

APPLICATION OF WIRELESS SENSOR NETWORK IN HEALTHCARE MONITORING

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Abstract:

The application of the wireless sensor network increases day by day. Starting from the military application the wireless sensor network grew on promise of environmental sensing and low cost data processing. Wireless Sensor Network (WSN) refers to a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions and organizing the collected data at a central location. These networks can hold hundreds or even thousands of smart sensing nodes with processing and sensing capabilities and even integrated power through a dedicated battery. This paper surveys on the application of wireless sensor network in the health care monitoring using the biosensor technology to gather the data from the victim even when they are doing their day to day activities. Here we discuss about three type of biosensor like implanted, wearable and environment-embedded. Wireless sensor networks provide the technology to built wireless sensing and create a convenient

Infrastructure for multiple data gathering in healthcare applications.

Keywords: wireless sensor network, architecture, application in health monitoring, biosensor-implanted, wearable, and environment embedded.

Introduction

The wireless sensor network finds application in the areas of military applications, health applications, environmental applications, home applications, commercial applications, area monitoring, health care monitoring, environmental/earth sensing, air pollution monitoring, forest fire detection, landslide detection, water quality monitoring, industrial monitoring[1].

Even though a wireless sensor network is a network of several nodes equipped with one or more sensors, wireless transceiver and energy source, they tend to have low power consumption. Because of its easy installation it is simple for the military to air drop the wireless sensor nodes at strategic locations and quickly enable the network remotely. In addition to that the wireless sensor networks that use the mesh networking scheme transmits data from one point to another using a mesh network takes less energy as compared to transmit data directly between two points as per the characteristics of

the RF communication. This are all the advantages of wireless sensor network over traditional sensing technology.

Wireless sensor network is the key for IOT the Internet Of Things. It is expected that the world will benefit from the services of wireless sensor network with internet access. As an example of wireless sensor network importance, intel proactive health believes that wireless sensor network may be “crucial to address the pending global age wave and public health crisis”. Wireless sensor network can be effectively used in healthcare to enhance the quality of healthcare services. In the following paper section 1 reviews the about the architecture and working of wireless sensor network. Section 2 shows the survey report on health care and need for wireless sensor network in healthcare monitoring .Section 3describes about biosensor and their roll in healthcare monitoring section 4deals with the types of biosensor and their enhancement. Finally the section 5concludes the paper.

1. Wireless Sensor Network

Wireless Sensor Network (WSN) refers to a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location.

1. 1 Working

A collection of sensor nodes collects the data from the surroundings to achieve specific application objectives. The communication between motes(a large number of circulating, self-directed, minute, low powered devices named sensor nodes called **motes**) can be done with each other using transceivers. In a wireless sensor network, the number of motes can be in the order of hundreds/ even thousands.

1.2 Architecture of wireless sensor network and typical sensor

Wireless sensor network architecture follows the OSI architecture model. The architecture of the wireless sensor network includes five layers and three cross layers[2].

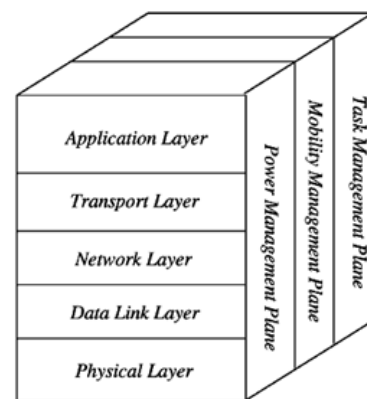


Figure 1. WSN Architecture

Physical layer: the physical layer provides an edge for transferring a stream of bits above physical medium. This layer is responsible for the selection of frequency, generation of a carrier frequency, signal detection, modulation & data encryption.

Data link layer: the data link layer is liable for multiplexing data frame detection, data streams, MAC, & error control, confirm the reliability of point–point (or)point–multipoint.

Network layer: the main function of the network layer is routing, it has a lot of tasks based on the application, but actually, the main tasks are in the power conserving, partial memory, buffers, and sensor don't have a universal id and have to be self-organized. **Transport layer:** the function of the transport layer is to deliver congestion avoidance and reliability. The transport layer is exactly needed when a system is planned to contact other networks. **Application layer:** the application layer is liable for traffic management and offers software for numerous applications that convert the data in a clear form to find positive information.

1.3 Structure of typical sensor

Controller: the controller performs tasks, processes data and controls the functionality of other components in the sensor node.

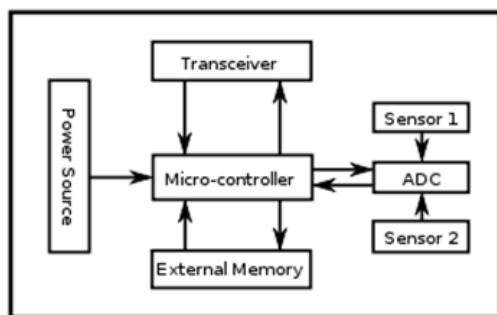


Figure 2. Structure of sensor

Transceivers : The functionality of both transmitter and receiver are combined into a single device known as a transceiver. Transceivers often lack unique identifiers. The operational states are transmit, receive, idle, and sleep. Current generation transceivers have built-in state machines that perform some operations automatically.

External memory: There are two categories of memory based on the purpose of storage. They are: user memory used for storing application related or personal data, and program memory used for programming the device. Program memory also contains identification data of the device if present.

Power source: The sensor node consumes power for sensing, communicating and data processing.

Sensors:

Sensors measure physical data of the parameter to be monitored and have specific characteristics such as accuracy, sensitivity etc.

Analog-to-digital converter : the continual analog signal produced by the sensors is digitized by an analog-to-digital converter and sent to controllers for further processing.

2. Survey reports on health care monitoring

Globally, the elderly population is growing and the general population is aging. Life expectancy continues to increase with new advancements in health care. Throughout the world, the over age 65 population is projected to more than double from 357 million in 1990 to 761 million by 2025.

2.1 Need for wireless sensor network in healthcare monitoring

Because of this huge amount of population it is difficult for the doctors to monitor each and every patient's health individually. Therefore wireless sensor network is implemented in healthcare monitoring [11]. Wireless sensor networks in healthcare systems can be divided into three main categories:

1. Monitoring of patients in clinical settings
2. Home & elderly care center monitoring for chronic and elderly patients
3. Collection of long-term databases of clinical data

3. Biosensors

A biosensor is a self-contained integrated device that is capable of providing specific quantitative or semi-quantitative analytical information using a biological recognition element which is in direct spatial contact with a transduction element.

1) Biosensor is not equal to bio-analytical system

2) An enzyme electrode is a biosensor

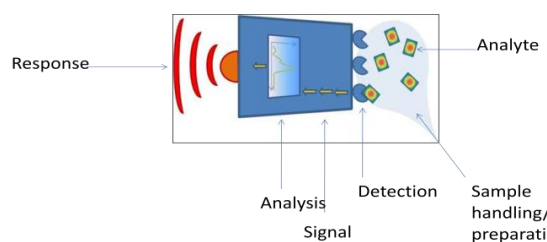


Figure 3. Biosensor

Current definition

A sensor that integrates a biological element with a physiochemical transducer to produce an electronic signal proportional to a single analyte which is then conveyed to a detector.

3.1 Role of biosensor in healthcare monitoring

In healthcare, biosensors provide analyses of chemical or physiological processes and transmit that physiologic data to an observer or to a monitoring device. Historically, data outputs generated from these devices was either analog in nature. [9]

Biosensors can be categorized into six different diagnostic types- non-invasive, in vitro, transcutaneous, ingested, wearable, implanted, environment embedded.[10]

3.2 Components of a biosensor

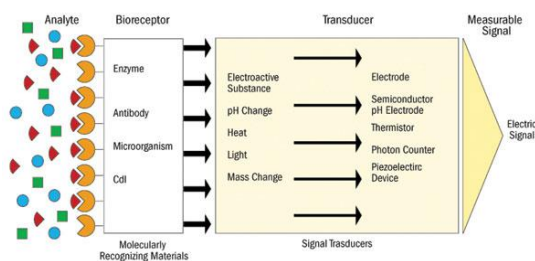


Figure 4. Components in biosensor

4. Classification of biosensor

Here we mainly concentrate on the application, challenges and enhancement of three basic types of biosensors such as implanted, wearable, and environmental embedded.

4.1 Implanted biosensors

4.1.1 Introduction

Devices implanted within us, which require minimal human action in providing continuous information about chemicals in our bodies, could be a central component in delivering this personalization[3]. Implantable biosensors include a range of devices, but they all work on the same principle. A biological sensing element - which interacts with the substance being monitored - is coupled to a transducer that converts the signal produced by their interaction into one that can be more easily measured and quantified.

4.1.2 Application of implanted biosensors

Driven by need and demand from the diabetic community, the traditional market pull for biosensors has been for blood glucose measurement. An unobtrusive implantable biosensor, such as senseonics' Continuous Glucose Monitoring (CGM) system, could further improve the management of chronic conditions such as diabetes by removing the non-compliance factor associated with portable and wearable devices. For example, some diabetes patients may stop taking regular glucose readings due to the pain and time associated with finger-prick tests; with an implantable this obstacle is removed. Of course, even with the continuous monitoring from an implantable, the user might not act on results; the human body has a multitude of inbuilt sensors, such as pain, which humans frequently fail to act upon promptly. To overcome this 'human' challenge, some implantable could be

paired with a continuous drug delivery method, such as a fully implantable artificial pancreas - the ultimate aim for diabetes patients.

4.1.3 Challenges in the implementation of implanted biosensor and their enhancement

there remain a number of important technical issues to address, such as improving the lifetime of the sensor and ensuring not only that the biosensor is tolerated by the body, but also that its presence and interactions do not in themselves affect the accuracy of its readings. Speeding up the development of personalized drugs is another area where implantable biosensors could have a significant impact. Miniaturization of implantable biosensors together with the utilization of a drug-eluting biocompatible composite coating may be a promising strategy to achieve long-term reliable continuous glucose monitoring. The implantable biosensor chips, can measure in real time more than one metabolite in the human body, along with pH and temperature could allow researchers to track the effects of candidate drugs on the body precisely, allowing them to determine more quickly whether a drug should continue in clinical development.

Implantable biosensors can also be used in personalized cancer therapies by measuring the rapid, highly localized and transitory changes of certain biomarkers that influence a tumor's response to radiotherapy and chemotherapy treatment.

The power of implantable biosensors to improve patient care and disease management is great, but there are technological barriers to overcome, as well as a need to develop validated biomarkers.

The management of chronic conditions and detection of disease may be more effective – and cost effective – approaches. But it is also not yet known whether being continuously monitored

by devices that cannot be easily removed will be generally acceptable to the public; if not, their use will certainly be impeded.

4.2 Wearable biosensors

4.2.1 Introduction

Wearable systems are devices that allow physicians to overcome the limitations of technology and provide a response to the need for monitoring individuals over weeks or months. Wearable biosensors typically rely on wireless sensors enclosed in bandages or patches or in items that can be worn. The data sets recorded using these systems are then processed to detect events predictive of possible worsening of the patient's clinical situations and they are explored to access the impact of clinical interventions [4-8].

Wearable biosensors: “wearable’s+ biosensors”

Wearable biosensors are generally a combination of wearable and biosensors. Wearable biosensors are digital devices that can be worn on the body in the form of wearable systems or devices such as smart shirts, smart watches, thin bandages or tattoos, patches, spectacles, rings etc. —allowing blood glucose levels, blood pressure, heart beat rate and other biometric to be measured

4.2.2 Applications

Wearable biosensors are bringing out a wave of innovation to the society. This real time data availability will allow better clinical decision and will result in better health results and more efficient use of health systems. For the human society, wearable biosensors may help in early detection of health events and avoidance of hospitalization. The potential of wearable biosensors to shorten hospital stays and reduce

readmissions will surely attract favorable attention in the coming future. Research statistics says that wearable biosensors will surely bring a cost effective wearable health technology to the society.

4.2.3 Recent developments in wearable biosensors: based on the transparency market research, the market value for wearable biosensors is huge; the biosensors market is expected to witness considerable growth owing to its wide array of applications in cardiac monitoring, diabetes monitoring, agriculture, bio-defense practices, environmental and drug discovery. Some recent developments of wearable biosensors are google smart lens, health patch biosensor, sim band wearable biosensors, ring sensor

1. Google smart lens: a smart contact lens measuring the glucose amount in tears was recently brought out by google as wearable biosensors. It consists of a small glucose sensor and a wireless chip. The aim of these wearable biosensors is to help diabetic patients. A small pin size hole in the lens allows the tear fluid to go into the sensor to measure blood sugar levels. Electronics lie outside the pupil and iris hence there is no damage to the eye.**2. Healthpatch biosensor:** health patch, as wearable biosensors has the ability to monitor chronic diseases. Biometric data and any disease sign is wirelessly sent and are monitored by doctors and patients via Bluetooth. In health patch, the sensor is fitted to a disposable and adhesive patch. This patch is designed such that it is suitable to be placed on the chest. The sensor here has the ability to gather biometric data like pulmonary (sleep duration, respiratory rate, sleep quality), neurologic (gait analysis, fall detection/severity), cardiovascular (heart rate variability, heart rate, contextual heart rate), and other (step count, posture, temperature summarized activity, energy expenditure, stress)
3. Simband wearable biosensors: simband uses

a sensor filled wristband and a large display for monitoring body metrics in real time. The sensors in the band project beams of light into the skin at varying strengths in order to reach tissue near the surface or deeper in. The screen then displays metrics like heart rate and blood pressure in real time. Simband has a 1 GHz and 28nm arm cortex-a7 chip with Bluetooth and Wi-Fi.**4. Ring sensor:** ring sensor is a pulse oximetry sensor which allows monitoring heart rate and oxygen saturation. The device is shaped like a ring and it can be worn for long periods of time. Red led, infra-red led and a photodiode are embedded in the ring. The whole process is scheduled and controlled by a single processor. Transmitted waves are sent through a digital wireless communication link which when received are analyzed by a home computer. Technology of pulse oximetry is built into the computer for monitoring the patient's pulses and blood oxygen saturation**5. Wearable smart shirt:** smart shirt uses optical fibers to detect wounds and special sensors and interconnects to monitor the body vital signs. The basic advantage of smart shirt as wearable biosensors is that it helps to provide a systematic way to monitor the vital signs of humans. T-connectors are used in the clothing and are attached to the optical fibers which act as a data bus to transmit the information from the sensors on the body. Since the shapes and sizes of humans are different, the sensors can be positioned on the right places for all users. Moreover this smart shirt can be laundered without any damage. It helps in monitoring the heart rate, respiratory rate and temperature.

4.2.4 Challenges in the implementation of wearable biosensor and their enhancement

Even though wearable technology is providing many advantages to healthcare, it is also being researched into whether wearable technology is safe due to the radiation it emits. At the moment,

it has been noted that wearable technologies are smaller than a lot of other devices and therefore they do emit less radiation than devices such as smart phone. These devices do emit heat which can be uncomfortable to many people. Enhancement of wearable biosensors can be achieved by designing the biosensor which will be free from radiation and heat.

4.3. Environmental-embedded biosensor

As the name implies the environmental embedded biosensors are those sensors embedded in the environment that capture behavior and activity patterns. Changes in patterns are detected as potential signs of changing health[5]. For example the system of in-home sensors and algorithms for automated health alerts provides a method for detecting health problems very early so that early treatment is possible.

4.3.1 Application of environmental embedded biosensor

Passive Infrared (PIR) motion sensors have been used to capture activity in a particular location in the home. Motion density from PIR motion sensors (i.e., number of events per unit time) can capture overall activity level that may be linked to health condition. In addition, sleep patterns have been studied using motion sensors, bed mats, or load cells, door sensing, medication tracking, use of a home computer, cognitive computer games for monitoring and remediation, and a phone sensor for detecting incoming and outgoing calls.

4.3.2 Challenges in implementing the environmental embedded biosensor and their enhancement

One challenge for researchers is collecting enough data in-home sensor to establish correlations with clinical assessments, although there is some recent work in this area. It is

important to identify the best parameters to track for health change; some parameters may be too late for early health change detection. If we increase the data synchronization and continuous performance capability we can overcome the challenge and this will enhance the roll of environmental embedded for future use.

5. Conclusion

This paper proves the wireless sensor network can be widely used in healthcare application and major challenges and evaluating metrics of wireless sensor network. Since the wireless sensor network have significant issues like robustness, security, interfacing communication and continuous performing the bioinformatics can further more enhanced by overcoming this issues. It is expected that in future, smart space enabled wireless sensor network can sense environmental condition and take preventive action based on the human present in that region.

References

- [1] Wireless Sensor Network, Technology, Protocols and Application by K.Sohraby, D.Minoli and T.Znati
- [2] Protocols and architecture for wireless sensor network by H.Karl and A.Willig.
- [3] Kotanen, christian, "Implantable Biosensors for Physiologic status Monitoring during Hemorrhage" (2013).
- [4] Flow Sensors and wearable in Biomedical Engineering. [Last accessed on 2014 Jun 17]. Available from: <http://vista.ir/article/258815>.
- [5] Szewczyk R., Mainwaring A., Polastre J., Anderson J., Culler D. An analysis of a large scale habitat monitoring application. Proceedings of the 2nd ACM International Conference on Embedded Networked Sensor Systems (SenSys'04); Baltimore, MD, USA. 3–5 November 2004; pp. 214–226.

- [6] Jubairahmed, L., Satheeskumaran, S., Venkatesan, C.: Contourlet transform based adaptive nonlinear diffusion filtering for speckle noise removal in ultrasound images. *Clust. Comput.* 1–10(2017).
<https://doi.org/10.1007/s10586-017-1370-x>
- [7] Satheeskumaran, S., Sabrigiriraj, M.: A new LMS based noise removal and DWT based R-peak detection in ECG signal for biotelemetry applications. *Natl Acad. Sci. Lett.* 37(4), 341–349 (2014).
- [8] Satheeskumaran, S., Sabrigiriraj, M.: VLSI implementation of a new LMS based algorithm for noise removal in ECG signal. *Int. J. Electron.* 103, 975–984 (2016).
- [9] Venkatesan C, Karthigaikumar P, Varatharajan R (2018) FPGA implementation of modified error normalized LMS adaptive filter for ECG noise removal. *Cluster Comput* 1-9. <https://doi.org/10.1007/s10586-017-1602-0>.
- [10] C.Venkatesan, P. Karthigaikumar, A. Paul, S. Satheeskumaran and R. Kumar, "ECG Signal Preprocessing and SVM Classifier-Based Abnormality Detection in Remote Healthcare Applications," in *IEEE Access*, vol. 6, pp. 9767-9773, 2018.
doi: 10.1109/ACCESS.2018.2794346
- [11] 12. Venkatesan, C., Karthigaikumar, P. & Varatharajan, R. *Multimed Tools Appl* (2018). A novel LMS algorithm for ECG signal preprocessing and KNN classifier based abnormality detection, 1-10.<https://doi.org/10.1007/s11042-018-5762-6>.

