Baby Forgot In Car Alarm System (ByFAR)

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ABSTRACT

Forgotten baby syndrome or the syndrome of forgetting children is an occurrence where a mother or father leaves their child, especially a baby in the car. Cases associated with this syndrome are not isolated incidents in Malaysia but are frequently reported worldwide. Although there are baby alert systems available in the market, they are built-in systems installed in specific car seats, making them costly, not easily transferable, and impractical for parents who already own baby car seats. These systems also cannot function to detect a baby in the seat if the baby seat is not being used and lacks IoT features. ByFAR is a safety alert system for babies designed to provide various types of warnings to nearby individuals and parents who are far away about the presence of a child in the vehicle. This system is controlled by an ESP32 microcontroller and is activated after the car is turned off to detect the presence of children in the vehicle using sensors. The system automatically lowers the vehicle's windows to a predetermined level, flashes the car lights, honks the horn, and displays LED warnings to attract the attention of people nearby. Additionally, the system can automatically send notifications to parents through the Telegram App and a long-range LoRa radio transmitter receiver. The need to produce safety warning devices for babies like this needs to be increased to assist parents with babies in ensuring the safety of their children and preventing infant deaths due to being left in vehicles.

1.0 Introduction

The Forgotten Child Syndrome in cars leading to deaths not only occurs in Malaysia but is a global issue. In the United States, the average number of child deaths due to heatstroke from 1998 to 2023 is 37 per year (Jan Null, 2022). Referring to a Harian Metro newspaper article dated April 17, 2022, the Director of the Bomba and Rescue Department's Bomba and Rescue Operations Division in Malaysia, Datuk Nor Hisham Mohamad, stated that this syndrome is not an isolated case but is frequently reported in Malaysian society today. JBPM statistics recorded a total of 309 cases in 2022, 298 cases in 2020, and 305 cases in 2019. Meanwhile, 41 cases were reported for 2023, with four deaths reported until November 2023. Statistics and studies show that most child deaths in cars occur to babies aged 3 and under. This is due to their limited response to threats and risks (Farah Nini Dusuki, 2023).

According to the Chief Research Officer of the Malaysian Institute of Road Safety Research (Miros), Azad Abdul Rashid, situations where parents unintentionally leave their children in cars are caused by cognitive impairment due to stress, lack of sleep, or sudden changes in routines. These factors may lead to the brain being less aware or forgetful of new or additional tasks that

need to be done, ultimately leading to forgetfulness. Additionally, parking spaces for cars are often located in open areas far from pedestrian pathways.
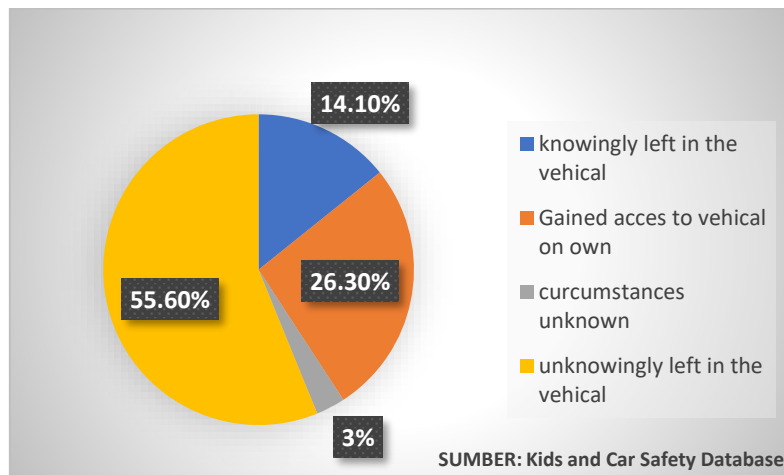

Figure 1.1: Child Death Cases by Circumstances 1990 - 2020

Figure 1.1 shows the percentage of children left in vehicles, where 55.6% are attributed to forgetting. Various emphasis on education and awareness focused on parents, drivers, and the public has been provided. However, this has not been able to prevent the number of children ending up in tragedy. This proves that it is crucial to develop devices or systems that can provide warnings to parents, drivers, or the public to prevent such tragedies from continuing to occur.

2.0   Literature Review

Hazizan et al. (2020) conducted a study and developed a Child Safety Car Alarm System Using Arduino and GSM Module. This system utilizes integrated devices to notify the driver if a child is accidentally left in the car. The system was developed using an Arduino board that integrates sensors and GSM modules. It utilizes pressure and motion sensors to detect the presence of children seated in the rear of the vehicle. GSM, or Global System for Mobile Communications, enables the system to send warning signals to the driver quickly via messages sent through mobile phones.

A subsequent study by Nur Suriya Mohamad and Ravenraj Mogan (2022) also developed a system as an alert and notification for the Forgotten Baby Syndrome. This system is designed to detect the sound of a baby's cries and subsequently alert parents who are far from the vehicle via Telegram about the presence of their baby in the car.

2.1   System Overview

The ByFAR system innovation is a safety alarm system controlled by the ESP32 microcontroller. When the system detects a baby in the car through sound and baby movement, it will lower the vehicle's windows to a preset level to prevent heat and gas buildup inside the car. Furthermore, it automatically sends notifications to parents who are far away via the Telegram application and a long-range radio transmitter-receiver, LoRa. The system also emits various warnings to nearby individuals through flashing car lights, honking, and LED displays.

The ESP32 is a microcontroller chip with integrated Wi-Fi and dual-mode Bluetooth with low-power consumption. It can be programmed using the Arduino IDE and its programming language. The Arduino IDE 1.8.19 used is an open-source platform that is easy for writing and uploading code to the ESP32 board. Figure 1.2 depicts the ByFAR system controlled by the ESP32 microcontroller chip. This system consists of two main parts: the detection and safety alert components. The ESP32 board is programmed using the Arduino IDE. The Arduino software (IDE) contains a text editor for writing code, area messages, text console, toolbar with buttons for

common functions, and a series of menus. Arduino IDE is the software used to write and upload programs to the ESP32 board.
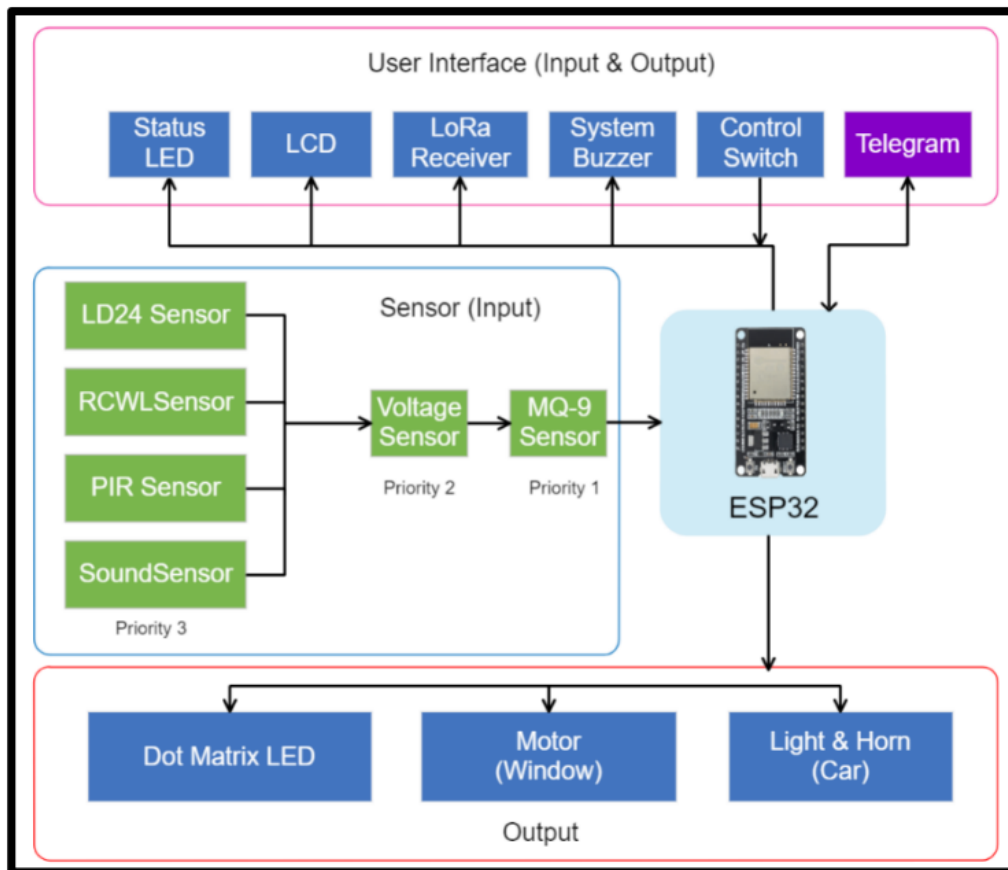

Figure 1.2: Block Diagram ByFAR System

2.1.1 Detection Component

The detection component utilizes 4 types of sensors: LD24 sensor, RCWL sensor, PIR sensor, and sound sensor. When the detection mechanism detects and confirms the presence of children while the driver is away, a signal will be sent to the control unit to trigger the GSM module (Prinima, 2016). The LD24 sensor module detects the presence of humans. Continuous Frequency Modulated Continuous Wave (FMCW) modulation is used to detect human targets in the designated space. This sensor has highly sensitive human presence detection capabilities, capable of identifying human bodies in motion and stationary conditions, and can also calculate additional information such as the distance to the target. The RCWL-0516 sensor is a radar-based motion detector. It emits microwave radiation and then detects the reflected waves when a moving object passes through.

2.1.2 Safety Alert Component

The safety alert component consists of LoRa, Telegram, buzzer, LCD, and LED. LoRa is a long-range physical radio communication technology with low power consumption (Ramon et al., 2018) and operates in the sub-gigahertz radio frequency band of 915–928 MHz in Asia. According to the LoRa Development Portal, the range provided by LoRa can reach up to 4.8 km in urban areas and more than 16 km line of sight for rural areas. LoRa devices are battery-operated and connect to the internet in a regional, national, or global wireless network. The advantages include IoT usage, low power consumption, and low bit rates. This is significantly different from wireless WAN device designs that consume more power to connect users to carry more data (Ferran et al., 2017).

The Telegram Bot API can be used for managing notification information sent via users' smartphones through the Telegram App. The Bot API allows Telegram bots to easily connect to applications and systems using Telegram messages as interfaces. Telegram accounts are HTTP-based interfaces controlled by software and have AI features. According to Mohammad Idhom et al. (2018), the Telegram Application Programming Interface (API) and Telegram are systems that can perform remote monitoring processes and send real-time notifications or messages. To create a monitoring system equipped with more optimal and flexible network checks and monitoring, the administrative server needs to directly connect with system administrators.

3.0   Methodology

The purpose of the ByFAR innovation is to provide warnings about the presence of a child in the vehicle to parents who are far from the vehicle and to nearby individuals. Figure 1.3 explains the proposed system flowchart, where the ESP32 is activated after 5 minutes of the car being turned off. When the sensors detect movement or sound, the motor rotates to lower the vehicle's windows to a predetermined level, the car lights flash, the horn sounds, and the LED display shows the word "WARNING" to alert nearby individuals. Furthermore, the system automatically sends notifications to the parents' smartphones via the Telegram application and a long-range radio transmitter receiver, LoRa. Table 1.1 is an authorization table showing the operation of the ByFAR System.
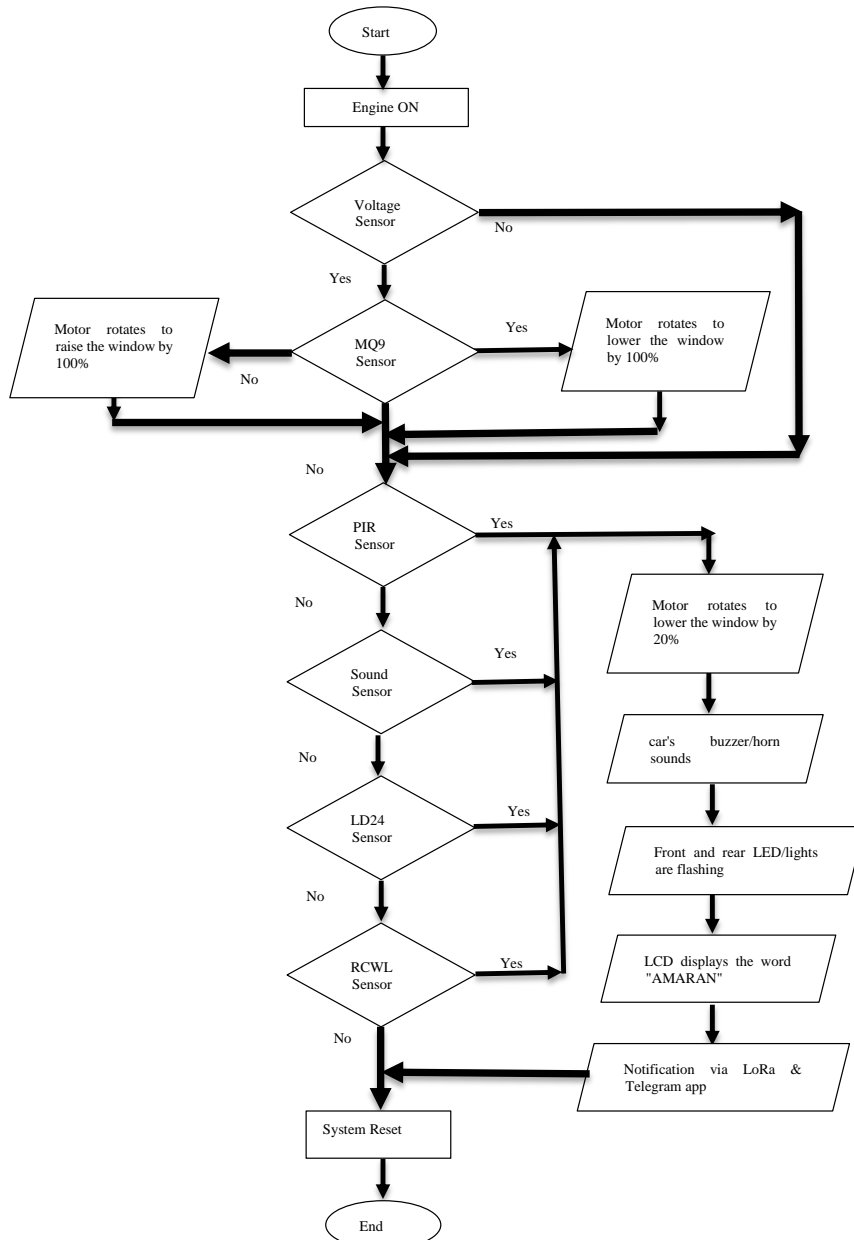
Figure 1.3: Flow Chart ByFAR System

Figure 1.4: Design Prototype ByFAR System

4.0   Discussion of analysis and findings

This system utilizes two types of sensors: analogue sensors such as sound sensor and voltage sensor, and digital sensors such as MQ9 sensor, PIR sensor, RCWL sensor, and LD24 sensor. Digital sensors produce digital output signals measured in the form of logic "1" or logic "0". Meanwhile, analogue sensors tend to produce continuously changing output signals over time. However, these analogue signals are converted to digital signals for use in the ESP32 microcontroller system using an analogue-to-digital converter, or ADC. Table 1.1 shows the active logic levels used to operate the sensors used in the Arduino IDE programming language.

Sensor	voltageS	MQ9	PIR	SOUND	RCWL	LD24
ACTIVE	1(HIGH)	0(LOW)	1(HIGH)	0(LOW)	1(HIGH)	1(HIGH)

4.1 MQC9 Sensor Testing

The MQC9 sensor is sensitive to carbon monoxide and combustible gases. The developed prototype has the capability to detect gas leaks inside the vehicle.

| (a) LCD Display | (b) Telegram Display |

Figure 1.5: Prototype Testing of the ByFAR System using MQ9 Sensor

Table 1.2: MQ9 Sensor Testing Result

INPUT	OUTPUT			
MQ9 Sensor	Motor		LCD Display	Telegram & LORA
Combustible gas detected	0	100% Window lowered	ALERT MQ9 CO GAS	ALERT
No combustible gas detected	1	-	-	-

Table 1.2 presents the results of MQ9 sensor testing using combustible gas. The ByFAR System prototype demonstrates that it successfully lowers the vehicle's windows, triggers the LCD display alarm, and sends warnings via Telegram and LoRa as shown in Figure 1.5. Figure 1.5(b) illustrates the Telegram Bot display programmed to provide alerts to parents.

4.2 Voltage Sensor Testing

The voltage sensor functions to detect voltage (0-25VDC) in the circuit. It can also manage the speed of the car and ensure whether the speed increases or decreases. Table 1.3 shows the results of voltage sensor testing to indicate the current status of the vehicle through the LCD display. When the voltage sensor detects voltage in the circuit, the LCD will display "Car Engine ON" as shown in Figure 1.6.

Figure 1.6: Prototype Testing of the ByFAR System using Voltage Sensor

Table 1.3: Voltage Sensor Testing Result

INPUT		OUTPUT		
Voltage Sensor		LED Status	LCD Display	Telegram & LORA
		STND BY	ALERT		
No voltage detected	0	ON	ON	CAR ENGINE OFF	ALERT
Voltange detected	1	OFF	OFF	CAR ENGINE ON	No ALERT

4.3   ByFAR System Testing

The testing of the PIR sensor, sound sensor, LD24 sensor, and RCWL sensor in the ByFAR system is conducted when the voltage sensor and MQ9 sensor are in normal condition, meaning the car is turned off and no combustible gas is detected inside the car. The results of the system testing are shown in Table 1.4. The testing results indicate that the system will only function when 2 or more inputs are activated, where the vehicle windows will be lowered by 20%, triggering the LCD display alarm, and sending warnings via Telegram and LoRa. If only 1 input is activated, only the LCD will be activated and display relevant sensor information. Meanwhile, when no inputs are activated, no outputs will be activated.

Table 1.4: ByFAR System Testing Result

INPUT				OUTPUT				
PIR Sensor	Sound Sensor	RCWL Sensor	LD24SSensor	LCD Display	LORA & TELEGRAM	MOTOR	BUZZER/ HORN	LED/ LAMP
0	0	0	0	SndSr Only Active	No ALERT	No Output	OFF	OFF
0	0	0	1	ALERT LD24 &SOUND	ALERT	20% Window lowered	ON	ON
0	0	1	0	ALERT RCWL &SOUND	ALERT	20% Window lowered	ON	ON
0	0	1	1	ALERT LD24,RCWL&SOUND	ALERT	20% Window lowered	ON	ON
0	1	0	0	No ALERT	No ALERT	No Output	OFF	OFF
0	1	0	1	LD24 Only Active	No ALERT	No Output	OFF	OFF
0	1	1	0	RCWL Only Active	No ALERT	No Output	OFF	OFF
0	1	1	1	ALERT RCWL &LD24	ALERT	20% Window lowered	ON	ON
1	0	0	0	ALERT PIR &SOUND	ALERT	20% Window lowered	ON	ON
1	0	0	1	ALERT LD24,PIR&SOUND	ALERT	20% Window lowered	ON	ON
1	0	1	0	ALERT RCWL,PIR&SOUND	ALERT	20% Window lowered	ON	ON
1	0	1	1	ALERT ALL SENSOR	ALERT	20% Window lowered	ON	ON
1	1	0	0	PIR Only Active	No ALERT	No Output	OFF	OFF
1	1	0	1	ALERT PIR &LD24	ALERT	20% Window lowered	ON	ON
1	1	1	0	ALERT PIR &RCWL	ALERT	20% Window lowered	ON	ON
1	1	1	1	ALERT LD24,RCWL&PIR	ALERT	20% Window lowered	ON	ON

5.0 Conclusion and Future Research

The ByFAR system is a prototype product model that has not been tested in real-life situations. However, based on the construction of the prototype and testing conducted, it demonstrates that the ByFAR system can function as an emergency mechanism tool for cases of babies being left behind in cars. Therefore, the Baby Forgot In Car Alarm System (ByFAR) project is expected to be developed into one of the market products for ensuring the safety of babies from being left in cars. This system can be further improved with additional modules such as:

i. OV9655 recording camera module, which will capture images and record videos directly from inside the car.

ii. GPS location module to provide accurate location of the car's position in the parking area.

Author Contributions

Mohd Ruzaimi Bin Mat Juna: Conceptualization, Methodology, Hardware, Software, Testing; **Tuan Ida Syarmila Binti Tuan Mustafa:** Validation, Supervision- Hardware, Software, Testing; **Sheilani Binti Shaari**: Methodology, Data Curation, Validation, Writing-Reviewing and Editing.

Conflicts of Interest

The manuscript has not been published elsewhere and is not under consideration by other journals. All authors have approved the review, agree with its submission and declare no conflict of interest in the manuscript.

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