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Wearable Embedded Systems in Medical field for the Disabled

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Abstract

The embedded systems industry was born with the invention of microcontrollers and since then it has evolved into various forms, from machine control applications to various other new verticals with the convergence of communications.

In recent years, major technological advancements in the field of Electronics, especially in the medical and diagnostic fields has lead to enhancement of quality of life.

New microchips, nanotechnology and embedded systems have revolutionized the health-care industry. The integrated chips and wire-less communications have paved way for the design of low power, light weight implantable devices fitted with intelligent sensors.

These sensors can be seamlessly integrated into personal or body networks (Wire-less Personal Body Networks –WPANs / Wire-less Body Area Networks - WBANs) for health monitoring. Wire-less medical sensors should satisfy the main requirements such as wearability, reliability, security, and inter-operability. The present health-care monitoring system is facing challenges due to multiple factors, such as, increase in the population of elderly and disabled coupled with high cost of diagnostics and treatment.

Most of the wearable medical devices are small and do not have a regular shape. To Design such devices ,special skills and equipment is required. What differentiates a wearable device from the conventional embedded system is the management of power, that means to say that they need to be battery operated – either storage cells or rechargeable .

It is desirable to shift the focus of health-care to more affordable, more accessible and scalable solutions. Wearable health monitoring systems or implantable devices help to continuously monitor the changes in the vital signs of a patient and provide a feedback to the doctors in maintaining the optimal health status.

These implants can warn the patients of impending medical conditions. With the mobile devices the patient information can be accessed any time anywhere on real-time basis and improves the communication between caregivers and support team.

Radio Frequency Identification (RFID) technology facilitates the management of assets like wheel chairs, ambulatory equipment etc. and enhances the process of drug administration without much delay in saving the life of a patient.

This paper discusses the various aspects of Wearable Medical Devices using Embedded systems which is growing at a phenomenal speed to help the disabled persons.

Keywords: Wearable Devices, Convergence of communications, Medical and Diagnostic fields, Implantable devices, WBANs

Introduction

Recent advances in telecommunications, microelectronics, sensor manufacturing and data analysis techniques have opened up new possibilities for using wearable technology in the digital health ecosystem to achieve a range of health outcomes. In the past, the size of sensors

and front-end electronics made it too difficult to use them in wearable tech to gather physiological and movement data .Now, with miniature circuits, microcontroller functions, front-end amplification and wireless data transmission, wearable sensors can now be deployed in digital health monitoring systems.

Most of the present-day applications of sensors are wearables. 'Wearable' devices are miniature electronic devices worn on the body, often integrated with or designed to replace existing accessories .

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Health monitoring devices constitute the front-end components of the health information network and are primaraly responsible for a) collecting physiological data from the patient/user and b) transmitting them securely and reliably to a remote monitoring location. Traditionally, crude and bulky monitoring devices have been employed to collect patient vital signs, for example bedside Holter ECG monitors as the ones used in Intensive Care Units (ICU). These older devices of such size and cost, with several wires require the patient to be immobilized in order to acquire reliable measurements.

These wearable devices are smaller in size , less weight, portable and autonomous. As a result, personal health monitoring devices are popular.

Recent advances in microeletronics, nanotechnology, miniaturized biosensors, wireless communication techniques, low power computing, battery technologies and effective information processing have provided the means to realize wearable noninvasive systems that can monitor the wearer's health condition continuously and in real- time.

These sensors can be can be classified into the following five categories:

Health and Wellness Monitoring: Sensors and wearables that monitor physiological data of the disabled people and individuals with chronic conditions can facilitate timely clinical interventions.

Safety Monitoring : Many sensors and wearables have been developed to detect falls, epileptic seizures and heart attacks in older people and susceptible individuals—and then send alarm signals to caregivers or emergency response teams.

Home Rehabilitation: Sensing technology is sometimes used in combination with interactive gaming and Virtual Reality environments and augmented feedback systems to facilitate home-based rehabilitation for physiotherapy, patients with heart disease, and ageing individuals.

Treatment Efficacy Assessment: Using sensors and wearables, the efficacy of treatments and outcomes of clinical trials can be better assessed. They help to track physiological changes from chronic conditions, as well as the progress of treatments on a continuous basis. Sensors are also used to monitor, assess and improve patient compliance.

Early Detection of Disorders: By combining physiological sensors with activity monitors and consumer-end electronic devices, this application of digital health can be used for early detection of symptoms and adverse changes in a patient's health status—facilitating timely medical interventions.

The working principle:

The aim of the paper is to Design and Develop a wearable embedded system which can help the disabled persons in an emergency situation as

their mobility is limited. This embedded system employs a wearable sensor which enable continuous monitoring of a variety of human vital signs and other physiological parameters such as heart rate, respiration rate, body temperature, blood pressure, perspiration, oxygen saturation, electrocardiogram (ECG), body post- ure and activity etc. If it detects any change in the health condition immediately it sends an alert signal to the care takers or family members, whose mobile number is registered.

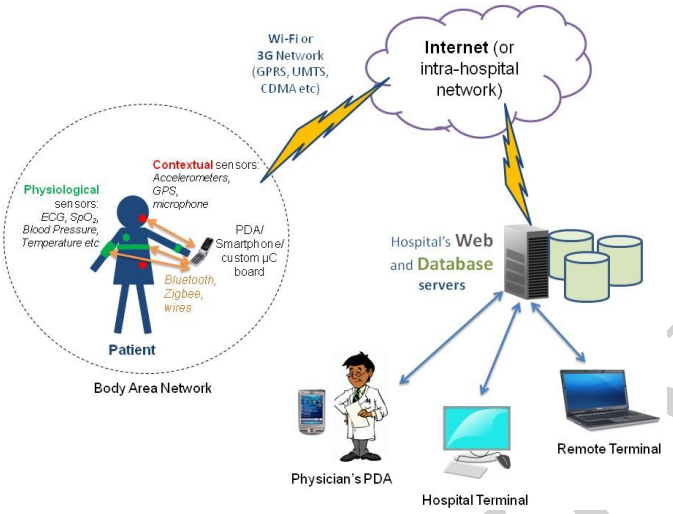

Fig: The health monitoring network structure

The above figure illustrates the case of one single patient using a Wearable health monitoring systems (WHMS) It lso introduces the term Body Area Network (BAN), which is widely used when referring to WHMS that employ bio-sensors with wireless communication capabilities.[1]

The sensor is the one which reads the physical quantity such as temperature, pressure, force and flow, etc. These are normally represented by electrical signal known as analog signals. These signals are converted into digital signal through ADC (Analog to Digital Converters). These digital data is stored and or processed with in the Microcontroller. The Microcontroller has its flash memory which is loaded with the necessary software program either in assembly language or high level language. The acquired digital data is compared with the set values in the program. If there is any mismatch the system sends an alert signal. This can be done by interfacing microcontrollers to buzzer or speaker, LED/LCD, GPRS/GSM Modem and mobile phones.The GPRS/GSM stands for General packet radio service and Global system for mobile communication. This GSM modem can be configured to send an SMS alert to the registered mobile phones.[2]

The following steps describes the complete working principle of these wearable sensor based embedded systems for healthcare monitoring and emergency attention. [5]

(1) Design and develop an embedded system which consist of wearable sensors
(2) Interface the Microcontroller to I/O Devices and acquire the needed signal through sensors
(3) Store and or process the signals using ADC /DAC Techniques
(4) Check the limit values of required parameters with the acquired data
(5) If any mismatch occurs send an SMS alert signal to the caretakers/family members

GPRS: The GPRS stands for Global Positioning Radio System. This GPRS system can be integrated in the new embedded system to get the Geographical systems information. It provides the Latitude and Longitude [7] data of the person whom we are interested to locate. This GPRS system consist of an SIM Card (Mobile Number) which is authorized to communicate to the numbers of their family or relatives , doctors , police or fire peoples. The Latitude gives the angle in degrees from equator of the earth in North and South. The Longitude gives the position in east and west distance. The coordinate of North – south and West-east gives the exact location of the object or person we are interested. The following picture describes the

earth's location finding with latitude and longitude details.

GSM: GSM stands for Global system for Mobile Communication. The GSM consist of Mobile station , Base Transceiver station, Base switching centre, Mobile switching center, Home location register , Visitor location centre , Authorization centre for text or voice data transmission.

The Impact of Design elements on the Wearable product:

The typical life cycle of a wearable product has four stages namely, the design ,manufacture ,use and support .[7]

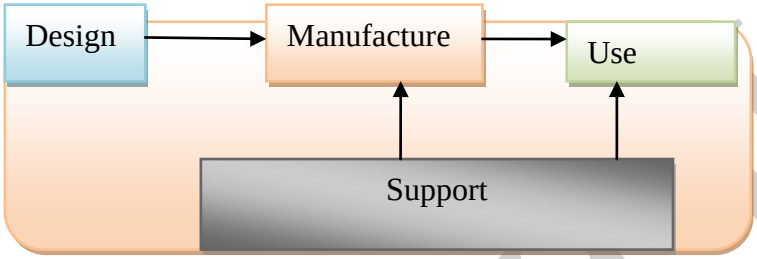

Fig: Life cycle of a Wearable Device

Design Phase: The designer need to consider the following things for successful wearble device.

- Since wearable devices use very low signals level, the corresponding analog and digital signals should be strong especially for the disabled.
- Since they are battery operated, they design should use low voltage and regulators.
- Management of processor speed and power consumption
- Types of battery used,their charging charecteristics, their behavior against temperature variations should be clearly given in the specifications.
- Accuracy in measurement to avoid sending false reports to the physicians.
- The wearable devices being small, the influence of neighbouring components , like in the case of a vibrators. The vibrators have a magnetic field and produce strong physical vibrations, any device sensitive to the magnetic fields can produce wrong results. This may prove to be fatal for the patients.
- Since the devices are miniature in nature, the components also are accordingly small, placing them correctly in the circuit is essential.
- With proliferation of USB based charging, most of the [products are sold without chargers. Since the devices need to be charged, and if it requires a special charger,it should be provided
- Wearable devices should be water proof , hence the designer can look into the packaging aspect.
- The robustness of the sotware used
- The use of PCB's and flexible circuits as the deices are small and irregular in shape.

Manufacturing stage:

- The product is successful only if the both design and manufacture team work together.
- The device being small, major space is covered by the batteries, leaving less space for the electronic components and the reliability is affected.
- Packing techniques like chip on board, normal IC packages will be a better solution.

Support system:

Support from the patients and care takers in the case of disabled persons will help the designers to improve further.

Solutions

The device can be worn like a watch or it can be implanted . The cost can be minimal if bulk productions are made and the government can consider for free or subsidy price to peoples residing at rural or villages. The comfort ability can be improved by practice. The location can be identified by integrating the GPS (Global Positioning System) with the embedded system.

Results

Wearable computing is an emerging concept building upon the success of today's mobile computing and communication devices. Due to rapid technological progress it is currently making a transition from a pure research stage to practical applications. Many of those applications are in health related domains, in particular, health monitoring, mobile treatment and nursing.

Conclusion

Within the next couple of years wearable systems and more general ubiquitous computing will introduce profound changes and new application types to health related systems. In particular they will prove useful in improving the quality and reducing the cost of caring for the disabled population.

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