Shruthi S *et al*, International Journal of Computer Science and Mobile Applications,
Vol.6 Issue. 2, February- 2018, pg. 139-144 **ISSN: 2321-8363**
Impact Factor: 5.515

DETECTION AND PREVENTION OF CHILD ABUSE USING IOT - A SURVEY

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Abstract
Child abuse is any action by a perpetrator that causes intentional harm to a child. Security systems must be designed to defend children from such difficult situations. The advancement in wearable sensor technology, tracking mechanisms, wireless communication protocols allows for development of smart systems that detect and prevent child abuse. In this paper, we have reviewed various technologies that are supporting to the human safety and security systems such as Wearable Sensors, Global Positioning System, Global System for Mobile Communication and fields such as e-health services and location based services. Various existing systems on child and women safety are discussed with their pros and cons.

Keywords: Wearable Sensors, GPS, GSM, Child Abuse, Women Security, Smart Band.

1. Introduction
Modern technology plays an increasingly dominant role on human life. It aids in better communication, in obtaining more accurate and immediate results particularly in the field of emergency services. Emergency services, also known as rescue services, ensure public health and safety by addressing various emergencies. It can range from fire and rescue, natural disaster management to medical and security services. Out of these, healthcare and public security is an everyday concern, where modern technology plays a vital role. Smart wearable devices have been emerging as a powerful monitoring system for health as the number of connected wearable devices worldwide is expected to jump from an estimate of 325 million in 2016 to over 830 million in 2020[18]. They are widely used to provide functions such as sleep monitoring, fitness tracking and health monitoring. Its pervasive power has unexplored usage in human security, specifically women and child safety. A survey [19] carried out across 13 states and with a sample size of 12,447, revealed that 53.22% of children reported having faced one or more forms of sexual abuse. Security systems must be designed to defend children from such difficult situations. According to United Nations International Children's Emergency Fund [17], violence against children can be "physical and mental abuse and injury, neglect or negligent treatment, exploitation and sexual abuse. Violence may affect the normal development of a child impairing their mental, physical and social being". It is possible to monitor child's body temperature, heart rate, brain activity, muscle motion and other critical data using sensors to accurately detect his/her psychological state. In the presence of an abnormality, immediate rescue can be done by using a GPS tracking facility present in the wearable device. Cellular communication using GSM is a highly efficient way to alert all concerned.

2. Sensor Data - Emergency Services
2.1 Wearable Sensors
In conventional clinical practice, electrocardiography (ECG) at hospitals is used for diagnosis of arrhythmia. However, as the irregular heartbeat caused by arrhythmia does not necessarily occur during medical examination at hospital, it is necessary to measure ECG in daily life. Since it is essential to attach some electrodes to the patient's chest in the case of the Holter ECG, checking for arrhythmia is troublesome for preventive healthcare.

Suzuki et al. [14] proposed the use of a photoplethysmography(PPG) sensor, which is a simpler device than the Holter ECG. They measured the 2-lead ECG and PPG for three patients suspected to have arrhythmia during one normal night of sleep and finally came to the conclusion that PPG sensor is more sensitive to observe the body movement than ECG.

Lee et al. [16] suggested a new photoplethysmography (PPG) signal sensing method using a wristwatch-type PPG array sensor. Finger-type PPG probe requires a tight fitting that can cause discomfort to patients. The proposed system provides a novel solution by measuring the PPG signal from radial artery and ulnar artery of the wrist. Phototransistors and Infrared emitting diodes are placed in an array form to drastically improve signal sensitivity and accuracy. External noise is reduced to a minimum by the use of conductive fiber wristband.

Mukhopadhyay [13] proposed a Human Activity Monitoring System in which sensors are used to measure physiological parameters such as body temperature and heart-rate. All the measured physiological data collected by a microcontroller are processed and analyzed. The controller generates a warning message to the caregiver, pertaining to the current physiological situation of the person being monitored, which helps to detect any possible health threat.

2.2 GPS and GSM Technology

Huafang Li et al. [8] proposed a GPS software receiver with the ability of multi-path mitigation. It can perform acquisition, code and carrier tracking, navigation bit extraction, navigation data decoding, pseudo range calculations, and position calculations. They have concluded that the receiver is capable of navigating positions to accuracy of 2 meters, a breakthrough in GPS tracking.

GSM has two types of interconnection configurations, non-overlap and overlap. Lai et al.[15] proposed an analytic and simulation model to investigate the performance of overlap dual-band. It assumes that the DCS1800 cells (the radio coverage of DCS1800 BTSs) are of the same size as the GSM900 cells. They have also investigated the radio channel capacities, the inter-system handoff failure rate, the mobility rate and the originating call traffic ratio which affects the system performance such as call incompletion probability. Finally, they have concluded that GSM dual-band network can significantly improve the quality of cellular service.

Monti et al. [5] proposed a wearable logo-antenna using GPS–GSM based system for tracking of portable wearable accessories. It adopts PIN diodes to reconfigure the operating frequency of the antenna. In this way, an antenna can operate in three different bands - GSM band and up/downlink of GPS band. Initially, the system is in sleep mode, it gets activated upon reception of wake-up signal (e.g. an SMS) sent by the owner of the bag, when he/she realizes that the bag is missing. The SMS triggers the activation of the GPS receiver and the consequent acquisition of GPS coordinates of the position of the lost bag. The coordinates are sent (also in this case, via SMS) to the owner of the bag. Finally they have concluded that the proposed antenna is a promising solution for the development of a GPS–GSM tracking system, which can be fully and seamlessly integrated in leather bags or accessories.

Gowda et al. [4] proposes a system to track vehicles in real time. It uses embedded microprocessor, GPS receiver, GSM - GPRS modem, biometric sensor, camera and speakers. The system monitors the vehicle location, speed and time using GPS Receiver, driver information using fingerprint sensor. The data is periodically transmitted to the remote server using GPRS HTTP protocol. A physical panic button is used to alert in emergency situations through SMS/CALL and server gets updated along with images using FTP protocol. The speaker acts as a voice alarm for security, which is activated/deactivated from base station.

3. Mobile Application

3.1 *Location Based Services*

Jahan et al. [9] proposed an android application for tracking live location of Chittagong University of Engineering & Technology (CUET) buses. They have implemented two modules - First module is installed in the server phone which will reside inside the bus. It periodically finds the GPS coordinates of the bus by using location service of the android phone i.e., the GPS receiver of that phone. It also includes a SMS gateway service. Second module is a mobile application installed in the client's phone. It has three sub-modules - First one is a Live location module. It shows the location of particular bus along with its recorded time on Google Maps. Second one is SMS alert. It gives location information to client's phone as text message. Third one is SMS tracker for getting the location information without using any internet connectivity or Android phone.

Chandra et al. [2] proposed a system which has a regular mobile phone equipped with GPS receptor and connected to global system for mobile (GSM/CDMA) network that allows us to get the device's geographic position in real time. A J2ME mobile application based on Location Based Service using GPS acts as location provider. In the scenario of an emergency situation when the user is threatened, GPS Locator permits the user to send his GPS coordinate through a SMS.

3.2 e-Health Services

Omer et al. [10] proposed a solution for real-time health monitoring system using Smart Wearable. Body parameters such as temperature, electrocardiogram, pulse and oxygen in blood, airflow and body position is measured through e-Health sensors and sent to the smart phone, enabling doctors to check the health status of their patients remotely. It uses XBee wireless (802.15.4) technology, internet and SMS to transmit measured body parameters of patient to either mobile application or database on a cloud server. Artificial Intelligence is used to examine this data in order to notify health professionals using SMS services or e-mail if there is any deviation in the parameters.

Ahmed et al. [11] proposed a device that is capable of transferring the data of a patient's vital signs to a remote device wirelessly. The output from temperature and ECG sensors are fed to the Bluetooth model. The Bluetooth is connected to the Arduino which processes the input from the sensors. Xoscillo software is used along with Arduino UNO to generate a readable output which can be seen in PC. The main aim of their work is to alleviate the difficulty that is encountered by medical experts in monitoring multiple patients simultaneously.

4. Alert System

Choudhury et al. [3] proposed an SMS based security system where the press of a button notifies the given emergency contacts. An alert message along with GPS location of the sender is transmitted. A mobile application is used to configure the hardware device. This system is reliable and very cost-effective due to its specific functionality.

Jatti et al. [1] proposed a wearable device for women security that analyses physiological signals such as galvanic skin resistance, temperature and motion of body to infer whether the individual is stressed or relaxed. Raw sensor data is analyzed using a specialized machine learning algorithm. If the individual is stressed, Activity recognition is done to monitor the parameters and notify the system to take action when any dangerous situation occurs. Changes in the monitored signals are detected, upon which appropriate action is taken by sending notifications/alert to emergency contacts. Finally the paper concludes that the device periodically monitors state of the individual wearing it using cloud computing.

Hussain et al. [12] developed the prototype of an Intelligent Women Safety System. The main idea here is using an active RFID tag with passive RFID reader to scan details of the victim which is transferred to a microcontroller where emergency contact numbers are stored in the database. Once the information is received by the controller, it sends an alert message to the contacts through GSM module and the location is tracked through the GPS module.

Helen et al. [7] proposed the idea of a Smart watch for Women Safety. The main component of this watch is a sensor used to detect the heart beat of a person. The principle used is, heartbeat rate becomes high at sudden moment by the secretion of epinephrine hormone from hypothalamic-pituitary-adrenal axis. When this occurs, the alert system gets activated and alarm is sounded to gain the attention of nearby people and automatically makes a call to the registered contact persons. It also helps in tracking the location using GPS and sends the coordinates via GSM to the nearby police station.

Harikiran et al. [6] proposed a Security System for Women. A Smart phone is connected to the Smart Band through Bluetooth to detect the real-time situation of women. The device communicates with the smart phone through a mobile application. Data directed by the smart band such as the pulse rate, temperature and motion of the body is continuously monitored by the application which is pre-installed in the phone. The GPS in the smart phone is used to track the victim. Finally, an SOS (Save Our Souls) message is sent to the family members and the nearest police station through the GSM facility that is inbuilt in the phone.

5. Discussion

From the papers discussed, we found that use of photoplethysmography [14] to detect heartbeat of a child is simpler in daily life and more sensitive than Electrocardiogram (ECG), which is normally used in hospitals. Since the measurement of heartbeat using finger probe is not practical for a child, a wristwatch embedded with PPG sensor array [16] can be used. It also increases the signal sensitivity and accuracy. Use of conductive fiber [16] in the wristband reduces noise. By analyzing the PPG sensor data using a microcontroller [14] in the wristband, an alert message can be sent through an SMS if there is an abnormality. Global System for Mobile Communication (GSM) must be used for the SMS facility. To increase the quality of the cellular service, GSM dual band network [15] can be used.

Knowledge of location of the victimized child is required to secure him/her when an abnormality is reported. Global Positioning System (GPS) is an efficient way to track the child. To increase the tracking accuracy, a high functioning GPS software receiver [8] can be used. An antenna for GSM and GPS can be molded into a wearable logo [16] to make sure that it will not be evident to the abuser.

At the receiver's end, a mobile phone is required to get the alert notifications and track the child. Ease of use is accomplished by means of a mobile application. Live location [9] of particular child along with its recorded time can be shown on Google Maps. If any abnormality in the pulse is encountered, XBee wireless technology, internet or SMS [10] may also be used to transmit the child's body parameters to either a mobile application or database on a cloud server.

Different authors have worked on key techniques in the field of women and child security. In the system proposed by Choudhary et al.[3], an alert message is sent along with the GPS location of the sender by the push of a button. One of the key problems faced in this work, is that a child cannot comprehend the situation and take action by pressing the button. Jatti et al. [1] suggested a specialized machine learning algorithm to analyze physiological signals to infer whether the individual is stressed/relaxed. If stressed, activity recognition is to be done and emergency contacts are to be alerted. The estimated cost is high due to the sensors and cloud storage. System proposed by Hussain et al. [12] uses RFID technology to scan details of the victim and alert the emergency contacts. It is difficult for the child to fathom the situation and scan the RFID tag using the reader. Helen et al. [7] proposed that when heart-rate is high, the smart watch activates the alert system and generates an alarm. Location is sent via SMS to the nearby police station. The main problem is that the attacker can identify the intention of smart watch due to the alarm sound. Harikiran et al. [6] proposed a smart band that detects abnormalities in heart-rate and a mobile application is used to alert the guardian. The child must always carry a smart phone with internet connectivity, which cannot be expected.

6. Conclusion

PPG sensor is theoretically proved to be more efficient than ECG in relation to analysis of heartbeat variations especially when embedded in a wristwatch that can be used by a child. At the time of threat to the child, a press key mechanism or RFID is inefficient because the child may not understand the situation. The child cannot

always carry a smart phone, connected to the wearable device via Bluetooth, used to notify the emergency contacts. The wearable device must be of specific functionality and cost-effective. An SOS message is alone not enough to alert the guardian. A wearable device which detects the high heart-rate of the child under threat, automatically generates an SMS and voice call to the guardian and records voice evidence, will support to enhance the child security.

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