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A review study on Vehicle Anti-Theft Immobilization System using Face Recognition

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Abstract - *For preventing vehicle thefts, we propose an advanced security system for vehicles based on facial recognition using Raspberry Pi. It contains a facial detection system that authorizes the user, and if the user is discovered to be unknown, the car is immobilized via a relay circuit in the car's internal circuitry, and a notification is issued to the user via a mobile application. The authorized personnel can also add other users and get the vehicle's location as the GPS (Global Positioning System) module, connected to the Raspberry Pi, will store the location information in a real-time database Google Firebase, which will provide the vehicle's location on the mobile application.*

***Key Words*: Face Detection, Anti-theft, Vehicle tracking, Raspberry pi, Relay circuit, Vehicle Immobilization**

1. INTRODUCTION

In today's world, almost everyone owns a car. People are concerned about advanced technologies in the automobile industry since buying a car is such a large expenditure. Today's biggest issue for automobile owners is the continual concern of their vehicles being stolen from a public parking lot or from outside their houses. Duplicates of car keys are easy to create, and employing them raises the danger of thievery. There has been a significant increase in automobile thefts as the number of vehicles on the road has increased.

Car security system design and analysis are continually improving as a result of the expansion and use of various Raspberry Pi techniques. Many modern techniques, such as biometric recognition, image processing, communication, and so on, have been integrated into vehicle security systems. At the same time, the number of car accidents, particularly fatalities, remains high. As a result, a practical car security system should be efficient, sturdy, and dependable. Traditional car security systems are expensive and rely on a large number of sensors. When an automobile is truly lost, no further feedback can be useful in assisting people in locating it. We propose that the automobile immobilization approach with face detection be used in car security systems since it is efficient fast and cheap in that it ensures that the theft is permanently prevented before it even begins. Face detection algorithms have received a lot of attention in recent years, and it is a significant computer vision problem with applications in surveillance, multimedia processing, and consumer products. Many modern face detection techniques have been developed in order to attain a greater detection rate and a faster detection rate. By interpreting the received GPS signal, the GPS module determines the specific location.

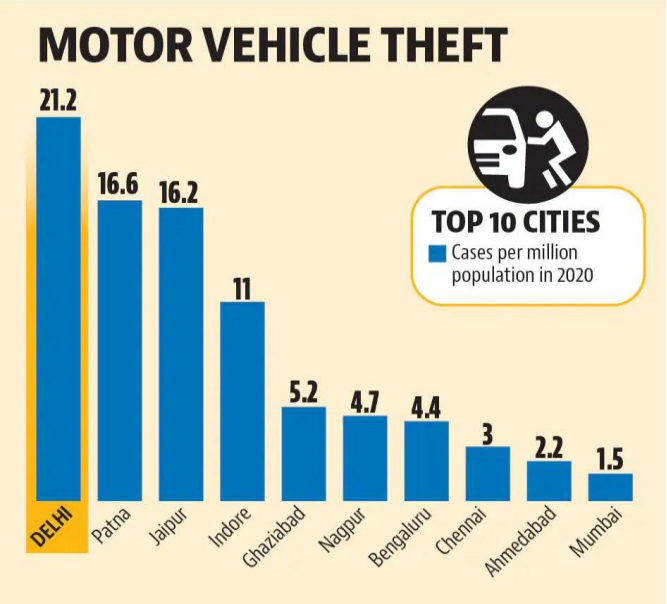

Fig-1: Cases in the last 10 years (2011-2020),

A total of 307000 vehicles were stolen.

[Source:

<https://www.hindustantimes.com/cities/delhi-news/city-of-cars-delhi-reports-maximum-vehicle-thefts-95-stolen-everyday-ncrb-report-101631730601005.html >]

The Raspberry Pi control center module controls all activities, including image acquisition, face detection, car immobilization through relay, GPS data acquisition, and notification to the user. According to Delhi Police personnel, car theft accounts for around 14 percent of all crimes in the city. Even during the first harsh lockdown, which restricted people's movement, between March 15 and 30, 2020, over 83 automobiles (more than three per hour) were stolen in

Delhi. To limit the number of thefts, engine immobilizers and sophisticated alarm systems have become standard equipment in many autos.

Despite the tough regulations in place and security measures implemented by auto manufacturers and the government, criminals have grown increasingly tech-savvy, discovering a plethora of ways to get access to vehicles. In this document, we propose a new mechanism that would help prevent the car from being stolen.

2. Literature Survey

S.Padmapriya et al.[1] proposed an improved face detection and recognition method based on information of skin color. Skin color detection is first performed on the input color image to reduce the computational complexity. Morphological operations were used which gives prior knowledge for face detection. Here, the Adaboost algorithm was used for face detection. By using principal component analysis (PCA) algorithm, a specific face can be recognized by comparing the principal components of the current face to those of the known individuals in a facial database built in advance. This method of security was cost efficient.

C. Nandakumar et al. [2] presented an embedded automotive security system involving face recognition. This system is used to reduce the increased vehicle theft and allows the owner to identify the intruder thereby having the vehicle under control. Microprocessor (ARM 7) is used as the control unit in the system. The processing of images involves two parts, face detection which makes use of Viola-Jones Algorithm by cascade object detection and face recognition which makes use of Linear Discriminant Analysis (LDA) algorithm which performs the feature extraction of the stored images in the database. When the image processing unit classifies the image as unknown, the unauthenticated face image is sent to the owner mobile through Multimedia Messaging Services (MMS) using a GSM modem. The system updates the GPS information about the vehicle location to the owner.

Ahmed A. Elngar et al. [3] proposed a new intelligent vehicle security system called VSS − IoT using a secure, efficient, low-cost, and Low Power Processing chip with the Internet as its important part. Moreover, this paper employed a hybrid mechanism (Haar Cascade + PCA) for face detection and recognition of the captured image by a USB camera. This system converts the images captured by the USB camera installed in the vehicle to Gray-scale images to detect and recognize faces in real-time. While PCA is a mathematical method that is expressed as a transformation of high-dimensional facial images into few-dimensional principal components called Eigenface which is used to recognize faces in the digital image.

The primary purpose of Prof. P.R. Shahane et al. [4] is to reduce the number of vehicle theft using face detection by an image processing algorithm. Only a set of authorized members (feeded in the database) will be able to access the ignition system. The face is detected and recognized using Eigen Face in PCA algorithm. The recognized image is then compared with the authorized image of the users in the database. If the face is unauthorized, the system will not let the engines turn on. The system will send a request to the owner through a Local application using MQTT protocol demanding a pass code to start the relay.

The paper [5] by Sagnik Basu Choudhuri et al. aims to replace the existing RFID-based engine immobilizer with a better and foolproof system which is achieved by implementing Face Recognition as the primary defense mechanism against vehicle theft, using NI LabVIEW and its toolkits. A Third-Party Access mode has also been developed to help people who do not have their templates stored in the system run the vehicle for a pre-programmed amount of time. The Passive Defence System (PDS), which includes the OTP generation and its mailing, is also implemented using the State Machine in NI LabVIEW. A Transdermal Alcohol Sensor interface is proposed which adds to the safety of the driver and the surroundings by avoiding Driving in Impaired conditions. Apart from these, an ultrasonic sensor-based guidance system is also integrated into the vehicle to provide a guidance system to the driver during adverse cases such as heavy fog or poor visibility. All these systems work as a package and offer greater passenger safety while reducing the risk of vehicle theft.

The system proposed by Prof. M.M Bulhe et al. [6] consists of Raspberry pi as the central processing unit that receives the data using a camera. This hidden camera captures the facial data and sends it to the processing unit for comparison. A database is maintained that contains the facial data as given by the user and cannot be manipulated by any other unauthorized user. This system also has a GSM module that helps the CPU to generate SMS to the owner of the car when unauthorized access is noticed. Then the CPU generates a command that switches off the motor. The algorithm is programmed in Raspberry pi which helps to compare camera captured images with database information, it also generates commands to operate other devices/components or other add-ons as defined by the programmer.

Mahesh R. Pawar and Imdad Rizvi [7] proposed an IoT Based Embedded System for Vehicle Security. The system is designed and developed using raspberry pi, a high-resolution camera, a vibration sensor and an open-source software. For face recognition, 'Local Binary Patterns Histograms' (LBPH) is used as it is simpler and gives better results in different light conditions. The internal part of the vehicle i.e., the key components of the vehicle (ignition system) will be handled by the controlling unit. The controlling unit and the owner's device are connected wirelessly and the other devices like sensors will be interfaced using wired media. If the image captured does not match with the existing database (includes only the

authorized members), an email of the picture is sent to the owner.

3. Proposed Solution

The idea behind this project is to implement a security system for vehicles using Raspberry pi which will help the owner to authorize the accessibility and keep a track of his vehicle through a mobile application.

The first step of this proposed system includes the face recognition technique using Raspberry pi which provides user authentication by verifying the real-time database of authorized users. The Raspberry pi is programmed using Python and connected to the real-time database.

Whenever a user tries to access the vehicle, Raspberry pi captures an image and verifies it with the real-time database to provide authentication. If the user details are not present in the database a notification is sent to the user on the mobile application. Whenever the owner detects a suspicious activity, he can get the current location of his vehicle on the mobile application through the GPS module installed in the project hardware circuitry.

When an unauthorized user is detected, Raspberry pi sends a signal to the relay circuit installed in the vehicle networking system. This detected signal cuts off the fuel supply to the engine hence, the mobility of the vehicle is restricted. Another important feature of this proposed system is the user-friendly mobile application. This application allows the vehicle owner to authorize the new user by adding user information into the real-time database and also allows users to view the database of authorized users.

Appropriate implementation of all the functions and methods proposed in this solution can build a secure system and provide foolproof protection against vehicle theft.

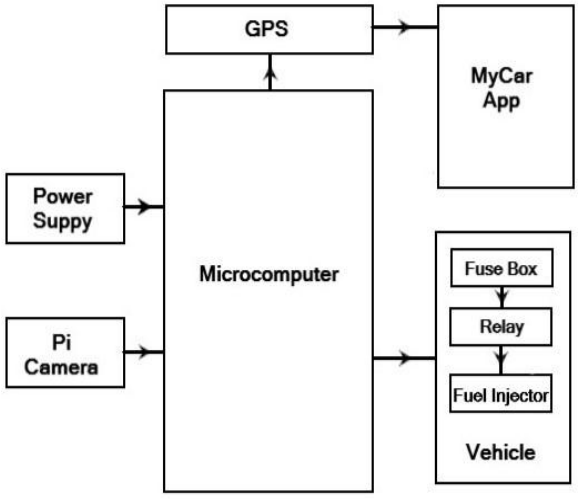

Fig-2: Proposed block diagram

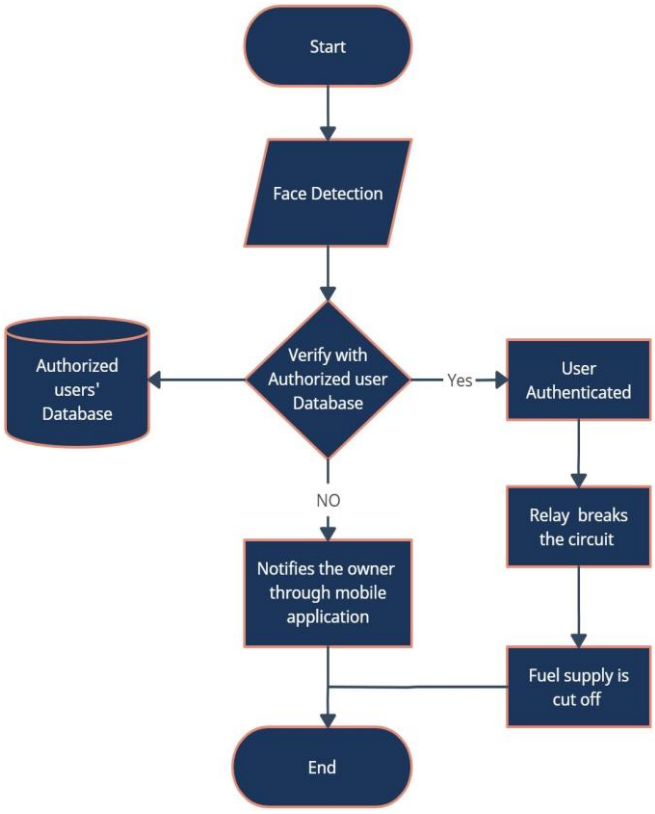

Fig-3: Flowchart of the system

4. Methodology

A. Hardware:

As a user enters the automobile, an image is captured using the pi camera. The Raspberry Pi includes pre-programmed code that compares the taken image to the existing user database created in Google's real-time database firebase. If the user's face matches one of the users in the database, the user is authorized and has control of the automobile; otherwise, the fuel supply to the car is cut off. The system will also send a notification to the authorized employees if an unknown user attempts to enter the car. In addition, the owner can use the mobile application to track the whereabouts of the vehicle. A GPS module will save the vehicle's current location in Google's database.

1) Raspberry Pi: The proposed system includes a Raspberry Pi to execute facial recognition, database connection, and to send notifications to the owner's phone via a mobile application. The user database is kept in the Raspberry Pi memory unit. The Raspberry Pi does image detection and recognition. It is also harnessed as a control platform for this project. In this system, we use the Raspberry pi 3B+ model that works on a 64-bit quad-core processor running at

1.4GHz, has a dual-band of 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and PoE capability via a separate PoE HAT. The Raspberry Pi 3 Model B+ maintains

the same mechanical footprint as both the Raspberry Pi 2 Model B and the Raspberry Pi 3 Model B.

2) Pi Camera: The Pi camera module is a portable lightweight camera that works with the Raspberry Pi. It communicates with the Raspberry Pi using the MIPI camera serial interface protocol. It is most commonly utilized in image processing, machine learning, and surveillance projects. The Pi Camera module is a camera that can be used to take photos and record high-definition videos. Raspberry Pi Board has CSI (Camera Serial Interface) interface to which we can attach the PiCamera module directly. This Pi Camera module can attach to the Raspberry Pi's CSI port using a 15-pin ribbon cable. Here, we have used Pi camera v1.3. It has a resolution of 5 MP and can capture wide, still (motionless) images of resolution 2592x1944 pixels.

3) GPS Module: The Global Positioning System (GPS) is a satellite-based navigation system that delivers position and timing information. Anyone with a GPS receiver and an unobstructed line of sight to at least four GPS satellites can use the system for free. A GPS receiver estimates its position by accurately timing the signals supplied by GPS satellites. The GPS module used in the proposed system is NEO-6M that has a position update rate of 5Hz, a rechargeable battery for Backup, EEPROM to save configuration settings, and an operating temperature in the range -40 to 85°CUART TTL socket. GPS is nowadays widely used and also has become an integral part of smartphones.

B. Software:

1) Face Recognition: A face recognition system is built using python libraries. OpenCV library is used for importing images and pandas library is used for data analysis. The face recognition library and OpenCV are used to process the images captured through the pi-camera. The python program uses Deep-Learning based facial embeddings which are highly accurate up to 99.38 percent and are capable of being executed in real-time. The face recognition library is a python package that wraps dlib's face recognition functions into a simple, easy-to-use API. It helps in training the model by obtaining the pattern and outlines of a person's eyes, nose, mouth, and chin.

2) Mobile Application: A mobile application integrated with the hardware has been built using Android Studio and Flutter which will perform the following three functionalities:

i) Accessibility notification:

After face detection, a notification is sent to the owner when an unauthorized user tries to access the vehicle. This notification is received on the mobile application integrated with the raspberry pi.

ii) Authorizing new users:

The mobile application has a user-friendly interface and provides the feature of authorizing a new user. The vehicle owner can authorize new users by adding their details to the real-time database. The owner has to click on the upload button present on the mobile application to send the photo to the database which contains the data of other authorized users.

iii) Vehicle Tracking:

The mobile application also provides the feature of location tracking. The owner can access the location of the vehicle at any time whenever a suspicious activity is detected. This tracking takes place through the GPS module connected to the raspberry pi. The GPS module sends the location in the form of latitude and longitude values to the real-time database and these values reflect the current location of the vehicle on the mobile application.

C. Car Immobilization Circuitry

In a vehicle circuitry, the fuse box is connected to several components under the hood of an automobile, one of which is the fuel injector. The ECU (Electronic Control Unit) is attached to one terminal of the injector, while the other is connected to the fuse box, which is connected to a 12V battery. ECU, the engine management system's heart, controls fuel delivery, air management, fuel injection, and ignition. Relays are electronic switches that open or close a circuit to control its flow. So an automotive relay is installed between the fuse box and the injector (figure 4). When the relay receives a signal about unauthorized access from raspberry pi it cuts off the fuel supply to the engine and restricts the mobility of the vehicle.

Relays are also used to control high voltage circuits using low voltage signals hence, to send signals to the vehicle's networking system through a low voltage signal device like raspberry pi a relay is used. The relay alone cannot be connected as the raspberry pi can give out a maximum of only 3.3V. Hence, a MOSFET is added to energize and de-energize the relay without damaging the raspberry pi.

After the face detection process, one of the two outcomes occurs: face recognized, not recognized. When the user's face does not match with the database, the raspberry pi gives a command to the relay which breaks the fuel injector circuit thereby cutting off the fuel supply to the engine.

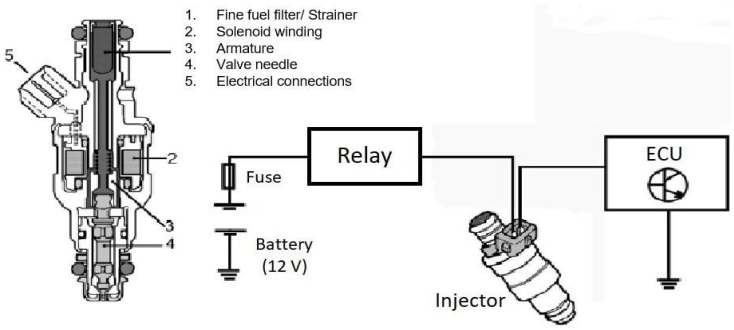

Fig-4: Fuel Injector circuit diagram [Source: < www.semanticscholar.org >]

5. Future Scope

The fuel injection circuitry of all commercial vehicles controlled by the ECU (Electronic Control Unit)are generally equipped with locks for protection to prevent the users from tampering with the circuit. In racecars, the case is slightly different; instructions can also be given to the ECU to tune and enhance the performance of the vehicle.

The On-Board Diagnostics (OBD) is a computer-based system included in all automobiles and trucks manufactured after 1996. ECU is the central part of the OBD system as it collects various data from the sensors and uses it to control different parts of the vehicle (eg. the fuel injector). Currently, the OBD is used only to read the status of a vehicle. In near future, this could be tweaked to receive instructions from the user to improve the performance and security of the vehicles.

In a commercial vehicle, different modes are available sports mode, power mode, etc. for efficient usage. Similarly, a new virtual mode, the "Theft Mode" could be added so that, whenever an unauthorized user tries to access the vehicle, the raspberry pi will send out specific codes given by the manufacturer to the ECU to turn on the Theft Mode. These codes will instruct the ECU to shut down the vehicle networking system or turn on the sleep mode.

For this to occur, the ECU should be able to function bi-directionally so that it can receive and execute the instructions accordingly. Introducing this feature to the ECU during the manufacturing stage itself will result in a reliable and infallible secure system.

6. Conclusion

This paper proposes an efficient Vehicle anti-theft system that includes Raspberry Pi as its core processing unit and GPS module. With the help of this system, we can reduce the vehicle theft issue significantly. It includes a Facial Recognition system and a mobile application which provides user-friendly features which will not only be useful to eradicate the theft but also provide additional features like authorization of new users by adding a new user to the database and tracking the location of the car. The Facial Recognition algorithm uses an efficient python program that gives excellent accuracy. In case of theft, when an unauthorized person tries to access the vehicle, our system provides an effective solution to prevent the unauthorized user from accessing the vehicle by adding a relay to the circuit thereby cutting off the fuel supply to the engine. By using this system, we can ensure the safety of the vehicles and can prevent the car from being stolen.

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