Sensor-Based Detection and Localization of Living Object Inside a Vehicle: A Novel Approach

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Abstract: Nowadays a lot of sensors are used in order to detect the presence of humans in different places. With the advance of technology and the increased use of cars the chances of mishaps like forgetting a baby or pet inside a car is increasing. So, to prevent this, different techniques are being studied so that we can come up with a proposed solution. Studying different techniques can help us come up with the best possible solution to a problem. Here we have studied different techniques and did a comparison among them so that we can analyze different solutions for detecting biological components inside the car. The advantages and disadvantages of different papers are studied and then a comparison table is made. Combinations of sensors can be used instead of a single sensor to detect biological components inside the car is something that is found out after analysis. Even with the help of a camera, we can improve the quality of the model. The techniques given in this review paper are using RF transmitters, Grid eye, temperature, PIR sensors, depth camera, IP camera, and GSM modules respectively. The effects of all these are studied collectively and then the review paper is made into different sections. Also, after studying all these techniques, we have decided on a proposed model. This model will use a combination of sensors like PIR sensor, ultrasonic sound sensor and GSM module to detect living things inside a car. We will also be using the technology of IP cameras to be certain that our detection is accurate.

IndexTerms – **Living object, Vehicle, sensor, GSM Module.**

I. INTRODUCTION

The review paper is on human detection in a vehicle which is being researched through a lot of techniques. The techniques used are the Human Detection Technique using Frequency Domain, the Detection, and tracking of a Human using the Infrared thermopile Array sensor- the "Grid Eye", Human Detection Technique using a Temperature Sensor, and the Human Detection technique using a PIR Sensor, Human Detection using IP camera, Human Detection using GSM Module and Human detection using Depth Camera [5]. The human detection technique using the frequency domain detects motionless objects on the basis of entropy where RF transmitters are used to measure the sending and receiving signals.[7] In the Detection and tracking of a human using Grid Eye sensor detects both motion and motionless human bodies by infrared radiation.[3] The absorbed incident radiation changes the temperature and collects the temperature data. In the human detection technique using a temperature sensor senses the temperature of the human body and converts the electronic data and records the signal temperature changes.[1] The human detection technique using a PIR sensor detects on the basis of the distance between the sensor module and object accurate readings.[8] It is very simple and easy. In human detection using an IP Camera, which is connected to a network through which one can send and receive video footage.[6] In human detection using GSM Module, in this technique PIR Sensor is used to detect human motion or any voice and then the GSM Module will be activated and it will send a message to alert the parent.[1] In human detection using Depth Camera, which uses the principle of the Mobilenet SSD algorithm, and the camera is used for internal sense.[4] The algorithm uses the concept of linear depth analysis.

The entire research work is divided into 7 sections. The remainder of this paper has been organized as follows: Section I is about the abstract. Section II briefly explained the introduction of the proposed work. Section III is all about the techniques we researched and made a brief explanation of every technique. Section IV is mainly focused on the comparison table of all the techniques where it is discussed their working principle, parameters, and their pros and cons. Section V deals with the proposed work and section VI is about conclusion and future scope. The last section is the reference section.
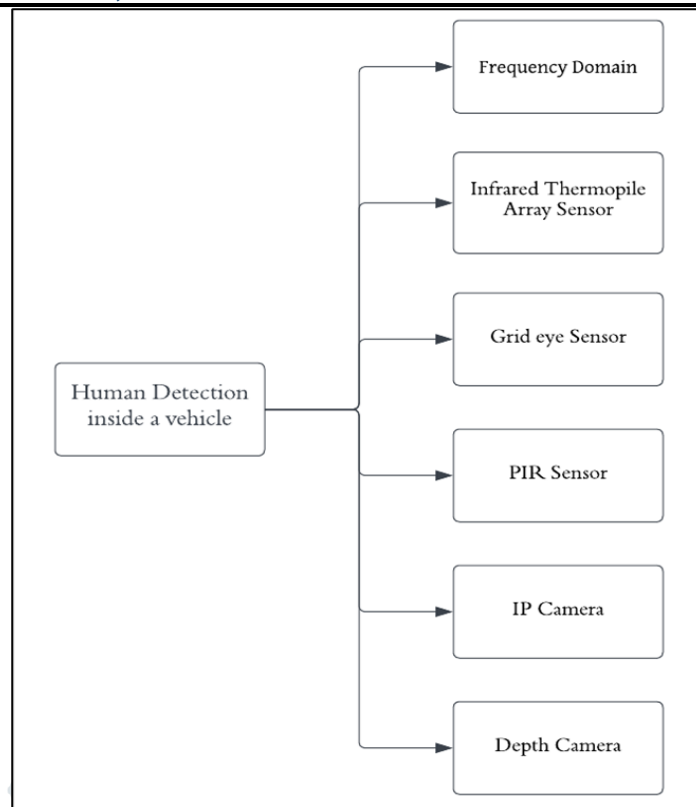
Fig 1. Flowchart of different techniques used in human detection inside a vehicle

II. LITERATURE SURVEY

Human detection technique using Temperature Sensor:

A temperature sensor, an electronic device, measures the temperature of its environment. Then the sensor converts the input data into electronic data and records it for monitoring the signal temperature changes. Temperature sensors work on the readings that are provided via electrical signals. Sensors consist of two metals. One that generates an electrical voltage or resistance when a temperature change occurs after measuring the voltage across the diode terminals. The temperature also increases as the voltage increases. Plain thermal sensors can detect the presence of human body heat but the disadvantage is it is failed to detect movement or identify the number of persons.[1]
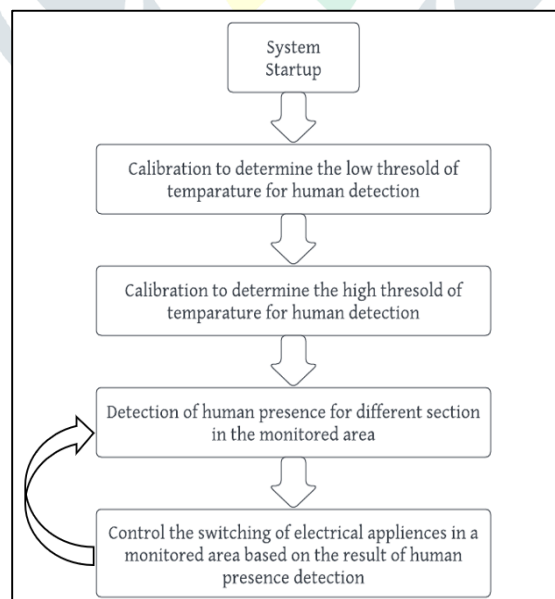

Fig 2. Flow diagram of thermal sensor

Human detection technique using PIR Sensor:

One of the most common sensor detectors is Passive infrared (PIR) sensors. Based on some aspects like the distance between the sensor module and the object accurate readings and output of the sensor are being detected. In comparison to other motion-detecting sensors one advantage of PIR sensor is it works in a very simple and easy way. It's one disadvantage is it does not operate greater than 35-degree C. [2]
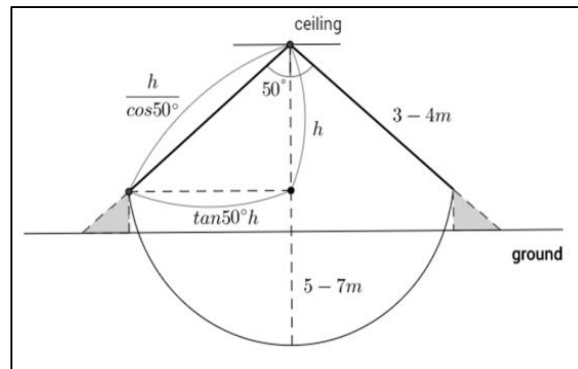

Fig 3. Passive Infrared Sensor (PIR) working

Human Position Detection Based on Depth Camera:

Depth Camera is used for mechanical safety in order to detect human presence. It uses the principle of Mobilenet SSD algorithm and the camera used is of Intel real sense. The algorithm uses the concept of linear depth analysis and it gradually decreases the number of parameters for consideration. Thus, the detection speed is improved as compared to many other techniques. But the disadvantage lies in the fact that it is a costly equipment and thus cannot be used in normal scenarios. The distance is calculated on the basis of the following formula.

$$Z = fb/(XL - XR)$$
Z=distance in mm
f= camera focus
b=distance between left and right camera in mm
XL= distance in x coordinate of object in mm
XR=distance in y coordinate of object in mm
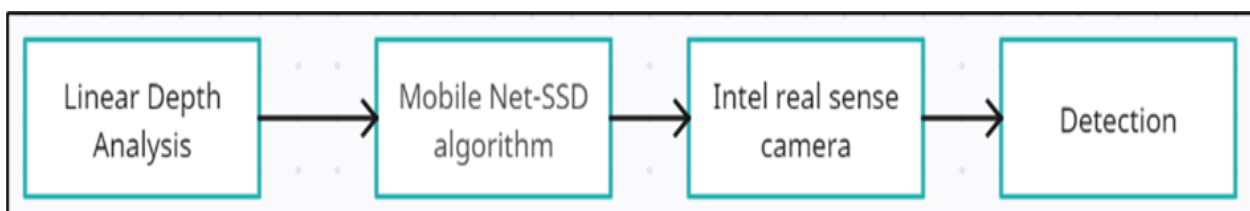

Fig 4. Depth Camera Analysis

Fig 5. Block Diagram of Human Position Detection Based on Depth Camera

Detection and tracking of a human using the infrared thermopile array sensor "Grid -EYE":

Detection and tracking of a human using the infrared thermopile array sensor "Grid -EYE": Human detection is done by PIR Sensor which is used to detect presence of humans only when there is a motion. But Grid Eye sensor overcomes the limitation of PIR sensor by detecting human presence without any movement detection of human body. It mainly detects the human body by the infrared radiation radiated from the human body. Now the absorbed incident radiation changes the temperature and through this we collect the temperature data and estimate the motion of the objects. Hence it is also known as thermal infrared sensor which consists of 64 thermophile elements arranged in a grid format.

n. In a single thermopile element the voltage obtained V is directly proportional to the difference in temperature between two junctions 'T given by:

$$v = n(SAB\ \Delta T) \tag{1}$$

where SAB(µV/K) is the Seebeck coefficient, n represents the total number of thermocouples in a single thermopile.

```
                          Start

        Temparature velues from infrared thermopile array
                    sensor (Grid eye sensor)

              Temparature mapping into a thermal frame

                  Bicubic interpolation of a frame

                  Background subtraction algorithm

          Segmentaion of a frame using the thresold value
                selected by iterative thresold algorithm

                   Connected component analysis

              Extracting fore ground regions from a frame

          Calculation of centroid values of all fore ground

          Estimation of centroid values using Kalman filter

          Representation of track fore ground region based
                on centroid values using bounding box

                          Stop
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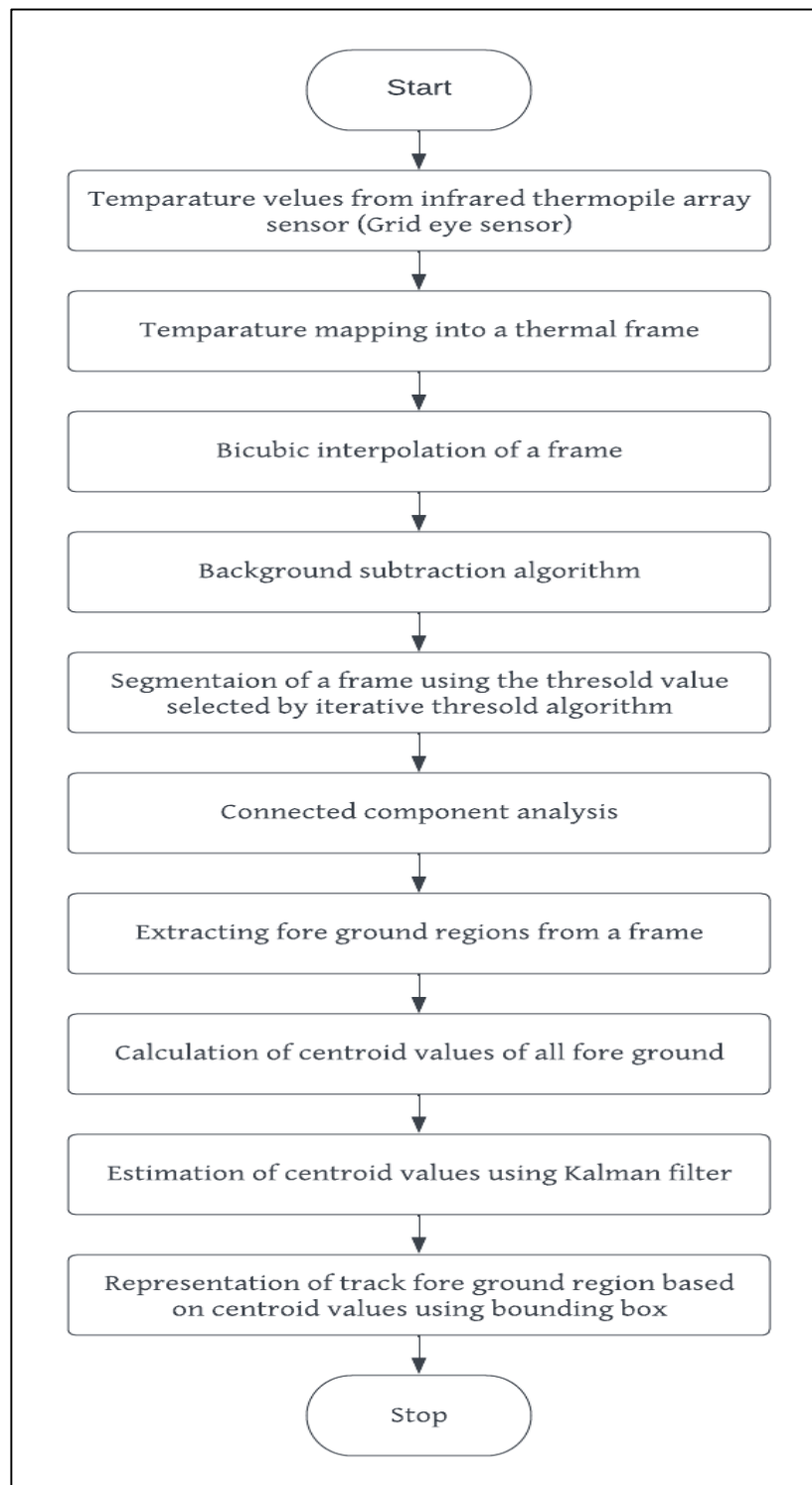
Fig 6. Block Diagram of Human Position Detection Based on Depth Camera

Child in car: alarm system using GSM module:

Human Detection using GSM Module, in this technique PIR Sensor is used to detect the motion or any voice. And then the GSM Module will send a message to alert the parent. The motion sensor needs to be triggered when detecting movements occurring inside the vehicle. This situation can occur when the vehicle's door is locked or the engine ignition is off. When a movement is detected, the microprocessor will generate a command with an alert message to the GSM module to be sent to the driver as an SMS text message. And in this way the parent will be alerted.
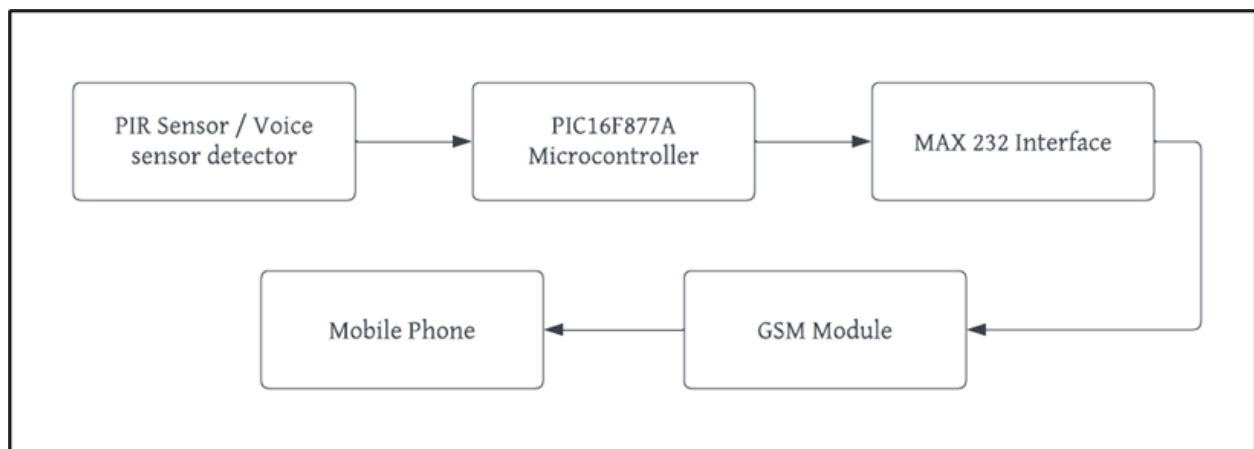

Fig 7. Block diagram of Car Alarm System using GSM Module

Human detection technique using frequency domain:

RF transmitters are used as nodes which are used to measure the sending and receiving signals at each node. These nodes are present in different parts of an enclosed area and help to distinguish between animate and inanimate objects based on their entropy. It removes the disadvantage of the PIR sensor which has less detection accuracy when there is a temperature change. The disadvantage lies in the fact that it still fails to identify motionless objects and only objects with motion can be detected more accurately by this pair of sensors.
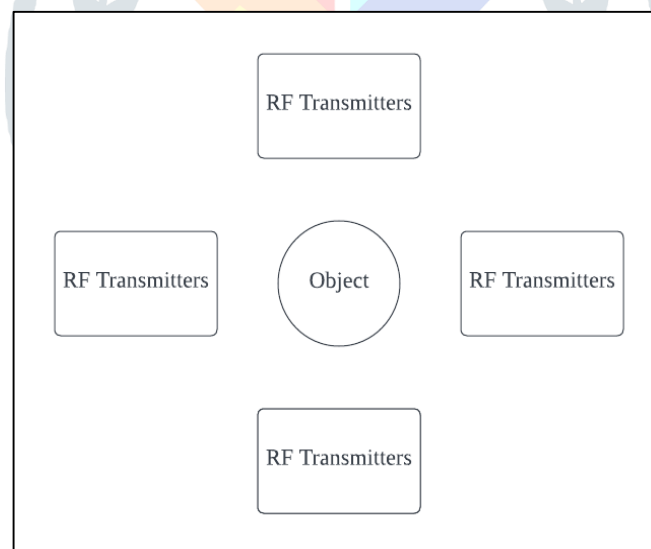

Fig 8. Block diagram of Human detection technique using frequency domain

Human Detection Technique using IP Camera:

An internet protocol camera or IP camera, one of the types of digital security camera that receives and sends video footage via an IP network. Like computers and phones, IP cameras also connect to a network in the same way. Maximum up to 16 megapixels an IP camera can capture footage in high definition—resolution that depends on the camera model. Data containing capacity of each video recording depending on the higher the camera resolution. But IP cameras have to compress or make smaller files to send HD files through the network to avoid consuming too much bandwidth. Modern compression standards like h.264 and MPEG-4 don't need to drop file size or just a small drop-in frame rate and resolution at the time to send the footage to phone or computer.
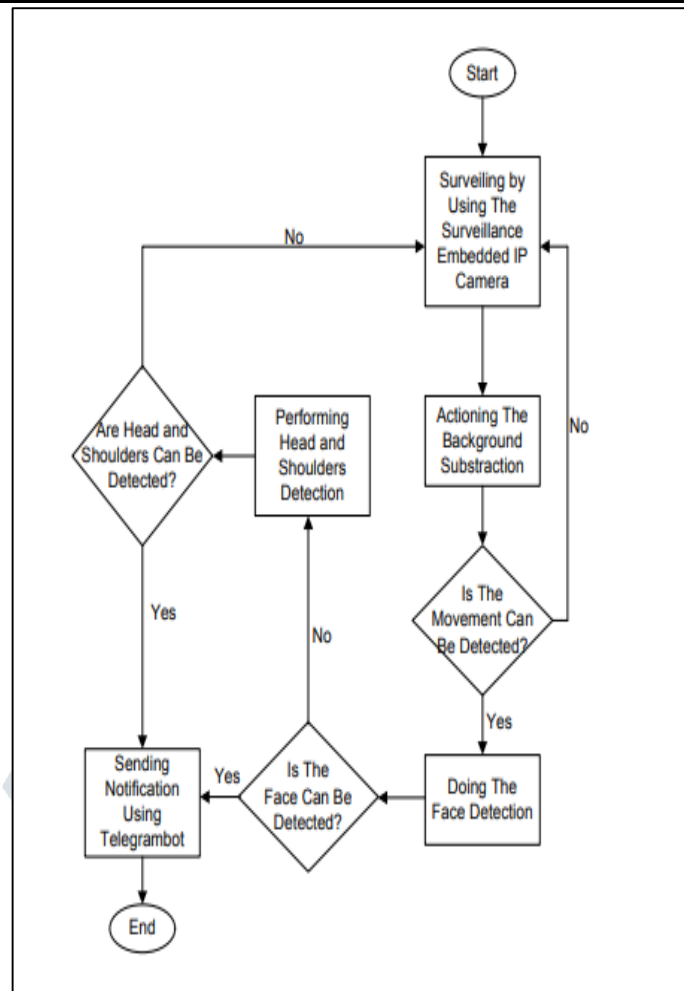
Fig. 9 Flowchart of working of IP camera

Table.1 Gap analysis

Parameters	Sensor used	Performance analysis	Working	Advantage	Limitations
Human detection technique using frequency domain	RF transmitters	80%-90%	RF transmitters are used as nodes which are used to measure the sending and receiving signals at each node.	It removes the disadvantage of the PIR sensor which has less detection accuracy when there is a temperature change.	The disadvantage lies in the fact that it still fails to identify motionless objects.
Detection and tracking of a human using the infrared thermopile array sensor — "Grid-EYE"	Grid eye sensors	92.2%	It mainly detects the human body by the infrared radiation radiated from the human body.	Overcomes the limitation of PIR sensor by detecting human presence without any movement detection of the human body.	Temperature fluctuations can sometimes affect this type of sensor.

Human detection technique using Temperature Sensor	Temperature sensor	88.78%	measures the temperature of its environment.	Plain thermal sensors can detect the presence of human body heat	It has failed to detect movement or identify the number of persons.
Human detection technique using PIR Sensor	PIR sensor	89%-95%	measures the distance between objects	PIR sensor is it works in a very simple and easy way	It is one disadvantage is it does not operate greater than 35-degree C.
Human Position Detection Based on Depth Camera	Depth camera	82%	Depth Camera is used for mechanical safety in order to detect human presence. It uses the principle of Mobile Net-SSD algorithm and the camera used is of Intel real sense.	the detection speed is higher improved as compared to many other techniques.	But the disadvantage lies in the fact that it is a costly equipment and thus cannot be used in normal scenarios.
Child in car alarm system using GSM module	GSM module, PIR sensor	98%	In this technique PIR Sensor is used to detect the motion or any voice. And then the GSM Module will send a message to alert the parent.	It uses wireless technology and is easy to integrate into systems.	No end-to-end security(encryption) is available for the users.
Human Detection Technique using IP Camera	IP camera	92%	An internet protocol camera or IP camera, one of the types of digital security camera that receives and sends video footage via an IP network.	It gives high quality image and is easy to install.	It is costlier and is prone to cyber-attacks by hackers.

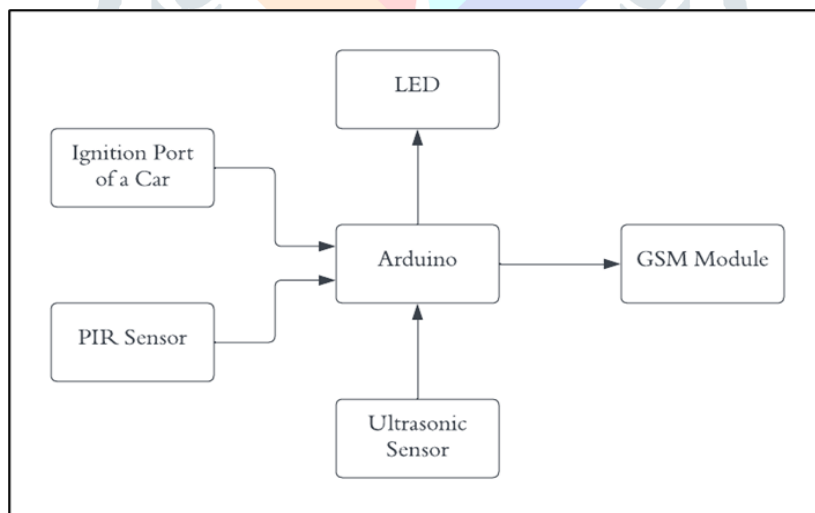| Sensor based detection and localization of living object inside a vehicle	PIR sensor, Ultrasonic Sound Sensor, GSM Module, IP camera	91%	Both PIR and Ultrasonic sensors work together to detect living objects and send messages via GSM. It can be verified with an IP camera.	Motion is detected multiple times to send message	A person may not always check his phone.

III. PROPOSED METHOD

The finalized idea is to use IoT and sensors, including PIR and ultrasonic sound sensors, to detect human presence inside a car. It sends notifications to a registered user's phone when it detects movement within the threshold range of the car seat. The device is controlled by Arduino and C++ code and connected to the internet, as well as the car's ignition port. An IP camera is also installed for the user to confirm the presence of a living object inside the car.

IV. WORKING PRINCIPLE

The approach is to build a smart car security system that uses IoT technology and a combination of sensors to detect the presence of living objects, particularly humans, inside a car. The system utilizes a PIR sensor and an ultrasonic sound sensor to detect motion and an object's presence within the specific range of the car seat. When the system detects human presence inside a locked car, it immediately sends a notification to the user's registered number through the node MCU. The device is connected to the internet and the car's ignition port and is controlled by Arduino and C++ code. The inclusion of an IP camera allows the user to confirm the presence of a living object inside the car when a notification is sent. This device aims to provide an additional layer of security to prevent harm or accidents caused by leaving a living object inside a car.

V. WORKFLOW DIAGRAM

VI. CONCLUSION AND FUTURE SCOPE

After careful consideration of our project, the need for proper equipment to address daily difficulties has become apparent, particularly when it comes to situations like inadvertently leaving babies or pets inside locked vehicles. To address this issue and prevent potential dangers, we have developed a rescue device. Additionally, we have recognized the significant potential for future development in this area. Below are some of the ideas that will aid to possible future development of our idea.

Advanced sensors can be used like human sensors for human presence detection. Radio frequency can be used to detect the human breathing which will be an added advantage if the person is not moving. Receiving and transmitting frequency measurement will be used to achieve this task. The wireless cloud can be made more secure. Better sensors can also be used for more particular outcomes like UWB radar to detect humans by respiration rate. This device can be made more portable, compact, and handy so that it can be more convenient to use.

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