Internet Of Things Based Wearable Sensors For Healthcare Industry

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Abstract-- Wearable health devices are able to monitor a large amount of vital signs of human body, from advance sensor supervision in the case of infant respiratory to fitness applications or even soldiers on the battlefield. This particularity of WHDs creates a big excitement around this technology and many opportunities to continue its development. With new advances in new materials, electronics and telecommunication information technology, together with the entry of big multinational companies, such as Google, but also of small startups, WHDs are expected to overcome their challenges and enter in the consumer market with a higher impact

Keywords: *Internet Of Things, Wearable Sensors , Healthcare Industry.*

I. INTRODUCTION

Doctors in rural areas are mostly non specialist physicians and hence it is necessary for a critical patient to travel long in order to get specialized medical services. It is studied that most of the patients died on the way with serious illness like lungs or heart diseases before reaching the specialist [1]. Wearable devices with remote parameter tracking can fill this gap with the help of integrated transmitter. The figure 1 shows the block diagram of the parameter monitoring system for human through wearable sensors. Now a day many flexible user friendly wearable sensors are available and that can perform a range of physiological and physical parameter measurements. These parameters are broadly classified into i) Physical sensors and ii) Chemical sensors. These technologies can be utilized for medical prosthetics, consumer electronics, soft robotics, artificial skin, drug delivery, therapy and health parameter monitoring. An interfacing unit is used to connect the wearer and the outside world. The interface is studied as input interface and output interface based on the operation. In early stage the input interfaces are keyboards or buttons which are less prone to error but later as the complexity of wearable devices increases, writing pad and voice recognition systems are in use. In contrast to input interface, the output interfaces provides information to the wearers from the outside world. Some of the output interfaces are audio interfaces, vibrations, voice synthesis and visual interface.

II. TYPES OF WEARABLE SENSORS

The design and development of wearable devices mainly depend upon the sensors which collect the precise data for health monitoring system. With the advancement of technologies like microelectronics, micromechanics have enabled the growth of many sensors to track human activities with low power consumption. To measure the physiological parameters, the sensors are classified into two namely, invasive sensors and non invasive sensors.

A. Invasive sensors

Invasive sensors require the body fluids to collect the relevant health data. Blood is a vital body fluid which can provide the essential parameters of different organs. Living cells are also needed to collect to get the status of living organs, for example, the bronchoscopy needs lung sample to identify the disease. The invasive nature of this sensor panic the patients as it is to be inserted through natural cavities or pierced into human body to take samples. Extracorporeal sensor or Ex Vivo sensor is an example for invasive sensor which incessantly monitors the pH and blood gases during cardiopulmonary bypass. Invasive sensors are not suitable for continuous parameter monitoring system such as fitness level monitoring of athletes, glucose monitoring of diabetic patients, cholesterol monitoring of heart patients, oxygen saturation monitoring for lung patients [2]. These hurdles pave the way to another type of sensors, called the invasive sensor.

B. Non-invasive wearable sensors

Non invasive wearable sensors do not need the body fluid and hence it is not necessary to penetrate the body using incision or injection, hence it is painless and more attractive. The body fluids used in this sensor may be sweat, skin interstitial fluids, saliva and tears [3].

Table 1. Invasive and Non Invasive sensors

Invasive / Implantable sensor	Non Invasive / Wearable sensor
Pulse oximeter	Electronic pill for drug delivery
Glucose sensor	Retina Implants
Temperature	Deep Brain Simulator
Electromyography	Pacemaker
Electroencephalogram	Wireless capsule endoscope
Blood pressure	Implantable defibrillators
pH value	Cochlear implants

III. Small Wearable Antennas for Healthcare System

Small antennas play a vital role in the fabrication of wearable wireless communications systems. Printed antennas are mostly employed in wearable communication systems as it is light weight, low profile and low production cost [1]. Fractal technology and Meta material are used to fabricate small antennas with high efficiency [2]. The bandwidth of the antenna with metallic strips and Split-ring resonators is around 50%. In human body the resonant frequency of the antenna with Split-ring resonators is shifted by 3%.

(1) (2) (3)

Figure 2 (1)Feed line printed antenna on paper (2) Split ring resonator (3) Fractal stacked patch antenna

The wearable antennas are placed on the human body which is connected to the medical system. The signals received by the antenna are transferred to the receiver and the signal with utmost power is considered by the medical system.

IV. Functions of Wearable Sensors in Healthcare Industries

Non-intrusive, non invasive sensors are the crucial components of long term and ambulatory health monitoring systems [9]. Wearable sensors are considered as a less obtrusive and more comfortable are suitable for monitoring patient's health without disrupting their daily activities. The sensors can be placed on different parts of the body to measure the physiological parameters. Aging in place, an application using wearable devices for aging people is promoting by several countries which allows the individuals and senior adults with chronic conditions to stay at home while they are remotely monitored for clinical interventions. Accelerometers are used to identify the performance of activities of daily living by senior adults in their home environment [4]. Long-term monitoring of physiological data such as blood pressure, respiratory rate, oxygen saturation, galvanic skin, body temperature and heart rate shows the development in the analysis and treatment of various diseases. Many clinical studies have been carried out to asses and validate the smartness of the wearable sensors in monitoring physiological data over long periods of time [5]. Electrocardiograms are a non invasive sensor application is a diagnostic tool to identify cardiac problems by measuring and recording the fluctuations of cardiac potential. Textile electrode made from silver based conductive yarn with SpO2 sensor and a three-axis accelerometer for fall detection is embedded in belts and T-shirt is used to monitor Heart rate, ECG and R-R interval [6,7,8]. Various non invasive based body temperatures monitoring system is under research and Buller et al.[9] proposed the human core body temperature determining system from the heart rate using Kalman filter. Bertolotti et al. [10] proposed a weightless, wireless wearable device for monitoring the steadiness of the body by reading the limb movements for long duration with the help of a gyroscope, magnetometer and an accelerometer. Through a body sensor network, several units can be connected in a body for gathering more detailed measurements [11]. Yoon et al.[12] proposed a piezoelectric pressure sensor fabricated on a polyimide substrate for the estimation of heart rate by sensing the pulse wave in human artery. A piezoresistive pressure sensors constructed from a nonwoven acrylate-modified polytetrafluoroethylene sensor coated on an aluminium electrode on a polyethyleneterephthalate film in a wristband is used for heart rate monitoring, having similar pattern as the ECG signal with more accuracy and less vulnerable to noise induced due to motion [13].

V. Wearable Devices in Pharmaceutical Industry

Wearable devices are presently at the core regarding the discussion related to Internet of Things. Wearable devices are the peripherals for the smart applications and rapidly growing toward a massive deployment of intelligence about everything in the environment. Wearable devices are performing different tasks related to sensing and security. For instance, wearable badges provide features such as identification and security particularly useful in the working environment. The advanced badges also has biometric capabilities (fingerprint activation), so that the badge owner can utilize it to unlock the door in the aspect of security. It can also be used for location sensing, in case of emergencies which ensures that everyone has evacuated the premises successfully. A wearable bracelet provides the reliable information about the location if it is placed in a jacket that is left on the chair.

Health and fitness wearable devices provide biometric measurements such as perspiration level, heart rate, oxygen levels in the blood flow. Nowadays, due to the technological advancement even the alcohol levels can also be tracked with the wearable device. Such devices are capable of sensing, storing and monitoring measurements periodically and the results are analyzed efficiently. By tracking the body

temperature, the device can provide the prior indication of either it is the symptom of a cold or the flu.

Smart wristband can track the perspiration level and that information can be helpful for adjusting the humidity level and the temperature.

Smart phone is acting as a centralized device for delivering such capabilities in the mentioned examples. Instead if IoT devices are communicating directly, there is no intervention of smart phone to monitor the transactions of wearable devices. Wearable devices are automatically interconnected with the devices in the surroundings. Preferred lighting adjustment can be done while watching television by sitting on a particular chair. The television can be switched on and the lighting level can be adjusted according to the connected LED lights in the particular room. An intelligent smart home set up might support automatically to block the lighting from windows which produces glare on the television. Perhaps the backlighting on the television screen can be adjusted to create a suitable environment to obtain the favorable experience. The interactions among devices can be done automatically once the platform is equipped well with the smart phone interface. The wearable devices such as watches, armbands etc can be recharged easily and provide the required high-power, long-term functions. Due to the advancement in battery technology, it provides longer lifetime with small space and it could be charged easily. The sensor-oriented wearable devices utilize the processing power periodically, however, the time consumption of wireless data transmission is minimized. Such devices should be more integrated with IoT in order to offer the wide range of features that are expected.

Table 2 . Wearable devices in pharmaceutical applications

Accessories	Description	Available Prototypes
Smart band	Wrist-worn devices have fitness tracking capabilities and other functionalities, without a touchscreen display	Wrist-worn Smoking Gesture Detector, Wrist-worn Bioimpedance Sensor, Ultrasonic-speaker Embedded Wrist Piece and Neck Piece
Wrist watch	Wrist-worn devices with a touchscreen display.	Finger-writing with Smart-watch, Smart-watch Life Saver
Smart jewellery	Smart jewellery designed with characteristics such as health-monitoring.	Gesture Detection Ring , Typing ring
Strap	Chest straps, arm bands, belts, or knee straps embedded with sensors for health tracking.	BodyBeat , Pneumatic Armband
Smart foot-wear	Socks, shoes, gloves, or insoles, equipped with sensors.	Gait Analysis Foot Worns, Foot-worn Inertial Sensors, LookUp
Smart garment	Clothing items such as pants, shirts and undergarments serve as wearables.	Dopplesleep, Myovibe
Smart eyewear	Contact lenses or spectacles with sensing used as wearables.	Chroma, iShadow Mobile Gaze Tracker, Indoor Landmark Identification, Google Glass, Google Contact Lens, Object Modelling Eye-Wear, Supporting Wearables
Ear bud and headset	Bluetooth enabled ear plugs or headsets. Sensor-equipped hats and neck-worn devices are also identified.	
Sensor patch	Sensor patches that could be adhered to the body skin for fitness tracking.	Smart Tooth Patch, DuoSkin, Tattoo-Based Iontophoretic-Biosensing System
E-skin / E-tattoo	Tattoos with stretchable and flexible electronic circuit realize wireless data transmission and sensing.	

VI. WEARABLE DEVICES REVOLUTIONIZE THE ENTIRE PARADIGM IN DRUG DISPENSING

The objective of self-injectable devices is to afford therapeutic value to physicians and patients. Self – administrative injectable drug therapies have shown an influence in the number of diseases such as rheumatoid arthritis, psoriasis, lupus, multiple sclerosis, diabetes, chronic pain, asthma, high cholesterol, mental health, chronic obstructive pulmonary disease (COPD), hemophilia

disorders, cancers etc. If patients are suffered with more than one chronical diseases, they face problem in managing their treatment schedule with the self-administered drug therapies. It creates an immense pressure in lot of cases and if emotional obstacles are not defeated, the proper outcome may not be obtained. Nowadays, the advanced drug-administrative devices are available which overcome many hurdles such as cognitive challenges or physical dexterity, mechanical complexity, needle phobia and pain. Self drug administrative device aids patients to take medications without any physician's knowledge.

The challenges in drug-delivery system is today's highly expensive biologic therapies such as therapeutic proteins and monoclonal antibodies tend to have complicated molecules with high-viscosity and highly concentration dosage is required which is incompatible with auto-injection devices have a dosing limit of 1 mL or traditional syringe. The handheld or advanced wearable drug-administrative devices use prefilled cartridges and 2-10 mL of the medication could be managed well in a single dose episode.

A wearable drug-administrative device easily adheres to the human body and the medication can be continued over a period of time. The advanced wearable devices are able to reduce pain, minimize hassle and ease administration compared to legacy self-injection devices and traditional syringes. The patients adhere faithfully to this type of therapeutic because of its significant factors. Lot of studies and patient interaction were undergone to improve on-going design process to make ease of using the device with minimal discomfort and steps. Less frequent dosing choice with self-administration drug therapy acts as a driving force for the ongoing research in wearable technology platform.

There is single-dose self administrative monthly injection choice 'Repatha' for high cholesterol, it was predicted to use as wearable on-body device with prefilled cartridge namely Pushtronex in smartdose platform. Pushtronex auto injected wearable device can be placed beneath the skin which permits 420-mg single dose of Repatha 3.5 mL in 9 minutes. The steps followed by the patient to use Pushtronex device, place pre-filled drug cartridge in the device and stick the device to the human body skin. A slight push of a button induces the needle to deliver the drug within few minutes. Once the drug administration is over, it is indicated via onboard electronics and it is ready for device disposal. Nowadays, smartdose devices are capable of delivering 3.5-mL to 10-mL doses with high-viscosity formulation which minimizes patient discomfort and injection timing relatively.

VII. CONCLUSION

Wearable health devices are able to monitor a large amount of vital signs of human body, from advance sensor supervision in the case of infant respiratory to fitness applications or even soldiers on the battlefield. This particularity of WHDs creates a big excitement around this technology and many opportunities to continue its development. With new advances in new materials, electronics and telecommunication information technology, together with the entry of big multinational companies, such as Google, but also of small startups, WHDs are expected to overcome their challenges and enter in the consumer market with a higher impact in the following years.

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