E-Base: Real Time Wearable Health Monitoring Cardiorespiratory System

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Abstract-- **The last few decades have shown enormous growth in the development of wireless communication technologies, Nano engineering, information technologies, and miniaturization of electronic devices. Humans are close to textiles more than anything, and certainly we carry it most, other than anything. Researchers are now evaluating the new ideas and possibilities to functionalize this 'natural necessity feature of human beings' by hybridizing the Smart or Intelligent Technology in Textiles. E-textiles, also called Smart Fabrics have not only wearable capabilities like any other garment, but also local monitoring and computation, entertainment, heath care and threat detection as well as wireless communication and tracking capabilities. This paper reports how the smart textiles are being incorporated in health care sector to aid diagnosis, recording and transmission of bio signals with tele-monitoring of the body vitals by implementing the core concepts of smart materials under the light of the recent developments and projects.**

Keywords-- Smart textile, Electromagnetic Induction Shielding, Electrocardiogram, Thread based battery.

I. INTRODUCTION

Smart Textiles are defined as textile products such as fibers and filaments, yarns together with woven, knitted or non-woven structures, which can interact with the environment/user. Smart textiles are a class of smart materials and structures that sense and react to environmental conditions or stimuli. Depending on the degree to which intelligence is imparted into these textiles, they may be passive, active or very smart. Passive smart textiles can only able to sense the environment/user, based on sensors, Active smart textile may have reactive sensing to stimuli from the environment, integrating an actuator function and a sensing device, Very smart textiles can able to sense, react and adapt their behavior according to the given circumstances. These smart textiles can communicate, transform, conduct energy and even grow accordingly. Wearable and ultraportable electronics coupled with pervasive computing are poised to revolutionize healthcare services delivery. In biomedical applications for long-term physiological signal monitoring, textiles are the preferred platform for sensors because they are the most natural materials close to the skin.

II. PROBLEM

Despite technological advancements in computing, smart phones, there is lack of a multipurpose product for proper health monitoring. The technological devices available for continuous health monitoring are bulky, non-locomotive machinery which lack real time monitoring and continuous process updating. Recently real time monitoring has been evolved with various gadgets for various purposes which leads to usage of multiple gadgets and confusion. The average survival rate of heart stroke and cardiac arrest is 10.6% in year 2015 which is very low and needs continuous monitoring.

III.SOLUTION

This paper proposes the usage of fabric based sensor assisted with Bluetooth for continuous health updates. The wearable formed is lightweight, easily wearable and extremely comfortable so that wearer can be free from fear of hurting themselves or the wearable. The textile basically acts as a smart computer which is enriched in real time monitoring of the patients who needs continuous study and updates of the cardiac, respiratory system etc. the wearable possess multipurpose, designed for heartbeat sensing, respiratory system monitoring, organ functionality monitoring, workout tracking, and enables water repellent technology to avoid circuitry damage along with solar charging property.

IV.THE E-BASE OVERVIEW

E-Base is the electronic base layer or smart base layer suitable for both men and women of all ages. E-Base is a challenging resource in several fields such as the medical, sport, and artistic communities, the military and aerospace. It is made up of conductive fibers twisted with normal fibers or else yarn based transistors are used which are very thin, light and feels so natural that it looks like normal yarn but it is conductive in nature. Circuits are integrated in fabric with wire grid approach. E-Base possess certain properties conductivity, flexibility, biocompatibility, mechanical resistance and washability. The yarns are developed by conductive threads, treated coatings which provide protection from static charge and electromagnetic shielding , the fabric is blended with conductive metallic or polymeric fibers such as polypyrrole, polyaniline. Direct printing of conductive tracks of conductive ink on a fabric is a versatile technique. Most conductive inks and pastes are based on silver filler. One of the most desirable feature of E-Base is stretchable sensor which is robust to stress and strain. It is made up of thermoplastic elastomer and carbon black particles. Other sensors provided are pressure sensors and electrochemical sensors, sparkfun Tanotis for electrocardiogram, respiratory piezoelectric sensor, and Sparkfun SEM 10972 electrochemical sensor. The Lilypad Arduino Main Board is based on the ATmega 328V. It offers the same functionality as in other Arduino board, in a lightweight, round package designed to minimize snagging, with wide tab that can sew down and connected with conductive thread. The shielding can reduce the coupling of radio waves, electromagnetic fields and electrostatic fields. It is a layered arrangement of metalized textile sheets, separated by insulating layers, which is used for screening electromagnetic waves in broad range from 10MHz to 1000GHz. The output from Lilypad microcontroller sends data to PC via ZigBee wireless radio that receives and plots incoming data from the person wearing it.

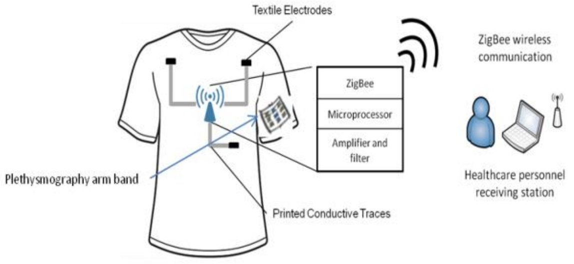

Fig. 1 E- Base with Cardiorespiratory sensor system

A. Power source and storage

A small inexpensive and easy to use battery would enhance the capabilities of e-textile. This e-textile can have dual power source from a thread based battery along with flexible and conformable solar cell. The thread based battery uses chemistry similar to an alkaline battery. The fabrication process involves patterning of current collector (silver epoxy or carbon ink) followed by zinc electroplating and manganese dioxide deposition. Thread present in between these two electrodes serve as salt bridge. Chemicals needed for redox reaction (aluminum chloride) which can be impregnated in the thread in solid form.

Specification (for 1 cell):

- Voltage = 1 volt(open circuit)
- Current = 18uA
- Resistance = 12kohm

Meanwhile the development of solar cells on polymeric films and woven fabrics by coating these substrates with organic dye molecules and titanium dioxide. The mixture of organic dye molecules and the titanium dioxide nano-particles is sandwiched between two conductive electrodes. There is a layer between organic dye and titanium dioxide mixtures and the lower electrode. the top conductive layer is transparent and allows light to pass through it and react with organic dye molecules. Charge is generated, transferred to titanium dioxide nano-particles and collected by electrodes thereby producing electrical energy from solar energy.

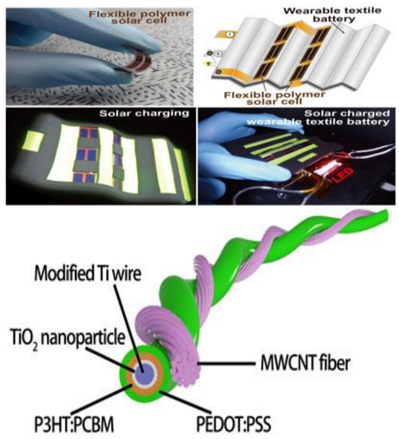

Fig. 2 Thread based cell with solar cell coating

B. Circuit monitoring board

Building electric circuit into textile substrate is one of the vital building part of our product. With the power distribution board, keeping in mind of battery management system, we move on to the next part how to function the sensor parts and how it is controlled by microcontroller and connection between them is done by conductive thread. We mainly deal with the 5 major sensor including zig-bee module. To controller its function and communicate to remote device we are using Lilypad Arduino328V.Conductive threads are made up of cotton and steel fiber blends, that guarantees a shielding of 20-40dB against electromagnetic radiation at a frequency of 10GHz. Conductive and non-conductive fibers woven orthogonal to one another define a simple grid. Conductive fibers provide wired coupling between the electronic unit and the power source, with all other components attach to it.In future, planning to make this conductive fabric act as antenna for transmission and receipt signal.

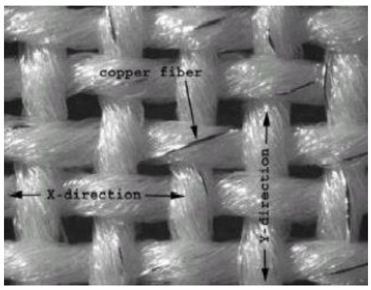

Fig. 3 Fiber woven in co-axial manner

1) *Microcontroller –Lilypad Arduino 328*

The Lilypad Arduino Main Board is based on the ATmega 328V. It offers the same functionality as in other arduino board, in a lightweight, round package designed to minimize snagging , with wide tab that can sewn down and connected with conductive thread. The Lilypad Arduino was designed and developed by Leah Buechley and SparkFun Electronics. To configure board, use the Arduino Software (IDE), and start to tinker with coding and electronics.

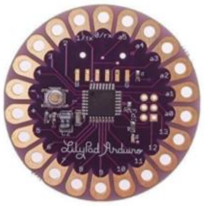

Fig. 4 Microcontroller- Lilypad Arduino 328

Technical specification

Microcontroller	ATmega328V
Operating Voltage	2.7-5.5 V
Input Voltage	2.7-5.5 V
Digital I/O Pins	14
PWM Channels	6
Analog Input Channels	6
DC Current per I/O Pin	40 mA
Flash Memory	16 KB (of which 2 KB used by boot loader)
SRAM	1 KB
EEPROM	512 bytes
Clock Speed	8 MHz

Caution: Don't power the Lilypad Arduino with more than 5.5 volts, or plug the power in backwards: you'll kill it.

2) Sensory system

Sensor plays vital role to interconnect with human stimuli and external computer. Here, in E-Base, Central control unit, together with the sensors, act as essential elements for active smart material. We are mainly focused on fabric-based sensing, that can be used for electrocardiogram (ECG), electromyography sensing, incorporating thermocouples and pH level indicator.

2.1 Heart rate pulse sensor

Each E-base uses an array of SparkFun Tanotis Heart Rate Pulse Sensor for feedback of electrocardiogram (ECG). Principle of ballistocardiography (BCG) is used in heart signal sensing.

Fig. 5 Tanotis Heart Rate Pulse sensor

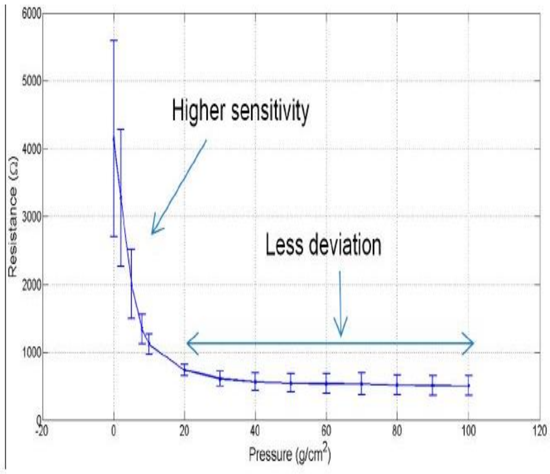

Fig. 6 Sensor characteristic curve

2.2 Respiratory piezoelectric sensor

Sensing the breathing rate we are going with respiratory sensor that operate in principle of change in piezoelectric resonance frequency with the applied pressure or capacitance variation caused by an elastic foam, overlaid with the matrix of conductive threads. Piezoelectric mat is formed that sense and send data to Lilypad.

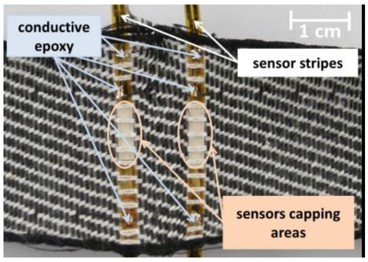

Fig. 7 Respiratory piezoelectric sensor

Specification:
Voltage: 3.3V-5V (CMOS level)
Controller: Analog signal is feed to Lilypad Arduino 328.
2.3Electrochemical sensor for pH level
Sparkfun SEN 10972 electrochemical sensor will able to measure and analyze sweat in real-time on body. Color change of the pH sensitive fabric was detected by placing a surface mount (SMT) LED and photodiode module on either side of chip, aligned with the pH sensitive fabric. Device is 180 um thick flexible and can adapt of body.

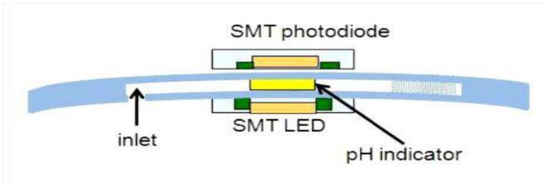

Fig. 8 Electrochemical sensor

Specification:
Voltage: 3.3V-5V (CMOS level)
Indicator: Surface Mount LED. Also analog signal is feed to Lilypad Arduino 328.

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Additional, active thermal detection is also added which monitors the body temperature and simultaneously deviate the temperature if necessary.

2.4 Active Thermal Detection

Active thermal detection acquires the principle of the resistive heating of conductive elements. Fabric consists of stainless steel microfibers and woven yarns act as a heating source and provide uniform distribution of heat throughout the entire fabric.

Single thread based battery provides 20Kohm resistance. Since heat energy ∝ resistance, we could able to generate more amount of heat as per required and simultaneous monitor through Lilypad.

Fig. 9 Active thermal detection module

C. EMI shield

EMI Shielding is the basic principle of the conducting yarns used in the formation of textile. Electromagnetic Shielding is reducing the electromagnetic field in a space by blocking the field with barriers made of conducting or magnetic materials. The shielding can reduce the coupling of radio waves, electromagnetic fields and electrostatic fields. It is a layered arrangement of metalized textile sheets, separated by insulating layers, which is used for screening electromagnetic waves in broad range from 10MHz to 1000GHz.these textiles based metallized sheets are flexible, comfortable, have elastic properties and attenuate the electromagnetic radiation in transmission by 30-40dB.

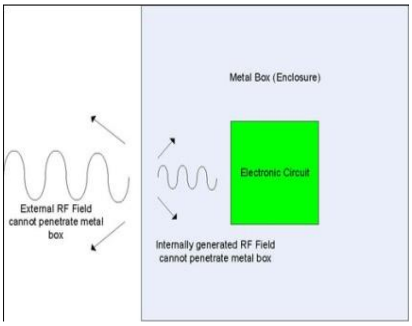

Fig. 10 Basic principle of EMI Shielding Effect

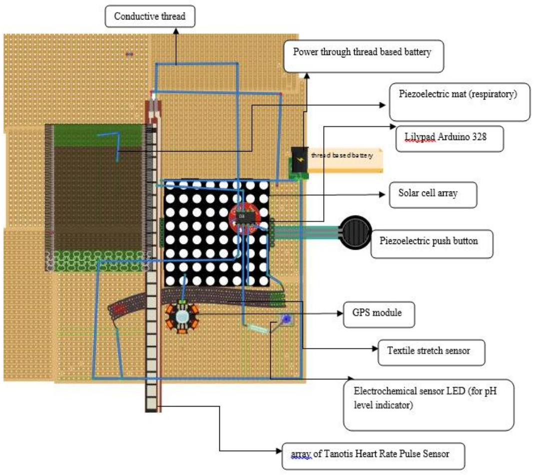

Fig.11 Schematic of Sensory Circuit of E-Base

D. Fabric PCB

Printed circuit boards (PCBs) allow the precise placing of electrical components into small spaces. In prototyping and hobby contexts a circuit board pattern is first etched out of copper-clad board then holes for hardware are drilled into the board and finally components are soldered to the copper traces. This section will present an analogous technique for creating PCBs on cloth using conductive fabric and an iron-on adhesive. Steps to building a laser cut fabric PCB given below:

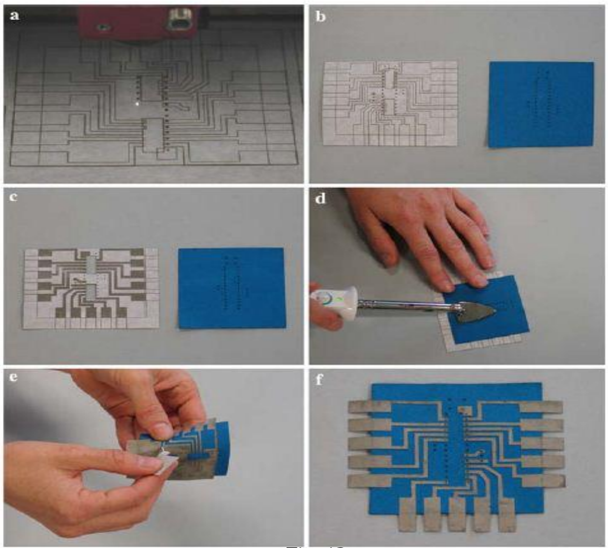

Fig. 12

a The circuit is cut by a laser cutter
b The cut circuit and its backing fabric.
c The paper underneath the circuit is removed.
d The circuit is ironed onto its backing fabric.
e The conductive fabric that is not part of the circuit is removed.
f The completed circuit

V. CONCLUSION:

In his paper, a smart textile system is shown, describe the convergence of electronics and textiles into fabrics which are able to sense, compute, communicate and actuate. E-base is basically a health monitoring system that could be used to monitor heart- beat pulse rate, breathing rate, pH level of body, and body temperature controlling in a real time operation. Finally, microprocessor fetch the data either to PC or wireless remote device via Zig-bee module. Moreover, it is user friendly. All the sensors and microcontroller are washable with soft detergent. Simultaneously we could charge it with solar cell panel also.

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