problems such as incorporate microchip and computer systems into clothing or solving washability problems. Application developments focused on the clothing industry are still unusual and do not take into consideration or integrate the special product development and processing techniques of this sector. Because of this unstable situation, it is really challenging to achieve full adoption of electronics and fashion trends. As a result, smart textiles are difficult to differentiate themselves both from normal clothing and existing electronic devices. Successful design and development need a multidisciplinary group of technicians made of textile scientists, polymer chemists, physicists, bioengineers, software engineers, consumer specialists, and fashion designers.

Finding a common point and sorting out the jargon associated with each section can be challenging. Moreover, there is a limitation in the coherent vision for smart textile development between different research laboratories and universities. Product development can also have a high cost and often fruitless effort. For example, only in 2004 Eleksen developed textile keyboard prototypes and landed only three deals.

As a result smart textiles can be with high cost for the average consumer with smart textile jackets retailing for as much as $3000. Efforts to integrate electronic devices within clothing can result in safety concerns and lack of acceptance with the target audience (e.g., elderly people).

Finally, the section that present lacks a clear “killer” application that can lead development into a specific direction [14].

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Partnership

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