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Smart Textiles and Their Applications-A Review

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Abstract

The 21st century has been marked as the extreme of technological growth, which has produced some pretty interesting results. In this we are going to explore the concept of smart textiles and to judge our future in textile industry. The concept of smart textiles is basically classified in three categories according to its functional activities. With the development of technology and its application all across the industry, smart textiles have risen to immense prominence lately. Smart textiles can be defined as textiles that are able to sense and respond to the changes in their environmental conditions. By integrating electronic components, sensors and inter connectivity directly into protective garment, a wide range of functions can be accomplished. The technology of smart textiles is an integration of almost all disciplines of applied sciences. Using a novel fabrication process, MIT researchers have produced smart textiles that snugly conform to the body so that they can sense wearer's posture and motion. Textiles make smart wearable devices flexible, lighter and friendly existing nest to our skin. The expressions or smart and intelligent textiles or wearable electronic textiles are commonly used interchangeably. At its core, technical textiles manufacturing is a vast landscape of advanced yarn system combined with textile formation techniques.

Keywords- *performance enhancing, ultra smart textiles, shape memory textiles, textile electronics, protective garment, fibre technology, integrated sensors, smart wearable system*

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INTRODUCTION

A textile is an object made by weaving threads or yarns into a fabric. Originally these yarns were made of natural, animal or plant based fibres. Then, a technology is improved synthetic fibres were manufactured in laboratories that were stronger and more versatile. Now digital communications technology has reached the point where the same extremely thin fibres that run through our smart phone and relay data can be woven into cloth textiles. That is what a smart textile is: a cloth that has modern computer-based technology woven into it. The whole idea is that smart textiles are adaptive. For example when our laptop is over heated the change is registered as data. That creates an automated response, the computer fan turns on. That's how it works with smart textiles. The technology woven into fabrics will be to perceive environmental changes and respond accordingly depending on the programming or type of technology being used. Already smart textiles are beginning to become groped into one of two categories: aesthetic and performance enhancing Aesthetic smart textiles are those that use technology for fashion and design purposes bringing lights and sound into the world of textiles. Performance enhancing textiles assist in human functions, like jogging, by monitoring things like body temperature and adjusting the breathability of the fabric accordingly. This is a very young field, only started around 2006, so defining what is and is not within the realm of smart textiles is, in many ways, still up for debate. The key factors however are responsiveness to external stimuli and the use of thin technological fibres woven into fabric **[1].**

Smart textiles are classified in three categories according to its functional activity. Passive smart textile is the first generation of smart textiles, which can only sense the environmental conditions. Active smart textile is the second generation which has both actuators and sensors. The actuators act upon the detected signal either directly or from a central control unit. Active smart textiles are shape memory, water resistant, chameleonic and vapour permeable heat storage, thermo regulated, vapour absorbing and heat evolving fabric. Ultra-smart textile is also known as very smart textile. It is the third generation of smart textiles, which can sense, react and adopt themselves to environmental conditions. A very smart textile essentially consists of unit which works like the brain, with cognition, reasoning and activating capabilities. There is a difference between

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smart textiles and intelligent textiles. To overcome this, the relation between environmental condition and stimuli must have to understand. Actually intelligent textile is those which is capable of responding or activate to perform a function in a manner pre-programmed manner. Some characteristics of fibres used in smart textiles are (i) it should be of high strength (ii) it should be high chemical and combustion resistant organic fibre (iii) it should be high modulus organic fibre (iv) it can be ultra-fine fibre and novelty fibre (v) it should be high performance inorganic fibre **[2]**.

The textile industry has been progressing in leaps and bounds over the years. In recent times the industry celebrated many new innovations and progress that have been pioneering a big change and adding a lot of characters to the industry. With the developments of technology and its applications across the industry smart textiles have risen to immense prominence lately and their application areas like medicine care, protective clothing, shape memory textiles, sports textiles, etc, have been brought under the spot light. That is why we must look at this concept more closely. Smart clothing, thus is defined as a new garment feature that can provide interactive by sensing signals, processing information and actuating the responses. They are capable of showing a significant change in their mechanical properties such as shape, colour and stiffness or their thermal or electronic properties. Typical examples of smart textiles are fabric and dyes that will change their colour where the clothes are made out of conductive polymers which give light when get electromagnetic signals. They also regulate fabrics surface temperature of the garments in order to achieve physiological comfort. The first smart textile material was silk thread which has a shape memory. Keeping this in mind the thoughts have been generated to understand the concept of smart textiles through the varied types of smart fibres which are discussed as follows: Shape memory fibres are referred to as that possesses a shape memory effect. It means that when deformed a fibre is given some external stimulus by means of pressure and temperature, the deformed fibre would return to its original shape. Conductive fibres possess excellently specific resistance and electrical conductivity, absorb electromagnetic waves, detect and transmit electrical signals. These are classified as electro conductive fibres, ion conductive fibres and inductive fibres. Health smart fibres are developed for the enhancement of people's awareness against anti-bacterial

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fibre, safety and implant resistance fibre. Among them selective anti-bacterial fibres will inhibit or kill the surface bacteria by the addition of an antibacterial agent **[3].**

Smart textiles can be defined as textiles that are able to sense and respond to changes in their environment. They are divided into two classes: passive and active smart textiles. The scope of the article discussed here is focussed on smart textiles that are classified according to their mainfibres of applications: (i) medical (ii) transportation (iii) protection, security communication and textile electronics. The object is to present the latest research results together with basic concepts related to the most promising applications. This article is highlighting all the main fields of applications of smart textiles. The scientific issues and proposed solutions regarding various results, prototypes and achievement obtained in the best academic and industrial laboratories solutions and their realization, believe to be the industrial partners. The term smart textile is used to describe material s of its structure, composition and behaviour in special conditions. To achieve wound care product which may be classified as smart, it is necessary to refine plain dresses. It is very important for the healing process to provide a moist environment for wounds, while still enabling adequate gaseous exchange. Therefore, the occlusive and adherent properties of covering dressing must be preserved. In contrast, dressing should be easily removable, without causing additional post-wound trauma and they should be supported by epithelisation the process which in turn causes wound closure and therefore healing **[4].**

A great example of smart clothing is a work environment for emergency first responders such as fire fighters and rescue workers. A goal is to improve their safety coordination and efficiency and the survival management they provide for civilians. By integrating electronics components, sensors and interconnectivity directly into protective garments, a wide range of functions can be accomplished. Continuous monitoring of the life signs, continuous monitoring biosensors, pose and activity monitoring, low-power local wireless communication, including integrated fibre antennae, that automatically transmit this data, active visibility enhancement, light emitting fibres, internal temperature monitoring sensors, external chemical detection, including toxic gases and vapours, integrated flexible displays that provide key sensor outputs to the wearer, power

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generation and power storage. Similar protective smart clothing can be used in other areas such as health care, building workers, transportation maintenance. Of course, the military is an early adopter of these technologies as well. By embedding electric, electrochemical and optical sensors into a textile substrate it is possible to create sensing patches that able to monitor the biochemical parameters of a user. These sensors can monitor bodily fluids such as blood, sweat and urine of the wearer throughout the day. They could find applications in medical monitoring from diapers to hospitals to elderly care **[5].**

When the myriad sciences are blended with one another they produce fashionable textiles which make our lives comfortable and luxurious. Smart textiles, however, are not just restricted to clothing and appear but extended to many applications like automobiles, robotics, aircrafts, medicine and surgery, etc. The importance of these materials is so profound at some places that they virtually act as life saving materials. Smart textiles are also made to meet the demands of military. For example, clothing that can change colour to produce camouflage effects for protection was developed by US army in collaboration with various industrial firms to meet military requirements. Smart textiles have number of applications and some of the examples are mentioned as follows: an optical fibre consists of a core surrounding by cladding whose refractive index is slightly smaller than that of the core. Optical fibre is normally coated with a protective layer of an outside diameter of approximately250 micrometer. The sensors made of optical fibres are small and flexible. They will not affect the structural integrity of the composite materials and can be integratedwith the reinforcing fabric to form the backbones in structures. Some of the types of surgical sutures may also be regarded as intelligent fibres. Many types of sutures are described as absorbable materials, which are intelligent materials in that they hold the edges of the wound together until the wound has healed sufficiently. The data wear incorporates sensors at each of the body joints plotting their position on a graph, which can be calculated on a computer. The sensors are made from conductive elastane. Data wear clothes consist of magnetic position sensors. TCAS system measures the angle of each of these joints to determine their absolute position. The sensors can be placed to specifications for individual applications. The Data wear body unit consists of jackets **[6].**

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Using novel fabrication process, MIT researchers have produced smart textiles that snugly conform to the body so that they can sense the wearer's posture and motions. By incorporating a special type of plastic yarn and using heat to slightly melt it, a process called thermoforming the researchers were able to greatly improve the precision of pressure sensors woven into multi-layers knit textiles which they call 3D knits. They used this processes to create a smart shoe and mat and then built a hardware and software system to measure and interpret data from the pressure sensors in real-time. The machine learning system predicted motions and yoga poses performed by an individual standing on the smart textile mat with about 99% accuracy. The fabrication process, which takes advantages of digital knitting technology enables rapid prototype and can be easily scaled up for large scale manufacturing says Ormandy Wicaksono, research assistant in the MIT Lab and lead author of a paper presenting 3DKnits. The technique could have many applications, especially in health care and rehabilitation. For example it could be used to produce smart shoes that track the gait of someone who is learning to walk again after an injury or socks that monitor pressure on a diabetic patient's foot to prevent the formation of ulcers **[7].**

Orica co Shirt is a smart shirt, whose ling sleeves could roll up with the increase in temperature beat away the heat with the help of shape memory polymers. The fabric was woven from fibres of the shape memory alloy Ni Tinol, interspersed with nylon Kimberly Clark came up with a smart diaper made out of laminated textile which is responsive to humidity. When in dry state, moisture absorbing polymer is deformed and as the moisture content rise the modulus of the materials decrease and triggers shape change of the material. It takes desired configuration which can shield against leakages. Textiles make a smart wearable device flexible, lighter and friendly, existing next to our skin. Off late consumers are found to often relate smart wearable with smart textiles, unlike in the early 19th century. That might be the reason why the trending search for Smart wearable and Smart Textiles started emerging together around 2009 and they are now clubbed together as a category **[8].**

Clothing has been on e of the three basic human needs since the begging of our species. In the primitive age textile was used for clothing purposes and progressively extended to household and domestic applications. The textile was also used for technical applications such as sailcloth, tent, protective garments, ropes,

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etc., which leveraged the textiles properties to create a technical performance advantage. Smart textiles ate materials and structures that sense and react to environmental conditions or stimuli, such as those from mechanical, thermal, chemical, electrical, magnetic or other sources. Textiles are materials that can that react on themselves, unlike ordinaryclothes. The expressions or smart and intelligent or wearable electronic textiles are commonly used interchangeably. The term smart textiles may refer to either a smart textile material or a smart textile system. Smart textile materials are functional textiles materials actively interacting with either environment, i. e., responding or adapting to changes in the environment and smart textile systems are exhibiting an intended and exploitable response as a reaction either to change in its surrounding/environment or external signal/input. For instant, Steele, et al, developed a bionic bra using electro-material sensors and artificial muscle technology to detect the increase in breast motion and their respond with increase breast support to improve active living **[9]**.

Since smart fabrics are a newer technology, many people aren't aware of their potential. Smart textiles provide an added benefit to the user beyond the typical value of the fabric. They respond and adopt their environment. Fabrics are combination of fibres and polymers, natural and man-made are constructed through a variety of techniques, the most popular being the knitted or woven. Each blend or fabric serves a different purpose, individualized for a particular climate but since fabric is the foundation of so many products and more, it makes sense to see how its utility can be expanded. For example, temperature of cotton or linen clothing is perfect for hot environment, as they are breathable and light. However, the allowance for air floe that keeps us cool creates a problem, in colder temperature. Going back and to cold areas can be nuisance when choosing what clothing to wear. Functional textiles change that. The can adapt based on design structure or external stimuli. A fabric that can respond to a temperature change and keeps us comfortable, much like our skin along with new capabilities, smart fabrics create a more sustainable culture **[10].**

What Are Smart Textiles?

The 21st century has been characterized by an extreme rate of technological growth and it has produced some pretty interesting results. Let us imagine about our gloves that feel too cold and then having them

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respond by heating up or if we imagine about an astronaut floating out in the space and having the suit we wear automatically change its composition to compensate for changing levels of space radiation or any awesome dance club the shirt changes colours to the beat of the music what is going to happen? These are all within the realm of possibility at least theoretically. The newest stage of the technological revolution in the 21st century is the development of woven fabrics that can be infused with the latest technologies. We call these Smart Textiles and they are absolutely genius. A textile is an object made by weaving threads or yarns into a fabric. Originally, these yarns were made of natural animal or plant-base fibres. Then as technology improved synthetic fibres were manufactured in laboratories that were stronger and more versatile. Now global communication technology has reached the point where the same extremity thin fibres that run through our smart phone and relay data can be woven into cloth textiles. That's why smart textile really a cloth that modern computer-based technology woven into it. For instance when our laptop overheated that change is registered as data that creates an automated response, the computer fan turns on. That's how it works as Smart Textile. The technology woven into the fabrics will be able to perceive environmental changes and respond accordingly depending on the programming or type of technology being used **[1].**

We often do mistake to understand clearly smart textile and intelligent textile. To overcomethis we must have to know about the difference between two. Actually intelligent textile is that which is capable of responding or achieve to perform a function in a manual pre-programmed manner. Some of the important characteristics of fibres used in the Smart Textiles are such as high strength, high chemical and combustion resistance organic fibres, high modulus organic fibre, ultra-fine fibre and novelty fibre, high performance inorganic fibre. The smart textiles have five functions to complete its functions, which are such as sensors to capture parameter from the environment, data processing required when active processing is required, actuators to respond the resulting functions of sensors, simulation is found from the environment and giving response which comes from the actuators to give respond. There are various types of applications of smart textiles which we see in our daily life. This includes health care and telemedicine, sportswear and leisure, military, police and

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emergency services, equipment, entertainment and fashion wear **[2].**

Smart clothing is defined as a new garment feature that can provide interactive reactions by sensing signals, processing information and actuating the responses. They are capable of showing significant change in their mechanical properties such as shape, colour and stiffness or their thermal or electromagnetic properties. Typical example of smart textiles are fabrics and dyes that will change their colour where the clothes are made out of conductive polymers which give light when they get electromagnetic signals. Shape memory fibres are referred to as fibre that possesses a shape memory effect. It means when a deformed fibre is given some external stimuli's by means of pressure and temperature, the deformed fibre would return to its original shape. Temperature sensitive fibres are those fibres whose properties will change reversibly with temperature. Conductive fibres possess excellent specific resistance and electrical conductivity, absorb electromagnetic waves, detect and transmit signals. Health smart fibres are developed for the enhancement of people's awareness against anti-bacterial, safety and impact-0resistance fibre. Among them selective anti-bacterial fibres will inhibit or kill the surface bacteria by the addition of an anti-bacterial agent **[3].**

Smart clothing or e-textiles are fabrics embedded with ultrathin, flexible and transparent sensors, actuators, electronics, mobile connectivity and even nano-to power them. The combination of these components gives smart clothes new functionality that improves their performance and usefulness for the wearer when compared to their non-smart counterpart. One of the key challenges for smart textiles is the requirement to achieve and combine different properties like flexibility. To do this, researchers are making use of different materials like nano-materials, dielectric ellastomers, and composites. These are tailor made to specific application depending on their different characteristics behaviour upon different stimuli. Smart clothing is more than glamour. A great example of smart clothing in a work environment is for emergency first responders such as fire fighters and rescue workers. The goal is to improve their safety, coordination and efficiency and the survival management they provide for civilians **[4].**

Applications of Smart Textiles

Smart textiles synonymously electronic textiles, e-textiles, intelligent textiles and

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alike is a class of materials, where textile play a vital role but where functionalities form other disciplines are added. The smart textiles may comprise of conducting sensing, measuring and recently even actuating elements embedded in the otherwise passive fabric. During the last few years, smart textiles have grown to be an area of its own taking advantage of benefits that textiles offer. Electrically conductive textile structures are often regarded as the fundamental starting point for creating smartness and devices with more complex functionalities, other technologies such as chemistry and photonics can also be integrated. Smart fabrics can sense different environmental conditions and intelligent textiles or e-textiles cannot only sense environmental changes but can automatically respond to their surroundings or stimuli, such as thermal, chemical or mechanical changes as well. Smart textiles are a key component for sensing physiological parameters close to the human body supporting and assisting people in daily living. Flexible electronic textiles and wearable electronic devices are becoming more and more interesting every day. With the increasing interest in wearable electronics, production processes are developing and their usage is becoming wide spread. Electronic textiles are textiles that are part of electronic components that create systems capable of sensing, heating, lighting or transmitting data. Ultimately, e-textiles will have an important role to play in the field of medicine, safety and protection **[5].**

The smart textiles are materials and structures, that sense and react to environmental conditions or stimuli, such as those from mechanical, thermal, chemical, electrical, magnetic or other sources. Textile science today stands on a novel, unexplored and fantasy filled horizon. The technology of smart textiles is an integration of almost all disciplines of applied sciences. These myriad sciences are blended with one another to produce fashionable textiles which make our lives comfortable and luxurious. Smart textiles are not just restricted to clothing and apparels but extended to many other applications like automobiles, robotics, aircrafts, medicine and surgery, etc. The importance of these materials is so profound at some places like military, battle fields that they virtually act as saving materials. An optical fibre consists of a core whose refractive index is slightly less than that of the core. The sensors made from optical fibres are small and flexible and they will not affect the structural integrity of the composite

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materials and can be integrated with the reinforcing fabric to form the backbones of structures. They are based on a technology that enables devices to be developed for sensing numerous physical stimuli of mechanical, acoustic, electric, magnetic and thermal types. Fibre type optic sensors are ideal components to be embedded in textiles structural composites for monitoring the manufacturing processes and internal health conditions. Some of the surgical sutures may also be regarded as intelligent fibres. A suture is a length of fibre used to tie blood vessels or to sew tissues together. Data wear incorporates sensors at each of the body joints plotting their position on a graph, which can be calculated on a computer. The sensors are made from conductive elastane. Data wear clothes consist of each of magnetic position sensors, TCAS system measures the angle of each joint to determine their absolute position. The integration of functional electronics into textiles can be realized in two extreme ways. One is to produce an apparel or technical textile and then integrate the electronic component **[6].**

Using a novel fabrication process, MIT researchers have produced smart textiles that snugly conform to the body so that they can sense the wearer's posture and motion. By incorporating a special type of plastic yarn and using heat to slightly melt it, a process called thermoforming the researchers were able to greatly improve the precision of pressure sensors woven into multi-layered knit textiles, which they called 3DKnITS. They used this process to create a smart shoe and mat and then built ahardware and software system to measure and interpret data from the pressure sensors in real-time. The machine learning system predicted motions and yoga poses performed an individual standing on the smart textile mat with about 99% accuracy. With digital knitting, we have the freedom to design our own patterns and also integrate sensors within the structure itself, so that it becomes seamless and comfortable and we can develop it based on our body. To produce a smart textile the researchers use a digital knitting machine that weaves together layers of fabric with the rows of standard and functional yarn. The multi-layered knit textile is composed of two layers of conductive yarns knit sandwiched around a piezo-resistive knit, which changes its resistance when squeezed. Following a pattern, the machine stitches this functional yarn throughout the textile in horizontal and vertical rows. Where the functional fibres intersect, they create a pressure sensor **[7].**

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The Future of Smart Textile Industry

Oricalo Shirt is a smart shirt whose long sleeve could roll up with the increase in temperature to beat away the heat, with the help of shape memory polymer. The fabric was woven from fibres of the shape memory alloy **NiTinol** (Nickel-Titanium-Alloy), interspersed with nylon. Kimberly-Clark came up with a smart diaper made out of laminated textile which is a responsive to humidity. When in dry state, moisture absorbing polymer is developed and as the moisture content rise, the modulus of the material decreases and triggers shape changes of the material. It takes desired configuration which can shield against leakage. Textiles make smart wearable devices flexible, lighter and friendly, existing next to our skin. Of late consumers are found to often relate smart textile with smart wearable, unlike in the early 19th century. That might be reason why the trending search for smart wearable and smart textiles, started merging together around 2009 and they are now clubbed together a category. A smart garment is having a piezo-restive sensor just sensing velocity/ temperature/ embedded with piezo-resistive sensor which would sense the environmental temperature and further active the thermal actuator made up of electro-conductive material to act as heating element by exploiting electrical resistance of the material. **Owlet Smart** Socks are one of the wearable designed for infants and kids up to the weight of 25 Kgs, available in varying sizes and colours. They are embedded with sensors to monitor heat rate, oxygen level, and sleep trends. These may be placed under 1st generation STWs. The heart rate and oxygen levels are mentioned through pulse Oximeter **[8]**.

The success of inkjet printing for printed electronics has been attributed to the emergence of functional printable inks with different nano-scale and structures. Based on their constituents conductive inks can be categorized into three-dimensional manufacturing materials as nano—tubes or they may exhibit plate-like shapes. The semi-conductive inks can be prepared from metal-oxides, organic polymers and inorganic semi-conductors. Di-electric ink is organic polymer in solvents, organic polymer thermo-sets or ceramic filled organic shapes. The carbon-based conductive fabric materials can be used to produce a conductive textile with different ranges of conductance up to more than 0.29/m depending on the load content. Other integration technique like plating, transfer printing, inkjet printing, solution and electro-spinning of carbon based conductive materials could also provide a

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textile material with better conductivity and bulk property.

The success of inkjet printing for printed electronics has been attributed to the emergencyof functional printable inks with different nano-scale sizes and structures. Based on their constituents, conductive inks can be categorized into three-dimensional nano-structured materials as nano-tubes or they may exhibit plate-like shapes,. The sami-conductive inks can be prepared from metal-oxides, organic polymers and inorganic semi-conductors. Dielectric inks are organic polymers in solvents, organic polymers thermo-sets or ceramic-filled organic shapes. The carbon-based conductive fabric materials can be used to produce a conductive e-textile with different ranges of conductance up to more that 0.2s/m depending on the load content. Other integration techniques like plating, transfer printing, inkjet printing, solution and electro spinning of carbon based conductive materials could also provide a textile material with better conductivity and bulk property. At present intrinsically conductive polymers are widely used in the development of electro-conductive textiles. Traditionally organic polymers are electrical insulators or semi-conductors, so the discovery of conductive polymers in 1970s, opened a new opportunity to produce electro-conductive textiles. Conductive polymers are those polymers that contain a conjugated molecular structure that is alternative single and double bonds between carbon atoms. They can combine the electrical properties of metals, such as price, structural diversity, flexibility and durability which makes them an ideal choice for textile based electrodes. Electrically conductive polymers composites are polymers consisting of single or hybrid conductive fillers such as carbonaceous metallic and conducting polymeric particles dispersed in a polymer matrix. A lot of conductive polymeric composites have been introduced and used in developing conductive textiles **[9].**

In 2015, while most of the technological advancements in smart fabrics have occurred in scientific spaces, smart fabric started becoming commercially available in stores in 2015. Most of the first releases available centred around athlete and baby care including big names like Hexoskin and Ralph Lauren’s Polo Tech Shirt. In 2020, Cute Circuit a popular and fashionable brand launched the ground breaking Sound Shirt. This is marked the U S commerce department’s first smart centred gathering. In 2017, Google collaborated with Levi’s to create and

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release a Blue Tooth enabled Jacket Levi's Computer X Jacquard. Its next generation jacket was released in September 2019. In 2016, at the Inter-Olympic Games, hosted in Pyeong Chang, the entirely on team USA wore self-heating jacket. Created by a collaborating of Ralph Lauren and several tech companies, these jackets kept the athletes from suffering in the frigid temperature. 2019, technology brand Lomita releases a winter coat with a textile substrate layered heating system. The system minimizes the bulk of traditionally warm coats and allows for user control of their comfort setting. Smart Textiles are continually advancing in their capabilities. Some of the latest e-textile to nit stores include temperature controlled, integrate payment options, and health tracking features **[10].**

CONCLUSION

Communications are the backbone of the modern technological revolution and integrating communication technology into clothing can continue that trend. There are various applications of smart textiles we can see in our daily life. Smart fibres/smart textiles and their applications are research hotspots in today's textile field as well as future development trends. Current development in textile technologies, new materials, nano-technology and miniaturized electronics are making wearable system more feasible, nevertheless, the final key factor for user acceptanceof wearable devices is the fit comfort. By embedding electric, electrochemical and optical sensors into a textile substrate it is possible to create sensing patches that able to monitor the bio-chemical parameters of a user. Musical jackets allow the wearer to play notes, chords, rhythms, and accompanying using any instrument available in the general music scheme. It is incredible to think that the clothing we wear, arm sleeve or a sock can be created in ways that its three-dimensional structure can be used for sensing. Textiles make smart wearable devices, flexible, lighter and friendly, existing next to our skin. Smart textiles are materials and structures, that sense and react to environmental conditions or stimuli, such as those from mechanical, thermal, chemical, electrical, magnetic or other sources. Sensors can track work out posture and the fabrics can respond to muscle vibrations, ensuring correct athletic form and reducing the risk of injury.

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