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Performance Overview and comparative analysis of Wearable Textile Sensors

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ABSTRACT

This review paper summarizes the new developments made into field of electronics and textiles. The integrated results obtained using electronics in combination with textiles gave us revolutionary ideas to make day to day life easy and monitoring it closely. In this review paper we have covered many fields where textiles sensor is used. Generally, these textiles sensors are used for monitoring healthcare e.g. in muscle activity and motion detection, detection of breathing frequency, heart rate estimator and also sweat rate detection etc. Textile sensors also contribute in sports for measuring body kinematics of athletes.These sensors are made using various electrodes, capacitance, resistance and different types of conductive yarns. Since these sensors are integrated in garments, it becomes easy to wear and is comfortable for long term use.

Keywords: E-textiles, yarns, organic electronic, sensitivity, repeatability, smart sensors, wearable

INTRODUCTION

Wearable textile sensors also known as E-textiles are smart garments embedded with electronic items. These smart fabrics have provided great development in field of medical and sports. Wearable textiles are categorised into two parts: Aesthetic and performance enhancing. In this review we will focus only on performance enhancing textile sensors. Such type of textile sensors is used in athletics and in medical field. Wearable computers have been developed integrating electronic element like microcontrollers and sensors. [1]

Conductive textiles are used in making E-textile sensor. These conductive fibres are made using metal strands. Even semiconducting textiles made from carbon or metal based powder is useful in making such conductive fabric. Electronically conductive materials, often carbon, nickel, copper, gold, silver or titanium are use for making of E-textile sensors. [2]

Smart textiles have attracted many R&D centres where research is carried out every day in new fields to develop various studies in order to bring ease to our daily life. Some of the developments are piezo-resistive sensors, smart watch, training shoes.

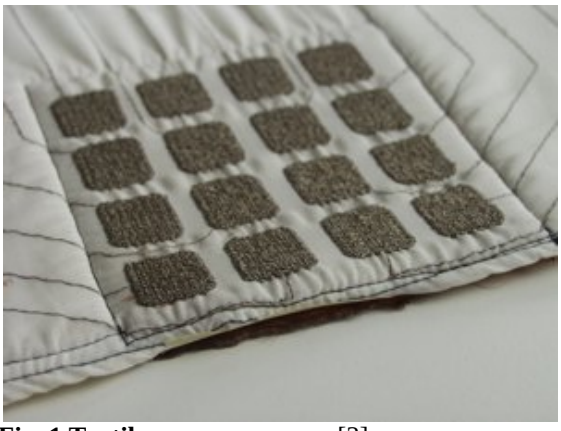

Fig. 1 Textile pressure sensor [3]

The various applications based on wearable textile sensors are as follows:

A. Wearable pressure sensors for muscle activity and motion detection.

Capacitive pressure sensors are introduced in clothes so that human body pressure can be measured. Such type of sensors are used in rehabilitation, muscle motion detection, pressure-sore prevention etc.Such type of sensors is used for personal body monitoring.

Pressure sensors can analyze gait when installed in shoes. These technologies are easy to monitor but it is important to make such garment flexible and comfortable to wear. The pressure sensors should be placed in such a portion of body where maximum variation of pressure is observed. Hence, these sensors are placed around biceps and triceps

in a form of a band. It works as when muscle contracts the band thickens and pressure of the hand on the band increases. This experiment does not only show the motion of arms but also notes the activity performed by biceps and triceps. In future this sensor can be made to work for whole body. [4]

Fig. 2 Wearable monitoring sensor [5]

B. E-sensors for detecting breathing frequency.

Here we study about the detection of respiratory rate using textile material. With the help of such technology we can easily detect any abnormalities in our respiratory system. Much research had been carried out in earlier days and many successful projects have been processed. The problem faced by this technology using convectional sensors was irritation caused due to adhesive chemicals or gel. 'E-vital wear' is the new foundation in the field of human wearable health monitoring system using textile digital system. The textile sensors have been classified in two types with reference to their structure.1.' Dome shaped' made of SBR (styrene butadiene rubber) where the connecting surface of it is knitted with electronic conductive fibre. 2.'Clip type' is clip set in a belt full of rubber thread, each side of clip is knitted with electronic conductive fibre. The belt is designed with a ratio of 33:17 using nylon and rubber thread respectively. Disadvantage of using belt is that they are non-washable. Dome shape is much more comfortable, has washing ability and power saving feature and is also more user friendly. [6]

Fig. 3 Breath rate testing

This type of sensor is used for early detection of respiratory disease in small children. They are low cost sensor and sensitive to skin. [7]

C. Maximum likelihood heart rate estimator using ECG.

Here we observe heart rate using ECG data with the help of wearable textile sensors. Using this process we can measure signals such as ECG, respiration and body temperature, Due to various motion in human body we get fluctuating result which can get overcome by subspace technique. Heart rate estimator works on the principle of FFT (Fast Fourier Transform). Certain sensors such as temperature sensor, ECG electrode, Sweatiness sensor, Control bar and respiration sensor are integrated in a shirt made up of steel. [8]Various experiments are performed for measuring ECG data including jogging, running etc.

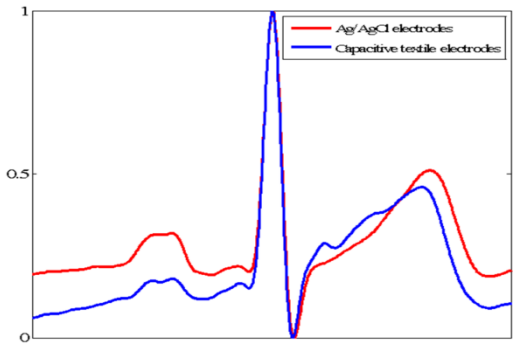

Fig.4 The normalized ECG waveforms measured from Ag/AgCl electrodes (red line) and capacitive textile electrodes (blue line). [9]

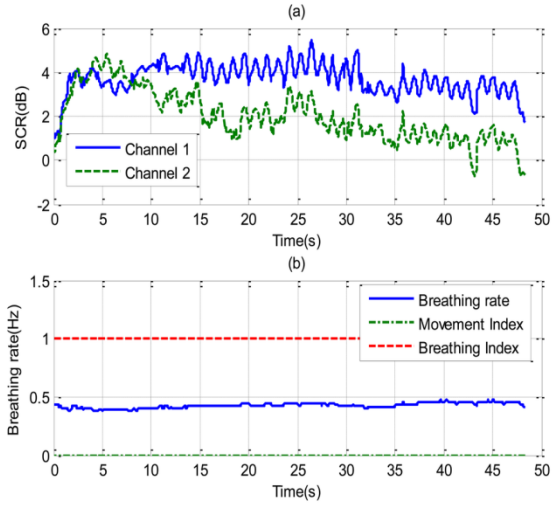

Fig.5 breathing rate movement recorded by sensor.

Some of the disease like sleep apnoea syndrome and infant death syndrome are directly related to respiratory and cardiac abnormalities which required continuous monitoring. Thus these sensor help in sensing the defects threading to the body. Other than these, construction of automobile safety belts is integrated with such sensors. Piezo-resistive sensors are attached inside a narrow woven fabric. [10]

Fig.6 safety belt impregnated with sensors

D. Sensor to measure sweats pH and sweat rate during exercise.

This type of wearable textile sensor used for determination of sweats pH and detect the sweat rate. These sensors are generally waist band and are controlled using wireless connection central unit. Sweat rate are important to measure to avoid gradual rise of body temperature caused by increase in metabolism rate. Such tool can also be helpful in sports for improving the performance of athlete.

Not only sweat rate but also sweat pattern is important to note. This means sweat coming from different body part can help us to identify nervous system dysfunction. Thus this tells us about the type of textile based sensor used for measuring chemical generated from human body to understand body properly. Suchtype of experiments is hard to perform due to lack in sample collection. [11]

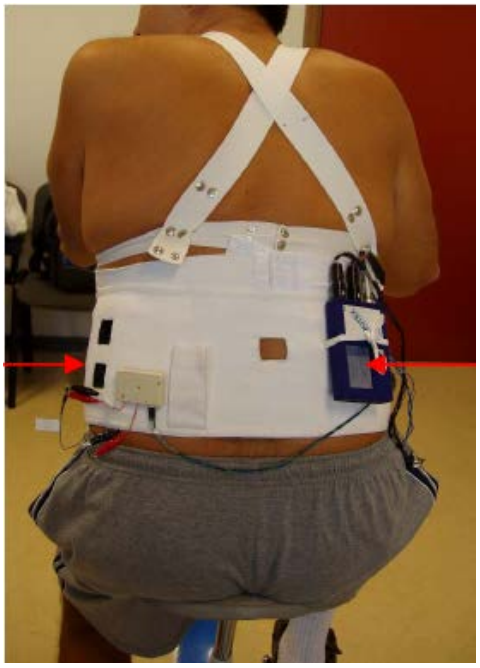

Fig.7 Experimental set-up, sweat rates sensor is positioned on the left, the pH textile patch on the right behind the control unit.

E. Textile moisture sensor

The purpose of this research is to support study on prevention of pressure ulcer for the patients who are on bed rest or on wheel-chair. These ulcer damage skin tissue found in elderly people. Cushion or Mattress is made with pressure, temperature and moisture measurement. This is also used for measuring sweat.

In order to detect the presence of moisture it is important to cover that area where the patient is

lying in order to get proper distribution of moisture. One of the software was developed that scans the matrix sensor which display two parts: One displaying the voltage of upper sensing layer and other part displaying value between upper and lower part. This research maximise the value of therapeutic element. [12]

Fig. 8 moisture sensor

Fig. 9 Conductive fabric pressure sensor. Conductive fabric and anti-static plastic are sew together.

F. Textile humidity sensor

Relative and absolute humidity is very important for industrial, home, health care and other places. Hence, its detection is very significant. Physiological, biological and chemical process isaffected by level of humidity and amount of moisture present in atmosphere. With the increase of moisture chances become greater for bacteria and fungus and also less amount of water causes health issue, so therefore humidity rate must be maintained with standard rates. Food factories and health care factories have adopted the usage of humidity sensor. Two important properties which affect performance are accuracy and sensitivity. Chemical nature, shape and type of fibre used for making structure and chemical finishing, are the major aspects of its performance. The alternative solution to convectional or miniaturized sensor can be these types of textile sensors.

It also consumes less space and is more accurate as compared to convectional sensor.[13]

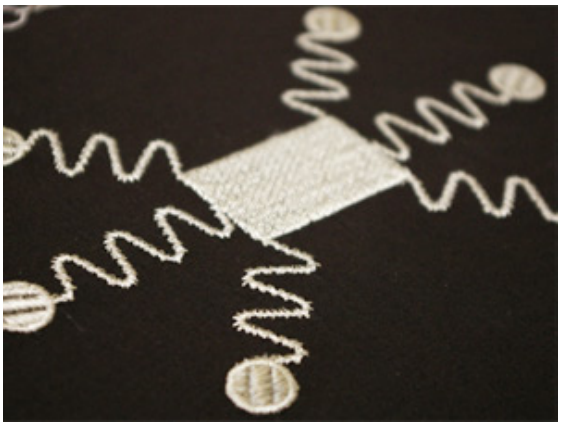

Fig. 10 Humidity sensor knitted in clothes

Fig. 11 humidity sensor wrist band. [14]

G. Textile sensor for electrocardiogram monitoring.

Electrocardiogram is a display of persons heart beat produced by electrocardiography; it is the process of recording the electrical activities of heart over a period of time using electrodes placed on skin. Such sensor is very important to measure the heart rate to avoid heart related problems. The use of Bluetooth facility makes this device suitable to wear and comfortable for the patients.

The fabric used for this device is micro-fibre polyester due to its elastic nature. The main disturbance caused by this device is noise.

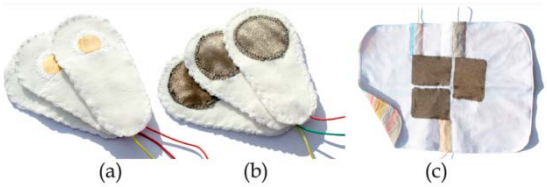

Fig.12. wearable sensor

Discussions

The sensors used in above devices must be cheap and easy to use. It should be sensitive to the pressure and other parameters needed to get the favourable result. At the same time these sensors should not get affected by the temperature in its surrounding. It should have minimum error and maximum accuracy. As discussed above organic electronic can be replaced by normal sensors in future. These organic electronic are mechanically flexible and have very high thermal stability due to this feature, it become easy for wearer to use it for long term comfortably. For muscle activities the pressure sensor used must have three layers; electrode array (electrodes are interconnected to each other), spacer (foam used to separate front and back electrode), back electrode and shield (to protect the capacitor against outer electrostatic field). The sensor used for detection of breathing are of two types from which doom shaped type is more preferred over clip type, doom shaped accurate reading and is more user friendly. Moisture sensors used must be handled with care.

Conclusion and future scope

We have studied that the wearable textile sensors are useful for human body. The various sensors mentioned above gives us complete idea about how E-Textiles are made possible to wear on human body without harming them. This also allows us to monitor human body closely. Various athletes around the world use such devices to improve their performance and note down there muscle movement. Not only in sports or medical, such devices are very useful in defence field which helps in detecting various structures. The R&D department perform everyday experiment in order to develop new devices and explore more about E-Textile. Instead of using electrodes we can replace them by capacitance, the only problem faced by researchers is that it lags behind in time.

Some new types of electronic materials that can be used in future in making such E-textile sensors are organic electronics. In future, nano technologies and other techniques will bring in global change for smart textiles. Smart textiles are expected to find their application in the field of medical, fashion, electronics and defence. In coming future defence and military will mainly work upon E- textile. This brings upon a great change.

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