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Article

Wearable Sensors and Internet of Things Integration to Track and Monitor Children Students with Chronic Diseases Using Arduino UNO

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Abstract: Parents concerns for their children who has a critical health conditions may limit the children movements and live to engage with others peers anytime and anywhere. Thus, in this study aims to propose a framework to help the children who has critical disease to have more activity and engagement with other peers. Additionally, reducing their parents' concerns by providing monitoring and tracking system to their parents for their children health conditions. However, this study proposed a framework include tracking and monitoring wearable (TMW) device and decision system to alert healthcare providers and parents for any failure in the children health condition and status. The framework was designed based on the IoT environments and architecture. This project is also limited to apply in health IoT environments and may can be extend in future to apply in different internet coverage area.

Keywords: IoT; WSN; TMW; healthcare; children

1 Introduction

Over the past two decades, the size and composition of the world's population have changed and these trends are expected to continue. These demographic trends have important implications for almost all sectors of society, especially health and healthcare. Life expectancy, especially in rich countries, has risen dramatically, which is worth celebrating and should be seen as an opportunity for people to live longer and better lives. However, this requires major improvements in both the healthcare system and the living environment [1]. With this increase in population and rapid development, the IoT has emerged, where refers to a group of devices and systems that remain interconnected with sensors and motors in the real world over the Internet, where the IoT also contains many objects such as modules control, microprocessors, sensors, applications of various software and protocols that enable them to communicate. And speaking of these other living things that have become a major thing in our daily life and with this increasing spread of the IoT in the world, they provide real-time services that help save time, resources, and even manpower [2].

There is a problem related to children's health and parental control, as children generally need more health care than their older counterparts, especially more attention from parents, as children do not know whether there are risks around them or have a chronic disease because they are not aware of these things [3]. Therefore, they are most at risk of being kidnapped or raped by people of weak souls or assaulted for taking money and exploiting them. All these risks surrounding children have prompted us to create an integrated system to monitor children's health, monitor their movements, and track their locations so that they are in a safer environment [4].

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In the current scenario, there is a concern on the part of parents that their children will go out or go to school or play with their friends, especially children with chronic diseases, or exposing them to a case of kidnapping in addition to the child staying for hours outside the home without supervision and sometimes the parents are far from them because the children love playing and having fun with their peers in the neighborhood or at school, so the need to treat all of these problems arose.

This paper proposes a system for sensing and tracking a child's health, tracking their location, and sending an alert if something happens in real-time. It is important to provide safety and security for our children, and this system is an integrated system that provides these requirements to the party that monitors the child, whether parents or a doctor specializing in pediatric diseases, and through reading sensors such as temperature, heartbeat, fatigue and the child's location, and through the Arduino Uno connection to a network such as Wi-Fi or GSM and an alert can be sent to parent and doctor (decision maker) connected to the cloud to record data values in any emergency situation or changes in the child's health status, such as increased heart rate or temperature.

2 Internet of Things Layers and Devices Integration

The IoT architecture is still in the established process. However, a high-level architecture with four-layer architecture is widely accepted [5–6]. The architecture consists of four main layers: Sensing Layer, Network Layer, Processing Layer, and Application layer as shown in Fig. 1.

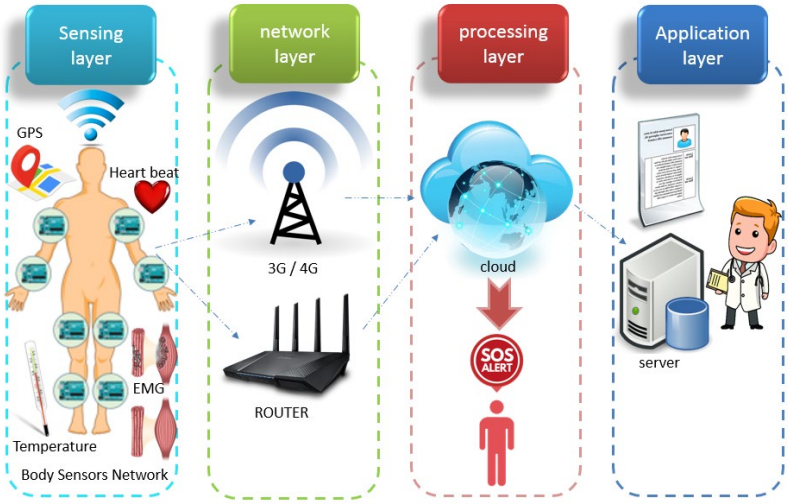

Figure 1: The architecture of four main layers

2.1 Sensing Layer

Sensing layer is a bottom layer in the IoT environment responsible to collect different object data and send it network layer. In this study sensing layer aims to design and develop sensing technologies for effectively and efficiently collecting a variety of types of health data in an IoT environment. Existing sensors and wearable devices, such as temperature sensors, GPS (Global Positioning System), heartbeat sensor, Myoware muscle sensor, EMG (electromyography) are capable of observing and recording multiple type health data, includes temperature, location, heart rate, muscle and movement activities. So far, these sensory methods have become reasonably scientifically and theoretically advanced in manually controlled settings [5].

2.2 Network Layer

This layer is mainly used to connect sensing devices in sensing layer to the internet layer. This in order to allow sensing data to be collected, stored, transmitted, shared, and aggregated under IoT

infrastructures. Also, it provides interoperability and security needed in the context of IoT for healthcare. Network layer is also play a key role in the IoT communication, in which connect all devices with WAN using different protocols (TCP/IP), technologies and standards like 3G, 4G, ADSL, DSLAM, and Routers. In this study network layer used to connect TMW device with the processing layer in order to collect, analyze, and store the data [2].

2.3 Processing Layer

Processing layer is a layer that provides functionality of storage data and management. Thus, in this study we proposed cloud computing that can provide better facility to store, manager and analyze the data into logical pool. The physical storage may be one server or multiple servers, typically owned and managed by a hosting company. The cloud provides different services and algorithms on demand like cloud storage, cloud data store, cloud SQL, bigquery, restful services for ios, Android, javascript and machine learning algorithms. However, in processing layer different algorithm can be applied to support clinical decision system and getting notification alerts in critical health conditions [7].

2.4 Application Layer

This layer is also called as a presentation layer [7–8] in which used the processed data by previous layer and present the information. Furthermore, this layer called as a front end layer to provide high quality services and easy-to-use interfaces to end users. The decision makers can monitor the patients' status easily to give their feedback and receive the notifications. In this study, we proposed the information present in three level to the healthcare staff. The first level called normal level which categorized all stable health cases for children who have chronic diseases. The second level called intermediate, this level includes all children who are under treatments procedure and should be monitor. The third level called emergency, which categorized all children who have chronic disease with their information and location.

3 Tracking and Monitoring Health Children Framework

This study proposed a framework in order to keep the children who has a critical health conditions under tracking and monitoring system to send alert for any filed in health conditions. The framework consists three parts include TMW device, alert notification and decision systemas shown in Fig. 2 (tracking and monitoring system architecture).

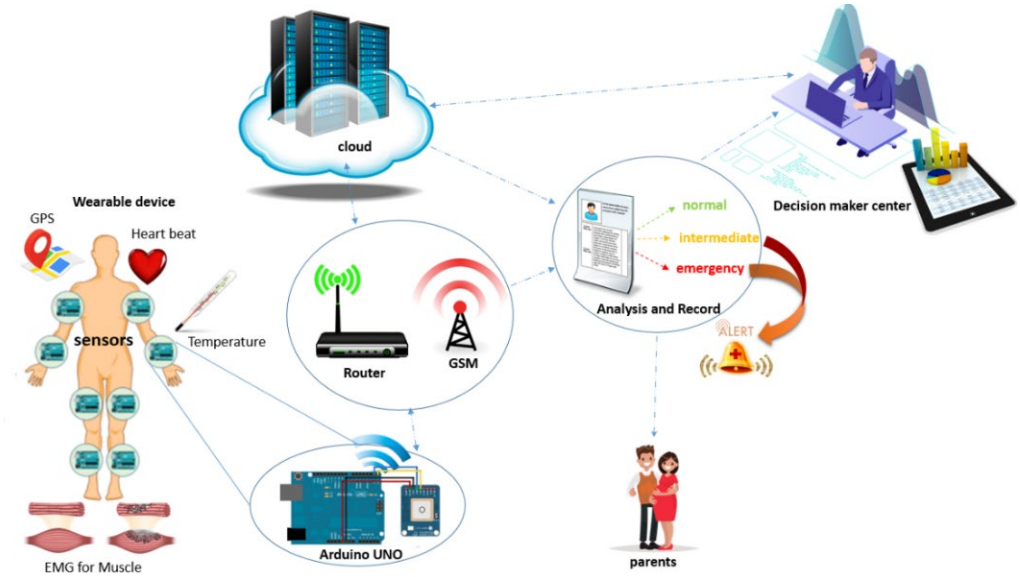

Figure 2: Tracking and monitoring system architecture

The TMW device has been design with many small health sensors and components. These components were designed to be suitable to implement in small device to be easy to carry. However, the following sections explain the approach of TMW device design.

3.1 Health Device Sensors Kit

In this study, many sensors are used to collect health information and tracking the children health and location. These sensors are used with the Arduino to be able to gather related data and send it through the wireless network; for instance, personal heartrate, muscle activity, temperature and location [9]. The Table 1 describes the functionality of these sensors and components individually.

Table 1: Health device sensors

Sensor	Description
Heartbeat Sensor	It is a small sensor that can measure a person's heart rate per minute by using red led on finger.
Myoware Muscle sensor	It is a sensor that uses EMG (electromyography) to sense muscle electrical activity.
Temperature sensor	It is a sensor used to measure body temperature.
Global Positioning System (GPS) sensor	This sensor provides Geo-location information wherever on or near the Earth
Wi-Fi ESP 8266	This electronic device is used to provide communication between the Arduino and the Internet for the purpose of transmitting the sensor data associated with the Arduino to the Internet

3.2 Communication Protocol

Sensors can collect and send measurements automatically to the software at any time interval depending on their individual settings. This allow to display data from all sensors in real-time. Users could be able to interact and operate with sensors: to request a sensor's current value, to stop data recovery, to set the time interval, etc. Sending data must be confidential and reliable by the hospital and the specialists because it is sensitive and important data for the person, so the sensors associated with the Arduino can send the data via Wi-Fi or other communication protocols to the IoT application, which can create a dedicated channel and it contains counters to measure and store data for certain periods of time.

Thingspeak has been used as an IoT application to store and retrieve data from the TMW devices. In the TMW device has been used HTTP and message queuing telemetry transport (MQTT) protocol over the Internet. This study, assume that the internet connection is available through any available services in the surrounded area such as 3G, 4G, etc. The TMW device send all sensing data such temperature, heartrate, location, and muscles activity through the internet layer [10].

3.3 Portable Embedded System

Recently, Arduino board has expanded its family of tiny Nano boards with new offerings that deliver better specs for a lower price. It integrates a computer board with support for many peripherals input and output via standard interfaces (Serial, Bluetooth, and Wi-Fi) and powered with a battery. The size of the device is 68.6 mm/53.3 mm, weighing about 25 grams, it is suitable also for embedding high-level applications in a wide range of applications that allow interaction with various devices and users. Thus, Arduino has been used for the features, functionality, and low price offered in this project. Additionally, testing ready-to-use portable systems and replacing computers in the way they communicate and process information from multiple e-Health sensors [11].

3.4 Design of Experiments

In the experiments Arduino has been used regarding functionality and applicability to integrate many electronic components, sensors with applications and to build efficient projects and systems. The official Arduino website contains many comprehensive information, free applications, educational programs, and examples of how to use the basic system and some practical experiences on it. Thus, this study used TMW device include Arduino microcontroller with four health sensors and wireless connection device to send data to thingspeak application. Fig. 3 shows the TMW device board include Arduino microcontroller and connected sensors.

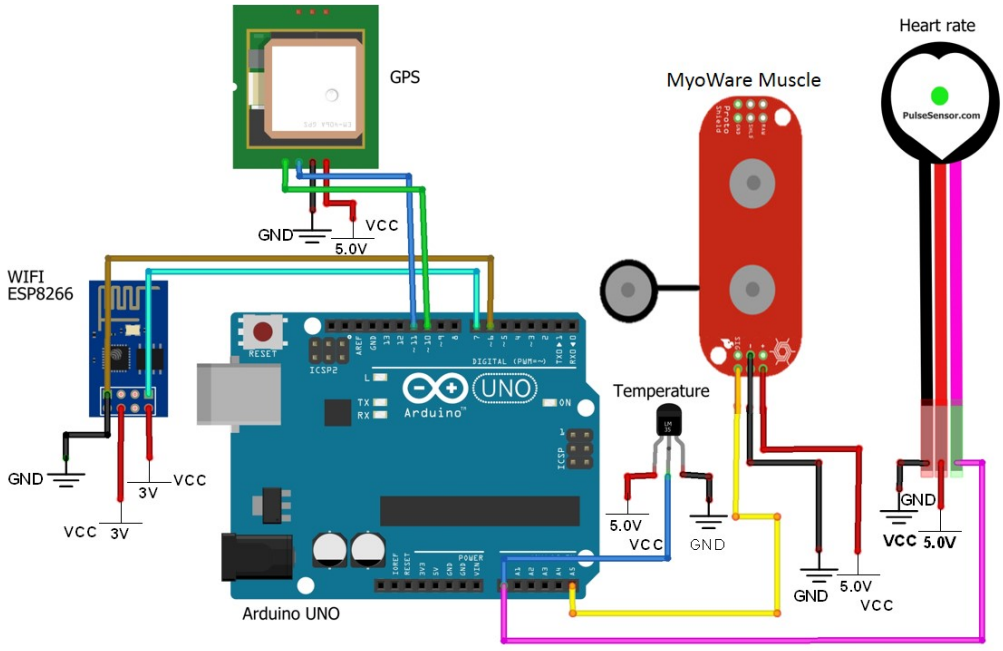

Figure 3: Tracking and monitoring wearable (TMW) devices

4 Decision System

Decision system is a computerized program used to support the healthcare providers for any determinations in the patient's condition by analyzing health data gathered from patient records and current sensing data. The decision system in this project help the healthcare to understand the situation of children who has chronic disease and sending alerts when it necessary.

The decision system being design based on three critical health levels include normal, intermediate and emergency. The children who has stable health conditions are classified in normal level. The intermediate level includes the children who are under treatment process and necessary monitoring. For those who are under intermediate level, if any changing happened the system change their level to be in emergency level, then the notification is start to alert. This process is being done when the data import to the system and analyzed based on three conditions as it proposed in this project. The following flowchart in Fig. 4 explained these conditions:

Decision 1: In this step, the sensing temperature data flow the threshold value of normal body temperature. So, if the temperature is above a critical threshold (greater than 38°C) the system send alert notification to the parents and healthcare providers to notify them about the children temperature status.

Decision 2: In this step, the sensing heartrate data flows the standard value of heartrate measurement. In our project, if the data are above 140 beats means that the children facing a difficulty in his/her health status and need to further assistance from parents and health providers.

Decision 3: In the step, the electromyography (EMG) describe the muscle activity and fatigue. The health conditions stated in this step is to measure the fatigue of children by sending alert notification to their parents and health providers. This measurement may help health providers to discover other health issues related to physical activity. In this current work, the system flow the critical value of EMG to send alert notification, if the value is above (0) or less than (600) then the system being notify the parent and health providers about the health failure.

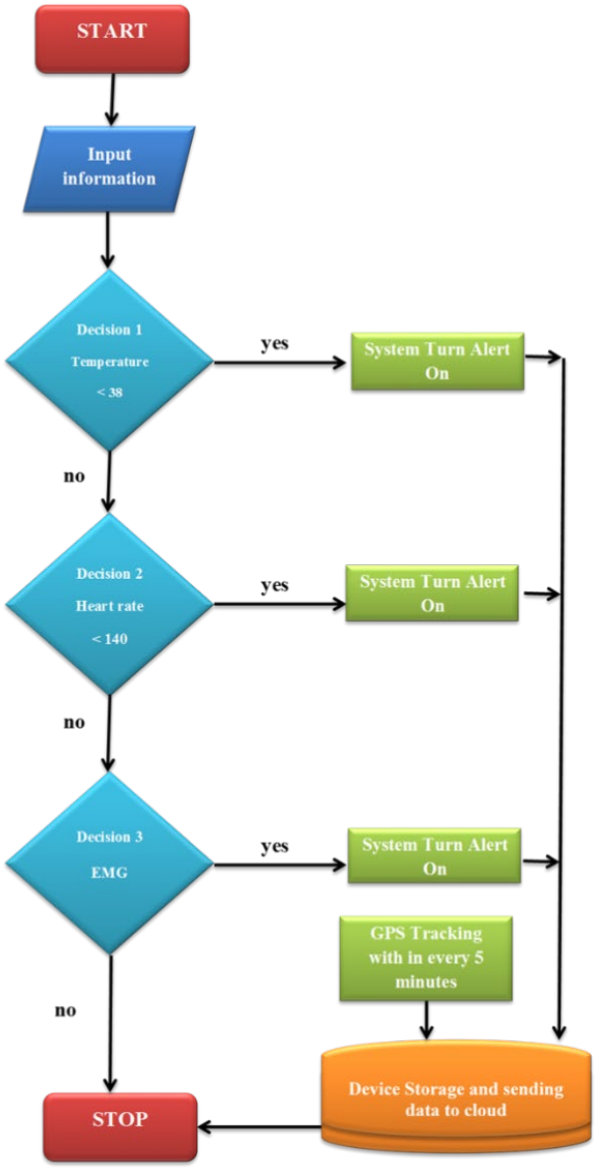

Figure 4: Tracking and monitoring flowchart steps in the system

5 Parent Notification Alert

In order to tracking and morning the movement activities, health conditions for children who have chronic disease, Arduino microcontroller used to integrate the important sensors kits. These sensors are connected to the Arduino to read sensing information immediately to send it through internet layer. Thus, the authors applied same flowchart algorithm in the Arduino to analyzed the data; this start when sensing information start reading through Arduino; then start to analyzed based on the same flowchart that has

been proposed in decision system. This information pass in three main conditions to give a decision to continue or sending health alert to the healthcare providers and parents. This applied to reduce the workload on the healthcare providers and to satisfied parent concerns on their children.

6 Conclusion

This study proposed a framework to track and monitor the children who have chronic disease by their parents and healthcare providers. The aims of this framework is to reduce the parent concerns and avoid any health failure for the children; additionally, reduce the workload for health providers and let the parents to assist in the monitoring and tracking. The framework was designed in this study based on the IoT layers to record health information and send the alert notification when it necessary. The contribution of this study added on the internet layer; in which two paths of notifications send in the sometime, first to parents and then to health providers. The project was focused on the children with chronic diseases only and may can be extent in future to be applicable on the other patients and cases.

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