Wireless body area networks for child healthcare monitoring: a review

INTRODUCTION

It is due to the recursive researches and enhancement in technologies that the cost and the size of the sensor have been reduced dramatically which make it possible to use sensor network [1] in different fields. Healthcare is one of the fields where enhancement of technology is at a great pace. Use of the sensor network in the field of healthcare makes it possible to create a network that will monitor the vital signs of a patient using different types of sensors, context-aware applications [2] and special communication protocols that give the flexibility to take precautionary measures before the event will occur and take immediate action in case of emergency [3]. Use of Wireless Body Area Network (WBAN) [4] provides real-time monitoring of patient's vitals provide quick rehabilitation and improve quality of medical assistance in case of emergency as compare to traditional healthcare services. This paper will mainly focus the use of WBAN technology in child healthcare monitoring. In this paper, section II will provide a brief classification of the disease that required monitoring under different age groups. Sensors and devices used in WBANs for the child health monitoring are present in section III. Discussion and comparison on the technologies used in WBAN for the child health monitoring can be seen in section IV Section V highlights the challenges implementing the WBAN in child healthcare. Discussion on the diseases associated with the children that will affect the routine life of children and required monitoring to improve the quality of life will be in section VI and finally, section VII is a conclusion and further directions regarding this survey paper.

CLASSIFICATION OF DISEASES IN CHILD HEALHTCARE

Differentiating a disease from any age group is difficult nowadays as any disease can be associated with any age group. Change in the living style, increase of social and economic stress became the cause of many diseases such as hypertension [5], high blood pressure that leads to Hearth attack [6], diabetes [7], cancer [8] and other mental and physical diseases. Figure 1. Extended version of Pervasive Child Healthcare domains [3] The objective of using sensor network in healthcare is to provide the monitoring of patients suffering from chronic disease and in case of emergency provide the medical assistance immediately or as soon as possible. Moreover, it helps to track the symptoms and send the first information before any event can occur. Use of sensor network helps to monitor the patient's activity continuously without disturbing his/her normal life routine. There are diseases for different age group but this paper is focused on monitoring the domain of child healthcare.

SENSORS AND DEVICES USED IN WBAN FOR CHILD HEALTH CARE MONITORING

Different types of sensor are used in WBAN to monitor the activities or conditions of the patient. Sensors that are used in WBAN are not only collect data but also process data based on some algorithm in order to serve the need of patient [9]. Lists are some common sensors that can be used in either implantable sensor devices or wearable sensor device in body area network for the purpose of child health monitoring. Table 2, which has been extracted from [3] will give the comprehensive detail regarding the list of sensors used in pervasive healthcare applications for child health monitoring.

A. Inertial Motion Sensors Inertial Motion Sensors are used to monitor the body's posture and movement of the human body. The most commonly used devices used to monitor the postural moment and other moments are gyroscopes and accelerometers [10-11]. The combination of two will give the orientation information and diverse motion patterns [9].

B. Bioelectrical Sensors Bioelectrical sensors used the electrical signals generated during the bodily activities used to monitor and diagnosis the current activity or the condition of a body organ [12-13]. Electrocardiography (ECG) sensors and electromyography (EMG) sensors are the common examples of bioelectrical sensors.

C. Temperature Sensors Temperature sensors are usually placed over the skin to monitor the body temperature. Temperature sensors have great significance in medical as the diagnosis of the different disease can be done by monitoring the body temperature. D. Optical Sensors Optical sensors emit and received normal and infrared light to calculate the amount of oxygen present in the blood of the human body.

E. Wearable Sensor Devices In such sensors, there is a different verity of shape and size. With the recent advancement in technology, there is a big room for wearable sensor devices in healthcare applications. Some of the examples of wearable sensors include Electrocardiography (ECG) sensors, blood sugar monitoring sensors, Pulse oximeter sensor, postural movement sensors etc.

F. Implantable Sensor Devices Implantable sensors are used when external sensor is not able to provide the desired result or in the case where there is a no alternative to secure the patient with an unexpected incident such as cardiac pacemakers. Implanted sensors are needed to be more accurate and reliable as it is not easy to replace them. The power consumption is very low to increase the battery life. The devices are more responsiveness as compared to wearable devices in order to give an immediate response to the lifecritical triggering event. The reliability of data is one of the key concerns in the implanted devices as on the bases of the information the practitioner will set the direction for the treatment. TABLE I. SENSORS USED IN PERVASIVE CHILD HEALTHCARE APPLICATIONS [3]

WIRELESS TECHNOLOGIES USED FOR CHILD HEALTH MONITORING

In this section we will discuss some radio technologies that supports the advancement and deployment of WBAN infrastructure which are used in child health monitoring. Table. 3 give you a brief summary of the communication technologies used in the field of wireless sensor networks. A. Bluetooth Bluetooth is the most commonly used technology in WBAN. It is short-range wireless technology maintain a high standard of energy with low energy consumption [14]. The IEEE standard for Bluetooth is 802. 15. 1 with 1 Mbps of data rate and covers an area of 100 meters. The operation frequency 2. 4 GHz, exercising 16-bit CRC for security [15].

B. ZigBee Another low power technology with the data rate of 250 Kbps and communicate in the range of 100 meters. ZigBee operates at the frequency

of 868/915 MHz and 2. 4 GHz providing 16-bit CRC for security [16]. The IEEE standard for ZigBee is 802. 15. 4 (MAC). The most important feature of ZigBee is to be operated in low power environment. The major disadvantage of this technology is low data rate due to which ZigBee is unsuitable in the environment where the high data rate is required such as hospitals and clinics [17-18].

C. Wi-Fi Wi-Fi is medium power consumption technology which operates at a higher data rate of 54 Mbps. The IEEE standard for Wi-Fi is 802. 11 with different variation as a/b/g/n and with the operating frequency of 2. 4 GHz. Wi-Fi cover area of 100 meters providing 32-bit CRC for security [18-19]. Since the Wi-Fi devices are deployed at many public places which make it suitable for different WBAN application.

D. LoRaWAN Low Power Wide Area Network (LoRaWAN) is a low power consumption technology designed to support large networks. The IEEE standard for LoRaWAN is 802. 11ah with data rate of 50 Kbps covering a area of 15 Kilometers [18], [20]. The operating frequency is 433/868/915 MHz with 16-bit CRC for security. LoRaWAN is design to support millions of devices to implement the paradigm of IoT will be a good choice for designing any IoT model of WBAN.

E. 6LoWPAN 6LoWPAN is the combination of IPv6 and Low-power Wireless Personal Area Networks (LoWPAN). This technology allows low-power devices to communication by using internet protocol. IEEE standard of 6LoWPAN is 802. 15. 4 with data rate is 250 Kbps having cover area of 50 meters.

6LoWPAN has an operating frequency of 2. 4 GHz with 16-bit CRC for security [18], [21] and [15]. F. RFID RFID, commonly known as Radio Frequency Identification is used to read information from tag place on an object. Information from this tag can be collected from the distance of several feet and line of sight (LOS) direction is not mandatory. RFID system is composed of two things which are namely label and a reader [22].

Normally RFID chip is able to carry data of around 2 Kbytes. In medial scanning, there is a vast use of RFID technology. Beside above mention technologies, there are other technologies such as DASH, Wi-Max, and a variant of ZigBee called Xbee are used in WBAN.

CHILD HEALTH MONITORING CHALLENGES IN WBAN

There are several challenges associated with the implementation of WBAN in child healthcare. Some of the key challenges are as follows. A. Reliability Reliability of data is very important because inaccurate data may lead to inaccurate diagnosis, waste of resources and sometimes even life threating [4], [23]. Reliability of data should be maintained during data acquisition, data transmission, and data processing. Since the sensors are prone to failure, it is necessary to use an extra sensor to make sure the reliability of data but it should also be considered that applying extra sensors should not create discomfort to the patient.

B. Mobility Mobility is another concerned in using sensors in body area network. One of the biggest challenges in WBAN is that it should not restrict the mobility of user due the use of sensors.

The technology and sensor used in WBAN usually assure the user mobility but still, there are many challenges to developing a fully functional mobile WBAN, especially in children where they perform a different physical activity with frequent body movement [24].

C. Efficiency & Power Management The algorithm embedded in the sensor should be designed in a way that should use energy efficiently [25]. Since many sensors used in WBAN are wearable so battery replacement is easy but it is very crucial when they are planted in the body. In such cases, sensors should be designed in a manner that consumes very low energy and provides long battery life (i-e last for year or more)

D. Safety & Comfort The sensor used in the child healthcare should be used with extra care as children usually have crustily about the thing and they try to pull them out. Children of younger age usually have a habit to put everything in the mouth. Safety and comfort should be considered that the sensors are properly hidden or out of their reach to avoid any unusual incident. Sensors should be used in such a manner that they will not bother them and use them with ease.

E. Security & Privacy Since privacy is not the major concern for young children but older are sensitive regarding their health matters. In such case, privacy should be maintained so the person's social life should not effect. Data confidentiality, data integrity, accountability, availability, and access control should be maintained in order to avoid any malicious intention of a person [26-27]. F. Cost Cost is the major factor in using the Wireless body

sensor. Although the prices of the sensor have been reduced tremendously still the prices need to be reduced so they are accessible to everyone and people having low monthly income will able to effort them and can provide better treatment to their children.