International Journal of Synergy in Engineering and Technology
IJSET

The Development of Mobile Alert System to Prevent Baby Fatalities in Parked Vehicle

Nur Sukinah Aziz*, Nor Amira Tasha Mohd Zaki, Aini Zuriyati Abdul Kadir, Noor Suhana Sulaiman, Wan Nur Idayu Tun Mohd Hassan, Saadiah A Rahman, Nur Liyana Zakaria and Azliza Yacob

Faculty of Computer, Media and Technology Management, University College TATI (UC TATI), Telok Kalong, Kemaman, Terengganu, MALAYSIA

*Corresponding author e-mail: nursukinah@uctati.edu.my

KEYWORDS

Internet of Things
Baby Fatalities
Mobile Alert System
SMS

ABSTRACT

The Internet of Things (IoT) has reignited interest in children safety sector. Newspapers and Internet sites report several incidences of babies and children dying in baby car seats due to being left alone in the car. Safety is the most vital part of our daily lives; which becomes even more important when family members are involved. Parents are concerned about their children, particularly for them to lead a healthy lifestyle. However, with longer working hours and more employment responsibilities than ever before, parents are becoming more tense and appear to be less focused on their children's safety. Therefore, this study developes a mobile alert system to prevent baby fatality in parked vehicle. The system was tested in real environment with a baby in the car. The system detects the baby's movement and notified parents via SMS and call. By using this mobile alert system, baby fatality can be prevented as parents will receive notification of the baby being left in a parked vehicle.

1.0 Introduction

Nowadays, mobile phones or smart devices are being used extensively. Due to this, integrating a safety application that could save a child's life is something worth looking into [1]. Recent growth of internet of Things (IoT) provides the opportunity to explore this application in child safety area. When it comes to our loved ones, safety is an aspect that could not be compromised. As a result of longer job hours and more workplace duties than ever before, many parents are becoming more tense and appear to be less focused on their children's safety. The number of children's deaths and injuries caused by being left in a car has risen dramatically in recent years. More reports of children dying in car seats have appeared in newspapers and on the internet [2]. Changes in parents' daily routines, lack of sleep, depression, lack of energy, distraction, hormone imbalances, and symptoms experienced by new parents are just a few of the factors that could play a role in causing such scenarios. Some parents rarely check the passenger seats at the back, especially in such a quiet moment. A baby placed in a car seat, falls asleep regularly and becomes

Received 06 Nov 2022; received in revised form 12 January 2023; accepted 31 March 2023.

a silent and unnoticeable passenger. One of the biggest causes of death in children is heat stroke [3]. When normal body cooling process fails and its temperature goes dangerously high, it puts strain on the lung, brain, heart, kidney and liver, providing a life-threatening hazard. A child's body heats up three to five times faster than an adult. Aside from that, heat builds up quickly inside a vehicle; even with the windows cracked, the temperature inside a car can reach 125 degrees Fahrenheit in minutes. Cracking the automobile window does not help to lower the temperature inside the vehicle. The first 10 minutes account for over 80% of the temperature increase. Children can die from heatstroke in a vehicle at a temperature as low as 60 degrees Fahrenheit [4]. Therefore, this study designed Mobile Alert System (MAS) based on motion detection to overcome this problem. Cars are the most suitable place to use motion detector as many cases involved babies killed in parked cars, and the number of these cases is growing every year. Many researchers conducted studies on the factors of the problem, but not nearly as many have performed research to develop a concept or technique in providing solution to this dilemma [2]. By sending an alarm to parents' mobile phone, MAS is able to remind parents about their children's whereabout in the car. Because the phone has become such a necessity in our everyday lives, it is a sensible option utilized to alert parents so that immediate action should be taken to rescue a child left in the car.

The structure of the paper is as follows. First, it discusses the research problems of the study, followed by a literature review about mobile alert systems, notification systems, SMS technology, and IoT. Then, it documents the research methodology of the study. Finally, the paper concludes with a discussion of the study limitations, future research directions, and implications of the findings towards practice.

Literature Review

1.1 Mobile Alert System

Mobile alert system (MAS) allows users to readily connect with emergencies to monitor help whenever they need to. MAS is intently to be simple so that it can be easily implemented and installed in any type of vehicle. The system generally consists various types of system such as fire alert system, medical alert system and emergency alert system. The fire alert system is a system developed based on the fundamental ideas of safety, security and control. According to [5], once the system is set up and the temperature and smoke thresholds are set, in the event of an emergency resulting from the temperature and/or smoke at the location exceeding the thresholds, the system sends out automatic alert-notifications to the users who are affected. Even when the emergency scenario is completed, the user has total control over the system via mobile SMS, including the option to alter the threshold, turn on/off the ability to send alert alerts, and reset the system once the emergency scenario is over. This system is designed with security in mind, ensuring that it can be employed in industries and businesses where security is a top priority. As a result, the system guarantees complete essential concepts of safety, security, and control.

During critical occurrences, a medical alert system is utilized to help with communication, care, and intervention. Medical monitors measure and collect a subject's physiological and vital signs data; whereas, the system communicates with them. A database including the subject's medical records and emergency contact list is kept by a service provider. When a critical event is detected, the subject's physiological data and location coordinates are transmitted to the service provider via a two-way mobile communication device configured to communicate with the monitor. Then, a phone call with members of the emergency contact list is initiated to help facilitate aid. A device and GPS technology may be part of the two-way mobile communication gadget. It may also include self-activating features, such as sending pre-recorded messages describing potential hazards to the subject as physiological and vital signs data reach dangerous level. The emergency alert system consists of a wireless telecommunication network with

predetermined radio channels, at least one wireless emergency call transmission device that reads emergency data and transmits it in an emergency call message on at least one of the radio channels to at least one emergency call receiver device [2]. At least one emergency call receiver device receives and analyzes the emergency call message before activating at least one alarm function and transmitting the emergency data to a wireless communications network-connected alarm center. The system can also be implemented via a wired network.

Only few studies on mobile alert systems focus on preventing children from dying as a result of being left unattended in parked vehicles. According to the studies, the most common sensors utilized are motion and temperature sensors because they are significantly less expensive. Sulaiman et al.(2017) is one of such studies integrating both sensors to mobile alert system and send notification via SMS. After the vehicle is parked for five minutes, the system automatically activates. The car is considered as in parked situation if the ignition engine is turned on, handbrake is locked, or ignition engine is turned off. Parents receive an alert voice message; once the detection and feedback systems are activated. First activated is the temperature sensor, followed by motion, voice, and odor detectors. Any detector activated will set-off the feedback system; which will send an SMS to the vehicle's driver, sound the horn, and roll down the window. If the child's parents or caregivers do not assist in saving him or her, the system will automatically intervene [5].

1.2 Notification System

A receiver obtains notification alert in a variety of ways. Electronic mail (email), call, fax, and SMS are available options for sending notification to users. Numerous users can make advantage of the various remote notification alert systems. One that is popular and familiar to many users is SMS technology. SMS notification alert system technology often used by businesses and organizations as one of their communication channels [6]. In fact, National SMS emergency alert system was created in 2011 in the United States with the primary purpose of sending alerts to residents in New York City and Washington in the case of disasters, such as a natural disaster, a terrorist attack, or any other emergency condition.

1.3 SMS Technology

SMS is a service allowing users to send and receive text messages up to 160 characters over mobile networks. It is transmitted from a device to another and vice versa. As a matter of fact, it appears to be a viable option for transmitting data via the technology. Users are frequently notified or alerted using SMS technology. According to Malaysian Communication and Media Commission (MCMC), total number of text messages sent in 2011 was around 93120.5 millions; whereas in the first quarter of 2012 was 22507.0 millions. It may be inferred that Malaysians use SMS extensively to communicate and remain in touch with one another.

1.4 Internet of Things

Internet of Things (IoT) refers to the networked interconnection of common things frequently endowed with ubiquitous intelligence. The IoT increases the ubiquity by integrating objects for interaction via embedded systems, resulting in a highly spread network of devices communicating with humans and other gadgets [7]. Researchers and practitioners worldwide have been paying attention to the IoT in recent years. As it is generally known, the internet is essential today and provides benefits in all aspects of life, its shortcomings need to be improved to have a better future [8]. A person with a heart monitor implant, a farm animal with a biochip transponder, an automobile with built-in sensors to alert the driver of low tire pressure, or any other natural or man-made object that can be assigned an IP address and provided with the ability to transfer data over a network are all examples of things in the IoT. Wireless technologies, microelectromechanical systems (MEMS), microservices, and the internet have all come together to form the IoT. The convergence breaks down the barriers between operational technology (OT)

and information technology (IT). Hence, it enables the analysis of unstructured machine-generated data for insights that will drive improvements. Computers and the internet are now nearly entirely reliant on humans for data [9]. Humans capture and create nearly all of the internet's roughly 50 petabytes (1,024 terabytes) data by typing, pushing a record button, snapping a digital photo, or scanning a bar code. Precision agriculture, building management, healthcare, energy, and transportation are just a few of the industries where IoT technology is currently being utilized electronic engineers and software developers working on IoT devices and systems have a variety of connectivity possibilities. Process monitoring, measurement, and data collecting are all important tasks of sensors in the Industrial Internet of Things (IIoT) [10].

Methodology

This study employed system and project development in the process of which ADDIE methodology was implemented. This study involves developing hardware and software process. The methodological phases were constructed to ensure a smooth and error-free project development. During the development phase, every aspect requires extra attention. ADDIE methodology is commonly utilized by instructional designers and training developers to develop a system. "ADDIE" stands for **A**nalyze, **D**esign, **D**evelop, **I**mplement, and **E**valuate. The model suggests a systematic and sequential approach for system and project development; whereby, each stage is well defined with milestones for easy use and understanding. Figure 1 shows the phases of ADDIE methodology. The development of one phase only starts when the previous phase is complete. Because of this nature, each phase is precisely defined. The tasks carried out in each phase of the system development life cycle is identified and explained below.

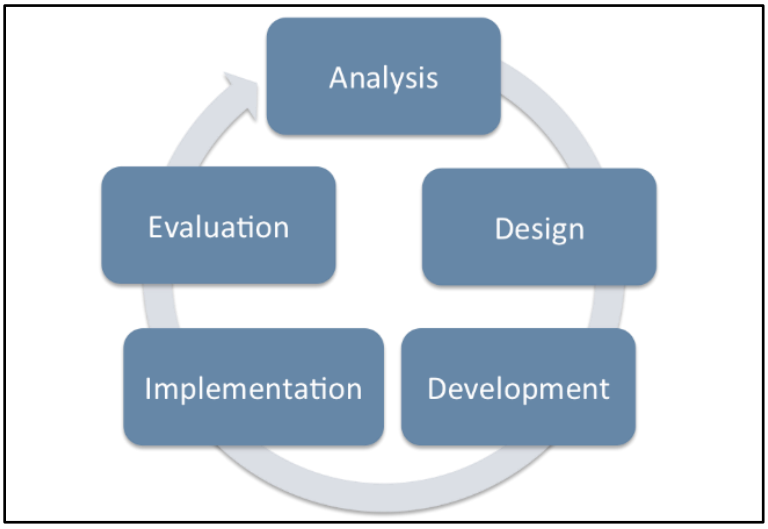

Figure 1: ADDIE Methodology

1.5 Analysis Phase

The analysis phase is an important aspect of this study, and it began with the gathering of information about the research topic. This data collection process helps in identifying the problem statement; while, determining the research goals and research questions of the project. Next, the preparatory study was undertaken by analyzing articles such as journals and proceedings in order to identify the research purpose, scope, and significance of the project. A review of the literature in the areas of the mobile alert systems, notification systems, and the IoT was conducted. The review helps the system developers to understand the processes of mobile alert system and identify issues that may restrict the project. Hence, previous sections *(refer 2. Literature Review)*

present the findings from the literature review. Then, the tools, hardware, software, and equipment required in the project were determined. Whilst, user requirements were ascertained to better develop the system; the system activities, including both functional and non-functional needs, were comprehensively described. Finally, requirement modeling was developed based on a variety of fact gathering and analyses.

1.6 Design Phase

The design phase starts with the creation of a system specification that outlines the requirements of the project. A physical depiction of the system is shown below. It specifies the data, files, input, and output of the design system. At this phase, users' needs were identified and any setbacks arisen were resolved. The design system also contains a flowchart, data flow, and block diagram. Figure 2 shows the flowchart of MAS.

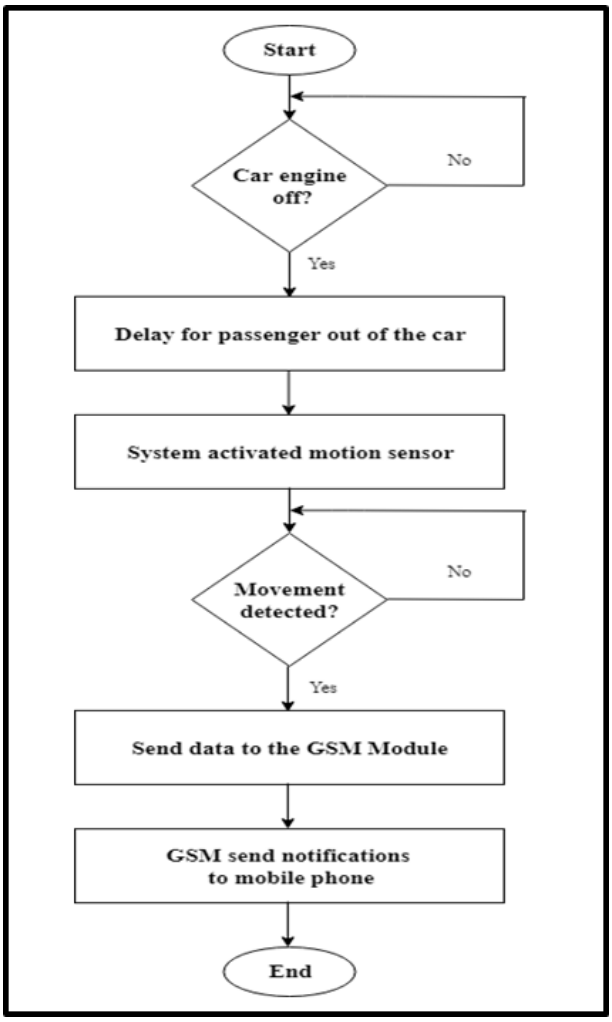

Figure 2: Flowchart of Mobile Alert System (MAS)

The flowchart shows how MAS works. First, when baby movement in the vehicle is detected, the system sends out notifications to the parents. The parents shall receive the notification twice via SMS. Afterward, the system also notifies the parents by an automatic phone call. These three (3) alerts should remind the parents that their baby is left alone in the car. Meanwhile, Figure 3

displays the block diagram of MAS. The block diagram illustrates the placement of the motion sensor, GSM module, Arduino nano, power supply board, and LED in MAS.

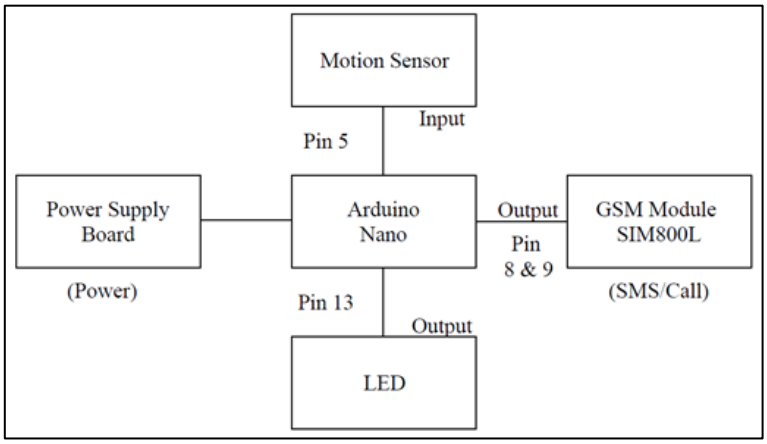

Figure 3: Block Diagram of Mobile Alert System (MAS)

1.7 Development Phase

Generally, the development phase is divided into two (2) phases: hardware and software developments. First, the hardware and devices to create the prototype were prepared and checked to ensure the requirements were followed, Those include Arduino Nano, motion sensor, LED light, Donut Board, USB cable, laptop, mobile phone, and GSM Sim800L. Next, those components were tested to ensure they worked well before the assembly. Then, they were assembled according to the topology designed as described in the project requirements at the design phase. This phase is discussed in the previous section. Finally, the software employed was written in the C programming language. The entire coding and scripting were completed in Arduino IDE, which is compatible with the Arduino Nano board.

1.8 Implementation Phase

Both hardware and software are required to complete the development of MAS. Whilst, the Arduino Nano board is the most crucial component of the hardware; GSM is used to send and receive alert notifications The unit-tested code was also integrate and tested. Then, MAS was installed in a car with the presence of a baby.

1.9 Evaluation Phase

In the evaluation phase, all functional and non-functional testings were performed to ensure the system meets the criteria required. Those include evaluating MAS performance in each testing so that it works properly and users can effectively utilize the system. More importantly, it is to ensure the application is running and operating in the appropriate and intended environment. In the testings, response time was monitored and evaluated. When flaws were discovered, they were immediately rectified. Therefore, the system was constantly improved to include appropriate features and an up-to-date environment.

Proposed System

MAS requires a Global System for Mobile Communication (GSM), Notification System, SMS Technology, and Arduino Nano, Internet of Things (IoT) for its components. Meanwhile, the programming language used by Arduino Nano for its software is C Language. Apart from that, a motion sensor was also employed in creating MAS. A motion sensor is an electrical device that detects and converts physical movement into an electric signal. It can detect the movement of any object or human being and is widely used in security for alert systems [10]. GSM connection is

responsible for data transfer from the sensor to the mobile phone. In MAS, GSM SIM800L functions to send this notification to the mobile phone. Donut Board was utilized to link the components using copper wire and a light-emitting LED. The Arduino Nano board uses the C programming language. The software is critical in the process because the Arduino board must first be coded using the software before it can work. Figure 4 shows the GSM coding. The first step in making the GSM library start operating and functioning is to place it in the library software folder. Generally, SoftwareSerial.h, SIM800L, "SMS," and "call" are included in the basic GSM library. The commands must be coupled for GSM to work. When the Arduino board and GSM module are connected, the commands will be concatenated. A function is saved in the library and will be called to compile both scripts.

Figure 4: Arduino IDE to Send SMS and Make Phone Call

Several hardware were required in developing MAS such as Arduino Nano and GSM SIM800L to send notifications to mobile phone, motion sensor to detect movement, LED to emit light when activated, donut board to connect the components with copper wire and power supply board to supply electricity to MAS. The motion sensor, and GSM module are connected to the Arduino UNO board using jumper wire. Meanwhile, the Arduino Nano board is connected to the power supply. Figure 5 shows MAS device installed in a car. When the motion sensor detects any human movement in the car, it sends an alert message and alert phone calls to the parents.

Figure 5: Mobile Alert System in the car with baby

Figure 6 shows the notification via SMS when the motion was detected in the car in the testing process. Thus, the parents were alerted that their baby was in the car.

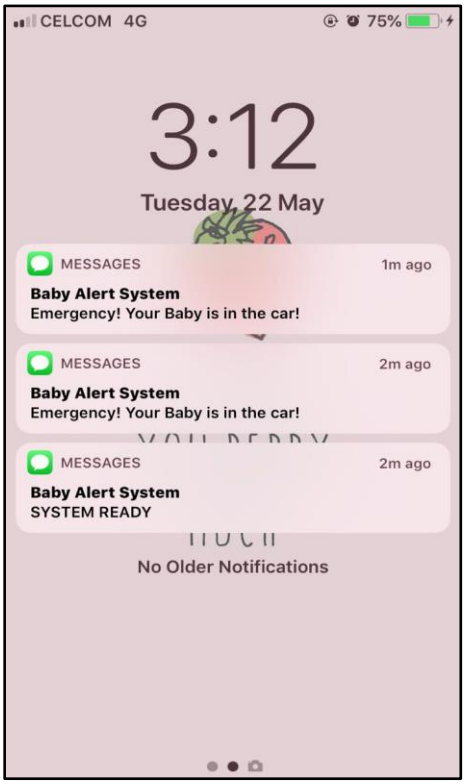

Figure 6: Notification via SMS

When the motion sensor detected the movement from the baby in the car, the parents received the first SMS. After a few minutes, the system sent the second SMS to parents. Then, if the parents did not respond and the system still detected movement in the car, the system automatically sent a call to the parents as shown in Figure 7.

Figure 7: Notification via call

Conclusion

The GSM network was selected for MAS development because it is inexpensive and has wide coverage region. The GSM was utilized to deliver information to user's mobile phone as an alert notice. The objectives of the study were attained as the system functions well at sending text messages and phone calls to the mobile phones to warn users about a baby left in a vehicle. Furthermore, the sensors perform efficiently and produce positive results. Because the GSM module serves as a barrier between the Arduino Nano board and the mobile station, the phone can be utilized as a mobile station without the need for any additional hardware or software. The sensor can detect movement and send an alert to the parents to prevent the occurrence of the worst scenario. A mobile alert system will be further evaluated or tested in the upcoming research project. The response time will be used to assess the system; whereby, the average response time for three tests will be computed. The duration for Arduino to send alert notification to users can be used to calculate the reaction time.

Based on the outcomes of this study, a mobile alert system of a vehicle's motion sensor could also be suggested as a research topic; which is to determine the best location to place the sensors in the vehicle. Some recommendations for future projects will aid in the improvement of current MAS. First, the system can be linked to a cooler so that as it sends the second signal, the cooler will immediately switch on, averting baby deaths from heatstroke. Connecting the device to the

vehicle's security system is another recommendation. In the event that the parents are unable to locate their phone, the vehicle's alert system will notify another person. One more recommendation for future research is to install a mobile phone-controlled switch on the vehicle's alarm. Internet of Things (IoT) is projected to play a vital role in the creation of a diversified integrated development environment. Today, IoT-based services have been widely used in health care, transportation, smart-home automation, industrial automation, smart agriculture, and smart cities, to name a few [11].

Acknowledgments

This research is supported by UC TATI Short-Term Grant (STG) GPJP 1/2021 9001-2111. The authors fully acknowledged University College TATI (UC TATI) for the approved fund, which makes this important research viable and effective.

References

[1] M. Valinejadshoubi, O. Moselhi, A. Bagchi, and A. Salem, "Development of an IoT and BIM-based automated alert system for thermal comfort monitoring in buildings," *Sustain. Cities Soc.*, vol. 66, 2021.

[2] N. H. F. Ismail *et al.*, "Child Presence Detection System and Technologies," *J. Soc. Automot. Eng. Malaysia*, vol. 3, no. 3, pp. 290–297, 2019.

[3] S. Garethiya, V. Suresh, A. Kudale, and R. Girishchandra, "Affordable System for Alerting , Monitoring and Controlling Heat Stroke inside Vehicles," in *2015 International Conference on Industrial Instrumentation and Control (ICIC)*, 2015, no. IClC, pp. 1506–1511, doi: 10.1109/IIC.2015.7150988.

[4] M. F. Abulkhair, A. Aldahiri, H. Alkhatabi, H. Alonezi, L. Mulla, and S. Razzaq, "Sensor based hyperthermia alert car application," *Commun. Appl. Electron.*, vol. 5, no. 2, pp. 44–55, 2016.

[5] N. Sulaiman *et al.*, "Development of comprehensive unattended child warning and feedback system in vehicle," 2017.

[6] D. Karolidis, A. Papadakis, P. Prentakis, and M. Samarakou, "MoBINo : An Integrated Mobile and Web Based Environment for Automatic SMS Notification," 2005.

[7] A. I. Taloba, I. Abdalla, A. Ben, and L. F. Hussein, "IoT enabled modulated residential surveillance system using Fuzzy logic," *Mater. Today Proc.*, 2021.

[8] A. Yacob, Z. Baharum, N. S. Aziz, N. S. Sulaiman, and W. M. A. F. W. Hamzah, "A review of internet of things (IoT): Implementations and challenges," *Int. J. Adv. Trends Comput. Sci. Eng.*, vol. 9, no. 1, pp. 373–376, 2020, doi: 10.30534/ijatcse/2020/5891.32020.

[9] R. Karthikeyan, K. Sakthisudhan, G. Sreena, C. Veevasvan, and S. Yuvasri, "Industry safety measurement using multi-sensing robot with IIoT," *Mater. Today Proc.*, pp. 8125–8129, 2021.

[10] M. Javaid, A. Haleem, S. Rab, R. Pratap, and R. Suman, "Sensors for daily life : A review," *Sensors Int.*, vol. 2, 2021.

[11] P. P. Ray, D. Dash, and N. Kumar, "Sensors for internet of medical things: State-of-the-art, security and privacy issues, challenges and future directions," *Comput. Commun.*, vol. 160, pp. 111–131, 2020.

