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IoT-Based Safety Baby Car Seat with Mobile Application

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Abstract

Forgotten Baby Syndrome (FBS), where caregivers accidentally leave babies in cars, can have fatal consequences. This IoT-Based Safety Baby Car Seat with Mobile Application project is designed to prevent such tragedies. Leveraging IoT technology, the system enables real-time monitoring, alert notifications, and data analysis to enhance the safety of baby car seats. It features sensors to detect a baby's presence by detecting weight on a seat and monitoring environmental conditions, such as temperature and humidity inside the vehicle. The collected data is securely transmitted to a cloud platform for analysis. When hazardous conditions are identified, such as an unattended baby or extreme temperatures, the system triggers alerts via the Blynk Application and activates car ventilation to maintain safe conditions. The testing results demonstrated the system's effectiveness in gaining an accurate, fast response every time it was executed to ensure reliable performance. However, the alert notification depends on the weather and temperature outside. This innovative approach improves child safety and provides caregivers peace of mind through continuous monitoring and rapid responses. The project represents a significant advancement in ensuring safer travel for babies.

1. Introduction

Human life is rapidly changing with technological advancements, and child safety is no exception. Modern safety measures are essential, as shown by the tragic cases of children dying in cars when left unattended by their parents. Usually, children die because of heatstroke or Hyperthermia [1]. These incidents highlight the need for innovative solutions like IoT-enabled baby car seats. These seats use sensors to alert parents if a child is left alone, reducing the risk of heat-related deaths. This technology can protect children and ease parents' worries. Leaving children in cars can lead to fatal heatstroke within 20–30 minutes of full sun exposure [2]. Sadly, cases of children dying this way, often due to parents forgetting them in the car, continue to rise globally. This phenomenon, called "Forgotten Baby Syndrome," often occurs when parents are distracted or overwhelmed [3]. It affects people of all backgrounds and does not depend on race, gender, income, or education.

2. Literature review

The literature review is the previous research that includes studies, experiments, or related projects. These studies set the standard for current research, identify errors, and provide key information. By reviewing them, a project can highlight its unique contributions, show how it builds on past work, and address earlier limitations.

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2.1 Baby car seat with warning system using IoT

This project introduces an automated system that activates when the car engine starts, and a baby is detected on the seat using a weight sensor. The system sends a push notification to the driver via the Blynk App, reminding them of the baby's presence. If the driver exits the car, follow-up notifications are sent to the driver and a designated guardian every minute for up to ten minutes until the baby is displaced [4].

A potential drawback is the system's inability to distinguish between multiple adults in the car, which could cause false alarms. From this project, a weight sensor can be helpful to detect the presence of the baby by detecting the weight, then the other sensor could also help in determining the certain condition if the baby is left alone. This HX711 load cell amplifier is chosen because it provides a simple interface, which is a clock and data wire, and low power consumption [5]. Typically, this sensor operates less than 1.5 mA. The Fig.1 below shows the prototype of the projects.

Fig. 1 *Prototype baby car seat with warning system using IoT [4]*

2.2 Car seat alert system using IoT

This project aims to create an IoT car seat alert system using the NodeMCU ESP8266 microcontroller. The system monitors the car seat with force, magnetic switch, and temperature sensors. It displays data on an LCD screen and uses lights, buzzers, and an LED strip to alert caregivers. If the car's temperature exceeds a set limit, the power window motor lowers the window to cool the interior. Alerts, including warnings and the car's location, are sent via WhatsApp [6].

The system is portable and compatible with any car seat. Despite this, when it comes to the alert message, this project could implement the cloud platform, Blynk App. This is because of enterprise-ready applications, quick design and deployment, drag-and-drop simplicity, and the ability to gain real-time control and monitoring of the devices [7]. The Fig.2 below shows the system design.

Fig. 2 *Prototype car seat alert system using IoT [6]*

2.3 Car seat alert system through telegram application

This system integrates a car seat alert with the Telegram app to notify caregivers of potential heatstroke incidents. It activates when a child is detected, sending alerts via Telegram. A servo motor lowers the windows, and an LCD displays the temperature and the baby's presence. Alerts are triggered when the temperature exceeds 38°C [8].

This project is suitable for use in hot weather or high-temperature conditions. Still, instead of setting a fixed temperature limit, this project can be more systematic, with the temperature limit not fixed so that the system can adapt to different temperatures and weather. The same sensor could be used to read the temperature because it is suitable for its characteristics of small size, low power consumption, and the range between 0-50°C which is suitable for the situation. and accuracy of only ±2°C [9]. The Fig.3 below shows the prototype of the projects.

Fig. 3 *Prototype car seat alert system through telegram application [8]*

3. Methodology

In Fig. 4, this process outlined the block diagram of an IoT-Based Baby Car Seat with Mobile Application. The HX711 load cell amplifier is an input device that amplifies signals from a load cell to measure weight or force [10]. This sensor is used because its popularity means extensive community support, documentation, and libraries are available, which can significantly reduce development time. [11] Besides, there are many choices in terms of the sensor range. This project used 0-20kg for suitable use of baby weight.

The same goes for the DHT11 temperature and humidity sensor. This sensor also acts as an input device, measuring temperature and humidity and sending data to the controller. Since this sensor also provides a suitable temperature reading, which is 0-50°C to read the inside car temperature [9].

The system uses a NodeMCU ESP32 module for control, which processes data from the sensors and manages outputs. It also interacts with the Blynk App via Wi-Fi. Outputs include a hardware component (a fan ventilation system) and a software tool (the Blynk App). Due to component limitations, the fan keeps the car's temperature safe and is represented in the prototype by a motor driver and a car fan ventilation. The Blynk App displays real-time data and allows users to control the system.

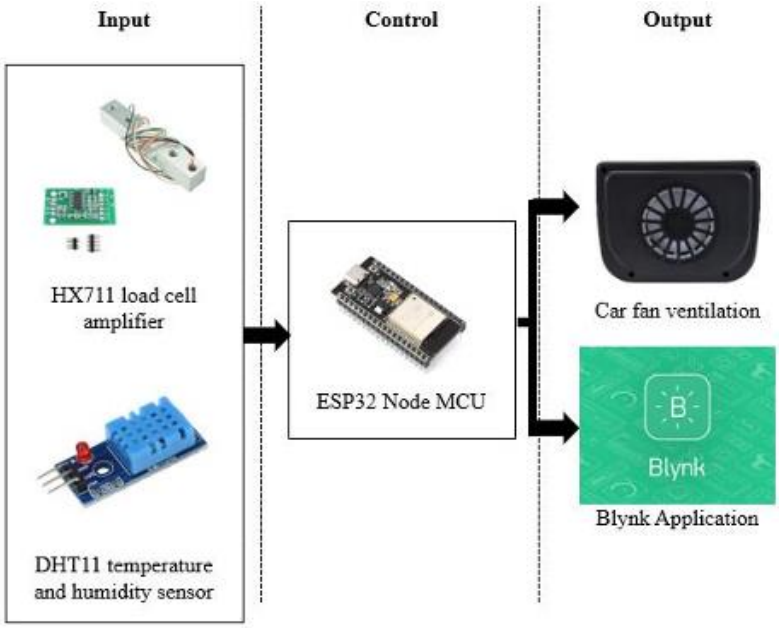

Fig. 4 *Block diagram of IoT-Based Safety Baby Car Seat with mobile application*

The flowchart for the project is shown in Fig. 5 The system uses a DHT11 sensor to monitor temperature and humidity and an HX711 load cell amplifier to detect weight on the seat, both controlled by an ESP32 microcontroller, which also transmits data to a smartphone via the Blynk App. The system initializes libraries, sensors, and network connections before detecting the baby's presence through the load cell. Suppose the temperature rises by more than 3°C with a baby present. In that case, it sends real-time notifications to the Blynk App, repeatedly alerting users with messages like "Baby in a car!" and displaying temperature and humidity data. To regulate temperature, a ventilation fan activates when abnormal heat is detected and remains off otherwise to conserve power. The system stays in standby mode when weight is detected and only stops alerts if the weight is removed or notifications are manually disabled via the app, ensuring consistent safety

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measures. Regarding the challenges of implementing this project, the system must be suitable. It must be tested in different conditions and set up with a suitable temperature rise to avoid false alarms.

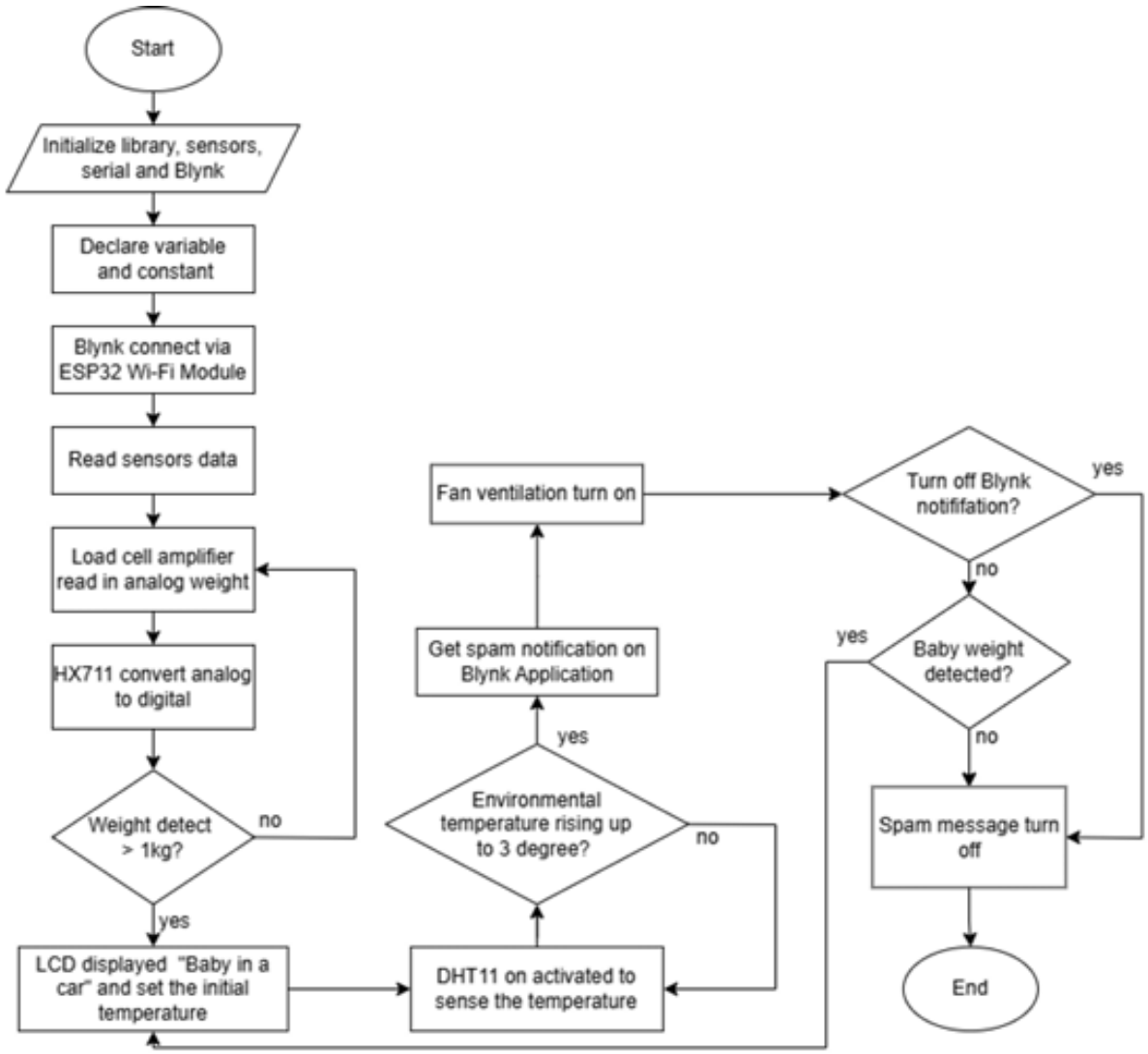

Fig. 5 *Flowchart for IoT-Based Safety Baby Car Seat with Mobile Application*

4. Results and Discussion

This section provides a detailed analysis of the device prototype's functionality, performance, and usability. It evaluates the effectiveness of the temperature and humidity sensor in capturing environmental conditions, as well as the calibration accuracy of the load cell amplifier for weight detection. Furthermore, it outlines the operational mechanics of the product, including both software interface and hardware performance

4.1 Testing analysis

The analysis measures temperature changes to determine the duration required for significant temperature increases. Table 1 below shows the reading temperature taken after 30 minutes of the baby car seat being left in the car and comparison between the initial temperature and environmental temperature. From the table, it can be concluded that within 30 minutes, the interior temperature can be higher than the outside temperature.

Testing was conducted on three separate days at varying times, with temperature readings taken at intervals from 0 to 30 minutes. Notably, the interior temperature reached levels that could be fatal to babies. The primary objective of this test was to identify safe temperature thresholds and quantify their rise under different conditions. The Blynk App provided alert notifications within 5 to 16 minutes when a temperature increases of 3°C was detected. These results align with safety guidelines indicating that potentially dangerous conditions for babies can develop within 20 to 30 minutes of exposure to direct sunlight [12][13], and the testing result is shown in Fig. 6 below. From this test, it can be claimed that the product can be used in any weather.

Table 1 *Testing result to determine the temperature rising*

Date	Time (Hours)	Interior Temperature (°C)	Environmental temperature (°C)
6 Dec	0930	35.2	28.0
6 Dec	1355	34.5	31.0
6 Dec	2140	28.9	26.0
7 Dec	0830	30.5	25.8
7 Dec	1300	39.5	31.0
7 Dec	2140	25.8	23.7
8 Dec	0840	31.3	27.4
8 Dec	1400	34.2	26.8
8 Dec	2030	30.2	25.5

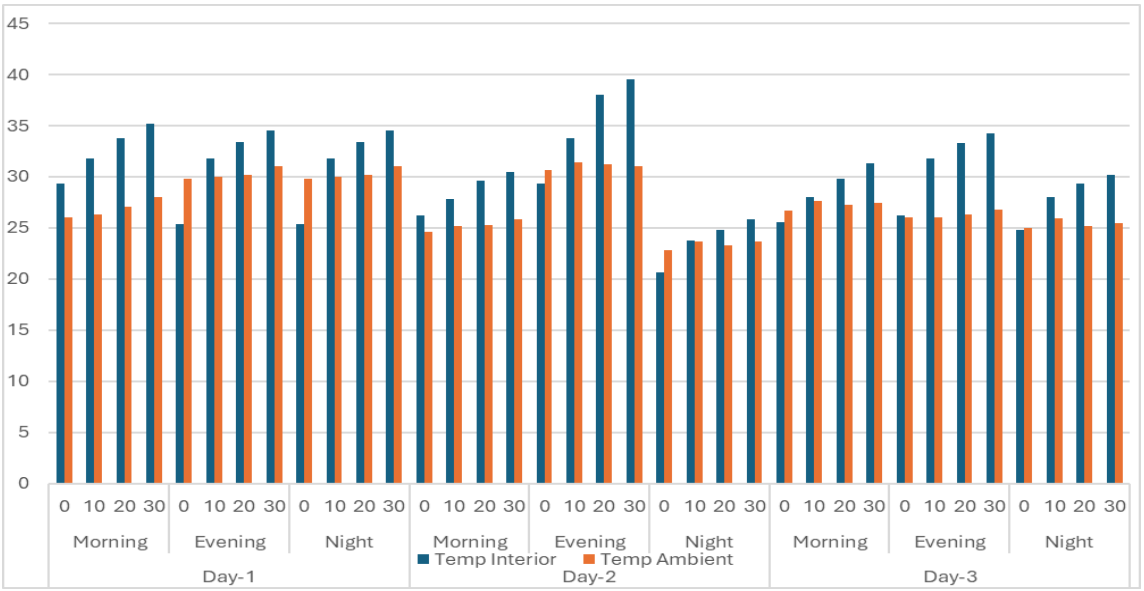

Fig. 6 *Bar graph of interior temperature compared with ambient temperature in 30 minutes reading*

4.2 Software result

The Blynk App serves as the system's output interface. Users must log in with a registered account and synchronize the authentication key with Arduino IDE to establish a connection with the hardware components. Upon activation, real-time readings are displayed on the LCD and within the app.

When the weight on the baby seat exceeds 1kg, the app notifies that a baby is present, confirming the system is working. Regarding high temperatures, the app shows the temperature and humidity levels inside the car and sends repeated alerts if the temperature rises more than the system setup. During the testing, the notification is sent in an absolute time that can meet the objective, which is a real-time notification every time it is executed. This performance also depends on the Wi-Fi connection speed. Alerts stop only when the weight is removed. Fig. 7 below shows the software interface.

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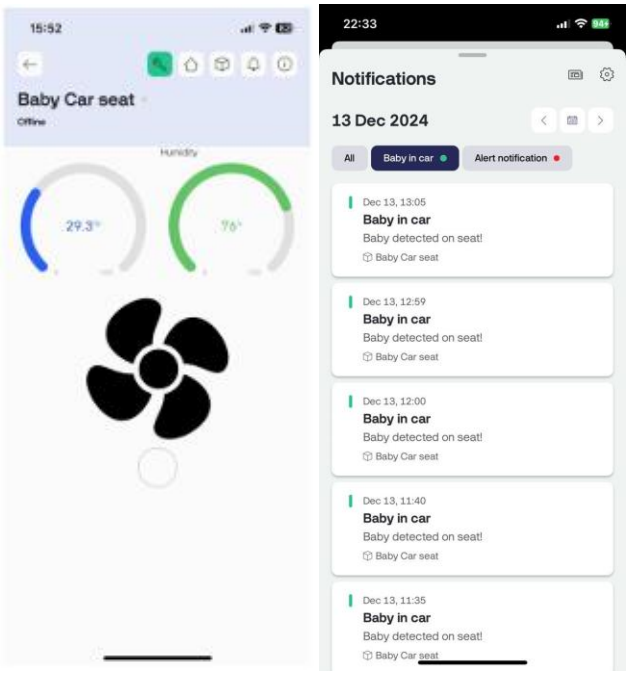

(a) (b)

Fig. 7 *Software interface of (a) mobile phone (b) notification timeline*

4.3 Prototype of IoT-Based Safety Baby Car Seat with Mobile Application

Fig. 8 illustrates the prototype of an IoT-Based Safety Baby Car Seat integrated with a mobile application. The prototype features a circuit installed at the back of the seat, with a weight sensor positioned beneath the seat cover for accurate weight detection, alongside a car fan controlled by an ESP32 board for ventilation.

Comparing this project with recent studies, the system initializes all components, including the DHT11 sensor, HX711 load cell amplifier, motor, LCD display, and ESP32 module. upon activation via a switch. Following connection to pre-configured Wi-Fi, the weight sensor undergoes calibration and zeroing procedures. If it detects over 1 kg, it concludes that a baby is seated and sends a notification via the Blynk App confirming that it is in standby mode. This action prevents false notification if the weight sensor is unstable or has a load of not more than 1kg. The weight threshold is 1 kg because most babies using car seats are more than 1.8kg [14].

Simultaneously, the app interface monitors and displays temperature and humidity levels. The system prevents babies from being left unattended in potentially dangerous conditions. Repeated notifications are sent if temperatures rise beyond a threshold of 3°C until a baby is removed from the seat. Additionally, the activation of a car fan mitigates temperature increases until conditions normalize. This feature allows caregivers to respond promptly in emergency situations.

Once a baby is removed and weight falls below threshold levels, the system reverts to standby mode, ensuring ongoing safety monitoring without unnecessary alerts or interventions. This revised version employs precise language to clarify data interpretation and implications while maintaining an engaging tone throughout the discussion of results and functionality.

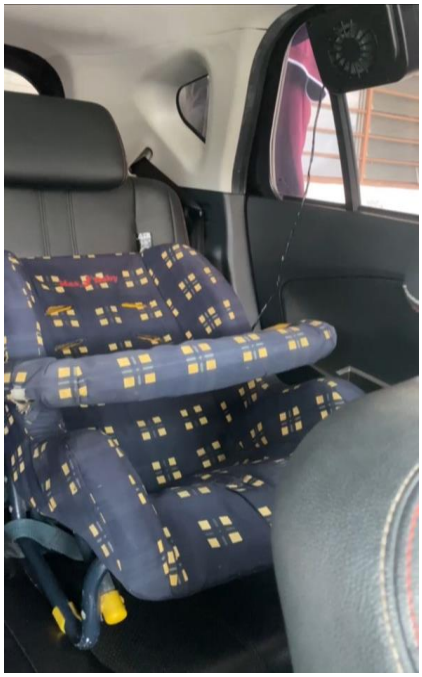

Fig. 8 *prototype of IoT-Based Safety Baby Car Seat with mobile application*

5. Conclusion and recommendation

In conclusion, the IoT-based safety baby car seat with a mobile app successfully achieves its three main objectives. First, it ensures safety by using sensors to monitor temperature and detect the baby's presence. Second, it provides reliable communication by transmitting real-time data to parents through the Blynk App. Finally, it offers a real-time precaution system via the mobile app, ensuring dependable alerts for users.

Some improvements are recommended to enhance safety and convenience. Adding an internal Wi-Fi connection would ensure uninterrupted connectivity. Integrating machine learning could improve detection accuracy, preventing false alarms. Connecting the baby car seat to the car's system could enable features like warnings when the engine is off and reminding caregivers to check for the baby. These upgrades would make the system more secure and advanced, improving child safety in vehicles.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors attest to having sole responsibility for the following: planning and designing the study, data collection, analysis and interpretation of the outcomes, and paper writing

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