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IoT Based Smart Gadget for Child Safety and Tracking

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***Abstract*: This paper is mainly streamed towards child safety solutions by developing a gadget which can be tracked via its GPS locations and also a panic button on gadget is provided to alert the parent via GSM module calling for help. Parental android app is developed to manage and track the device anytime. Smart gadget device is always connected to parental phone which can receive and make phone calls and also receive SMS on gadget via GSM module, also a wireless technology is implemented on device which is useful to bound the device within a region of monitoring range, if device is moving out of monitoring range then an alert will be triggered on binding gadget, this helps you keep a virtual eye on child. Health monitoring system on gadget checking for parameters like heart beat/pulse rate and temperature is included which can be monitored on parental app. Gadget also monitors whether it is plugged on hand or not using contact switch and alert the parent as soon as it is unplugged.**

***Keywords*: IoT, Children safety, Arduino mega [ATMEGA 2560]; GPS, GSM, Sensor, Mobile communications, Smart phone.**

1. Introduction

The internet of things (IoT) refers to the set of devices and system that stay interconnected with real-world sensor and to the internet. During years' Child safety is under threat and it is very important to provide a technology-based solution which will help them under panic situations and monitor them using a smart gadget. The proposed system is equipped with GSM and GPS modules for sending and receiving call and SMS between safety gadget and parental phone, the proposed system also consists of Wi-Fi module used to implement IoT and send all the monitoring parameters to the cloud for android app monitoring on parental phone. Android application can be used to track the current location of safety gadget using its location coordinates on parental phone android app and also via SMS request from parent phone to safety gadget. Panic alert system is used during panic situations and automatic SMS alert and phone call is triggered from safety gadget to the parental phone seeking for help and also monitored for plug and unplug from hand, as soon the gadget is unplugged from hand a SMS is triggered to parental phone and the alert parameter is also updated to the cloud.

Heart-beats, temperature is monitored and the values are updated to cloud continuously for parent app monitoring. Boundary monitoring system is implemented on safety gadget with the help of BEACON technology, as soon as the safety gadget moves far away from the binding gadget an alert is provided to parent on binding gadget. the system is used to monitor the health parameters and also used for location tracking during necessary situations in safety concern.

2. Literature Survey

[1] Authors: M Nandini Priyanka, S Murugan, K. N. H. Srinivas, T. D. S. Sarveswararao, E. Kusuma Kumari.

Title: Smart IoT Device for Child Safety and Tracking. Published in: 2019 IEEE.

The system is developed using Link-It ONE board programmed in embedded C and interfaced with temperature, heartbeat, touch sensors and also GPS, GSM & digital camera modules. The novelty of the work is that the system automatically alerts the parent/caretaker by sending SMS, when immediate attention is required for the child during emergency.

Merits: The parameters such as touch, temperature & heartbeat of the child are used for parametric analysis and results are plotted for the same.

Demerits: To implement the IoT device which ensures the complete solution for child safety problems.

[2] Authors: Akash Moodbidri, Hamid Shahnasser

Title: Child safety wearable device.

Published in: 2017 IEEE.

The purpose of this device is to help the parents to locate their children with ease. At the moment there are many wearable's in the market which helps to track the daily activity of children and also helps to find the child using Wi-Fi and Bluetooth services present on the device.

Merits: This wearable over other wearable is that it can be used in any phone and it is not necessary that an expensive smartphone is required and doesn't want to be very tech savvy individual to operate.

Demerits: As, this device's battery gives short life-time. High power efficient model will have to be used which can be

capable of giving the battery life for a longer time.

[3] Authors: Aditi Gupta, Vibhor Harit.

Published in: 2016 IEEE.

Title: Child Safety & Tracking Management System by using GPS.

This paper proposed a model for child safety through smart phones that provides the option to track the location of their children as well as in case of emergency children is able to send a quick message and its current location via Short Message services.

Merits: The advantages of smart phones which offers rich features like Google maps, GPS, SMS etc.

Demerits: This system is unable to sense human behavior of child.

[4] Authors: Dheeraj Sunehera, Pottabhatini Laxmi Priya.

Title: Children Location Monitoring on Google Maps Using GPS and GSM.

Published in: 2016 IEEE.

This paper provides an Android based solution for the parents to track their children in real time. Different devices are connected with a single device through channels of internet. The concerned device is connected to server via internet. The device can be used by parents to track their children in real time or for women safety. The proposed solution takes the location services provided by GSM module. It allows the parents to get their child's current-location via SMS.

Merits: A child tracking system using android terminal and hoc networks.

Demerits: This device cannot be used in rural areas.

3. Proposed System

A. *Safety Gadget*

Figure 1 shows the block diagram of the proposed child safety device. It consists of inbuilt Wi-Fi, GSM, GPS and Bluetooth modules. The link it one board is similar to the Arduino board and it is termed as all-in-one prototyping board for safety and IoT devices. The link it one is a robust development board for the hardware and also used for industrial applications. Different components such as temperature sensor, heartbeat sensor, panic button, contact switch are connected to the link it ONE board along with built in GSM, GPS modules. Safety gadget consists of BEACON and BLE packet is transmitted through it, this packet is received by binding gadget which has BLE receiver module, the packet usually contains information such as identification number, signal strength etc. Temperature is one of the most commonly measured variables. For measuring body temperature of the child DS18B20 temperature sensor is used. The heartbeat sensor is used in the proposed system for measuring the pulse rate. There is a heartbeat/pulse sensor which is combined to simple optical heart rate sensor with amplification and nullification circuitry making it is fast and easy to get reliable pulse reading. The GSM/GPRS block is activated with a SIM card on the board.

They mainly differ based on bandwidth and RF carrier frequency. GSM network consists of mobile station, base station subsystem network and operation subsystem. The GPS module is provided for identifying the location of the child. GPS module receives the signals from satellites. The latitude and longitude of the location can be identified by the GPS module. The device sends the monitored parameters data such as temperature and pulse rate to cloud. If any abnormalities occurs in temperature or pulse rate readings, a SMS and call triggers to the parent/caretaker mobile phone immediately and also updated to the mobile app only for the registries mobile no. We can use mobile application, cloud and database as the back end of storing and retrieving information and also a device for monitoring.

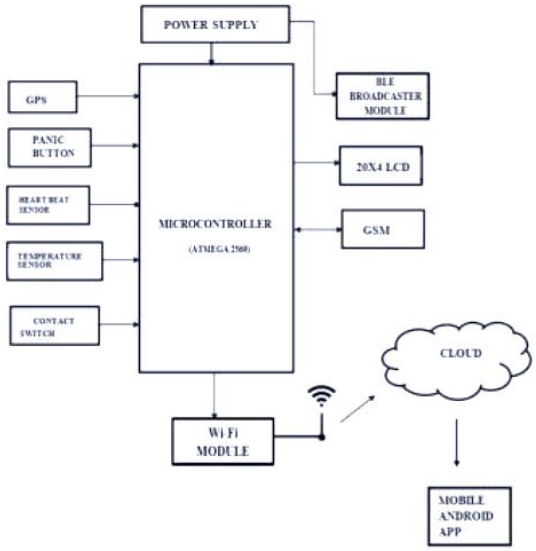

Fig. 1. Block diagram of smart gadget

B. *BLE Listener device*

Figure 2 shows the BLE Listener device is the device which is used to satisfy this feature along with safety gadget and parental phone. This gadget is also used to monitor safety gadget within a bounded area using wireless technology as follows, this feature of binding gadget is designed to work independently without phone network signal/internet so that safety gadget can even be under monitoring when it reaches remote areas where communication signals is not reachable like forest. Safety gadget consists of BEACON and BLE packet is transmitted through it, this packet is received by binding gadget which has BLE (Bluetooth Low Energy) receiver module, the packet usually contains information such as identification number, signal strength etc. Whenever the packet is received it checks for all the above information in the receiver device.

As the distance between safety gadget and binding gadget increases, the signal strength decreases. Once the safety gadget is moving out of threshold distance from the binding gadget then an alert is provided on binding gadget which will be used by parent/guardian.

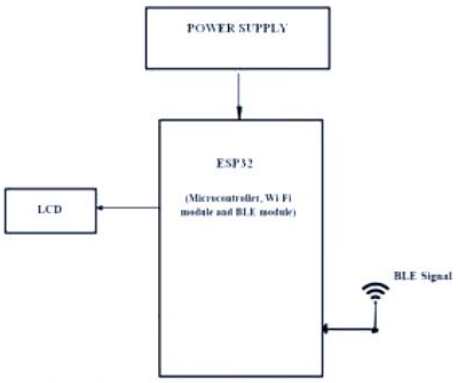

Fig. 2. Block diagram of BLE listener device

C. Tools Used

Hardware Requirements:

- Arduino Mega [ATMEGA 2560].
- GSM SIM 800C.
- GPS Neo 6m.
- 20X4 LCD.
- I2C LCD Driver
- 7805 Voltage Regulator.
- Heart Beat Sensor.
- DS18B20 Temperature Sensor.
- 1x4 Switch.
- ESP8266-12E
- Push Button
- Logic Level Convertor
- Buzzer
- LED
- ESP32
- OLED
- Jumper Cables

Software Requirements:

- Arduino IDE
- Android Studio

Languages Used:

- Embedded C
- Java

4. Methodology

This paper mainly focuses on child safety solutions which contain two major devices namely Smart gadget and BLE Listener device. The system also includes an Android app namely Parental App which will be developed and installed on parental phone.

This paper consists of 6 modules as follows:

1) Live Location Tracking: Safety gadget contains a GPS module which will fetch the current location and sends it to the microcontroller for required processing, the safety gadget is also installed with the GSM module to respond for location request sent via SMS from parental phone. The system is connected to cloud via Wi-Fi technology and hence the GPS location is updated to the cloud at regular intervals or on request, whenever parent want to monitor the location of safety device then parental app can be used which fetches all the data from the updated cloud and also display the current/live location of the safety gadget.

2) Panic Alert System: The gadget is equipped with panic alert system feature which mainly consist of a button that is triggered only during certain abnormal/panic situations, this button is programmed in such a way that, once it is triggered then multiple alerts in various forms occurs within few seconds of time, SMS and also phone call is triggered to the parental phone from the safety gadget GSM module to the parental phone, which consists of current location of gadget fetched from its GPS and a pre-installed panic message seeking for help. An alert notification on parental app is triggered via Wi-Fi on safety gadget communicating to cloud where parental app receives the information.

3) Stay Connected Feature: This feature is to communicate between safety gadget (GSM module) and parental phone always connected irrespective of the situation, safety gadget can make a phone call anytime to parental phone and vice-versa. Safety gadget which will be displayed on its screen.

4) Health Monitoring System: The gadget consists of heart beat and temperature sensor which is used to monitor the general health condition of child. Any abnormalities being detected in the health monitoring parameters by the safety gadget then an immediate alert is sent on the parental app via Wi-Fi. Also, displays on parental app.

5) Gadget Plug and Unplug Monitoring: This feature is to keep monitoring if the safety gadget is plugged or not by monitoring the contact switch, necessary alerts are provided on parental app whenever the device is unplugged.

6) Boundary Monitoring System: Binding gadget is the device which is used to satisfy this feature along with safety gadget and parental phone. This gadget is used to monitor safety gadget within a bounded area using wireless technology. Once the safety gadget is moving out of the threshold distance from the BLE listener device then an alert is provided on device itself, which will be used by parent/guardian. This feature of binding gadget is designed to work independently without phone network signal/internet so that safety gadget can even be under monitoring when it reaches remote areas where communication signals are not reachable like forest.

A. Software Specification

The Arduino Software (IDE) which is an open-source and makes it easy to write the code as well as to upload in to the board. It runs on the Linux, Mac, IOS and Windows. The programs are written in Java, based on the Processing and other open-source software. This software makes the interfacing with Arduino-Uno much more reliable. The primary reason for using the GS shield as the mode of communication over Wi-Fi and Bluetooth was that this gadget was aimed at being accessible to any smartphone user. Also, to make the user- friendly as

possible.

Applications for the Android operating system are programmed using the SDK Android software development kit and Java programming language that also may be used with C or C++. The Android Studio is the official programming environment that allows developers to build Android apps. The idea behind the Android app has been derived from having an automated bot to respond to text message responses from the user. It will provide the user with pre-defined response options at just the click of a button. The user doesn't need to memorize the specific keywords to send. Also, the both will be pre-programmed to present the user with a set of pre-defined keyword options such as "DEVICE_LOCATION".

5. Results

1) Live Location Tracking: GPS is installed on gadget to track its current location can be tracked on android app and via SMS request sent from parent phone to safety gadget.

Fig. 3. Outputs of live location tracking

2) Panic Alert Systems: Panic alert system on gadget is triggered during panic situation, automatic call and SMS are triggered to parental phone. The alert is also updated to the cloud for purpose of app monitoring.

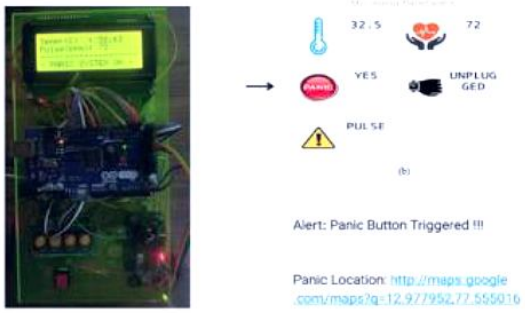

Fig. 4. Outputs of panic alert system

3) Stay Connected Feature: Stay connected feature is used to trigger call and pre-defined SMS anytime from gadget to parental phone by just pressing a button and also parent can make SMS and call to the gadget anytime.

4) Health Monitoring System: Health monitoring system is implemented using heart beat sensor, temperature sensor which is updated to the cloud and also can be monitored via app. The current value of sensors can be obtained using SMS request sent to gadget from parent phone.

Fig. 5. Outputs of health monitoring system

5) Gadget Plugged or Unplugged Monitoring: Gadget plug or unplugged is monitored using contact switch installed on smart gadget, as soon as the device is unplugged, an alert is provided to parent phone via SMS and it is also updated to cloud for app monitoring.

6) Boundary monitoring system: This is used to track the safety gadget using the binding gadget by implementing signal strength concept as soon as the safety gadget moves far away from the BLE listener gadget then an alert is provided to itself.

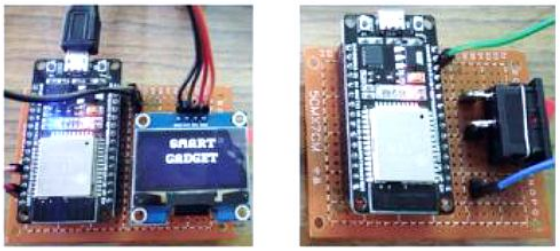

Fig. 6. Listener device and broad cast device

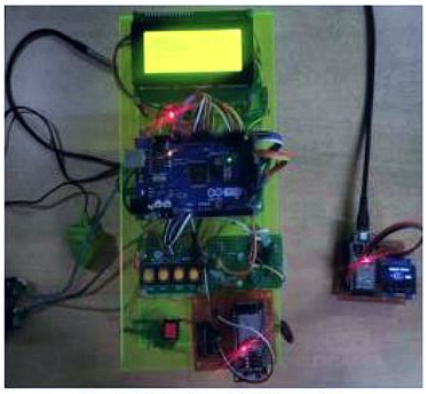

Fig. 7. Overview of safety gadget

Figure 7 shows the circuit connection with sensors. The temperature sensor, pulse sensor, BLE module, GSM module and GPS module are shown.

6. Limitation

The system is dependent on communication signal/network signal for the smart gadget to trigger automatic phone call/SMS during panic situation. It can be difficult to detect when network

signal is not reachable/weak/when the smart gadget moves outside the boundary range. Hence, it can be improved by increasing the range.

7. Conclusion

This research demonstrates Smart IoT device for child safety and tracking, to help the parents to locate and monitor their children.

If any abnormal readings are detected by the sensor, then an SMS and phone call is triggered to the parents mobile. Also, updated to the parental app through the cloud. The system is equipped with GSM and GPS modules for sending and receiving call, SMS between safety gadget and parental phone. The system also consists of Wi-Fi module used to implement IoT and send all the monitored parameters to the cloud for android app monitoring on parental phone. Panic alert system is used during panic situations alerts are sent to the parental phone, seeking for help also the alert parameters are updated to the cloud. Boundary monitoring system is implemented on safety gadget with the help of BEACON technology, as soon as the safety gadget moves far away from the BLE listener gadget an alert is provided to itself.

8. Future Scope of Work

This system can be further enhanced by installation of mini-camera inside smart gadget for better security so that live footage can be seen on parental phone during panic situations. The system can be modified by installation of small solar panels for charging the battery of smart gadget to gain maximum battery backup.

Acknowledgment

We would like to thank our guide Mr. Manjunatha N, Asst. Prof., for his precious guidance and for East West Institute of Technology, Bengaluru, Karnataka, India for providing this opportunity.

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IoT-based Child Security Monitoring System

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ABSTRACT

Nowadays, crime rate associated with children keeps increasing due to which draws peoples' attention regarding child safety. This research is conducted to propose a child security smart band utilizing IoT technology. Online questionnaire and semi-structured interview are methodologies used to collect data. The online questionnaire gains feedbacks by sending questions electronically, where answers need to be submitted online. In the semi structured interview, researcher meets and asks respondents some predetermined questions while other being asked are not planned in advanced. Through information obtained, a smart band have been proposed to monitor the safety of children. By this, parents know what is happening remotely and can take actions if something goes wrong. The future improvements of this device will be adding functions and software to make it works like a phone such as messaging, gallery, Google, YouTube, meanwhile, adding more child security features so that child safety is guaranteed.

Keywords: *Child security system, Child monitoring system, Internet of Things (IoT), IoT device, Smart band.*

1. INTRODUCTION

Internet of Things (IoT) is a set of systems and devices interconnected with real-world sensors and actuators to the Internet, according to [11] [27]. It is able to make decisions via detecting the surrounding environment without human interaction [14] [29]. In this research, IoT is applied to propose a wearable smart band which helps parents to monitor and get known of their child's condition at anywhere and anytime even if they are not by their children side. Via the IoT smart band, children safety is guaranteed, and crime rate is reduced as immediate actions can be taken in case the child is in danger. Besides, unlike existing smart band, which is less focusing on child security aspect, the proposed system emphasizes in getting as much data as possible so that actual situation can be identified. The use of IoT in this device is motivated by the need of child security system in Malaysia due to child safety issues resulting from increasing cases on child related crime.

In fact, IoT has been applied in domains such as smart home, smart city, smart factory, supply chain, retail, agriculture, lifestyle, transportation, emergency, health care, environment, energy, culture and tourism [4] [32]. However, it is seldom used to monitor child's safety in Malaysia. Actually, there is a need to use IoT-based child security system since the safety of children has become a major concern [14]. In fact, crimes on children keep increasing despite actions have been taken by the government. Revealed by [9], the overall percentage of child abasements worldwide is about 80% nowadays, out of which 74% are girls and the remaining are boys. For every 40 seconds, a child is gone missing in the world. Due to that, parents are worried for their children and perhaps, a hard challenge for them to guarantee safety of their children when they are out.

To cope with the issue, the system is proposed with these objectives:

- Enable tracking of the child's location and capturing of data remotely such as temperature, pulse, respiratory rate, quality of sleep and many more.
- To show the child's actual data with reference values.
- Enable sending of notification if the child is out of location or when the device realizes abnormal conditions/situations.
- To trigger the alarm and enable automatic video recording whenever the emergency button is pressed. Then, emergency notification along with real-time video will be sent to and display in the parents' mobile apps.
- Develop a prototype of IoT wearable smart band connected to parents' mobile apps so that they can monitor the actual condition of children at anytime and anyplace.

2. RELATED WORK

2.1 Internet of Things (IoT)

Internet of things (IoT) refers to networked interconnection of objects featured with ubiquity intelligence [3] [28]. In IoT, objects are connected via internet for communication, interaction, exchanging data and making decisions automatically at anywhere and anytime. Thus, introducing the hyper connectivity concept meaning individuals and organizations able to communicate with each other effortlessly and remotely [15]. Revealed by [17] and [15], IoT is a revolution in advancing technology causing transformation in information technology, humans' lifestyle, and in businesses processes. The advancements of IoT make it possible to be used in organizations for automating and monitoring business processes [6] [37-38]. In term of society, IoT can be used for simplifying daily tasks, creating smart homes, smart cities, devices or application which improves the quality of life. However, security and privacy are the main challenges of IoT [15] [33-34] which need to be solved as it gathers much personal data capable of revealing sensitive information.

2.2 Sensor

Sensor known as a device measuring physical value and converts it into data. Common sensors like the temperature sensor measures heat of an object. Proximity sensor used to detect nearby objects. For the pressure sensor, it calculates pressure applied. Optical sensor able to sense the light intensity [12]. Humidity sensor will detect the presence of water vapor in the air [10]. Micro sensor is designed to collects and relays information about the environment [10].

2.3 Cloud

Cloud computing means shared computing resources (networks, servers, storages, applications, services) are delivered as a service [18] [30-31] over the Internet from cloud to customer. According to [7], cloud is an interconnected network of servers providing services for people or businesses. In fact, cloud supports real-time operation, processing, analyzing, connecting, managing and securing IoT devices as well as applications [5] [35-36]. In addition, it reduces cost since users are paying based on usage without building the physical infrastructure. Furthermore, it allows developers to create projects faster [7]. Organizations can also access Big Data from the cloud [7]. Discovered by [16], the core concept of cloud is to reduce processing burden on users. Consequently, different devices like PC, laptop, smart phone able to access various utility programs, storage and application development platform over the internet.

2.4 Safety Device

The safety device protects individuals from potential harms and dangers. A research done by [1] proposed the child safety wearable device using raspberry pi 3. The raspberry pi 3 gathers data from pi camera, pulse sensor and sound sensors. Then, send collected data to parents' smartphones by SMS using GSM shield. Images captured from pi camera and children's location detected by GPS will also be sent to parents' devices. In another study, [2] designed a wearable smart watch for women security. Sensor inside the smartwatch senses the heartbeat of a child or woman who wears it [11]. When he/she is exposed to attacks, heartbeat rate will be high [11]. When this is detected, alarm sound will be triggered [11]. It will then automatically make calls to registered contact and to the nearest police station [11]. Based on the location provided by GPS, police will arrive soon at the correct destination.

2.5 Similar System

Figure 1 Gator Smart Watch

Source: https://cdn3.volusion.com/hvgjb.rxjov/v/vspfiles/photos/My-Gator-Watch--6.png?v-cache=1605859659

Gator, a kid's smartwatch from Gator Group Co. It comes with a SIM card and the free app is available on Play Store and Apple App Store [19]. Gator supports calling features up to 13 different numbers, enables two-way voice messages from the app and watch. The location tracking is based on GPS tracking when children are outdoors and Wi-Fi tracking when children are indoors. Notification will also be sent to parents when children leave the geofences. Pedometer sensor is included and the SOS alarm is supported which automatically calls 3 emergency contacts when pressed for 3 seconds. Other than that, school mode is available for setting up schedules to prevent callings during the school time. Not only that, Gator is splash proofing, enables remote voice monitoring and records historical routes.

Figure 2 Explora Go

Source: https://images-na.ssl-images-amazon.com/images/I/610FHcb9fJL._AC_SL1383_.jpg

Explora Go, a waterproof watch phone for children branded Explora which includes pedometer, alarm clock and stopwatch. It possesses an app available at Playstore and Appstore. With GPS and multiple services, Explora Go shows children's' location and supports the setup of safety zones. Meanwhile, it contains a SIM card and acts like a phone enables voice calls from 10 pre-saved contacts. Similar to a phone, Explora Go can send and receive text messages, emojis, images and voice messages. It is also equipped with the SOS button that children can press to notify emergency contacts of their location. Beyond that, Wi-Fi and Bluetooth are available in Explora Go. It also supports the schedule function in which school schedules can be specified during which watch will only display time and make emergency calls.

The table below shows comparison between systems:

Table 1: Comparison between Gator Smart Watch, Explora Go and the proposed system.

	Gator	Explora Go	Proposed System
Wifi	✓	✓	✓
Phone Calls	✓	✓	✓
Waterproof	X	✓	✓
Camera	X	✓	✓
Video Record	X	X	✓
Text Messages	X	✓	X
Schedule	✓	✓	X
GPS	✓	✓	✓
Safety Zones	✓	✓	✓
Emergency Button	✓	✓	✓
SOS Light	X	X	✓
Altimeter	X	X	✓
Blood Pressure Sensor	X	X	✓
Emotion Detector	X	X	✓
Heart Rate Sensor	X	X	✓
Motion Sensor	X	X	✓
Pedometer	✓	✓	✓
Respiratory Sensor	X	X	✓
Sleep Quality Sensor	X	X	✓
Temperature Sensor	X	X	✓

Based on the table, Gator and Explora Go does not support much sensors like the proposed system to obtain children's data regarding their actual conditions. Thus, if abnormal situations occurred, Gator and Explora may not be able to realize quickly, easily and inform parents at once. Due to that, parents are less informed about children's conditions and in case the child is in danger, actions are not able to be taken immediately. Furthermore, both systems do not record video and send it to parents during an emergency situation. Besides, SOS light function is not available in both systems but supported by the proposed system which will light up when the emergency button is pressed. In fact, Gator and Explora Go are emphasized in introducing mobile products for kids who are too young to use mobile phones. Because of that, they are less focusing on the child security aspect. On the other hand, the proposed system is more focused on tracking children's conditions that are suitable for child safety purposes

2.6 The Proposed System

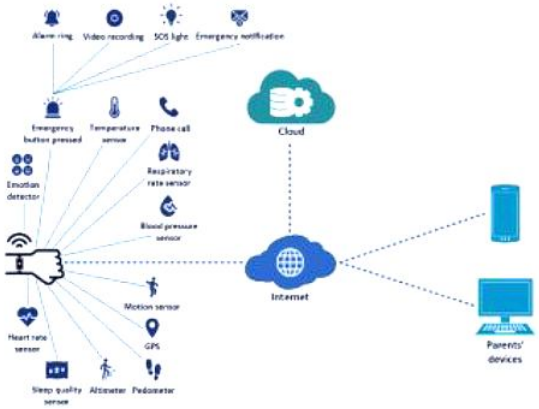

Figure 3 Diagram of the proposed smart band

An IoT based wearable smart band for children is proposed in this research for child security purposes. The smart band is waterproof, chargeable and equipped with sensors. Heart rate sensor measures pulse rate and BPM. Sleep quality sensor obtains children's sleep quality, cycle and positions. Altimeter detects changes in height and sense whether children are going down a slope or climbing stairs, thereby measuring calorie count. On the other hand, pedometer is used for counting steps. The motion sensor is applied to determines whether children are jogging or running. Blood pressure sensor used to measure blood pressure. In addition, the respiratory rate sensor detects breathing patterns and respiratory rate. Furthermore, the temperature sensor is used to detect body temperature. Besides, by using the emotion detector the emotional state, pressure and anxiety levels can be gained. Apart from that, this smart band contains GPS for tracking, identifying children's location and setting geofences. Via the smart band, children can also contact parents. Emergency button, a feature in which will automatically record video and automatically call 4 emergency contacts when it is pressed. An alert message along with the video clip is sent to parents' devices. The alarm and SOS light will be activated by parents through their devices. As the diagram shows, sensors are connected through the internet. They detect and capture different kinds of data. These collections of data will then be sent to the cloud over the internet for securely process, analyze, monitor, store, access and retrieve data

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IoT-based Child Security Monitoring System

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ABSTRACT

Nowadays, crime rate associated with children keeps increasing due to which draws peoples' attention regarding child safety. This research is conducted to propose a child security smart band utilizing IoT technology. Online questionnaire and semi-structured interview are methodologies used to collect data. The online questionnaire gains feedbacks by sending questions electronically, where answers need to be submitted online. In the semi structured interview, researcher meets and asks respondents some predetermined questions while other being asked are not planned in advanced. Through information obtained, a smart band have been proposed to monitor the safety of children. By this, parents know what is happening remotely and can take actions if something goes wrong. The future improvements of this device will be adding functions and software to make it works like a phone such as messaging, gallery, Google, YouTube, meanwhile, adding more child security features so that child safety is guaranteed.

Keywords: *Child security system, Child monitoring system, Internet of Things (IoT), IoT device, Smart band.*

1. INTRODUCTION

Internet of Things (IoT) is a set of systems and devices interconnected with real-world sensors and actuators to the Internet, according to [11] [27]. It is able to make decisions via detecting the surrounding environment without human interaction [14] [29]. In this research, IoT is applied to propose a wearable smart band which helps parents to monitor and get known of their child's condition at anywhere and anytime even if they are not by their children side. Via the IoT smart band, children safety is guaranteed, and crime rate is reduced as immediate actions can be taken in case the child is in danger. Besides, unlike existing smart band, which is less focusing on child security aspect, the proposed system emphasizes in getting as much data as possible so that actual situation can be identified. The use of IoT in this device is motivated by the need of child security system in Malaysia due to child safety issues resulting from increasing cases on child related crime.

In fact, IoT has been applied in domains such as smart home, smart city, smart factory, supply chain, retail, agriculture, lifestyle, transportation, emergency, health care, environment, energy, culture and tourism [4] [32]. However, it is seldom used to monitor child's safety in Malaysia. Actually, there is a need to use IoT-based child security system since the safety of children has become a major concern [14]. In fact, crimes on children keep increasing despite actions have been taken by the government. Revealed by [9], the overall percentage of child abasements worldwide is about 80% nowadays, out of which 74% are girls and the remaining are boys. For every 40 seconds, a child is gone missing in the world. Due to that, parents are worried for their children and perhaps, a hard challenge for them to guarantee safety of their children when they are out.

To cope with the issue, the system is proposed with these objectives:

- Enable tracking of the child's location and capturing of data remotely such as temperature, pulse, respiratory rate, quality of sleep and many more.
- To show the child's actual data with reference values.
- Enable sending of notification if the child is out of location or when the device realizes abnormal conditions/situations.
- To trigger the alarm and enable automatic video recording whenever the emergency button is pressed. Then, emergency notification along with real-time video will be sent to and display in the parents' mobile apps.
- Develop a prototype of IoT wearable smart band connected to parents' mobile apps so that they can monitor the actual condition of children at anytime and anyplace.

2. RELATED WORK

2.1 Internet of Things (IoT)

Internet of things (IoT) refers to networked interconnection of objects featured with ubiquity intelligence [3] [28]. In IoT, objects are connected via internet for communication, interaction, exchanging data and making decisions automatically at anywhere and anytime. Thus, introducing the hyper connectivity concept meaning individuals and organizations able to communicate with each other effortlessly and remotely [15]. Revealed by [17] and [15], IoT is a revolution in advancing technology causing transformation in information technology, humans' lifestyle, and in businesses processes. The advancements of IoT make it possible to be used in organizations for automating and monitoring business processes [6] [37-38]. In term of society, IoT can be used for simplifying daily tasks, creating smart homes, smart cities, devices or application which improves the quality of life. However, security and privacy are the main challenges of IoT [15] [33-34] which need to be solved as it gathers much personal data capable of revealing sensitive information.

2.2 Sensor

Sensor known as a device measuring physical value and converts it into data. Common sensors like the temperature sensor measures heat of an object. Proximity sensor used to detect nearby objects. For the pressure sensor, it calculates pressure applied. Optical sensor able to sense the light intensity [12]. Humidity sensor will detect the presence of water vapor in the air [10]. Micro sensor is designed to collects and relays information about the environment [10].

2.3 Cloud

Cloud computing means shared computing resources (networks, servers, storages, applications, services) are delivered as a service [18] [30-31] over the Internet from cloud to customer. According to [7], cloud is an interconnected network of servers providing services for people or businesses. In fact, cloud supports real-time operation, processing, analyzing, connecting, managing and securing IoT devices as well as applications [5] [35-36]. In addition, it reduces cost since users are paying based on usage without building the physical infrastructure. Furthermore, it allows developers to create projects faster [7]. Organizations can also access Big Data from the cloud [7]. Discovered by [16], the core concept of cloud is to reduce processing burden on users. Consequently, different devices like PC, laptop, smart phone able to access various utility programs, storage and application development platform over the internet.

2.4 Safety Device

The safety device protects individuals from potential harms and dangers. A research done by [1] proposed the child safety wearable device using raspberry pi 3. The raspberry pi 3 gathers data from pi camera, pulse sensor and sound sensors. Then, send collected data to parents' smartphones by SMS using GSM shield. Images captured from pi camera and children's location detected by GPS will also be sent to parents' devices. In another study, [2] designed a wearable smart watch for women security. Sensor inside the smartwatch senses the heartbeat of a child or woman who wears it [11]. When he/she is exposed to attacks, heartbeat rate will be high [11]. When this is detected, alarm sound will be triggered [11]. It will then automatically make calls to registered contact and to the nearest police station [11]. Based on the location provided by GPS, police will arrive soon at the correct destination.

2.5 Similar System

Figure 1 Gator Smart Watch

Source: https://cdn3.volusion.com/hvgjb.rxjov/v/vspfiles/photos/My-Gator-Watch--6.png?v-cache=1605859659

Gator, a kid's smartwatch from Gator Group Co. It comes with a SIM card and the free app is available on Play Store and Apple App Store [19]. Gator supports calling features up to 13 different numbers, enables two-way voice messages from the app and watch. The location tracking is based on GPS tracking when children are outdoors and Wi-Fi tracking when children are indoors. Notification will also be sent to parents when children leave the geofences. Pedometer sensor is included and the SOS alarm is supported which automatically calls 3 emergency contacts when pressed for 3 seconds. Other than that, school mode is available for setting up schedules to prevent callings during the school time. Not only that, Gator is splash proofing, enables remote voice monitoring and records historical routes.

Figure 2 Explora Go

Source: https://images-na.ssl-images-amazon.com/images/I/610FHcb9fJL._AC_SL1383_.jpg

Explora Go, a waterproof watch phone for children branded Explora which includes pedometer, alarm clock and stopwatch. It possesses an app available at Playstore and Appstore. With GPS and multiple services, Explora Go shows children's' location and supports the setup of safety zones. Meanwhile, it contains a SIM card and acts like a phone enables voice calls from 10 pre-saved contacts. Similar to a phone, Explora Go can send and receive text messages, emojis, images and voice messages. It is also equipped with the SOS button that children can press to notify emergency contacts of their location. Beyond that, Wi-Fi and Bluetooth are available in Explora Go. It also supports the schedule function in which school schedules can be specified during which watch will only display time and make emergency calls.

The table below shows comparison between systems:

Table 1: Comparison between Gator Smart Watch, Explora Go and the proposed system.

	Gator	Explora Go	Proposed System
Wifi	✓	✓	✓
Phone Calls	✓	✓	✓
Waterproof	X	✓	✓
Camera	X	✓	✓
Video Record	X	X	✓
Text Messages	X	✓	X
Schedule	✓	✓	X
GPS	✓	✓	✓
Safety Zones	✓	✓	✓
Emergency Button	✓	✓	✓
SOS Light	X	X	✓
Altimeter	X	X	✓
Blood Pressure Sensor	X	X	✓
Emotion Detector	X	X	✓
Heart Rate Sensor	X	X	✓
Motion Sensor	X	X	✓
Pedometer	✓	✓	✓
Respiratory Sensor	X	X	✓
Sleep Quality Sensor	X	X	✓
Temperature Sensor	X	X	✓

Based on the table, Gator and Explora Go does not support much sensors like the proposed system to obtain children's data regarding their actual conditions. Thus, if abnormal situations occurred, Gator and Explora may not be able to realize quickly, easily and inform parents at once. Due to that, parents are less informed about children's conditions and in case the child is in danger, actions are not able to be taken immediately. Furthermore, both systems do not record video and send it to parents during an emergency situation. Besides, SOS light function is not available in both systems but supported by the proposed system which will light up when the emergency button is pressed. In fact, Gator and Explora Go are emphasized in introducing mobile products for kids who are too young to use mobile phones. Because of that, they are less focusing on the child security aspect. On the other hand, the proposed system is more focused on tracking children's conditions that are suitable for child safety purposes

2.6 The Proposed System

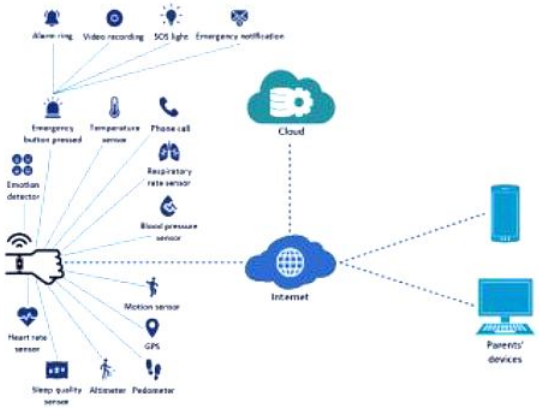

Figure 3 Diagram of the proposed smart band

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