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Development of Electronic-Based Textile Technology Innovation – A Literature Study

Application of Technology in Industry

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Abstract

The purpose of this review is to provide an overview of the key innovative pathways in developing electronics-based textiles to date using resources available in the public domain regarding "smart textiles" or "textile intelligence". The material of this paper is taken from various literatures which are textbooks (academic), commercial products and issued patents. Based on the literature obtained it is reported that electronics can be integrated into textiles, where integration can be achieved by inserting electronic into textile surfaces, and electronics are added at the textile or electronic manufacturing stage combined at the yarn stage. The integration method can affect the nature of the yarn network in fabrics / textiles, such as the flexibility of the fabric.

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1. Introduction

When we talk about the function of clothing, most of us will say that clothing is something that can be worn to provide protection, to be stylish for the wearer and protect it from environmental conditions. But after learning about the broader function of the term, we gain knowledge about the existence of smart textile terms in the English language "smart textile." According to some experts in the field, it was stated that smart textiles have paved the way for changes in the use of textiles to a wider directions[1, 2].

The question now is: what is meant by smart textiles? Smart textile is a fabric that has been developed with new technology that provides added value to the wearer [3]. In his article, Gaddis mentions that what makes a smart cloth revolutionary is that smart fabrics have the ability to do many things traditional fabrics cannot do, including communicating, changing colors, delivering energy, and even growing [3].

Smart textiles can be divided into two different categories, namely for: (1) aesthetic enhancements and (2) having performance. Examples of aesthetics are those that cover everything from burning fabrics to fabrics that can change color. Smart textiles are defined as textiles that can respond to influences from the outside or the surrounding environment in the form of mechanical stimuli (vibrations), changes in temperature (thermal), the presence of magnetic sources, chemistry, flow and electric fields, or others. The response to this smart textile can be controlled according to the needs of the application[4, 5].

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Some types of fabric can collect energy from the environment by utilizing vibration, sound or heat, reacting to the input that has been set. Then there are smart textiles that can improve performance, which will have a major impact on the athletic industry, extreme sports, and military[3, 5]. There are fabrics that help regulate body temperature, reduce wind resistance and control muscle vibrations - all of which help improve athletic performance. Other types of fabric have also been developed for protective clothing from extreme environmental hazards such as radiation and the effects of space travel[3]. The health and beauty industry also takes advantage of this innovation, which ranges from drug-releasing medical textiles, to fabrics that are filled with moisturizers, perfumes, and anti-aging properties[3].

Hughes argues that textiles are at the core of human technological advances, which textiles have been used by humans for approximately two thousand seven hundred decades[6], where textile development is closely related to the key to discovering the formation of global societies for decades. The interest and discovery of electronic textiles as smart textiles has revealed boundaries in unlocking the broader potential of clothing, where smart fabrics can be used for defense, sports, medicine and health monitoring purposes[7], this is characterized by an unusually large number of publications with a very wide spectrum of investigations of use, such as: power transmitters and signals for ECG measurements[8], strain sensors[8], motion capture devices[9], devices for electrotherapy[10], sensors[11], chemical sensors [12], and photovoltaic devices[13]. This multifunctional fiber can be a key component of smart and interactive text, such as its superior advantages, such as low cost, durability, and ease of adaptation. To use this conductive fiber, fiber must be strong, flexible, stable to the environment, and resistant to chemicals[12].

The purpose of this review is to provide an overview of the innovative key pathways in developing intelligent electronic-based textiles to date using resources available in the public domain regarding "smart textiles" or "textile intelligence".

2. Research Method

The paper is written based on various literatures, that are textbooks (academic), commercial products and issued patents. From the literatures obtained it is reported that electronics can be integrated into textiles, where integration can be achieved by inserting electronics onto the textile surface, and electronics added to the textile or electronic manufacturing stage are combined at the yarn stage. The integration method can affect the nature of the yarn network in fabrics or textiles, such as the flexibility of the fabric[2, 13].

In order for this review to be understood properly, it is necessary to describe the various terminology / terms used to indicate advanced textiles. Smart textiles will be used in this discussion as electronic-based textiles, where the fibers have electronic conductive properties related to textiles (electronic textiles). But for the time being in this discussion, electronic textiles will be called smart textiles, even though this naming is considered outdated[18], but starting writing in this field we use smart textile terms first so that they can attract attention especially for readers who are new to the presence of advanced textiles[24].

In studying intelligent textile materials, there are several key words found, they are: Textile, Material, Fiber, Fabric, Manufactured, Viscose, Lyocell, Cloth, Smart, Active, Sport, Sportswear, Function, Underwear, Comfort, Sensor, Biosensor, Thermoregulation, PCM, Antimicrobial, Moisture, Humidity, Conductive and Electrode.

The review of the historical literature on the development of smart textile technology is focused on patented technological innovations and commercialized products, from sources on the internet. Non-internet sources have been referred to wherever possible; However, in many cases, especially for smart textile products, only on the website.

This historical review will focus primarily on the results of research after 2010 in the field of health care. The interest of researchers in smart textiles has increased significantly since 2010. A more specific purpose of this literature study is to review the main pathways for developing smart textiles to be applied for medical and health care purposes.

3. Results and Analysis

Textile or also known as fabrics, is a product made from fibers derived from nature and artificial fibers (synthetic) which are spun into yarn. Yarn can be formed into cloth in various ways, depending on the needs of its use[7].

According to Rattfalt (2013) fiber can be categorized as follows (Figure 1)[8]:

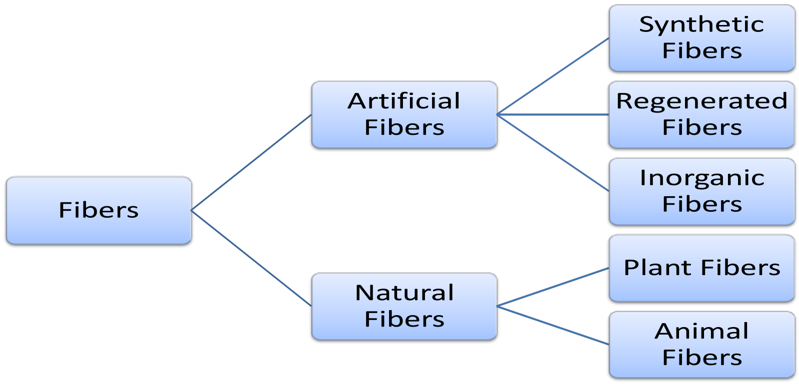


Figure 1. Fiber Classification[8]

Three components must be present in smart textiles, namely sensors, actuators and control units[14]. Textile materials are modified and installed miniature electronic devices to make smart fabrics. These textiles are like ordinary fabrics, but they can provide special functions in various situations according to design and application.

With the enactment of the millennium the human need for textiles has increased in the midst of times where the fabric is no longer just to protect the body from environmental conditions / conditions, but fabrics can also be used to show status, style, beauty and even wealth[15-17].

3.1. History of Smart Textile Innovation

The creation of textiles is closely related to discoveries that have shaped social or community life patterns, such as the existence of a frame of advancement by William Lee 1589[15], space shuttle by John Kay in 1733[16] and Spinning Jenny by James Hargreaves around 1765[16], and was set as the foundation for the first industrial revolution. A new revolution is taking place at this time, where the function of the textile has been developed by combining and inserting electronic components in textiles. One example of the use of the first electronic textiles was the use of headbands equipped with lighting devices at La Farandole's ballet in 1883[1]. Furthermore the Queen Elizabeth I dress, for example, is embroidered with thread wrapped in gold. At the end of the 19th century, in accordance with the development of human civilization, where people were getting used to electrical equipment, designers and engineers began to combine electricity with clothing as jewelry, developing a series of illuminated necklaces, hats, brooches and other costumes that were celebrating electricity[17]. Another example, in the late 1800s, one could employ young women decorated with light-dotted evening gowns from companies to provide entertainment for cocktail parties served by the girls called Electric Girl Lighting[18].

In 1968, the Contemporary Crafts Museum in New York City held an innovative exhibition called Body Covering that focused on the relationship between technology and clothing. This event is displayed in the astronaut's room in accordance with clothes that can expand and deflate on, heated and cool themselves [19]. The outfit displayed is a collection of works by Diana Dew, a designer who created an electronic fashion line, including an electro luminescent party dress and a belt that can sound an alarm siren[10].

By reducing the size and decreasing cost of producing electronic devices, as well as increasing the flexibility and complexity of geometry in small sizes, this has led to the ease of integrating electronic devices with clothing (textiles)[20].

The increasing use of smart textiles in the 20th century is inseparable from the development of material and electronic science and technology, in which the scope of electronic use planted in cloth is increasingly widespread. Conductive polymers are the main innovation discovered by Heeger et al. in 1977[18] whose new Noble prize was obtained after 33 years later[7, 21].

Another important development was the advancement in transistor technology, with the creation of the first MOS (ox-oxyde-semiconductor) field effect in 1960[22, 23]. The use of transistor-based electronics has given rise to the most beautiful clothing patented in 1979 [19].

Three different lines have been used to integrate electronics into textiles. These three different generations of electronic textiles add electronics or circuits to clothing (first generation), functional fabrics such as sensors and switches (second generation), and functional threads (third generation). Before E-textile creation there were also many examples of the use of conductive fibers in textile manufacturing, returning as far as the second century[2, 7]. The timeline that shows the evolution of E-text is given by Figure 2.

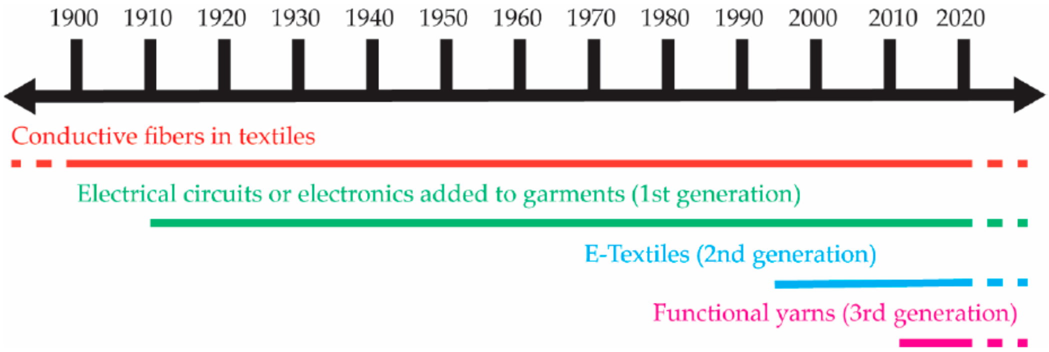


Figure 2. The timeline of various generations of electronic textiles showing when the technology began [7].

Each integration method will have an influence on textile properties such as the shear properties of the textile, or its flexibility, both of which affect the drapability properties. Figure 3 shows an example of each generation of electronic textiles, with contemporary examples of each generation of smart textiles[7].

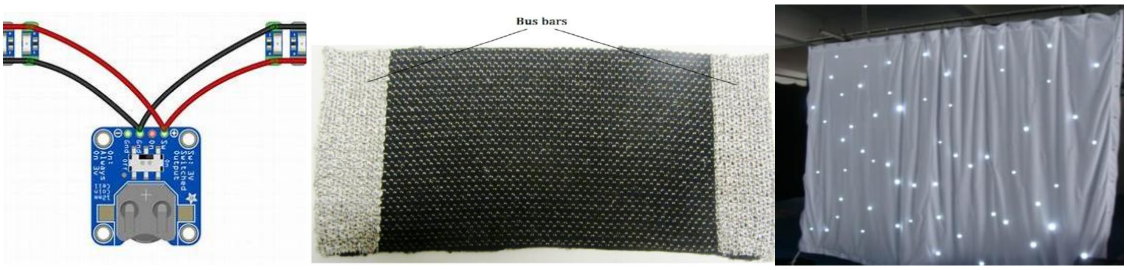


Figure 3. (Left) Adafruit coin cell battery holder. The first generation saw devices attached to textiles. (Middle) Knitted electrodes. The second generation of electronic textiles describes functional fabrics in which conductive elements are integrated into textiles. (Right) Example of functional thread (in this case LED Thread). The third generation of electronic textiles describes electronics embedded in textiles at thread level [7].

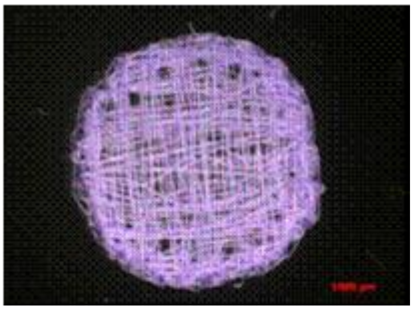
3.2. Application of Smart Textile for Healthcare

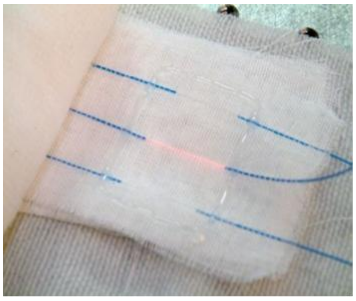
Smart textiles for health care include textile sensors, actuators, and electronic wearable systems, which are embedded into textiles to be able to register and transmit physiological data, as well as wireless communication between users and 'operators', for example, patients and nurses / private doctors. Such a system can control the mobility of the patient's movements, thus providing a patient's higher psycho-physiological level of comfort, especially when long-term bio-monitoring is needed [25-28].

In general, the application of smart textiles to medicines and health care varies from surgical applications using a single thread to more complex clothing with a complex axillary system for personal health care purposes. There is no classification of smart textiles for this application, but to begin with, it can be delivered by referring to groups that distinguish it from conventional medical textiles. Of course because the functions of implementing smart textiles are still developing. Now it is only known that this smart textile can be used in drug release systems, biometric performance textiles and active textiles for therapy and health. Table 1 below summarizes the main application fields of smart textiles for medical [4, 16, 23, 29].

Tabel 1. Application of Smart Textiles for Medicine and Health Care [15]

Application	In vitro	In vivo
Surgery	Bandages Wound-care	Sutures Self-tissues Orthopaedic implants Cardiovascular implants
Hygiene	Uniform for medical personal Hospital textile	-
Drug-release systems	Smart bandages and plasters	-
Bio-monitoring	Cardiovascular and haemodynamics activity Neural activity Muscle activity and kinematics Respirotary activity Thermoregulation	-
Therapy and wellness	Electrical simulation therapy Phsyoterapy Auxiliary systems Active thermoregulatuon systems	-


(a)


(b)


(c)

Figure 4. Embroided Scaffold[30] (a); wound dressing with a pH senso [12] (b); warm heating blanket[3] (c)

In its new achievements in the fields of material science, sophisticated products in the form of smart medical textiles were born in this world. Especially for surgical material that can be implanted, a real breakthrough has been obtained in tissue engineering using textile technology, for the purpose of developing two- and three-dimensional structures. With the structure that can be implanted, and compounds that encourage cell distribution and the adhesion properties in the body, the textile material can have extraordinary mechanical properties and can guarantee the opportunity to create different geometric structures. Figure 5 (a) displays a scaffold sample developed by chemical embroidery at TITV Greiz [31, 32].

Figure 5. A sample of Scaffold[33]

Smart, non-implantable or in vivo surgical textiles can also be characterized by dimensions of two or three structures and / or additional functional compounds. It can be fiber-based miniature biosensors that monitor or enhance the healing process. For example, there are already several scenarios suggested to ensure pH level monitoring for management of wounds and burns for assessment of biochemical changes in the wound environment (Figure 4 (b))[12].

A relatively new category of smart medical textiles is a textile-based drug delivery system (Figure 6 (a))[29, 34]. In some cases, giving transdermal drugs can be a good alternative to traditional pills and drugs in such situations when it is needed to reduce the effects on the stomach and intestinal tract, or drugs lose their activity. In fact, transdermal drug administration is a solution when oral administration is impossible or difficult[29]. The combination of textiles and biotechnology with chemical studies and pharmacy can offer various scenarios for the development of drug delivery systems.

(a) (b) (c)

Figure 6. Medical textiles with wrapping lubricating drugs [32] (a); TM motherboard that can be used for monitoring vital signs [34] (b); Philips phototherapy blanket for jaundice newborn treatment [9] (c)

In addition to the biomonitoring function, smart sensors can assist in prophylaxis and regulatory therapy as muscle electrical stimulation and posture monitoring [35-37]. For applications such as photo and photodynamic therapy, textiles can be a carrier material and textile manufacturing technology can be a means of a product manufacture. There are a number of developments such as pain relief and treatment of jaundice based on light emitting diode (LED) and fiber optic technology (Figure 6 (c)). For this application, textiles ensure the development of flexible systems that can be used and portable with a friendly interface. In addition, textile technology is a profitable approach for the manufacture of textile spreaders with different dimensions and structures. Electro-conductive materials are also used for the development of active thermoregulation systems. They can be integrated into clothing or clothing items to ensure external temperature regulation in clothing systems or become assets in infrared pain management[38].

3.3. Textile Sensors in Smart Textile for Healthcare

As mentioned above, textile sensors for physiological assessment and therapeutic purposes differ in functions and applications, materials and technological solutions, and the level of textile integration[39]. According to their general working principle, it can be physical, biochemical and optical transducers. Furthermore, the textile sensors can be divided into several categories according to the level of integration into the textile structure. This is largely determined by the technology approach chosen. According to the literature review, four common sensor structure categories are defined[4]:

(a) fiber-based, when the sensor is a single thread;
(b) structured textiles, when all transducer compounds are textile materials;
(c) textile-based, when textiles are substrate or other compounds that are insensitive, but cannot be separated from the transducer;
(d) integrated-textiles, when textiles carry carrier functions

On top of that, textile sensors can be characterized by functions, measurement units and their applications. Variations in the solution implementation approach ensure the application of the same technology for different purposes. For example, optical fiber technology offers scenarios for assessing these criteria such as temperature, humidity, blood oxygenation and sweat pH level, respiration rate and movement. Thus, to present an overview of the solutions available for health care, they are explained according to their sensory functions. Often smart sensors require a complex implementation approach by joining technology to achieve better performance. Although textile sensors differ in structure, the main compounds, which are based on the working principle, are substrate and, sensing or active materials. The sensor structure implemented by technologies such as coatings, thin films, lithography and inkjet printing, can also include functional elements such as coverings or encapsulations that protect sensitive compounds[40].

3.4. Textile Electrode

Textile electrodes can be divided into passive and active ones [41]. In both cases, their operating principle is similar to the conventional electrode working principle. Passive electrodes can be defined as textile sensors capable of acquiring electrical signals. They found that most applications in registering heart and muscle activity through detecting the electrical potential produced by the heart and muscles. They found an application for estimation of heart rate, analysis of heart rate (HRV) variability, electrocardiography (ECG) and electromyographic recording. There is also an investigation into the development of textile electrodes for the assessment of brain electrical activity. These electrodes measure voltage fluctuations that result from ionic current flows in neurons and are an alternative solution for conventional electroencephalographic electrodes. On top of that, passive textile electrodes can be used in the assessment of galvanic skin responses. They change their conductivity according to the saturation of electrolytes in sweat produced from the surface of the skin. Such electrodes find applications in textiles and smart clothing for biomonitoring and continuous wireless bio-feedback wearable systems. Active textile electrodes for smart medical textiles can be referred to electrodes for transcutaneous electrical stimulation. These electrodes transduce electrical current which is applied to a probe of tissue on the surface of the skin to activate targeted nerve cells, skin receptors or other bodily sensory and motor units or achieve pain relief through electrical nerve stimulation[22, 36, 42].

The most commonly used material for sensor implementation is conductive textile material that can be threaded which ensures the manufacture of textile electrodes through conventional textile manufacturing such technology as weaving, knitting and embroidering. Another approach offers solutions that are applied through inkjet and screen printing, and thin film technologies such as sol-gel and sputtering methods [8, 43]. Textile electrodes made by mentioned conventional techniques show efficiency even though they are higher in performance and use (washing).

3.5. Temperature Sensor

Another important parameter in health monitoring is body temperature. It results from a balance between heat production and heat loss and reflects the chemical and physical processes of thermoregulation combined with the activities of other organ systems, such as the endocrine system and nerves. For medical assessment, the most informative and significant parameter is the core temperature, which is a constant temperature in the body part that is deeper and in the part of the proximal limb. Another criterion is the temperature of the shell, which is measured on the surface of the skin and on the hands and feet approaching room temperature 19˚C in someone who stands in a cold room for hours[44].

Temperature sensors based on smart textile technology can provide an evaluation of the temperature changes on the surface of the skin and the environment near the body. These data can be used for that application as physiological assessment, control and improvement of patient comfort, and monitoring wound healing. Textile manufacturing and engineering technology offers solutions for fabrication of fiber-based sensors or single threads, woven, knitted, embroidery and printed for temperature estimation[43, 45]. With the principle of their operation, the reported temperature sensors are designed like thermocouples, resistive sensors or strain, semiconductive and optical[40].

Initially thermocouples can be called the simplest solution for implementing temperature sensors because of their structure. They consist of two different metal materials combined in one point and the voltage associated with the difference in temperature produced by the junction between metals[23]. The data achieved can then be converted into output temperature signals by electronic circuits[38]. Reject or filter the temperature sensor to function as a resistance temperature detector (RTD). The working principle of such a sensor is based on changes in the electrical resistance of metals related to temperature. The two types of temperature sensors mentioned are usually made from conductive yarn or with applications from monofilament metal wires. Semiconductive sensors based on polymers and temperature signals are achieved according to the analysis of semiconductor resistance. Another type of temperature sensor is a Bragg grating (FBG) fiber-based sensor, which is an optical sensitive material that reflects certain wavelengths of light and transmits others[39]. Fiber engineering and coating Technology inspires the development of single-threaded miniature sensors based on thermosensitive polymers and carbon nanotubes and FBG-based sensors[45].

3.6. Respiration Rate Sensors

In physiology, respiration is defined as the process of taking oxygen and removing carbon dioxide from cells in the body[3]. This is a two-stage biochemical process that produces exchange gas and cellular respiration. Breathing is marked by the rate of respiration (RR, breath per minute)[15, 27].

Breathing which consists of inhalation and respiratory activity is part of breathing and koher with stomach and chest movements. The strain sensor ensures the estimation of this movement efficiently and then the data obtained can be used for RR evaluation. Optical fiber is one of the materials most often used for this purpose because of the relative simplicity of fiber optic measurement and processing approaches with technologies such as weaving and embroidery[3].

Although respiration rates have limited application in the assessment of respiratory dysfunction, these parameters are often important in telemetry monitoring during certain clinical assessment procedures, sleep monitoring and a number of respiratory disorders. Textile sensors for RR estimation also found a number of applications in protective and combat clothing, smart textiles for the sudden prevention of infant death syndrome (SIDS), and monitoring vital signs for elderly or disabled patients[25,50,51]. For this purpose, breathing is first an indicator of normal physical activity. On top of that, these parameters along with cardiovascular parameters can also be important criteria in sports physiology in order to plan efficient training without risk to health[4].

3.7. Textile Sensors for Kinamatic Analyisis

In addition to registering physiological parameters, textile materials can help in kinematic analysis, monitoring of motion and body position. This criterion is important in the rehabilitation and assessment of skeletal systems during therapeutic and diagnostic treatments with the application of fiber optics, piezoelectric materials and elastomers[37, 42]. The approach ensures an integrated textile solution that can be used to monitor certain long-lasting gait, posture, body and joint units, and general position or patient movement activities. The data obtained can be processed and used for remote real-time capture images without using complicated camera applications or inertia sensor systems. Besides being able to use sensors, there are sensors to capture motion for applications such as Ambient Assisted Living (AAS) and sleep monitoring[46].

Figure 7. Textile sensors for Kinematic Analysis[52]

Solutions for these applications can be ensured by capacitive textile sensors and implemented according to scenario varieties using conductive textiles and piezoelectric materials[46].

Figure 8. Realizing pressure sensors using textile process e.g.: Keyboard[45]

3.8. Humidity Sensor

Humidity is an important criterion in many phylological and biological processes, and can significantly affect human health. Initially humidity can be referred to as absolute humidity which shows the actual amount of steam. Relative humidity (RH) implies the percentage of the amount of steam in the air at a specified temperature compared to the amount of steam, which can hold this temperature air. The capacitive humidity sensor consists of two electrodes and is placed dielectric between the electrodes. The RH value is determined according to changes in the capacitance of the dielectric constant, which is the relative humidity and dielectric temperature. So, the main requirement for dielectric materials is hydroscopicity, which is easy vapor absorption in the environment. The principle of operating a resistive humidity sensor is based on measuring changes in electrical impedance in a hydroscopic medium. Hygroscopic materials absorb water and ionic functional groups are separated, resulting in increased conductivity. Thus, as humidity increases, material resistance decreases[50]. Both are described as working principles of conventional moisture capacitive and resistive sensors can be transferred to textiles through different implementation scenarios. Efficient relative humidity measurements usually require a complex approach by combining technologies such as weaving, embroidery, fiber coating, inkjet printing and lithography[47-50]. The choice of the most appropriate approach is determined by the chosen sensor structure, material and application. Initially textiles can be successfully used as steam or moisture absorbent for substrate materials because of their physical and chemical characteristics. In addition, conductive textiles are also good candidates for the application of sensor electrodes[38].

At present, there are several approaches to developing moisture sensors through smart textile technology for health care applications such as stomach ulcer prevention, monitoring sweat and moisture levels in wounds. A research team from Spain offered a fully textile moisture sensor for bed rest patients developed with conductive threads and metal monofilament with weaving and pressing[47]. Researchers from Warsaw University of Technology showed another approach to sensor development by joining the inkjet-printing and coating technology. The sensor electrode is inkjet printed directly on the textile and then coated with a vapor absorption layer [49]. Conolly et al. printing technology is also used to develop a humidity monitoring system with integrated textile sensors for the assessment of wound healing [43]. Another scenario for textile moisture sensors is realized. in the frame of the Ero-pa Biotex Uni project. They have developed a sandwich sandwich structured capacitive sensor for monitoring sweat rates[45].

3.9. Sensors for pH Level Estimation

pH level is one of the important indicators in the assessment of biochemical processes in physiology and is governed by acid-base homeostasis. pH level is an important parameter in wound assessment of healing and sweat monitoring. Textile technology and modern techniques offer several scenarios for developing such sensors that ensure continuous, real-time pH monitoring. Despite various developments, there are several main scenarios for sensor implementation described in literature [12, 17, 45, 46, 51].

One of them is based on the application of halo-chromic materials such as dyes and hydrogels that are sensitive to pH and further colorimetric analysis. Such an approach for measuring the pH of sweat based on textile-based platforms is described by Coyle et al[45]. and Caldara et al[17].

The function of textiles for collection and storage of sweat. The pH-sensitive layer is immobilized on the fabric carried out as an environmental indicator of pH and the LED can carry out quantified sweat analysis. Another solution is the integration of optical fibers with pH-sensitive layers into dressing wounds[12, 51].

Another approach to assessing changes in the pH range in wounds is based on impedance measurements. Nocke et al. (2012) suggest scenarios for impedimetric single thread sensors[50]. The sensor consists of two monofimenter gold electrodes and a pH sensitive layer. The inner electrode is covered with a pH-sensitive hydrogel and the outer electrode wrinkles around the inside. Pulse sensor Pulse oximetry is a non-invasive technique for estimating arterial oxygen saturation (SpO2) in the biological tissue studied. Pulse oximeter measures the absorption of light oxygen and deoxygenated hemoglobin at two different wavelengths in the near-infrared spectrum. Pulse oximetry finds application in clinical applications such as emergency rooms and recovery, intensive care and during anesthesia[39, 52]. Figure 9 below illustrates the use of smart textiles in medicine and healthcare.

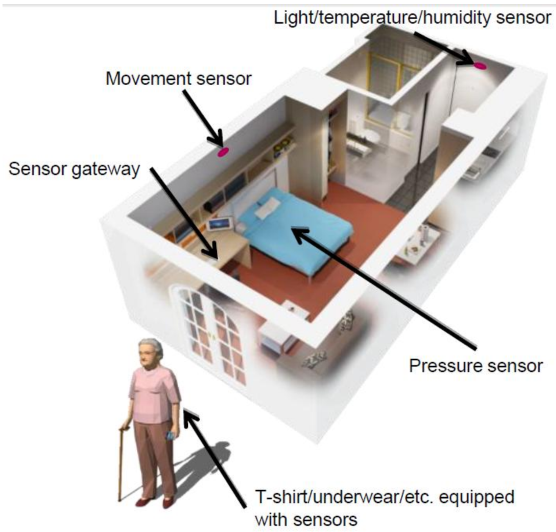


Figure 9. Illustration of smart textile use in the field of medicine and health care[51]

Although smart textile technology has not been explored much compared to the development of textile electrodes or other textile sensors, there are already solutions offered initially based on two scenarios. Zysset et al. has shown a scenario based on miniature electronic applications conventionally processed and integrated into textiles. LED Miniature and photodiode (PD) are placed on flexible plastic lines which are woven into a fabric with conductive threads, which ensures electrical interconnection between the entered compounds[39].

Another approach to the application of fiber optic technology has been suggested in the Ofseth research project and a research team from Switzerland. In the previous investigation frame, a mixture of optical fibers was used to measure blood oxygenation[52]. Zysset; De Jockkheer; and Roth-Maier et al offered three options for developing a SpO2 sensor by weaving and embroidering two techniques using plastic poly (methyl methacrylate) optical fiber (PMMA POF) as a sensing material and polyester fiber as material[52].

4. Conclusion

Smart textiles find a variety of applications and have sensing and driving functions that can be efficiently used in medicine, engineering and fashion. Smart textiles for previous use are one of the most important niches in the R & D field because of socio-economic and technological drivers.

Such textiles offer advanced solutions for smart clothing and textiles for sensing and driving, protective clothing, detectors of patients' individual activity / mobility movements in hospitals and during surgery, healing processes, improving safety, comfort and life of patients ensuring mobility.

There are already a large number of solutions and scenarios offered for manufacturing biosensor textiles, but most are still in the prototyping stage. Some products have been accepted by the industry and introduced to the market, but the technology transfer process for manufacturing is difficult to implement. The first step to overcoming barriers related to technical, strategic and socio-economic conditions is the making of prototypes, which are then made technological changes to lead to mass production. This solution will lead to a reduction in costs and make the price of smart textile products more competitive and attractive compared to the parent goods.

Until now, of all the varieties of textile sensors and actuators for health care, and textile electrodes have been developed and commercialized. Optical technology is also often intended to ensure sensing and driving (actuating in and between the face layers of textile products.

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