Smart Vehicle Child Safety System Using AI-Assisted Sensor Fusion and Mobile Alerts

P.Vyasa Omkar[1], K.Kusuma Navya Sri[2], P.Ganga Surya Prakash[2], Lav Kumar[2], N.Anil[2]

Department of ECE, Godavari Global University, Rajamahendravaram, INDIA.
Department of ECE, Godavari Institute of Engineering & Technology (A), Rajamahendravaram, INDIA.

To Cite this Article

Article Info

KEYWORDS	ABSTRACT
Artificial Intelligence, Internet of Things, Smart Vehicle Safety, Child Entrapment Detection, Multi-Sensor Fusion, Real-Time Alerts, Vehicle Cabin Monitoring	*The children who are left unattended in the parked cars always succumb to suffocation or heatstroke. In order to detect and avoid the scenario when children get locked in cars with locked doors, the paper presents an AI-assisted smart vehicle kid safety system with multi-sensors fusion and real-time IoT alerts. The suggested system constantly monitors the interior of the car with the assistance of DHT11 sensors which are employed to determine the temperature, MQ-2 sensors which are employed to determine the quantity of oxygen, sound sensors which aid in detecting the state of distress, LDR sensors which aid in detecting the amount of light, and infrared sensors which help in detecting the existence of a child. A sensor data processor and a sophisticated logic to decode dangerous conditions are utilized by a Raspberry Pi onboard to detect when the car engine is not on. When a risk situation is detected, the system will start sharing the live GPS position, automation of inside lights, exterior buzzer and real-time camera module image capturing. Through the Wi-Fi the temperature, the quality of air, the picture that is recorded, the time when an alert was activated, and the location are sent to the exclusive parent mobile app. The proposed solution to the smart car kid safety is feasible and sound, it is not expensive and can be fitted in the current cars, and sensor fusion would reduce false alarms.*

INTRODUCTION

The rate of personal cars use has led to the emergence of safety concerns which they do not even realize especially when they leave their children alone in parked cars. Long confinement, suffocation and heat strokes at times lead to deaths and severe injuries. Even the simplest car journeys may cause physiological discomfort of the newborns and small children and this is a severe social security concern. The reason is that, as the intensity of the role played by the mobile devices and

in-vehicle electronic systems continues to increase, researchers are making efforts to provide technologically advanced intelligent safety systems [1].

In the vehicles, alarming numbers of heatstrokes are registered by a number of child protection agencies and safety agencies. According to KidsandCars.org [2], child vehicular heatstroke among young children is still among the leading causes of death that is non-crash related regardless of the growing publicity and prevention initiatives. This kind of finding indicates that there is a need of real time automated detection and alerting systems since people are not as aware.

The harmfulness of the sphere where children are kept in cars is demonstrated by the injury prevention and medicine research. The examination of over 170 of such instances conducted by Guard and Gallagher revealed that the major cause of heat-related newborn death in parked automobiles is the swift rise in cabin temperature [3]. This showed them that the interior temperatures of a motor vehicle can reach potentially fatal levels in a matter of few minutes even during mild weather conditions, and this is why cabin monitoring devices should always be present.

The sensor technology has been improved to produce small and low power car detectors. The use of infrared sensors has elicited some interest since they can also be used to detect the presence of human beings even in the dark or during low lights, by using the heat radiations [4]. They can be used as a good base of a smart child protection system as they are combined with other environmental sensors such as temperature and gas sensors.

With the help of alarm system, child-in-car safety systems based on motion, temperature and gas sensor have been introduced. The sensor based child alarm system created by Hashim et al. [5] will alert drivers about the dangerous conditions. The majority of the modern solutions are characterized by the fact that most of them have single sensor-based verdicts, false alarms, and no real time checks. It signifies that, the absence of these benefits implies that there is a need to fuse with AI-aided IoT-based communication using multiple sensors to secure precise detection, prompt notification, and successful response.

LITERATURE SURVEY

In [1], the impact of the use of 2G and 3G networks on the mobile phone battery life is examined with regard to the volume of energy consumed during constant communication. The authors address the fact that data transmission by the devices is a very common phenomenon, which significantly influences the power efficiency of the devices. There is a need of low-power connectivity solutions in the scenario of the IoT-based safety systems in case of emergency, e.g. car child safety when the transmission of the alarm and its monitoring must be maintained even in the absence of power.

The report provides extensive explanations, trend, and exposure of kids abandoned in parked vehicles [2]. It is also indicated in the report that the caregivers have forgotten most of the cases. It is concerned with intelligent car child safety features and actively motivates automated child detection and warning features.

The analysis takes into account 171 cases of the demise of newborns in vehicles when parked in the heat during seven years [3]. The authors allege that the excessive growth of temperature in cars is the primary cause of deaths. The necessity of the cabin temperature control and early warning devices is demonstrated in the paper because it demonstrates that even moderate temperatures at the outdoors can quickly result in life-threatening situations.

The mechanism behind how a human presence can be detected through thermal radiation is explained by infra-red sensors [4]. The authors describe the usefulness of the nighttime sensing infrared. IR sensors can be used perfectly in terms of the inside subdivisions of the vehicles where the restroom lighting is not always consistent and the vision systems are prone to failure.
A child-in-car alarm system has different sensors that identify the potentially dangerous situations, as suggested by [5]. The authors demonstrate that sensor-based alarms are capable of alerting the care givers about any emergency. Multi-sensor fusion and AI-assisted decision-making are to help with addressing contextual intelligence and false alarms in order to increase reliability.

In the example of continuous monitoring systems, the discussion of the battery life extension methods of mobile and embedded devices is elaborated in [6]. They have smart power management, low power sensor and energy efficient communication protocols. To sustain consistent

running, IoT-based safety systems would be power-optimized, particularly when emergency cases arise whereby there is necessity to transfer and deliver alerts at a very high frequency.

The report released by WHO [7] also examines how to prevent child injuries across the world and the accidental injuries that can be caused by the vehicle. It dwells on how technology and safety can avert a good number of fatalities of kids. The paper supports the value of child protection smarts on the vehicle and highly suggests automated vehicle protection as a means of offsetting the human factor error.

In [8], a brief overview of the recent development in the sphere of car alarm system and the way it is used in regard to the context of safety and security is provided. The authors discuss the ways through which alarm setting can be used to keep a watch on the environment, motion and vibration. According to the research, regular alarm systems are good at identifying intrusions and fail dismally as far as contextual awareness and making wise decisions to protect children are concerned.

In [9], the system integration, efficiency and safety of the wireless power transmission of the electric vehicles are discussed. The study provides an insight into the automobile electrical architecture and power management, although its main goal was car charging. Where these results can be applied in the creation of add-on safety modules that are driven by the automobiles without affecting the performance of the system.

In [10], electric cars powertrain and energy consumption is analyzed. The authors examine the effect of auxiliary electronics on the power of cars. The paper makes the smart child safety solutions practically implementable by indirectly suggesting the implementation of sophisticated safety and monitoring systems in the modern automobiles without the need to consume large amount of energy overhead.

PROPOSED SYSTEM

The suggested system of car safety with the help of AI-enhanced smart cars can read the children who are trapped inside the parked cars and prevent the issue, as its multi-sensor surveillance and smart decision-making will help to achieve such a goal. The technology will only generate surveillance when the vehicle is not at the hands of an individual by turning on when the engine is not startup as well as when all the doors are closed. One of the sensors used in the detection of minors is the infrared based sensor, which follows the movement in the cabin. To check the environmental factors, MQ-2 air quality/oxygen threat sensor and DHT11 temperature sensor are continuously observed. A LDR sensor will be used to measure vehicle light and a sound sensor will be used to measure tears or distress. Raspberry Pis contains sensor fusion and rule-based intelligence to analyze all sensor information in order to detect the threat to the safety of children.

The system activates a multi-level emergency response system in case of a risky situation so that they may get assistance within the necessary time frame. A loud outer buzzer is turned on in order to warn the people around the area. It has a camera module that takes a real time image of the youngster, opens the ventilation/cooling fans to cool the cabin and automatically opens an internal light (when in low light) when no assistance has been given within a given period of time. The supply of oxygen (Ox) of an auxiliary oxygen supply is regulated using an oxygen regulator which is a servo motor so that adequate oxygen concentration in the cabin is maintained in case of low oxygen concentration. The app parent can change the oxygen regulator according to the sensor value and after getting the actual GPS position of a vehicle the Blynk app sends out a warning. A specific mobile application with the assistance of the IoT connection makes a parent or a guardian aware of the required information, such as the temperature, air quality, alarm time, and location. Through the process of visual validation and smart sensor fusion, by use of real-time notification, false alarms are minimized and the smart car kid presents a useful, reliable and affordable solution to car kid safety.
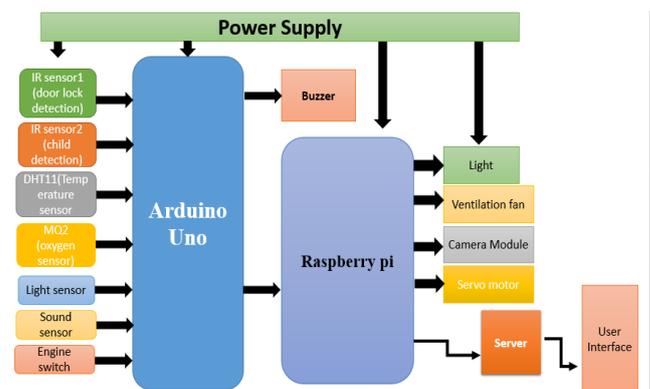
A. BLOCK DIAGRAM

Fig.1 Block Diagram

The block diagram presented below demonstrates the proposed AI-driven smart vehicle child safety system regarding the collection, decision-making, emergency response, and alarm transmission. The four principal elements of the system are the Sensor Module, Central Controller, Emergency Action Module and Parent Mobile Application. Whenever the child is discovered in the locked car, all the blocks will monitor them and interfere.

The Sensor Module will get live information about the car cabin. Its sensors (MQ-2) that monitor the air quality and oxygen danger, DHT11 sensors that monitor the cabin temperature, and its infrared sensors that monitor youngsters and their activities. Though LDR sensor examines the brightness of the vehicle, a sound sensor measures crying or displeasure. Such sensors continuously feed information to the central controller to be handled.

The Central Controller is the developed on a Raspberry Pi main execution unit of the system. It recognizes the dangerous states with sensor data in a combination with smart decision logic. The controller triggers alerts or increases emergency actions depending on the threshold and time parameters that are already identified. The Raspberry Pi is a device powered by GPS positioning to track the position, connected to external peripherals, and it has a relay module to drive actuators.

Emergency Action Module starts after the controller notices the danger. This street possesses an external siren which is loud to draw the attention of the surrounding residents. An inbuilt light that is an LED is activated in case of a low light situation to increase the visibility. A live image of the child in the car is taken by one of the CAM modules. In severe instances, auxiliary might be required on any of those measures including ventilation, turning on to cooling fan so as to reduce the risk until help is provided.

An oxygen regulator is a servo motor controlled system that regulates the flow of an additional supply of oxygen in the vehicle by ensuring that there is adequate supply of oxygen in the vehicle in a case of low oxygen supply, or when the quality of the air is substandard.

Lastly, Parent Mobile App receives real-time tracking information and notifying data through the assistance of the IoT connection. The app will show the child, temperature in the cabin, the quality of air, the state of the crying detector, the time of alarm, and the real-time GPS position of the child. This assists the parents in evaluating

the condition and embark on rescue mission within a short time. The block-wise architecture integrates to identify children in parked vehicles and offer them safety at a low cost using sensor fusion in order to reduce false alarms and enhance safety.

COMPONENTS AND DISCUSSION

The proposed smart vehicle child safety system integrates multiple sensing, processing, and alert components to ensure reliable detection and timely intervention during emergency situations. Infrared sensors are used for accurate child presence detection by minimal movement inside the vehicle cabin and to check the doors status, while a DHT11 sensor continuously monitors internal temperature to identify heatstroke risks. Air quality and oxygen-related conditions are assessed using an MQ-2 sensor, and a sound sensor detects crying or distress signals from the child. An LDR sensor evaluates lighting conditions and enables automatic interior light control in low-light environments. All sensor data are processed by an arduino and sent to raspberry pi, which performs sensor fusion and intelligent decision-making to determine unsafe conditions. Emergency response components such as a buzzer, relay-controlled actuators, ventilation or oxygen support mechanisms, and a camera module are activated when required. Real-time alerts, including environmental data, captured images, and GPS location, are transmitted to a parent mobile application via IoT connectivity, enabling continuous monitoring and rapid response.

A. Hardware Components:

   a) Arduino UNO

A microcontroller, the Arduino UNO, is the primary development and prototyping board of smart car kid safety systems. It is also easy to program and it is reliable in the development of infrared, temperature, sound and gas sensors. The present project will be designed to collect sensor data and execute a series of rudimentary decision logic on an Arduino UNO to identify vehicle cabin hazards. It is appropriate to rapid testing, sensor calibration and validation of threshold-based detection algorithms prior to integration into the system because of its simplicity and community participation.

Arduino UNO is applied to control sensor inputs to stabilize hardware stabilization and open cooling fans, relays, and buzzers. It is handy in troubleshooting and

optimization of parameters in a system by executing real-time serial communication of sensor outputs in the testing process. Arduino UNO makes the process much more simple, enables the testing of the parts in modular mode and test system-level logic before the actual vehicle deployment.
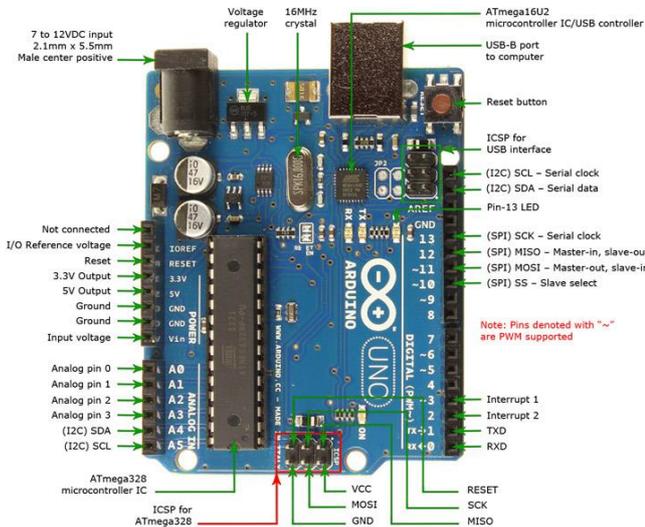

Fig.2 Arduino UNO

b)   IR Sensor Modules

An infrared sensor module will normally consist of a comparator circuit, a photodiode or phototransistor receiver, and an infrared LED transmitter. Standard modules have pins such as VCC, GND and OUT. The positive power source of 3.3V to 5V is connected to VCC, and the ground is connected to GND. The digital signals are sent by the sensor through its OUT pin. In the case of the IR LED, a photodiode is the element that takes location of the reflected infrared light of the surrounding objects. This signal is received by a comparator circuit depending on the sort and distance of the reflection of the infrared light. Analog photodiode signals are converted to digital logic with the aid of comparators. The OUT pin will be an indication of a LOW or HIGH signal with or without the sensor picking any information depending on the module. This signal can be received by a microcontroller or other electrical device. IR sensor modules typically have an indication LED that is lit when the sensor is reading something and a potentiometer of either sensitivity or detection range. The infrared sensor modules are best implemented in the identification of obstacles, tracking line, identification of motion and also the safety of the population by virtue of their simplicity.
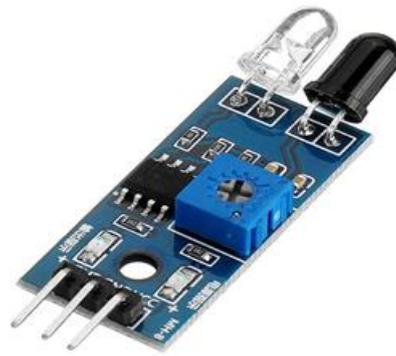

Fig.3 IR Sensor module

a)   Temperature sensor (DHT11)

The DHT11 temperature sensor monitors the temperature of the car within the car at all times to monitor unusual amounts of heat that may pose danger to a confined child. The sensor provides real time information to the controller to be considered because the cabin temperatures of the parked cars can rise very fast. The proposed system will be used to check whether heatstroke is present by comparing the results of the obtained measurement with the safety limits. The gadget notifies the parent on the mobile application, sends an alarm and switches the ventilators or cooling systems once the abnormal temperatures are detected. The low-priced and stable DHT 11 sensor can help to control the safety of the children and the timely response to them because of regular temperature checkups.
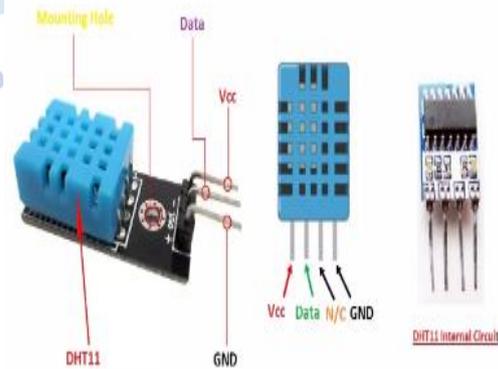

Fig.4 DH11 Module

b)   Raspberry Pi 5

The Pi 5 is the main high-performance processor of the proposed system of child safety of a smart car. It handles processing of data, real time image capture and also camera interface in case of an emergency. In case of a quick decision and to prove the parents, the Raspberry Pi 5 captures sharp photos of the cabin and a child condition

when a child is discovered in a closed car. Its CPU and memory enhancements make the journey easy when it comes to multitasking sensor information, image processing and communication. In this project, Raspberry 5 is a good device in terms of connectivity, which can be used to convey images, environmental and alarm data to the parent mobile app. Raspberry Pi 5 is suitable in vehicles surveillance systems that require real-time and safety critical performance because of its reliability, dynamism, and constant performance.

Fig.5 Raspberry Pi 5

c) Light Intensity Sensor (LDR)

One sensor that gauges light intensity is the LDR. The suggested system will utilize the Light Dependent Resistor (LDR) that will be relied upon to monitor the amount of light in the vehicle. Children can be simply lost in the parking lots, or dark cellars or vehicles at night. LDR sensors detect low light and it automatically gives the controller a signal that there is poor interior lighting. In the attempts to make the camera modules visible and to remove the fear of the dark in children, an inbuilt LED light is immediately turned on in the device. Moreover, parents should confirm with important emergency photos which should also be illuminated. The capability of responding to the emergencies and checking reliability is enhanced with the combination of LDR sensor with the other safety sensors.

Fig.6 LDR Sensor

d) MQ-2 gas sensor module

As a result of the LPG, methane, propane, hydrogen, and smoke sensing capabilities, MQ-2 gas sensor module is used in automation and safety systems. The appropriate operation of a thin layer of tin dioxide (SnO_2) depends on the changes in the resistance. The gas molecules dissociate with the SnO_2 layer therefore this reduces the sensor resistance in flammable gaseous environment although it is high in the atmosphere. The shift output is an analog gas concentration voltage which can be understood by a microcontroller. The module also has there the comparator circuit, such that on triggering (when the gas concentration goes beyond a potentiometer threshold) a digital output is triggered HIGH or LOW. A typical sensor module has four pins, DO, to give the digital output based on the detection threshold, AO, to give the analogue output, GND, to give the ground and VCC, to give the 5 V power. It reacts in less than 10 seconds, it is capable of functioning between -20 C and +50 C as well as 24-48 hours to obtain accurate results. The MQ-2 sensor module is typical of many Internet of Things (IoT)-based safety systems of smoke detectors, industrial gas monitoring, gas leak detectors, and microcontroller interface. It is also the best due to the fact that it is very sensitive and reliable.
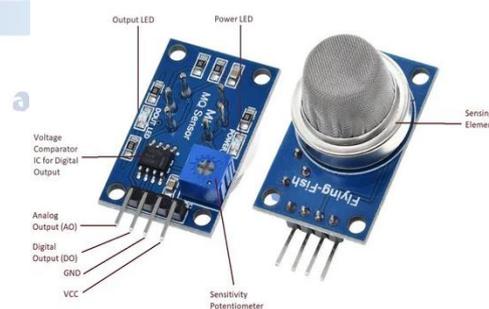

Fig.7 MQ-2 Gas sensor

e) Sound Sensor

The sound sensor module is a device that detects the ambient sound levels and transforms the data into a signal that may then be used by microcontrollers or other circuits. The typical module elements are signal amplifier, comparator/analog output circuit and a microphone. Sound waves are transduced into a little electrical signal by the microphone. The volume of the signal should be increased so that to be further

processed. The module includes a digital output (DO), which when an internal potentiometer threshold has been crossed, becomes HIGH and the analog output (AO), which is usually a constant voltage across the sound intensities it is sensing. Majority of sound sensor modules that can operate on 5V DC have three main connections namely VCC, GND and OUT. Noise in the environment influences interactive works, voice recognition, alarm systems, sound-activated lighting and noise sensors. The sensor sensitivity can be adjusted within a range of real time sound detection regardless of the sound volume whether loud or soft.

Fig.8 Sound sensor

f) Servo Motor to regulate oxygen cylinder

A servo motor for controlling an oxygen cylinder
The servo motors are used to manage posture, speed and torque in robotics, industrial automation, CNC machines and also aeronautical systems. In this situation, they are opened and closed properly so as to regulate the oxygen cylinder. The oxygen flow is then adjusted by the fine angular control of servo motor according to the sensor input or system needs. This automatic control will provide safe, reliable, and efficient oxygen delivery features that bring out the manual control and enhance the reliability of the systems.

Fig.9 *Servo Motor*

g) Rocker ON/OFF Switch

The simplest kind of an electromechanical device is a rocker ON/ OFF switch that is capable of turning electricity flow and switch devices and systems on and off. The name of the switch is named after the way the actuator is rocked to complete or incomplete the circuit. A rocker switch can have two or three terminals input (line), load and neutral or ground. The circuit is closed when a two terminal rocker switch is rolled on and the powered device is turned on and the circuit is broken when it is rolled off and the flow of current is stopped. The rocker switches can be used in industrial machines, domestic appliances, automotive electronics and power supply. They are characterized at 10A / 125 V AC and 5A/ 250 V AC. The popularity can be explained by the fact that they are simple to operate, have long shelf life rate, clear ON/ OFF indicator and can be easily installed. Rocker switches are now equipped with LEDs that indicate when the switch is on or off to make sure that the user is comfortable and safe.

Fig.10 Rocker ON/OFF Switch

h) Power Supply

The smart car kid safety system has the power supply unit to supply all the hardware. The proposed design will decrease 12 V vehicle battery and convert it to 5V and 3.3 V to provide power to the microcontroller, sensor and communication modules. All the processing of data, sensor management and producing alarms even in emergency situations will be made to be under uninterrupted power supply. Engine turned off. Proper control of the voltage guarantees safety and long-term functionality of the system in the vehicle and safeguards the fragile parts.

i) LED Light

LED Light USB lights are mini, low energy bulbs that are also connected to power banks and computers among other contemporary USB powered devices. Typical ones

include a tiny driver circuit to regulate current, a USB port that can be plugged and is capable of operating, and LEDs on a flexible or mounted strip. The device may be connected to a 5 V DC standard USB port. The LEDs do not require the use of any batteries; therefore, they can be turned on within a short period when they are connected to a charged USB port, this makes them a good tool to work in the workplace, read and type. The USB LED lights are flexible enough to be aimed at a point. They would be best in laptop computer, study table, travel and emergency lights because of their own portability, stability and low power consumption. Some luxury models have touch-capacitated switches or brightness controls in order to make them more comfortable and useful.

Fig.11 LED Light

j) USB Cable (Arduino connection)

A USB cable is needed for the Arduino connection.

An Arduino microcontroller board would require the use of USB cables to be connected to a computer or any other device capable of using USB. An arduino uses USB Type-C/type Micro-B connection (to send data and supply 5V DC to newer boards) or USB Type-B to Type-A connection (to older boards). The VCC (5V), GND (Ground), D+ and D- are the main conductors in the cable. VCC and GND feed the arduino board, D+ and D- send and receive digital data to establish the serial communication, programming process, and also upload sketches through the Arduino IDE. This connectivity enables the Arduino to be receiving of any serial commands that may be sent to it by sensors and modules and other devices. The USB connection is vital in the case of electronics and robotics research, prototyping, and real time connection because of the plug and play, consistent exchange of data and provision of power at the same time.

Fig.12 USB Cable

k) Jumper wires

The proposed smart car child safety system has sensors, microcontrollers, and output modules, that are connected through jumper cables. They offer a versatile and reliable solderless attachment of infrared, temperature, gas and buzzer and relay equipment. The use of male-male, male-female and female jumper wire in this project is to simplify making the project easier to test and debug, easy to make rapid changes and thus simplify the prototyping process. They improve the quality of the hardware and ease of installation and neatness of the wiring.
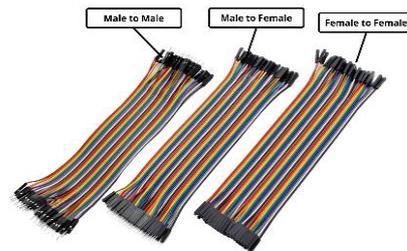

Fig.13 Jumper wires

l) USB Camera Module

The system monitors the car through a USB camera module located in the car. The camera is the best with a resolution of 640x480. It is a camera that is connected to a USB, night vision, and a microphone. The camera will record the pictures of the child in the vehicle in case of a dangerous situation that is observed. With the help of the IoT connection, the parent mobile app receives the images so that to make an emergency decision and be visually verified.

Fig.14 USB camera

m) Cooling Fan Mechanism

The case immediate safety is high-temperature case by a cooling fan which minimizes the cooling in the cabin. The fan is activated when a signal is passed on by the central controller to create more air and cool the vehicles down. This makes the heat nearer to relieving pain during the wait till it is reinforced.

Fig.15 cooling fan

n) Relay Module

The Raspberry Pi is linked to the high power devices like the oxygen regulator, interior light and cooling fan via a relay module. It has safe actuator switching between signals of central controller control and electrical isolation. The relay offers high-voltage and high-current protection of the microcontroller and renders the components that perform under cases of emergency.

Fig.16 Relay module

o) Buzzer

Buzzers are known as aural signaling devices and can be of either mechanical, piezoelectric or electromechanical type. It primarily has the aim of converting sound into audio. It is used by computers, game consoles, alarm clocks, etc. It sounds bell, siren, music and alarm according to the design. In the event that an infra red sensor detects that someone in the locked car is a kid, the buzzer is extremely loud in alerting the attention of anyone around the car.

Fig.17 Buzzer

WORKING

I. System Initialization

Upon shutting down of the engine with all the doors closed, the recommended process is activated. This is where the system will start automatically and prepare. Before he/she commences continuous monitoring, the controller must make sure that the vehicle is locked and parked. Through this, redundant processes in the system when driving is avoided.

II. Child Presence Detection

The infrared sensors will face children in the car once the sensor is triggered. These sensors are able to detect even slight movement of body even when the baby is asleep. The system enters the standby mode in case no child is detected. When a child is located in a locked automobile, the technology will create an alarm.

III. Initial Alert Activation

As a child is noticed there is a banging outside loud buzzer. The first one is the warning that is supposed to be given to the attention of the nearby pedestrians or security personnel so that an immediate rescue drill may be implemented before the matter gets out of hands. It is possible to wait a certain amount of time and have human interference.

IV. Surveillance and hazard assessment of the environment.

The system checks the environmental conditions of the vehicle such that in case assistance is not offered during the first alarm time, it will increase. Unlike MQ-2 gas sensors, which protect the risks of oxygen and air quality, DHT11 sensor protects against temperature. A sound sensor monitors tears or distress and LDR sensor monitors lights. Sensor fusion is a measure of severity and danger.

V. Emergency Response Measures.

The system initiates emergency operations as a result of risk assessment to reduce the threat at hand. These include the opening of an oxygen supply by means of an oxygen regulator which operates on a servo, turning on of internal lights in dark mode, turning on of cooling or ventilation in hot mode and taking real-time shots of the youngster using a camera module. The location of the car is also determined using the GPS in order to have a proper track.

VI. Parent Alert and Monitoring

The last one is to send the parent or the guardian images, the level of temperature, the air quality state, the alarm time and real-time GPS position via the Internet of

Things-powered smart phone application. This will enable the parents to be informed about the status of the child and rescue him or her instantly. Surveillance is also maintained until the problem is solved.

EXPERIMENTAL RESULTS

The smart car child safety system prototype was tested on a fully assembled hardware prototype comprising of Arduino UNO board, Raspberry Pi and some sensors mounted on a board. When the IR sensors are pressed during the experiment, it was found that in such a state when the engine is off, and the doors are closed, there is a child present. An air quality and the cabin temperature were measured using the MQ-2 and the DHT11, respectively. LDR could also detect low light and turn on an inbuilt LED light. The buzzer was turned on and immediately the noise sensor or the sobbing was sensed. The findings show that the interfaces of all the sensors were successful and were able to transmit data to the controller at any given time. A servo motor was used to regulate the amount of oxygen supplied through an auxiliary supply by an oxygen regulator to provide sufficient amount of oxygen in case of low oxygen content or low quality of air. When the temperature reached the safety limits, the relay module would activate the ventilation and cooling fan in order to limit the quantity of heat in the vehicle.

No human intervention was done, as to be expected during the waiting period, when the system goes out of control as expected in emergency simulation conditions. Raspberry Pi and the camera module were used to send real time images and sensor data to the IoT web interface. The precision with which the temperature, humidity, air quality, light status, sound detection, alarm flags, and timestamps were shown in the warning dashboard showed that there was an end-to-end data transfer. The visual evidence alerts were shown on the parent-side monitoring interface in a time-sensitive manner, which became the efficiency of the alert system. In accordance with the results of the testing, the system may be implemented in the automobile kid safety applications since it can be applied in the real time mode, it is capable of detecting dangerous conditions in a proper way, and sends necessary signals in a timely manner.
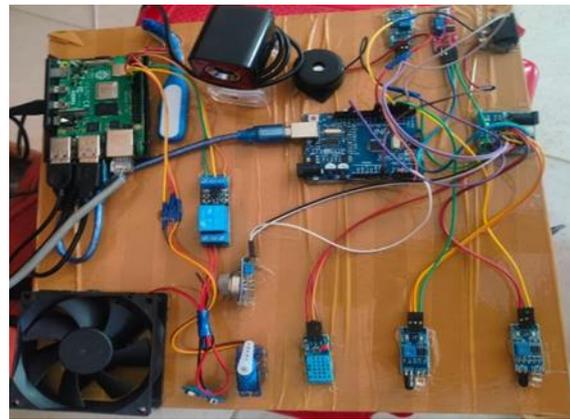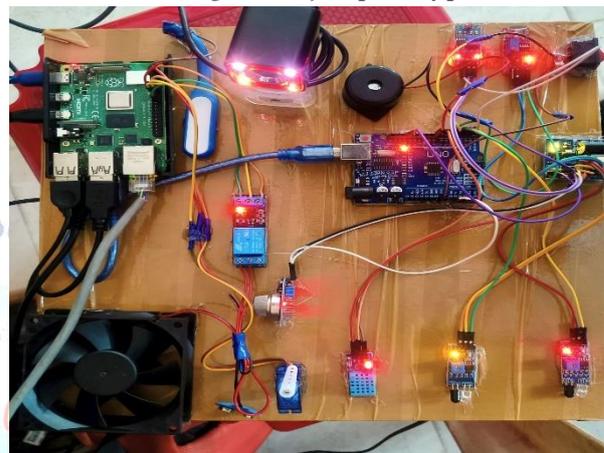

Fig.18 Project prototype
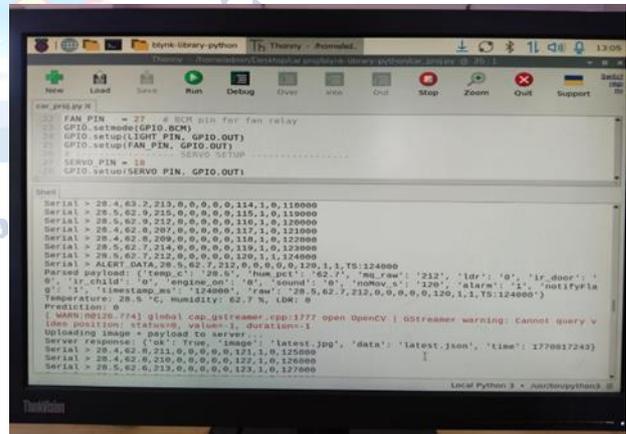

Fig.19 Prototype Testing

Fig.20 Output monitoring

Latest Alert Snapshot

Latest image: 2026-02-02 10:22:37

Open full image

Sensor Payload

temp_c	29.4
hum_pct	50.1
mq_raw	202
ldr	0
ir_door	0
ir_child	0
engine_on	0
sound	0
noMov_s	120
alarm	1
notifyFlag	1
timestamp_ms	147000
raw	29.4,50.1,202,0,0,0,0,0,120,1,1, TS:147000
server received_at	1770027757
remote_ip	117.239.51.67

Archive
Archive files (images & JSON) are kept in the folder for debugging.
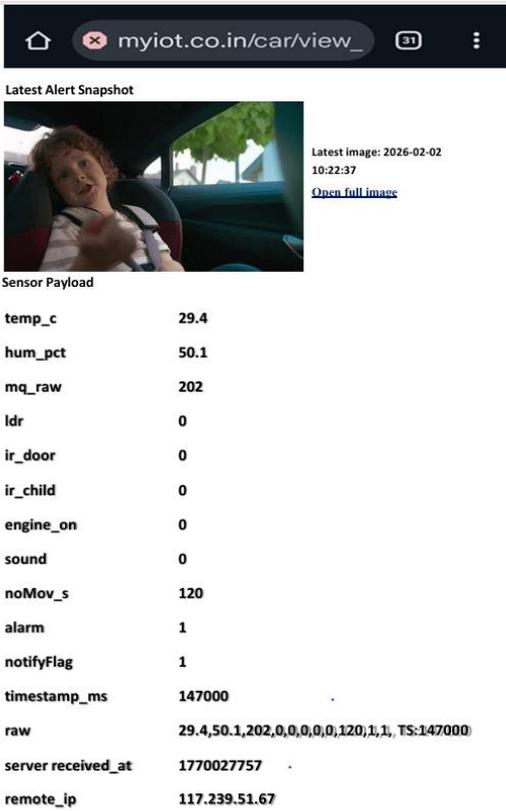
Fig.20 Output monitoring

Fig.21 Iot web interafce

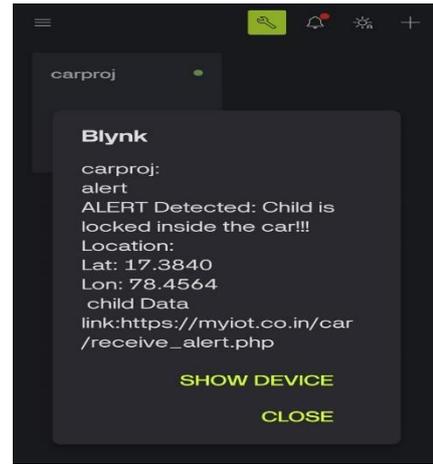| Parameters	Values
temp_c	29.4
hum_pct	50.1
mq_raw	202
ldr	0
ir_door	0
ir_child	0
engine_on	0
sound	0
noMov_s	120
alarm	1
notifyFlag	1
timestamp_ms	147000
raw	29.4,50.1,202,0,0,0,0,0,120,1,1, TS:147000
server received_at	1770027757
remote_ip	117.239.51.67

Fig.22 Blynk dashboard interface

CONCLUSION

A smart car kid safety system, which is an AI-driven operation, was launched to avoid possible fatal instances of children being left unattended in locked cars. The proposed system will be able to detect the presence of children, track essential environmental parameters, and react to the emergencies swiftly because of the high number of sensors and owing to cognitive decision-making and connection to the Internet of Things. Temperature, air quality, sound and light surveillance, real time photo capture and GPS alerts decrease the occurrence of false alarms.

According to the measurements, the sensor data sent to the parent monitoring interface when the system is receiving sensor data in case of an emergency will be sent and alarms will be triggered. Its cost effective technology, flexibility and scalability ensures that the system is comfortable with both the new and old vehicles. The solution presented is sufficient and viable to enhance safety of children in intelligent vehicles and may also decrease the number of child fatalities due to the entrapment in vehicles.

Key Findings

✓ The system successfully detected child presence inside a locked vehicle using IR sensors even when minimal movement was present.

✓ The buzzer alert reliably attracted nearby attention as an initial safety mechanism.

- Real-time temperature monitoring using the DHT11 sensor effectively identified dangerous heat buildup inside the vehicle cabin.
- Air quality monitoring through the MQ-2 sensor helped in identifying potential suffocation risks during prolonged enclosure.
- The LDR sensor accurately detected low-light conditions and automatically activated internal lighting for better visibility and image capture.
- The sound sensor provided additional confirmation of distress conditions by detecting crying or noise events.
- Arduino UNO acts as the primary unit for interfacing sensors and processing real-time inputs.
- Ventilation/Cooling Fan is automatically activated through a relay module when elevated temperature in car detected, helping to reduce heat buildup and improve air circulation inside the vehicle.
- Oxygen Regulator (Servo Motor): A servo motor–based oxygen regulator is triggered under poor air-quality or oxygen-deficient conditions to precisely control oxygen flow, ensuring a safer breathing environment for the child.
- Real-time image capture via a camera module and IoT data transmission were successfully achieved using the Raspberry Pi, enabling visual verification for parents.
- The parent monitoring interface received timely alerts with complete sensor data and GPS location, supporting quick rescue actions.
- Sensor fusion reduced false alarms compared to single-sensor-based detection methods.
- The experimental prototype demonstrated stable and reliable operation under simulated emergency conditions.

Future Scope
- The system can be enhanced by integrating advanced AI-based computer vision models to improve child detection accuracy under varied seating positions and lighting conditions.
- Future versions can include direct integration with vehicle control systems to enable automatic window lowering or door unlocking during critical emergencies.
- The hardware can be miniaturized and converted into a compact commercial-grade embedded module suitable for mass production.
- Integration with wearable devices or child seats can further improve detection reliability and personalization.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] R. Raghuvanshi and M. Gupta, "Vision-based hand gesture recognition for assistive communication using deep learning," IEEE Access, vol. 9, pp. 12345–12358, Jan. 2021.

[2] S. Khan, A. Ali, and H. Kim, "Hand landmark detection and gesture classification using lightweight CNN for real-time systems," IEEE Trans. Hum.-Mach. Syst., vol. 51, no. 4, pp. 332–341, Aug. 2021.

[3] L. Chen, J. Zhang, and Y. Li, "Real-time sign language recognition with embedded systems," IEEE Embedded Syst. Lett., vol. 13, no. 3, pp. 95–99, Jul. 2021.

[4] A. Singh and P. Sharma, "Raspberry Pi based IoT assistive device for the differently-abled," in Proc. IEEE Int. Conf. IoT & Smart Innov. (ICISI), pp. 78–83, Dec. 2021.

[5] H. Park, D. Lee, and S. Jung, "Low-cost gesture controlled communication aid for speech impaired users," IEEE Trans. Consum. Electron., vol. 68, no. 1, pp. 85–93, Feb. 2022.

[6] J. Han and Y. Wang, "Efficient hand pose estimation for embedded edge platforms," IEEE Trans. Image Process., vol. 31, pp. 2003–2015, Apr. 2022.

[7] M. Patel and K. Patel, "Sign language interpreter using Raspberry Pi and machine learning," IEEE Potentials, vol. 41, no. 2, pp. 24–29, Mar. 2022.

[8] M. Ashfaq, F. Shafait, and U. Qamar, "Hybrid CNN-based gesture recognition model for assistive robotics," IEEE Robot. Autom. Lett., vol. 7, no. 2, pp. 4621–4628, Apr. 2022.

[9] P. Thakur and G. Kaur, "Real-time hand gesture recognition using MediaPipe on embedded platforms," IEEE Access, vol. 10, pp. 47800–47810, May 2022.

[10] V. Kumar and N. Reddy, "IoT assisted multimodal communication system for sensory disabilities," in Proc. IEEE Int. Conf. Adv. Technol. Commun. (ICATC), pp. 159–164, Jul. 2023.

[11] S. Das and R. Roy, "Human–computer interaction interface for disabled persons using vision and wearable sensors," IEEE Sensors J., vol. 23, no. 8, pp. 7455–7464, Apr. 2023.

[12] K. Li and X. Zhang, "Low-latency text-to-speech systems on edge devices: design and evaluation," IEEE Trans. Speech Audio Process., vol. 31, pp. 380–389, May 2023.

[13] J. Wang et al., "Deep learning-based hand gesture recognition for medical assistive devices," IEEE Trans. Neural Syst. Rehabilitation Eng., vol. 31, pp. 987–995, Jul. 2023.

[14] A. Gupta and M. Singh, "Adaptive gesture recognition with real-time feedback for accessibility," IEEE Access, vol. 11, pp. 62450–62460, Jun. 2023.

[15] Y. Zhao and J. Sun, "Embedded vision systems for human activity interpretation," IEEE Trans. Circuits Syst. Video Technol., vol. 33, no. 10, pp. 4034–4045, Oct. 2023.

[16] T. Nguyen and H. Tran, "Assistive communication device with gesture recognition and IoT connectivity," in Proc. IEEE Global Conf. Signal Inf. Process. (GlobalSIP), pp. 540–545, Nov. 2024.

[17] R. Mehta and P. Singh, "Real-time multimodal assistive interface for speech and hearing impaired users," IEEE Trans. Human-Mach. Syst., vol. 54, no. 1, pp. 12–22, Jan. 2025.

[18] X. Liu et al., "Efficient feature extraction for wearable gesture recognition with resource-limited platforms," IEEE Wearable Comput. Lett., vol. 2, no. 2, pp. 45–52, Feb. 2025.

[19] K. S. Rao and V. Kumar, "Performance evaluation of embedded text-to-speech engines for assistive communication," IEEE Trans. Embedded Comput. Syst., vol. 14, no. 4, pp. 156–164, Mar. 2025.

[20] J. H. Park and S. Lee, "Vision and sensor fusion for next-generation assistive human–computer interaction," IEEE Trans. Pattern Anal. Mach. Intell., vol. 47, no. 5, pp. 1210–1222, May 2025.