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SaveTots: IoT System For Monitoring Children and Animal in Vehicles

SaveTots: Iot para monitoramento de crianças e animais em veículos.

SaveTots: sistema IoT para monitorizar niños y animales en vehículos.

Jovana Oliveira da Silva[1]
Jovana.silva01@etec.sp.gov.br

Karinne Angelo dos Santos Ventura[1]
karinne.ventura@etec.sp.gov.br

Leticia Guanaes Moreira[1]
leticia.moreira66.etec.sp.gov.br

Maria Eduarda Monteiro Viana[1]
maria.viana57@etec.sp.gov.br

Jeferson Roberto de Lima[1]
jeferson.lima17@etec.sp.gov.br

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Abstract:
This article addresses the development of SaveTots, an IoT prototype device designed to prevent the forgetting of children and animals in passenger vehicles. The proposal arose in response to the increasing cases of vehicular heatstroke deaths and the lack of effective alert systems. The project is based on the integration of sensors and wireless communication technologies, employing the ESP32 microcontroller and the LoRa protocol, capable of detecting the presence of occupants and the absence of the responsible person, triggering safety alerts in risk situations. A qualitative methodology was adopted, based on Lakatos and Marconi (2003), aiming to understand the human and technological factors that contribute to these occurrences and to guide the device's development. The results indicate that SaveTots is a viable solution, low-cost, and easily adaptable to different vehicle models. It is concluded that the device contributes to accident prevention and raises awareness about responsibility in the transportation of children and animals.

Resumo:
O presente artigo aborda o desenvolvimento do *SaveTots*, um protótipo *IoT* de dispositivo destinado a prevenir o esquecimento de crianças e animais em veículos de passeio. A proposta surgiu diante do aumento de casos de mortes por insolação veicular e da ausência de sistemas eficazes de alerta. O projeto tem como base a integração de sensores e tecnologias de comunicação sem fio, empregando o microcontrolador *ESP32* e o protocolo *LoRa*, capazes de identificar a presença do ocupante e a ausência do responsável, acionando alertas de segurança em situações de risco. Adotou-se uma metodologia qualitativa, fundamentada em Lakatos e Marconi (2003), com o intuito de compreender os fatores humanos e tecnológicos que contribuem para esse tipo de ocorrência e orientar o desenvolvimento do dispositivo. Os resultados indicam que o *SaveTots* é uma solução viável, de baixo custo e fácil adaptação a diferentes modelos de veículos. Conclui-se que o dispositivo contribui para a prevenção de acidentes e para a conscientização sobre a responsabilidade no transporte de crianças e animais.

Resumen:
El presente artículo aborda el desarrollo de *SaveTots*, un prototipo de dispositivo *IoT* destinado a prevenir el olvido de niños y animales en vehículos particulares. La propuesta surgió ante el aumento de casos de muertes por golpe de calor en vehículos y la ausencia de sistemas de alerta efectivos. El proyecto se basa en la integración de sensores y tecnologías de comunicación inalámbrica, utilizando el microcontrolador ESP32 y el protocolo LoRa, capaces de identificar la presencia de los ocupantes y la ausencia del responsable, activando alertas de seguridad en situaciones de riesgo. Se adoptó una metodología cualitativa, fundamentada en Lakatos y Marconi (2003), con el objetivo de comprender los factores humanos y tecnológicos que contribuyen a este tipo de ocurrencias y orientar el desarrollo del dispositivo. Los resultados indican que *SaveTots* es una solución viable, de bajo costo y fácilmente adaptable a diferentes modelos de vehículos. Se concluye que el dispositivo contribuye a la prevención de accidentes y a la concienciación sobre la responsabilidad en el transporte de niños y animales.

[1] ETEC da Zona Leste

1. Introduction

Forgetfulness children and small animals inside vehicles represent a recurring problem with serious consequences, mainly associated with mental overload, distractions, and changes in caregivers' routines. According to data from BBC News Brasil (2022), since 1988, the United States has recorded 906 deaths of children from heatstroke inside cars. In Brazil, although there are no official studies, researcher Driely Costa identified 59 occurrences between 2006 and 2018, according to a study published by the Metrópoles portal (2024).

A recent episode that reinforces the seriousness of the situation was reported by G1 Goiás (2025): in the municipality of Nerópolis, a 2-year-old child was left behind for approximately four hours inside a vehicle in intense heat by the owner of a daycare center responsible for transportation. The case resulted in a critical increase in the victim's body temperature and, tragically, in his death. Situations like this highlight the urgency of preventive solutions and the essential role of technology in protecting lives.

The issue addressed in this study refers to the lack of efficient and accessible systems that notify those responsible regarding the presence of vulnerable occupants in vehicles, especially in situations where caregivers' attention is compromised due to a hectic routine. The study is based on the hypothesis that these episodes of forgetfulness result from the mental overload of those responsible, changes in caregivers, and the limitations of warning systems in conventional vehicles, factors that contribute to the persistence of this problem and its serious consequences.

Given this reality, the SaveTots project emerges as a technologically and socially relevant proposal, with the aim of preventing children and small animals from being forgotten in passenger vehicles. The prototype is based on the principles of the Internet of Things (IoT) and integrates smart sensors in a microcontroller, enabling automatic detection of occupants in the child seat cushion or booster seat and sending real-time alerts when the guardian moves away from the vehicle. The system was designed to be accessible, versatile, and low-cost, with easy integration into different car models. The initiative aims to protect lives and promote a culture of attention and responsibility in the transportation of vulnerable passengers.

In this context, the specific objectives include identifying the presence of children or animals inside the vehicle, recognizing the presence of the person responsible both while driving and in the vicinity of the vehicle, issuing smart alerts quickly and reliably, and structuring the device's hardware to ensure its integration with different vehicle models, making it adaptable and effective in preventing accidents. The studys is delimited to the analysis of situations involving children and small animals in passenger vehicles, as well as the development of an IoT device with presence sensors and smart alerts.

The methodological approach adopted is qualitative, based on Lakatos and Marconi (2003), which aims to understand the social and behavioral phenomena related to forgetfulness, providing subsidies for the improvement of the technological solution.

The technical rationale is based on authors such as Eduardo Magrani (2018), who discusses the importance of connectivity and distributed intelligence, and José Morais (2023), who proposes guidelines for the development of accessible and sustainable solutions. The ESP32 was selected as the core of the system due to its versatility and Wi-Fi/Bluetooth connectivity, features that allow multiple functions to be integrated into a single device, while maintaining low cost and high energy efficiency. Wireless communication is established through the LoRa protocol, recognized for its low energy consumption and long range, according to Sérgio Oliveiro (2021), enabling monitoring even in distant environments or those with low coverage and conventional network. Structural shaping and documentation followed the methodologies proposed by Gilleanes Guedes (2018), using UML diagrams.

Considering the urgency of protecting lives before risky situations involving these potential victims, emerges as a central reflection that guides this study is: how can an intelligent system prevent children

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and animals from being forgotten in vehicles, ensuring greater safety for users and peace of mind for those responsible?

2.Theoretical Foundation

In this section, the research problem that motivated the development of the SaveTots prototype is presented, as well as the concepts employed in its conception, thus providing the theoretical basis necessary for the creation of an intelligent solution aimed at the prevention of forgetting children and animals in vehicles.

2.1 Forgetfulness of Children and Animals in Vehicles: Risks and Consequences

According to a report published by the digital newspaper AutoPapo (2021), Ford enterprise conducted an experiment to warn people about the danger of leaving children and animals inside cars, showing that the interior can heat up quickly, reaching 50°C, which can lead to death from heatstroke.

In 2025, another tragic accident was reported in Brazil, in Videira, Santa Catarina, where a 3-year-old child died after remaining locked inside a vehicle for ten hours, as reported by G1 (2025). Another similar case involving forgotten animals was also reported, according to Metrópoles (2024), two dogs died from asphyxiation after being forgotten in a pet shop car, in Goiás. These actions can be considered crimes under Article 133 of the Brazilian Penal Code, Law No. 2,848, of December 7, 1940:

> Art. 133 - Abandonar pessoa que está sob seu cuidado, guarda, vigilância ou autoridade, e, por qualquer motivo, incapaz de defender-se dos riscos resultantes do abandono. (BRASIL, 1940, Art. 133)
>
> [Art. 133 — To abandon a person under one's care, custody, supervision or authority, and, for any reason, unable to protect themselves from the risks resulting from abandonment.]

Furthermore, according to a report in the newspaper O Tempo (2023), no foolproof technologies have yet been implemented to address this problem. Solutions that alert drivers to the presence of children inside the vehicle still have limitations, but this is something that has been widely discussed among car manufacturers in the United States, although these solutions are not widely available and are limited to new models.

Therefore, the main focus of the project is to meet the safety needs of caregivers, reducing the risks of forgetfulness and preventing tragedies through an accessible and efficient technological solution.

2.2 Field Research: Perceptions Collected

In order to gain a deeper understanding of the public's needs and perceptions regarding the SaveTots project proposal, and considering that the study adopts a qualitative methodology, field research was conducted. This stage played a key role in collecting real data that could guide the development of the system, ensuring that its functionalities were aligned with user expectations.

The survey was conducted using an electronic form and involved 78 participants who answered 11 objective questions described below, which sought to understand transportation habits, level of concern about forgetting in vehicles, and understanding of the use of smart devices aimed at preventing such incidents.

1. Do you have: small children (0 to 6 years old), small pets (up to 15 kg), both, or neither?
2. Do you own a car or use a vehicle frequently?
3. How often do you transport your child(ren) or pet(s) in the car: daily, a few times a week, rarely, or never?

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4. Have you ever forgotten, or do you know someone who has forgotten, a child or pet inside a car, even for a short time?
5. On a scale of 0 to 10, how concerned are you about the possibility of forgetting a child or pet inside a car?
6. Do you usually use child seats or pet carriers in your car: yes, sometimes, or no?
7. Were you already familiar with or had you heard of this type of technology before?
8. On a scale of 0 to 10, how useful do you think a smart key fob that alerts the driver when it detects a baby or pet in the vehicle is?
9. Would you feel safer with this type of device installed in your car: yes, maybe, or it wouldn't make a difference?
10. Do you think this type of device should be required by law, just like the use of car seats: yes, maybe, or no?
11. Would you like to receive more information about this project or participate in future testing?

Among those interviewed, the majority stated that they have small pets, while a smaller proportion reported having children or both. It was also observed that almost all own or frequently use a vehicle, reinforcing the relevance of the topic in the context of family and daily transportation. Furthermore, most participants transport children or pets in their vehicles daily or a few times a week, which highlights frequent contact with situations that could pose a risk if they are distracted.

Despite this routine, only a small proportion reported having witnessed cases of children or animals witnessed cases of forgetfulness in vehicles. Even so, it was found significant collective concern, as evidenced by the fact that most participants gave high scores, between 8 and 10, when asked about the risk of forgetting. This result shows that even among those who have not directly experienced this type of situation, there is a clear awareness of the seriousness of the problem and the importance of preventive measures.

However, it was noted that most respondents do not consistently use child seats or pet carriers, which points to the need for greater awareness regarding vehicular transportation safety policies.

Regarding prior knowledge of technologies similar to SaveTots, most respondents stated that they were unfamiliar with this type of solution. However, the proposed device was widely recognized as useful and functional, with predominantly positive evaluations and interest shown by participants. In addition, most said they felt safer with the device installed in the vehicle, reinforcing their perception regarding the importance of technological resources aimed at safety

2.3 SaveTots: IoT System For Monitoring Children and Animals in Vehicles.

SaveTots is an IoT system developed to assist in monitoring children and animals in vehicles, preventing them from being forgotten due to busy routines or changes in the daily routes and commitments of their guardians, which can result in dangerous situations.

The prototype consists of two devices developed using 3D modeling: a vehicle structure complementary to the cushion with integrated sensors and a smart key fob. The module attached to the seat is responsible for detecting the presence of the child or animal in the vehicle, as well as monitoring the guardian's presence based on the connection with the mobile device, the key fob, which acts as an alert transmitter, receiving notifications whenever the system identifies that the caregiver has left while the child or animal is still inside the car, thus preventing possible accidents.

The two devices connect via ESP32 and LoRa modules, ensuring continuous supervision of the caregiver's presence after verifying the presence of the child or animal. Both have a battery indicator, charging port, and power switch.

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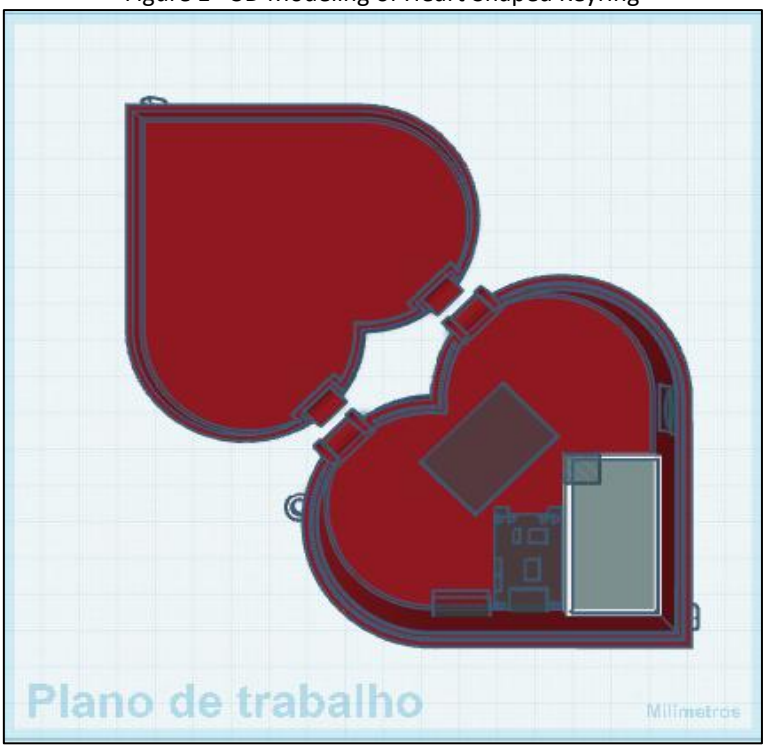
In designing the key fob, a design was sought that would represent the project and be simple and practical for everyday use. Based on this idea, a heart-shaped mold was chosen, referring to the SaveTots project symbol.

With a compartment for the battery, sought to isolate the component in order to prevent any type of interference in its operation. On the right side is the button to manually disable the audible alert emitted by the buzzer in dangerous situations, while on the opposite side are the power switch, the charging port, and the battery charge indicator.

The main challenge in this phase was to accommodate all the electronic components within the structure, which required several adjustments to measurements and molds until the current result was achieved.

Figure 1 - 3D Modeling of Heart-Shaped Keyring



Source: Own authorship (2025)

The choice of red for the device designs was carefully planned to maintain consistency with the intended visual identity of the SaveTots project. This shade, present in the logo, strengthens the connection between the physical prototype and the institutional image, ensuring harmony between the concept and its practical application, as well as making the set more attractive and easily recognizable in presentations and exhibitions.

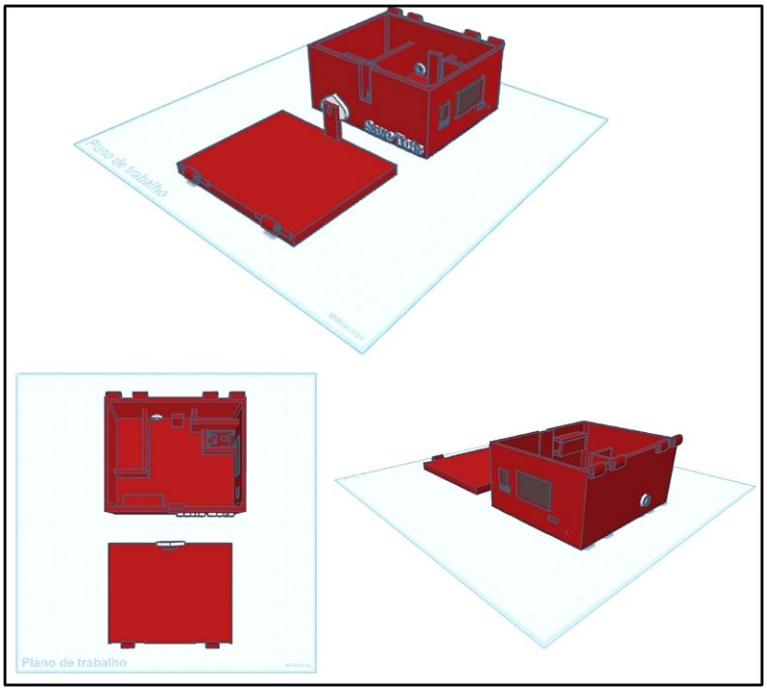
Red also carries symbolic meaning related to protection, attention, and care, principles that reflect the essence of the initiative, focused on safety and the preservation of life. Thus, the color goes beyond aesthetics, reinforcing the project's identity and conveying values of responsibility, innovation, and commitment to the well-being of users.

In the case of the seat, a protective side structure was designed to prevent damage to components, even when a child or animal sits on it. To ensure stability and safety, a rectangular shape with internal partitions was adopted, where each element is positioned according to predefined measurements. Strategic openings were also included, which are essential for the proper functioning of the weight and motion sensors.

This modeling houses the processor, LoRa module, battery, and circuits responsible for charging and monitoring energy. From this perspective, SaveTots was developed to assist in the care of children and

animals in vehicles, preventing forgetfulness and reducing the risk of accidents, especially in the hectic routines of caregivers.

Figure 2 - 3D Modeling of the Complementary Vehicle Structure

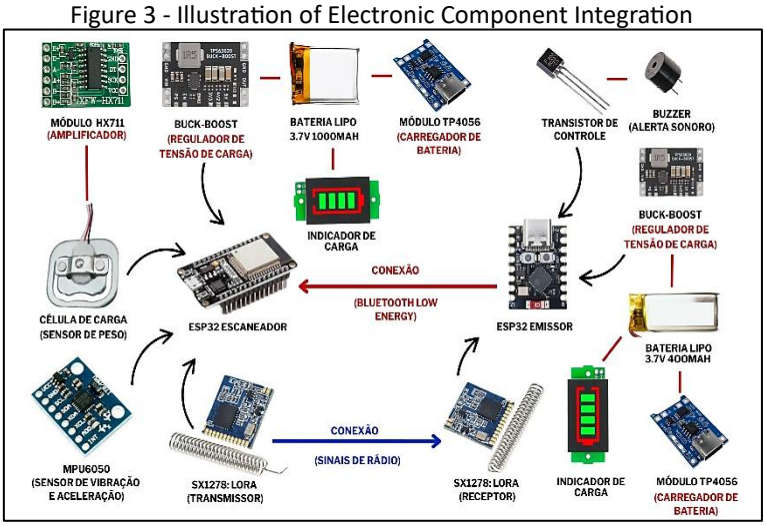


Source: Own authorship (2025)

3. Method

This section will describe the methods used in the development of the SaveTots project, having as the basis of the project the qualitative methodology described by Lakatos and Marconi (2003), which seeks to interpret and understand the social and behavioral aspects involved in forgetfulness. In addition, it addresses the representation of the components and the main technologies used in the development of the IoT system for monitoring children and animals in vehicles.

Figure 3 - Illustration of Electronic Component Integration



Source: Own authorship (2025)

The figure above illustrates how each element was interconnected, including the components mentioned later and other additional components incorporated into the prototype.

3.1 Internet of Things (IoT)

According to IBM (2025), the Internet of Things (IoT) applies to a network of physical devices that are integrated with sensors, softwares, and internet connectivity, making it possible to collect and share data.

Everyday devices that use sensors to capture factors around us, such as pressure and weight, and later use this information intelligently, are considered part of this concept (MAGRANI, 2018).

3.2 Programming Language for Embedded Systems

C++ is a programming language derived from the C language, developed in the context of building highly efficient systems, created by BJarne Stroustrup in 1979, its purpose was to assist in the management of programs that required an increasing level of sophistication (SCHILDT, 2002).

An application developed in C++ requires compilation after coding, a process that consists of converting the source code contained in one or more files into machine language, generating an executable file that the computer can interpret and process (MICROSOFT LEARN, 2023).

The figure below contains an annotated example of coding in C++, explaining how to control an LED by alternating its state between on and off.

Figure 4 - C++ Code Example

```
#include <Arduino.h>  // ESSENCIAL - inclui as funções do Arduino

void setup() {
  // Configura o pino do LED
  pinMode(2, OUTPUT);  // O número 2 representa o pino do LED interno
}

void loop() {
  // Liga o LED
  digitalWrite(2, HIGH);
  delay(1000); // Espera 1 segundo

  // Desliga o LED
  digitalWrite(2, LOW);
  delay(1000); // Espera mais 1 segundo

  // Isso se repete para sempre!
}
```

Source: Own authorship (2025)

3.4 ESP32

The ESP32 stands out for not requiring external boards for wireless communication, such as Wi-Fi and Bluetooth, even Bluetooth Low Energy, as it has integrated features in its own structure for these purposes (RALL; LEITE; MIRANDA, 2023). Among the microcontrollers available on the market, it is recognized for its high performance and high connectivity, offering extremely advantageous cost-effectiveness, as described by Morais (2023).

BLE is a wireless communication technology widely used in battery-powered devices, as it stands out mainly for its energy efficiency, making it ideal for devices that do not need to transmit large volumes of data (FERREIRA; ANTUNES, 2022). As evidenced by Eichner, Da Silva, and Rizzetti (2019), Bluetooth Low Energy (BLE) is capable of scanning nearby devices and establishing connections when requested, in addition to being easily integrated with various sensors and devices, including the ESP32.

It has 38 physical pins, 25 of which can be used as Pulse Width Modulation (PWM), carrying inputs and outputs, these inputs are like buttons that send signals to the microcontroller and can activate outputs such as LEDs, buzzers, and motors (ELETRÔNICA ÔMEGA, 2021).

The description of the ESP32 pins is illustrated in the figure below.

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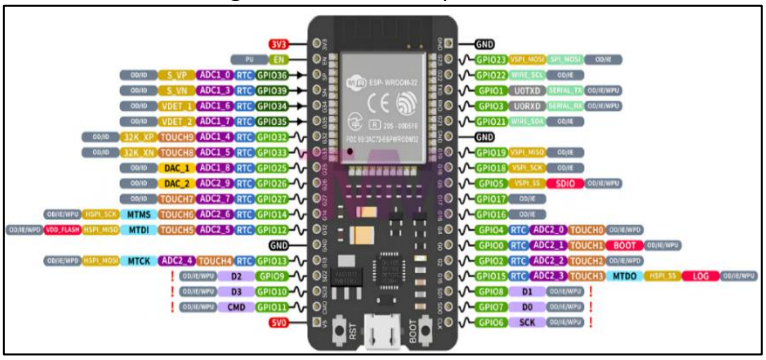
Figure 5 - ESP32 Pin Specifications



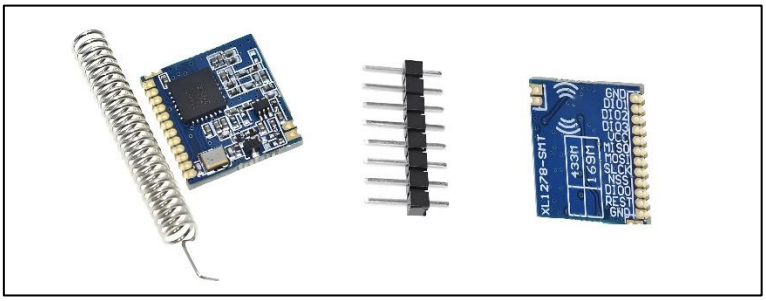
Source: Teach Me Micro (2025)

3.5 LoRa

With the proposal to create a technology that would cover long distances, a device called LoRa was developed in 2015, which, through radio frequency, allows qualified communications of up to 15 kilometers, according to Oliveira (2021).

It is used through a transceiver to transmit and receive signals, whose frequency can vary from 150 MHz to 960 MHz, and In Brazil, there are unlicensed frequencies, regulated by the National Telecommunications Agency (ANATEL), which provide bands between 915 MHz and 928 MHz, according to Bertoleti (2023).

Figure 6 - SX1278: Módulo de Comunicação LoRa para Aplicações



Source: Fermarc (2025)

3.6 Load Cell

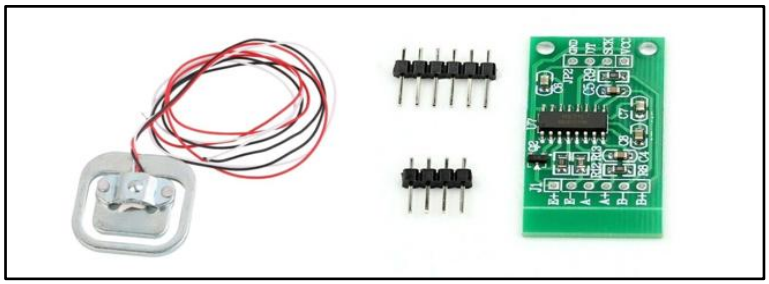
Load cells undergo small but significant deformations in their metallic structure when subjected to an applied load or force, and their operation is based on the variation of ohmic resistance detected by a strain gauge, which senses the deformation and converts it into a measurable electrical signal proportional to the applied weight (THOMAZINI; ALBUQUERQUE, 2011).

As demonstrated by Paixão, Santos, and Almeida (2021), the electrical signals generated by load cells are extremely small and therefore cannot be directly interpreted by a microcontroller, and for this reason the use of the HX711 module becomes essential, as it functions simultaneously as a signal amplifier and an analog-to-digital converter, ensuring that even minimal variations in resistance are accurately detected and processed.

According to Oliveira et al. (2020), this module facilitates effective communication and integration between the sensor and the microcontroller, enabling the construction of reliable and efficient monitoring systems.

The representation of these components can be seen in the following figure.

Figure 7 - Display of load cell and HX711 module



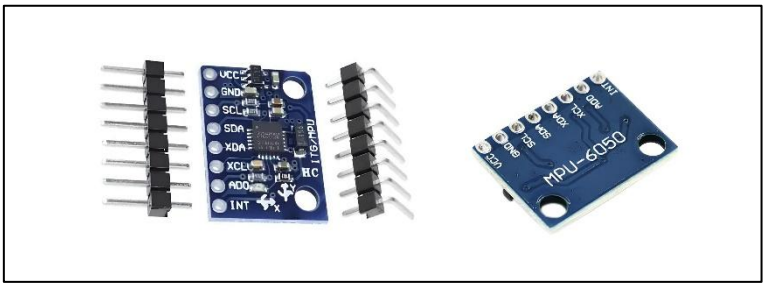
Source: Robocore (2025)

3.7 MPU6050 Sensor

The MPU6050 combines a 3-axis accelerometer and a 3-axis gyroscope on a single chip, being capable of capturing data from applications involving motion, tilt, and vibration detection (MATHIAS; JUNKES; VIANA, 2024). For acceleration, the sensor can be operated in the ranges of ±2 g, ±4 g, ±8 g, and ±16 g, and for rotation, it operates in selectable scales of ±250, ±500, ±1000, and ±2000 °/s, making it versatile for several different implementations (MIRANDA et al., 2022).

In addition, it contains a digital motion processor (DMP) qualified to perform complex sensor fusion calculations internally, reducing the processing load on the microcontroller to which it is connected (STUHLER, 2022).

Figure 8 – MPU6050 Sensor



Source: Robocore (2025)

3.8 LiPo battery

Based on studies by Torres (2018), batteries are fundamental electronic devices that store electrical energy through electrochemical principles and have the function of providing direct current to power electronic circuits and systems.

According to Brito and Delatore (2022), lithium polymer (LiPo) batteries, introduced to the market in 1999, use a solid electrolyte instead of a liquid, which significantly reduces the risk of explosions and ensures greater structural flexibility, in addition to offering an excellent relationship between energy density and safety, standing out for being lighter and thinner, although they have a higher cost.

Figure 9 - LiPo Battery

Source: Mercado Livre (2023)

3.9 UML

UML is characterized as a graphic and figurative representation system with applicability in various development scenarios, although its application extends to multiple areas, its main use lies in the diagramming of object-oriented systems (GUEDES, 2018).

According to Melo (2004), UML enables the documentation of the software development process by establishing a direct relationship between its models and the programming languages used, even allowing the transformation of UML models into code.

It can therefore be concluded that system modeling is important, as UML facilitates code construction and maintenance, and it is common to prepare diagrams even before the program is implemented (FOWLER, 2005).

4. Results and Discussions

The SaveTots system was designed to assist in monitoring children and animals transported in vehicles, targeting audience guardians who have a busy routine or undergo constant changes in route.

Each component underwent unit testing to ensure proper functioning. Subsequently, the integrated system was evaluated for power management, electrical and logical compatibility between the ESP32 and LoRa modules, and the physical organization of the elements, with the goal of reducing interference and facilitating future maintenance.

The tests demonstrated stable communication between the modules, ensuring continuous and reliable data transmission between the cushion and the keychain. Presence detection proved to be accurate, triggering the sound alert whenever the mobile device moved away from the vehicle. The battery life was considered satisfactory, and the response time between detection and alert transmission remained fast and consistent, demonstrating efficiency and reliability.

The integration of the modules allowed the system to operate in a coordinated manner, fully meeting the proposed requirements. The optimized layout of the circuits and connections contributed to reducing failures and simplifying possible future adjustments. These results demonstrate that SaveTots is capable of detecting the presence of children or animals, issuing immediate alerts, and operating stably for long periods.

The performance analysis confirms the technical feasibility of the prototype and its alignment with the project's objectives. Application in real-world contexts will allow the identification of improvement opportunities, such as adjustments in response time, enhancement of the interface, and optimization of energy autonomy. These advancements may consolidate SaveTots as a reliable and efficient tool for preventing accidents and promoting safety in the transportation of children and animals.

5. Conclusion

The SaveTots project highlights the importance of using technology as a tool for protection and care in everyday life. The proposal goes beyond the creation of an electronic device, as it seeks to contribute to the prevention of children and animals being forgotten in vehicles, as well as tragedies that could be avoided through simple and accessible solutions.

The study also highlights the potential of IoT technologies as allies in building a safer and more connected future, capable of responding to contemporary societal demands. In addition, the development of SaveTots provided continuous learning about the research process and practical implementation of the solution, from the conception of the idea to the completion of testing.

That way, it can be concluded that SaveTots represents not only a technical advance, but also an initiative with strong social relevance, paving the way for new improvements and future applications that can expand its reach. We are excited about the possibility of applying the system in real situations

and contributing to the prevention of cases of forgetfulness and risk, promoting greater safety for children and animals, as well as peace of mind for parents and pet owners.

Thus, the purpose of the project is reaffirmed: SaveTots, because forgetting your tots is not an option.

Figure 10 - Logo

Source: Own authorship (2025)

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