MANTECH Publications

Journal of Power Electronics and Drives
Volume 2, Issue 1, January-April 2017

Applications of Smart Clothing as Wearable Electronics

N. Tarafder
Emeritus Professor
Hooghly Engineering & Technology College,
Vibekananda Road, Pipul Pati
Email: *tarafdern.14@gmail.com*

Abstract

Electronic textiles are distinct from wearable computing because emphasis is placed on the seamless integration of textiles with electronic elements like microcontrollers, sensors, and actuators. In theory, the new technology could boost the reception of our smart phone or tablet. It could also send information to our phone or tablet about our health or athletic. Smart clothing has the potential to provide a very intimate form of interaction with the wearer, as it exists within the wearer's personal space. The wearable computer apparatus is embedded within non-transparent clothing which provides shielding. Smart textiles will serve as a means of increasing social welfare and they might lead to important savings on welfare budget.

Keywords: *Smart clothing, Wearable Electronics, Smart textiles, Microcontrollers*

INTRODUCTION

Smart textiles are fabrics that have been developed with new technologies that provide added value to the wearer. Smart fabrics have the ability to do many things that traditional fabrics cannot, including communicate, transform, conduct energy and even grow. Smart textiles can be classified into two different categories; aesthetic and performance enhancing [01}. Some of these fabrics gather energy from the environment by harnessing vibrations, sound and heat reacting to these inputs. Performance enhancing smart textiles intended for use in athletic, extreme sports, and military applications. These include

fabrics designed to regulate body temperature, reduce wind resistance and control muscle vibration, all of these may improve athletic performance. Electronic textiles are distinct from wearable from computing because emphasis is placed on the seamless integration of textiles with electronic elements like microcontroller, sensors, and actuators. Furthermore, e-textiles need not to be wearable.

The related field of fibretronics explores how electronic and computational functionality can be integrated into textile fibers. Turning rigid electronic parts into stretchy, smart clothing material has not proven easy. But early ideas have already hinted at practical uses beyond just wearing glowing "Tron" jumpsuits as fashion accessories. People may swipe a finger across a car's upholstery to turn down the heat or brush at their coat sleeves to adjust the volume of a connected music player, experiences that seamlessly blend "hard" gadget functions with "soft" objects [02].

Scientists have developed a way to embroider circuits into fabric with 0.1 mm precision, which is the perfect size to integrate electronic components such as sensors and computer memory devices [03]. These functional textiles, which are textiles with electronics, are known as e-textiles. They are created on a typical tabletop sewing machine. Like many modern swing machines, it embroiders threads into fabric automatically based on a pattern loaded via a computer file. Instead of thread, though, researchers load the machine with fine silver metal wires that, once embroidered, feel the same as traditional thread to the touch. Researchers believe that functional textiles are an enabling technology for communications and sensing and one day even medical applications like imaging and health monitoring. Smart clothing, the combination of mobile multimedia, wireless communication, and wearable computing provides the potential to make personal computers even more personal as suggested [04].

In the early 1980's the author was experimenting with wearable computing and wireless communications, people thought that some of the apparatus he was wearing had quite strange and so he did not wear it much, because it was both physically and socially awkward. People were shocked by the visceral combination of human and even by the fact that a computer could run without an AC outlet.

Thomas Bass, in his book "The Eudemonic Pie", describes shoe-based, computers of the 1970s that were designed and built by physicists and other researchers in California, for the purpose of assisting them at playing roulette. The author [04], have an antenna in his hat that is wirelessly connects him to the Internet through a network of antennas that have erected on rooftops of various buildings. This has allowed him to explore, in recent years, near-constant connectivity to the Internet.

Smart clothing represents a significant future direction for computing. The proliferation of wearable computers suggests that we are moving in that direction. However, many of the applications of wearable computers so-far envisioned, such as the land warrior, the intelligent maintenance aid, or various applications in the work places might better be described as "smart uniforms". A 'Smart uniform' might be issued to a soldier or employee at the start of a job, and then taken away the job is completed. Smart clothing has the potential to provide a very intimate form of interaction with the wearer, as it exists within the wearer's personal space. As such there are both the danger that it could violate this personal space, as well as the safety and capability to provide the wearer greater control.

Presently, conductive cloth in various forms is available, due in part to certain people's desire to shield themselves from radiation effects of cellular telephones and like, as well as for decorative purposes [05]. The wearable computer apparatus is imbedded within nontransparent clothing which provides shielding, of social interaction through enhanced abilities for self expression and self-actualization, as well as through self-determination. Equipped with various sensors which measure heart rate, respiration, etc. The apparatus can function as a personal safety device for reducing crime, as well as personal health monitor for improving health care by encouraging individuals to take an active role in diagnosis and body maintenance. Examples of smart clothing include internet – connected shoes, which allow one to run with a jogging partner located in some distant place, but connected via network. Towards the goal of self-determination and enhanced creative potential, a new form of computation has been proposed by Mann [05], which is eudemonic.

It means the apparatus is subsumed into the "eudemonic space" of the wearer. It may be worn or otherwise situated in a manner that makes it part of what the user considers "himself" or "herself", and in a manner that others also regard it as part of the user, e.g. not a separate object being carried by the user. It is sufficient that the interface be eudemonic (e.g. some of the compute power can be remote}. In some of the smart clothing, with the use of biosensors, when a patient wear his or her entire medical history would solve much of the medical records privacy problems we face today. With various biosensors, the most current and up-to- date information would be readily available within the very clothing that is taking the measurements.

Researchers who are working to develop wearable electronics have reached a milestone. The Ohio State University researchers [06} taken the next step towards the design of functional textiles, clothes that gather, store or transmit digital information. With further development, the technology could lead to shirts that act as antennas for our smart phone or tablet, workout clothes that monitor our stress level, sports equipment that monitors athletes performance, a bandage tells a doctor how well the tissue beneath is healing , or even a textile fabric can sense the activity in the brain. For decades, engineers and dreamers have been conjuring ideas for wearable computers. But microprocessor speeds were not always up to snuff and power concerns were paramount, because without power to bring them to life, electronics were just metal. Now, with better batteries, ever-increasing processor speed, ceaseless internet connectivity and clever software programming, wearable technology's potential seems not realistic but unlimited [07]. The field of wearable computing has great implications for medical applications, including early detection, treatment, compliance monitoring, care for the frail and elderly, telemedicine, physical therapy and many others.

The proposed system of early warning for heart disease and body temperature by smart clothing is based on electronics and android application. According to the author [08], wearable electronics and smart textiles based personal health recorder, generally normal wearable dresses can act as a health recorder devices. To make it more easier for the medical to monitor the ECG of their patients outside the hospital, systems have been developed and designed on ECG, body

temperature monitoring and alarming system based on Android smart phone. Electronics textiles are fabrics that feature electronics and interconnections woven into them, presenting physical flexibility and typical size that cannot be achieved with other existing electronic techniques. Body Area Network sensors interface with Lily pad control unit and woven act as conducting element.

Intelligent medical clothes are a key topic for the future. The new electronic fabrics, developed by the author [09], are blended with conductive materials, have been used in high-tech clothes, intelligent medical garments appeared in the market and their properties had been reviewed. Developments in telecommunication, information technology and computers are the main technical tools for telemedicine (Tele-health, Tele-care, e-health), which recently introduced in health care. The work of the author [10], on textile technology for the vital signs monitoring in telemedicine and extreme environments, illustrates two extensive applications of a smart garment previously developed for the monitoring of ECG, respiration, and movement. In the first application, the device was used for the home monitoring of cardiac patients.

FIBRETRONICS

The construction of electronic capabilities on textile fibers requires the use of conducting and semi-conducting materials such as a conductive textile. There are a number of commercial fibers today that include metallic fibers mixed with textile fibers to form conducting fibers that can be woven or sewn. However, because both metals and classical semiconductors are stiff material, they are not very suitable for textile fiber applications, since fibers are subjected to much stretch and bending during use. One of the most important issues of e-textiles is that fibers should be washable.

Electrical components would thus need to be insulated during washing to prevent damage. A new class of electronic materials that are more suitable for e-textiles is the class of organic electronics materials, because they can be conducting, as well as semiconducting, and designed as inks and plastics. Some of the most advanced functions that have been demonstrated in the lab include: organic fiber transistors, which is the first textile fiber transistor that is completely compatible with textile manufacturing and that contains no metals at all. The other one is the solar cells on

fibers. The uses of fibertronics are as follows:-

i. Health monitoring of vital signs of the wearer such as heart rate, respiration rate, temperature, activity and posture.

ii. Sports training data acquisition.

iii. Monitoring personnel handling hazardous materials.

iv. Tracking the position and status of soldiers in action.

v. Military app-Soldier's bullet proof Kevlar vest, if the wearer is shot, the material can sense the bullet's impact and send a radio message back to base.

vi. Monitoring pilot or truck driver fatigue.

vii. Innovative Fashion (wearable tech)

viii. Regain sensory perception that was previously lost by accident or birth.

INTERACTION BETWEEN SMART CLOTHING AND ENVIRONMENTAL INTELLIGENCE

It is said that when we take off our "smart clothing" at night, we might still choose to keep on our "smart underwear" which controls the heater or air conditioner in the room. Biosensors used in the author's "smart clothing" [02], apparatus include ProComp, ECG, EEG, respiration and sweat sensor built into a Jantzen bathing suit. Upon arriving home, late night, one is generally too hot just climbing the stairs, etc, so when first going sleep the underwear tells the heater to turn off, but after a couple of hours sleeping, when one's metabolism shows down, the underwear senses the resulting changes in one's body temperature connectivity, and turns up the heat.

Our clothing of the future may someday be interoperable and interconnected, so that it keeps track of our physical condition and allows us to decrypt this information for evaluation by a doctor or other professional of our choosing. Having a patient wear his or her entire medical history would solve much of the medical privacy problems we face today. With various biosensors, the most current and up-to date information would readily available within the very clothing that is taking the measurements. Of course, one would want to have one's medical records replicated in the clothing of

selected friends and relatives, to prevent data loss in the event of clothing failure.

This system would eliminate the need for, and the possible abuses that can arise with, a central database of medical records, and would eliminate the need to for a person to venture through bureaucratic procedures to access his or her own medical information. It would also eliminate the problems associated with smart cards, as clothing is almost always worn, while cards may be misplaced and inaccessible in times of emergency care. Epidemiological research would still be possible with the patient's data-participating patients could make the data accessible to organizations doing the research, but this would be done through a query to each participating patient's online "smart clothing" each time the data were needed, so that the patient's clothing would be kept "in the loop", that is access would be automatically generated in the "smart clothing", so that patients could trace the history/usage of their data at a later date if desired.

EXISTENTIAL TECHNOLOGY

The above examples illustrate even a small amount of intelligence, owned operated and controlled by an individual, may strike a balance, and reclaim some of the eudemonic space that has been eroded or lost modern technology. The first "existential computers", designed and built in the late 1970's and early 1980's were originally developed for applications in the visual arts, in particular still-life and landscape imaging-combining multiple exposure of a static scene to a variety of different light sources, using principles of linearity and superposition of light. Evolution of author's [05], "existential computer", with large head-mounted and separate inbound and outbound communication antennas of the late 70s was awkward in nature.

Author's waist-mounted television of the mid 80's was somewhat comfortable but not constantly visible. Current state of author's existential computer invention comprises a complete multimedia computer, with cameras, microphones, all built into an ordinary pair of eyeglasses. This rig is currently running the Linux 2.0 operating system, with XFree86 with a small box that clips on the author's belt or fits into a shirt pocket. The input device is fashioned into an ordinary belt, using micro switches, so that one can type or issue commands unobtrusively. Other variations of the input device include micro switches sewn into clothing and the like.

Wear Cam is a simple apparatus for effortless yet controlled capture, display, processing, and transmission of visual imagery. The Wear Cam invention is a particular variant of the existential computer invention which comprises the following entities: (1) one or more cameras that is/are attached to the body in some manner that permits both hands to be free (2) means of recording, processing and transmitting images from camera (s), processing means may be remote if facilitated through communications means (3) a display images and is also worn in a manner that permits both hands to be free. The Wear Cam view finder goes beyond merely setting the camera correctly. Since the apparatus is worn over an extended period of time, one adapts to it and it begins to function as a true extension of the body. In this way, the view finder transcends being just a compositional tool, toward allowing the camera to become the eye of the wearer.

A creative expressive application of the wear Cam is in personal documentary. Wearing the apparatus in day-today life has resulted in the ability to spontaneously capture events of interest, but in a more natural way than in other forms of personal documentary. One such personal documentary, Shooting Back was a meta-documentary of sorts- it was a documentary about making a documentary. In Shooting Back, the author carries a standard cam recorder into organizations characterized by totalitarian surveillance. Typically a conversation with the representative of the organization , where the representative states something to the effect that only criminals would be afraid of cameras, or that the author must be trying to steal something if he were afraid of cameras, or that cameras should be of no concern. Then, after pulling the cam recorder out of a satchel, the viewer sees the eye cup of the cam recorder moving up toward the eye and the resulting response from a representative.

CLOTHES THAT RECEIVE AND TRANSMIT DIGITAL INFORMATION

In Volakis Lab [06], the functional textiles, also called e-textiles are created in part on a typical tablet sewing machine, the kind that fabric artisans and hobbyists might have at home. Like other modern sewing machines, it embroiders thread into fabric automatically base on a pattern loaded via a computer. The researchers substitute the thread with fine sliver metal wires that, once embroidered, feel the softness of textile

thread to the touch. Volakis informed that for the first time, they had received the accuracy of printed metal circuit boards, and expressed that their new goal to take advantage of the precision to incorporate receivers and other electronic components. The shape of the embroidery determines the frequency of operation of the antenna or circuit, explained by Kiourt [06]. Shape determines function, and therefore they wanted have a technology that could embroider any shape for any application. The researchers had to find a way to work the fine thread into embroidery densities and shapes that would boost the surface conductivity, and thus the antenna/sensor performance.

One prototype antenna looks like a spiral and can be embroidered into clothing to improve cell phone signal reception. Another prototype, a stretchable antenna with an integrated RFID (radio-frequency identified) chip embedded in rubber, takes the applications for the technology beyond clothing. Another circuit resembles the Ohio state Block "O" logo with non-conductive scarlet and gray thread embroidered among the silver wires to demonstrate that e-textiles can be both decorative and functional, Kiourti said. They may be decorative, but the embroidered antennas and circuits actually work. Tests showed that an antenna measuring approximately six inches across transmitted signals at frequencies of 1 to 5 GHs with near perfect efficiency. The performance suggests that the spiral would be well-suited to broadband internet and cellular communication. In other words, the shirt on one's back could help boost the reception of the smart phone or tablet that someone is holding or send to devices with health or athletic performance data. Syscom Advanced Materials in Columbus provided the threads used in Volkis and Kiourti's initial work. The finer threads used in this study were purchased from Swiss manufacture. The research was funded by the National Science Foundation and Ohio State licensed the technology for further development.

WORKING PRINCIPLE OF WEARABLE TECHNOLOGY

For long decades, engineers and dreamers have been conjuring ideas for wearable computers. But microprocessor speeds weren't always up to snuff and power concerns were paramount, because without power to bring them to life, electronics are just dead metal. In the very recent past, using a computer meant sitting at a desk or

toting around the laptop bag. These days, due to smart phones and an avalanche of tiny portable computing products, we can crunch bits and bytes anytime, anywhere. We may not have to carry gadgets, which may be integrated into our hat, clothes or in sun glasses. The age of wearable computer/technology may finally be upon us [07]. Now, with better batteries, ever-increasing processor speed, internet connectivity and clever software programming, wearable technology's potential seems not only realistic but unlimited.

We may consider many possibilities like, yoga outfits which can monitor our form and provide instant feedback, watches and jewelry can monitor for a whole range of health conditions, from cardiovascular diseases to bipolar disorder and artery problems and alerts to the patient and the physician. Sensor and camera laden firefighting jackets track the vital signs and locations of squad members to keep them safe and to maximize tactical effectiveness. Teenagers can keep tabs on their messages with Bluetooth rings. Don a pair of Google Glasses (complete with prescription lenses) and one can execute all sorts of smart phones-like activities. Even our personal dog can get in on the wearable computing trend.

SMART TEXTILES BASED PERSONAL WEARABLE HEALTH RECORDER

The term textiles refer to a broad field of studies and products that extend the functionality and usefulness of common fabrics. 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. The convergence of textiles and electronics (e-textiles) can be relevant for the development f smart textiles [08] that can capable of accomplishing a wide range of functions fond in rigid and non-rigid electronic products now-a-days.

There are three classes of smart textiles: passive smart textiles, active textiles and very smart textiles. Intelligent bio-medical clothes [09] are a key topic for the future. The technology can quietly monitor the wearer's heart beat rate, respiration, temperature and other vital functions, alerting the wearer or physician if there is a problem. Developments in telecommunication, information technology and computers are the main technical tools for telemedicine, medicine at a distance,

provides among the many possibilities offered the tools for the doctors to consult more easily with each other. In extreme environments telemedicine have been illustrated by the author [10] in the paper 'The technology for the vital signs monitoring in telemedicine and environments'. This article illustrates two extensive applications of a smart garment previously developed for the monitoring of ECG, respiration, and movement.

The proposed Wireless Non-contact EEG/ECG Electrodes for Body Sensor Network [11] consists of a set of simple capacitive electrodes on a standard printed circuit board that can operate through fabric or other insulation. A small wireless base unit transmits EEG/ECG telemetry to a computer for storage and processing. Uma Maheswari and G. A. Divya presented a wireless base body sensor network for high quality EEG/ECG recording utilizing non-contact electrodes. It predicted that in the future more focus will be on minimizing and better packaging the electrodes as well as reducing the power consumption of the digital and wireless transmitter. Flexible textile sensors for real time health monitoring at micro wave frequencies have been proposed by the authors [12]. The system reports on testing of the performance of Smart Life e-textile material. The response of the integrated conductive pathways at micro wave frequencies in the region of 9 kHz and 6 GHz is investigated for both biomedical sensing and signal transmission purposes. The ability of the material to act as antenna, i.e to facilitate wireless transmission between garments, could significantly contribute to currently active research. The basic concept of smart Textile consists of a textile structure that senses and reacts to different stimuli from its environment.

In its simplest form the textile sense and reacts automatically without a controlling unit, and in a more complex form, smart textiles sense, react and activate a specific function through a processing unit. The main pars included in a smart textile system are the sensor, the actuator and the controlling unit [13]. LM35 series sensors are precision integrated-circuit temperature sensors, with an output voltage linearly proportional to the centigrade temperature. Low cost is assured by trimming and calibration at the water level. The low cost output impedance, linear output and price inherent calibration of the LM35 make interfacing to radiant or control circuitry

especially easy as explained [14]. The vision of wearable computing describes future electronic systems as an integral part of our everyday clothing serving as intelligent personal assistants. Therefore, such wearable sensors must maintain their sensing capabilities under the demands of normal wear, which can impose severe mechanical deformation of the underlying garment/substrate. The promising approach by the authors [15] is to reduce the rigidity of the electronic textiles and enhance its wear ability is to replace PCBs by flexible electronics.

CONCLUSION

Field of wearable computing has great implications for medical applications, including early detection, treatment, compliance monitoring, care for the frail and elderly, telemedicine, physiotherapy and others. The term Smart Textiles refers to a broad field of studies and products that extend the functionally and usefulness of common fabrics. Electronics Textiles (e-textiles) are fabrics that feature electronics and interconnections woven into them, presenting physical flexibility and typical size that cannot be achieved with other existing electronic manufacturing techniques. The convergence of textiles and electronics can be relevant for the development of smart materials that are capable of accomplishing a wide spectrum of functions. Smart Textiles represent an attractive class of substrate for realizing wearable bio-sensors. As many different electronic systems can be connected to any clothing, a wearable becomes more versatile, and the user can change its look depending on environmental changes and individual preference.

REFERENCES

1) E-textiles, from Wikipedia, the free encyclopedia,http://en.wikipedia.org /wiki/E-textiles.

2) 'Smart Clothing' Could Become New Wearable Gadgets, http://www.livescience.com/18238-smart-clothing-wearable-gadgets.html.

3) Computers In Your Clothes: New Circuits May Create Wearable Electronics, http://www.hngn.com/articles/19699 /2160415/computers-clothes-new-circuits-create-wearable-electronic.

4) 'Smart Clothing': Making Multimedia Computers and Wireless Communication more Personal-a Paradigm Shift in Wearable Computing,http://wearcam.org/mission-statement-1500 words.html.

5) 'Smart Clothing': The Wearable Computer and Wear Cam, http://n1nif-1.eecg.toronto.edu/personaltechnologies/

6) Computers in Your Clothes? A Milestone for Wearable Electronics, http://news.osu/news/2016/04/13/computers-in-your-clothes-a-milestone-for-wearable-electronics/

7) How Wearable Technology Works, http://electronics.how/stuffworks.com/gadgets/high-tech-gadgets/computer-clothing.htm.

8) Uma Maheswari G and A. Divya, "Wearable Electronics and Smart Textiles based Personal Health Recorder", Dept of Electronics and Communication Engineering, SAMS College of Engineering and Technology, Chennai, India.

9) Intelligent Biomedical Clothing,http://www.technicaltextilesnet/articles/medical-textiles/detail.aspx?article-id=6243.

10) Textile Technology for the Vital Signs Monitoring in Telemedicine and Extreme Environments, http://ieeexplore.ieee.org/abstract/document/5452969/

11) R.R.Fletcher and S.Kulkarni, "Wearable Doppler Radar with integrated Antenna for Patient Vital Monitoring", in 2010 IEEE Ratio and Wireless Symposium, RWW 2010, January 14, 2010, New Orleans, I.A, United States, 2010, pp 276-279.

12) P. Park, P. H. Chou, Y. Bai, R. Mathews and A. Hibbs, "An Ultra-wearable, Wireless, Low Power ECG Monitoring System, Proc. Engineering, pp 241-244, Nov'2006.

13) J. Mayer, P. Lukowicz and G. Troster: "Textile Pressure Sensor for Muscle Activity and Motion Detection", 10th IEEE International

Symposium of Wearable Computers, 69-72, 2006.

14) M. Sergio, M. Manaresi, M. Nicoline, D. Gennaretti, M. Tartagni and R. Guerrieri, "A Textile based Capacitive Pressure Sensor", Sensor Letters, 2(2): 153-160, 2004.

15) S. Ditiea, "The PC goes Ready to Wear", IEEE Spectr, Vol 37, pp 35-39, Oct'2000.