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Smart Textiles in Sportswear

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Abstract

The aim of this document is to provide information on the state-of-the-art related to the topics covered by each working group within the CONTEXT project. It provides information on materials and technologies used to develop smart textiles with targeted performance, general applications of smart textiles in the field, case studies on the use of smart textiles, opportunities for smart textiles considering the needs of each field, and trends in the development of smart textiles in terms of market and technical expectations.

Introduction

Smart textiles are defined as textiles (in the shape of shirts, socks, shorts, belts, etc.) that can sense and react to environmental conditions or stimuli, from mechanical, thermal, magnetic, chemical, electrical, or other sources to provide functions such as health monitoring and activity tracking. They are able to sense and respond to external conditions (stimuli) in a predetermined way. Smart textiles for sportswear and wearables have been at the centre of the textile research interest for the last years and numerous national and international programs have given impressive results.

Smart textiles for sportswear and wearables have also generated very interesting interactions between various branches of engineering such as electrical, electronics, telecommunications, micro-nano technologies microchips, mechanical, textile, chemical, materials, biology, physiology and physics etc. However, over the last years, although it was expected that the technology developed at the research labs would have shifted to pass into the application and industrial level, a delay has been observed.

Furthermore Smart Textiles in sports might support athletes in comfort, preparation, monitoring, undertaking and rehabilitation. Professional athletes might have a different focus on several of these aspects that consumer oriented sports.

Smart Textiles For Sportswear

Smart sportswear promises to offer effective solutions for wearers who seek more detailed data about their fitness and performance. Smart fabrics can also increase the comfort level of the user and eliminate the use of bulky equipment such as chest straps. Since athletes and major league players constantly strive to improve their performance, an opportunity of storing data for analysis by lightweight devices that can be embedded in their sportswear offers a high potential for further performance enhancement. Specifically, technology-enhanced sportswear, including compression garments designed to and muscle recovery, can provide an appropriate medium for carrying large numbers of sensors close enough to the wearer's skin, to pick up the weak electrical signals generated by physical effort.

Multiple extra data types, in addition to heart-rate electrocardiogram (ECG) signals, can be collected today, including electromyogram (EMG) for analyzing muscle activity. Furthermore, accurate body-temperature monitoring can be useful for monitoring fitness and can also protect the wearer against the dangers of over exercising. Finally, smart clothing products for sports have the potential to reduce or eliminate most of the preventable injuries. E-textile is a multidisciplinary domain, bringing together different scientific and technological expertise with broad application areas. This makes it a challenging domain with a large market potential.

Functions of Smart Textiles

The development of high-performance materials has made it possible to produce highly specialized products with specific programmes and even specific functions. A smart textile can interact with a wide range of parameters in different ways. For instance, it can receive or reflect a signal (parameter of interaction).

The absorbed signal can be converted into another readable signal, such as a change in colour, current, or voltage. On the other hand, protection against heat or cold, and natural phenomena such as snow, wind and rain is another important area of protection, and here too the comfort setting is important. Smart textiles are often developed to solve such problems and can provide solutions to them.

Sensors in Textiles

In general, systems intelligence can be created through the use of various types of sensors. Today, sensors have become an integral part of control systems and can convert physical quantities such as pressure, strain, heat, humidity, temperature, etc. Currently, smart textiles are systems that measure important features such as heart rate, respiration rate, temperature, movement, and humidity by installing traditional sensors in textiles. In the current stage of smart textiles, the sensors are made of real textiles.

A biosensor is a sensing tool that combines a biological component with a detector. This element replies with a feature change to an input analyte, for example; measuring blood glucose levels. Biosensor research is becoming a widely studied discipline due to its features such as easy, rapid, low cost, very sensitive, and highly selective, leading to advances in next-generation drugs such as individualized medicine and ultrasensitive point-of-care detection of markers for disease.

Actuators in Textiles

Actuators are devices that are designed and operated to perform the required operations according to the signals received from a sensor or process (Wilson, 2004). In this way, they can perform actions such as moving objects, releasing materials, and creating sound by passing the effect sent from the sensor through the information processor. Materials change their original shape as the temperature changes and return to their original shape by chemical, mechanical, magnetic, or electrical effects. Their reactivity of heat changes allows them to use shape-memory materials as a stimulus and meet the needs of smart textiles.

In this case, the emission seems to be released by stimulating other environmental variables such as temperature, pH, humidity, chemicals, etc. In fact, a system capable of actively controlling drug secretion is expected to integrate the body with smart clothing capable of receiving simple health findings. Therefore, drive motors are expected to have some technical and mechanical components and to address problems in both areas . Actuators can be used for heating, cooling, insulation, ventilation, and moisture control. Thermal actuators are simple actuators that generate actuation from thermal expansion and phase-change volumetric expansion.

Other Functions of Smart Textile Systems

Data Processing

The processing of data and information collected by sensors is necessary to achieve the desired output, in order to achieve the desired goal in smart textiles, a suitable processor is needed. The sensors used in textile fibres can provide a great deal of information, but how to evaluate the information and highlight the process is the main challenge for the processor. Because the electronic elements required for energy are not small or flexible enough, they vary in the structure of fabrics. Moreover, the need for waterproofing of these energy units is an important issue. These problems are generally more common in smart textiles. In the case of vehicles, waterproofing is not a problem because data-processing elements can be installed inside the vehicle.

Communication

Communication covers the connection between different components of the textile system and the user and/or other person. In other words, it is one of the components of smart textiles that are formed according to the type and communication need. The wearer requires feedback on the recorded data and issue instructions. There are many types of communication in smart textiles. An element of dressing can be installed between its two different elements. Currently, the connection inside the clothing is provided by optical fibres or thin conductive wires. They are woven naturally and can be seen into fabrics without the use of stitches. A particular communication protocol is followed to communicate with the owner. Pressure transmission systems are other communication rules used by smart textiles.

Energy Storage

Another feature of smart textiles that is not as important as the previous features is energy storage. However, smart textiles with better storage capacity seem to work independently. The information stored in smart textiles is energy. For example, in samples that release drugs or emit odours, it has been shown that this storage unit will also be useful in different areas. Tracking, computing, actuating, and communication units typically require electrical energy.

Innovations in Smart Textiles

Smart and technical textiles are of great interest because of their ability to sense, stimulate, and generate/store power where they are permitted under health monitoring, protection, and safety supervision . They have a wide range of applications including military, healthcare, sportswear, etc.

The integration of electronics into textiles could be possible via three main methods:

1. Directly mounted into the surface of the garment, without being a part of the textile structure (e.g. attachment of sports bras into the garment for heart rate monitoring).
2. Integrated into the textile structure via knitting, weaving, and embroidery (e.g. use of conductive fibres for the creation of electrodes or conductive).
3. Incorporated within the textile yarn (e.g. integration of polymer strips, populated with surface-mounted devices and conductive tracks, during the weaving process).

Recent Developments in Textiles for Sportswear Applications

Among the different types of smart textiles, those applicable for sportswear have gained increasing attention from researchers. This makes an interesting interaction between different fields of engineering including the textile, material, chemical, micro- nanotechnologies, microchips, mechanical, electrical, electronics, biology, physiology, and telecommunications areas. Despite the recent rapid development of innovative smart textiles for sportswear on the lab-scale, their industrial application on a large scale has been delayed. Some of the common examples of sportswear are athletic clothing, football clothing, swimwear, protective helmets, gloves.

Standards and Evaluation Criteria for Sportswear

Suitable sportswear has features such as comfort, high quality, and appropriate size. As the possibility of sweating in sports doubles, the importance of choosing appropriate sportswear to prevent sweating and fungal and skin diseases is doubled. Therefore, the clothing material should be allows the skin to breathe by absorbing sweat, and of course, it should have a material that keeps the body cool. The type of sports clothes has a direct relationship with the desired fabric.

Fabrics Designed for Vibrant, High-Mobility Activities must meet the Following Requirements

- Stay dry and cool for long periods of time
- Ability to absorb sweat
- Transfer hot air from inside to outside the shirt
- Proper elasticity.

Cotton sneakers, which are made of natural fibres, are light and easily absorb moisture and pass through the body. Therefore, they are suitable clothes for exercising. Synthetic fibres such as nylon, although light and comfortable, do not have the ability to absorb moisture and can cause skin problems. Synthetic fibres last longer than natural fibres and take longer to break down, while natural fibres are better for the skin. Excessive body temperature is very dangerous and can even cause a heart attack. Also, low body temperature and low-intensity exercise in cold weather can cause the individual to catch a cold or muscle dryness.

Therefore, it is better to wear clothes that are compatible with the environment in the training takes place in order to control the body temperature. The necessary functions for designing special sportswear are listed specifies the performance specifications of woven fabrics, including any fabric or mixture of fibres used in women's and girls' sportswear, shorts, slacks, and suit fabrics.

Design Considerations in Sportswear

The properties of common textures could also be enhanced through their modification, as in the case of synthetic fibres in which the thermo-physiological and sensorial properties can be improved by their modification during the synthesis process to produce hollow fibres, irregular cross-sectional fibres, or a combination of natural and synthetic fibres. Recent advances in fibre and textile engineering, along with the rapid development of various sports, could influence the design of sportswear in two basic areas e technical and aesthetic aspects e which are mainly related to enhancement of the protection/athletic performance and the introduction of new styling options, respectively. The use or comfort of sportswear which is directly related to the individual feelings of the wearer is one of the most crucial properties that should be considered in textile selection Regarding the direct contact of the sportswear's base layer with the athlete's skin, it should be able to maintain a heat balance between the excess heat produced by the athlete's body as a result of increasing the metabolic rate and the dissipation of heat from the body.

Smart Textiles for Human Safety

The safety of workers in dangerous situations has always been a matter of concern. Smart textiles for human protection in a dangerous environment need technical and scientific knowledge. Smart textiles for human safety have been used in the defence, police, and fire services and in therapies. Defence forces are highly reliant on technical textiles that can provide protection as well as camouflage features for soldiers. The protective textiles are woven, knitted, or nonwoven fabrics that are coated or laminated with various materials.

Outlook and Future Trends

In the modern world, because of advances in technology, textiles have a greater purpose than just appearance. The textile industry has focused on producing multifunctional fabrics that can provide essential requirements in dangerous situations such as fire, high pressure, and intense weather conditions. In addition, there is great interest in manufacturing smart textiles that can sense changes in the outside world and respond effectively to these triggers. The protective textile industry has a great outlook for human quality of life, including medical devices, safety applications, curing purposes, and sportswear.There are various functionalities in smart textiles which are simple systems that have four functions: sensor, communication, data processing, and energy storage.

The Commercialization Process of a Product has Various Obstacles, Including

1. The material selection stage
2. The technology needed for production, and
3. Engaging industry expert.

Currently, the responsibility for solving problems and overcoming obstacles to commercializing smart textiles lies with engineers who have adequate and updated knowledge. Fortunately, this market will bring on board valuable industry stakeholders.

Conclusions

The main and important task of textiles are to protect our bodies from environmental conditions such as the sun's rays, cold winds, rain, etc. These smart textiles do not only have the task of maintaining us in extreme environmental conditions, but also protecting and monitoring, and sometimes helping to treat damage or diseases. These kinds of fabrics provide new features, including these specific features, which can be attributed to the possibility of communication and data transfer. One of the growing sectors of the textile and clothing industry is the performance of clothing. Recently, exercise has become a vital part of daily lives of many in order to keep themselves physically and mentally fit.

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