Vehicle security system with monitoring of homeostatic processes and user validation via bluetooth

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Abstract. This project consist in evaluating a series of specific and general situations and thus to be able to collect data using some device that facilitate the reception, processing and sending of information that, when combined, can ignite the vehicle whose purpose is to reduce the rate of citizen insecurity in a significant in Peru and Latin American countries where the index of traffic accidents and thefts is critical. The project will avoid that people in an ethyl state of with cardiac diseases and thieves can drive since these situations have already been foressen and thus we have discovered a great security system making only the owner can access the vehicle.

1. Introduction

The study of the following project seeks to generate solutions to the various problems that today are presented in the transport sector, among the most prominent are: thefts and accidents. The traffic accident rate worldwide and the percentage of vehicular accidents is obtained from figure 1.

![Figure 1. Deaths by traffic accidents according to the type of user (2013), by WHO región.](image)

First, the thefts are the product of the low level of security that vehicles possess, even the most recent models, which is why access and use by multiple users is very practical. For example, the ignition of a car executed by a thief is simple since it is not subject to recognition to distinguish who monitors the vehicle. Secondly, accidents are mainly the result of excessive consumption of alcohol, narcotics and the handling of pilots with abnormal levels of cardiac pressure.

Because anyone can be a victim of the theft of their vehicle, there is a need to invest in a good security system that protects the owner and the vehicle. Of course you can always count on the
traditional alarms, locks or bars for the steering wheel, pedals and naturally with the GPS; however, given that thieves vary their methods of robbery more and more, it has been thought with the present proposal to develop a security system that increases the robustness, using current technology. [1]

The data source of the problem to be solved was obtained from reliable pages (example: Ministry of transport and communications and the World Health Organization (OM). [2] The figure below shows that each year the number of accidents vehicular, which increases progressively and is reflected in the slope of the line after a linear regression.

![Figure 2. Statistical study of the increase in the number of accidents by vehicle according to the MTC.](image)

The accelerated development of the road system of our country and the increasing use of motor transport has produced a significant increase in travel by road and urban roads, to the extent that drivers, motorcyclists, cyclists, passengers and pedestrians, who coexist in the road infrastructure, depend more and more on road signs and safety devices, for their protection and information. To satisfy this need, it is essential to standardize road signs at national and international levels, and install safety devices that minimize the severity of the damage caused by accidents. [3]. The data shown in figure 2 are passed to excel, where you can obtain a graph whose trend you can see in the following equation that is a linear regression of figure 3.

\[ T(x) = 1912.98X - 376120.60 \]  \hspace{1cm} (1)

![Figure 3. Graph of the trend of vehicle accidents.](image)

![Figure 4. Percentage of the number of robberies according to social class.](image)

The figure 4 shows the percent of robberies according to social class, having in the upper class with 74% as main objective, since they have a greater purchasing power of having modern vehicles. However, today most do not take into consideration the vehicular safety and the indifference of the different automotive companies towards that sector, since currently the vehicles have many sensors that only facilitate the visualization of certain parameters of control and comfort; but it should be
realized that investments must be made in efficient and economical vehicle safety systems to reduce the percentage of thefts and traffic accidents.

Automobiles have a large number of sensors, the number of sensors varies between 60 and 70, which are necessary in the electronic management of the car. They can capture travel, position, rotations, speed, acceleration, vibrations, pressure, flow, temperature, among others and are used by the control units that manage safety, engine operation and vehicle comfort. The control and data processing units allow rapid evaluation of the aforementioned parameters. [4] However, it should be mentioned that these sensors have little average hope of avoiding accidents and robberies, before this a solution is sought. Currently, automotive companies, together with their research departments, focus on introducing new devices to the market that reduce the consequences of the impact in an accident and also reduce the likelihood of their occurrence. [5]

The total automation of driving and control over real vehicles has been considered a utopian idea that only some research groups around the world have dared to address. [6] The goal of machine learning is to design and develop algorithms that allow systems to use empirical data, experience and training methods to evolve and adapt to the changes that occur in their environment. [7]

Under this directive, this project seeks to contribute to the search and application of futuristic systems, which, although they are on the market, cannot all be used because of their high cost and the lack of knowledge of systems that provide safe driving for the driver. [8]

For the start of the project, it is sought to carry out a process of identification of the user to be driven and thus validate the process of action of the sensors. Being the user validation an important and decisive factor for any vehicle security system considering the access control.

The physical access control is focused on three questions: Who? When? and how?; that is, who is authorized to enter or leave? When will you enter or leave the area? and How will it be done? [9]

One of the fields that has registered the greatest evolution in recent years has been telecommunication systems, especially mobile telephony, which day after day offers more services to users. For example, IP telephony, data packets, Wi-Fi networks, text messages, multimedia messages, Bluetooth, music and video players, analog television, virtual banking, information systems, among others.

Within the communications landscape, wireless data transmission systems appear, these systems are particularly suitable for telemetry or portable computer applications, which allows mobility, with the advantages of being connected to a network. [10]

Nowadays the use of the mobile phone is such an integrated accessory and is so widespread and widespread, within the daily life of any user, since everyone has one, so that no one will have any inconvenience of use so no transitional behavior will be necessary nor will it be a radical or gradual change. [11] Therefore, the system is composed of a receiver activated from a transmitter by fingerprint of a mobile device through the Bluetooth connection to give access to the user’s test. With the correct reception we can calculate the distance of the device for this we take the RSSI signal and perform the following test: [12]

\[
\text{Distance} = 1 - 10 (\text{RSSI})^{5.4916}
\]

By analyzing the fingerprint as an identification method, it is possible to establish the importance that has been given within the security and business sector and in the proper administration of justice, avoiding impersonations and infiltrations that result in the leakage of information and loss of tangible resources intangible. [13]

After carrying out the identification process automatically, the sensors are activated. The operation consists of controlling the ignition of the vehicle as long as the sensors capture information that it considers optimal for driving. Among the components and sensors to be used is the ultrasonic sensor whose equation for determining the distance is as follows:

\[
\text{Distance} = \frac{\text{duration}}{2} / 29.1
\]
\[ f - 2f_e \frac{V}{V_s} \cos \theta = f_s - f_r \]  \hspace{1cm} (4)

If what is desired is to know the time that the wave takes from leaving the emitter until it reaches the receiver, the following equation should be used: [14]

\[ t = \frac{(d / \sin \theta)}{V_s + V \cos \theta} \]  \hspace{1cm} (5)

It is one of the most economic and smallest ultrasonic sensors that exists in the market and is still one of the best for its performance, it is stable, the error is so low reaching 3mm, it has a high precision and works with 5V (DC). [15]

A system used in almost all vehicles, is composed of a belt that goes over the hip and another that is arranged diagonally from the anchor point to the shoulder. [15] The abdominal and diagonal three-point belt is the safest and most commonly used in automobiles, trucks, minibuses, trucks and in the seats of bus drivers, while the two-point belt is the more usual for bus passengers. In recent years, seat belts have been integrated into the vehicle's general safety systems, which include devices such as pretensions, load limiters and airbags. [16]

In view of this, the pressure sensor is located in the band of the driver's chest, because the information provided by the pressure sensor when placed in the hip band would cause difficulty in receiving sensor data. To calculate the theoretical maximum heart rate (FCMT) of the person to drive, we resort to the following approximate expression [17]:

\[ 189.50 - 0.55 \times \text{age} \]  \hspace{1cm} (6)

With an average error of: \(+ / - 14.957 \text{ beats} \times \text{min} \).

And for the minimum determined by:

\[ \text{FCmin} = 208 - (0.7 \times \text{age}) \]  \hspace{1cm} (7)

For which the sensor measures approximate higher values of the person's pulse in 700, due to this the same amount is subtracted to be the actual number of pulses, then:

\[ \text{pulse} - 700 > 0 \]  \hspace{1cm} (8)

Also, it will send an activation signal to the determined Arduino of the following equation, which will deny driving to the user.

\[ I(\%) = 20 \times V_{OUT} (v) \]  \hspace{1cm} (9)

The purpose of this device is to find the successive moments of each heartbeat and calculate the interval of time between them called IBI (Inter-Beat Interval), making use of the predictable form and pulse wave pattern. [18]

![Figure 5](image)

**Figure 5.** Driver's blood alcohol level.

As we can see in the figure 5, from 0.6 of the level of alcohol in the blood the motor is affected, the movements are slowed down. There is a feeling of euphoria and confidence, aggressive and reckless driving by impulses without reasoning. And the following equation obtained from figure 5 is available [19].
\[ N(x) = 1.018 \times (8.2396^{-x}) \]  

The MQ-3 sensor is a sensor that measures the concentration of alcohol in the air. It acts as a resistance that varies according to the amount of alcohol detected; the higher the alcohol concentration, the lower the resistance. [20] In this way for the sensor we programmed that, if the value of alcohol in the blood of the person subtracted to the limit value of alcohol that can possess is greater than zero, determined by equation (11), it will send a pulse that will disable the vehicle to be driven.

\[ \text{value} \_ \text{alcohol} - \text{value} \_ \text{limit} > 0 \]  

![Graph and equation of the MQ-3 sensor.](image)

**Figure 6.** Graph and equation of the MQ-3 sensor.

By plotting some points of the previous alcohol curve of the MQ-3 sensor in the figure 6 and applying a linear regression, its characteristic equation is obtained: [21]

\[ \frac{mg}{L} = 0.354 \times \left( \frac{R_s}{R_o} \right)^{-1.518} \]  

\[ V_{out} = \frac{R_o}{R_o + R_s} x V_{cc} \]  

\[ \text{Level}OH = \frac{\text{alcohol} (g)}{\text{weight} (kg) \times 7} \]  

This project developed to provide greater safety when driving, avoiding vehicle theft because it has an Android application for user validation by fingerprint and password that in turn communicates via Bluetooth with the microprocessor for the activation of the different sensors that they monitor those homeostatic processes to determine the driver’s status and approve the ignition of the vehicle.

The range of the Bluetooth signal \( r \) is determined by:

\[ X^2 + Y^2 - 2aX - 2bY + a^2 + b^2 + r^2 = 0 \]  

2. Development

The project process operates under two stages: identification phase and data collection phase. The authentication phase consists in the activation of the circuit that will give access to the ignition of the vehicle under an interface connected via Bluetooth by means of a mobile device and the phase of data collection consists of the activation of the circuit with microcontroller to begin the measurements of proximity, alcohol and cardiac pressure.

The fingerprint, a reinforcement password and the measurements of the 3 sensors are used as process control variables to obtain an output function that in this case is the motor of the vehicle. Table 1 shows the aforementioned. Whose logic is denoted in table 2.

| Table 1. Control and output variables. | Table 2. Logic of our output function. |
|--------------------------------------|---------------------------------------|
| **input variables** | **output variables** |
| fingerprint | Motor |
| password | sensors |
| | | Huella digital | Contrasena | Sensores | Motor |
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 0 |
| 0 | 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 | 0 |
| 1 | 0 | 1 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 |
It is schematized by means of the Karnaugh map method in table 3, it is considered as a logical "1" in response to the correct conditions for the user to carry out the operation. In addition, the variable sensors are a simplified representation of the three sensors (proximity sensor, breathalyzer and heart pressure).

**Table 3. Map of Karnaugh.**

| A | B | C |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

Since the circuit is very large, it is best represented by a block diagram that simplifies the entire process.

A detailed explanation is noted, with which it is easy to understand the operation of each material used in this project that will collect information from time to time to determine the safety of driving and will validate the user by means of a fingerprint and password, which without them will not light the vehicle.

To have a better understanding of this project it is necessary to have a flow diagram shown in figure 7.

**Figure 7. Block diagram.**

The Arduino UNO has a series of facilities to communicate with a computer, another Arduino, another microcontroller or, as in this case, with a mobile device. The ATmega328 offers UART TTL (5V), a serial communication, which is available on digital pins 0 (RX) and 1 (TX). In addition, thanks to the Atmega16U2 firmware that uses the standard USB COM drivers, the board does not need any external driver and will appear on the computer as a virtual COM port.

3. Result
The result of this project is a large decrease in the rate of accidents and vehicle thefts whose expected range is 15% to 40%.

**Table 4. Comparison of the cost of materials.**

| Sensor     | Price | Others     | Price |
|------------|-------|------------|-------|
| QM3        | $3.00 | AL6000     | $30.00|
| HCSR04     | $4.00 | PR3015DN   | $30.00|
| SEN0386    | $4.00 | 027i       | $15.00|
|            | $11.00|            | $75.00|
There is greater control and precision in the collection of data necessary for the monitoring of the homeostatic processes of the driver

![Figure 8. percentage of accidents causes.](image)

4. Conclusions
It is possible to optimize any vehicle safety system by 41%, this is due to the considerable difference between the total number of accidents and the one that does not consider accidents due to alcohol in the blood, whose value is specified in figure 8.

It reduces costs by 76.4% and materials to obtain a system accessible to the general public obtained from table 4.

5. Observations
In the case of users who perform physical exercise and must use their car, the system will make it impossible to access the vehicle because it has a cardiac pressure that exceeds the limit considered normal.

If any incident related to cardiac pressure occurs, the system does not react in time.

6. Recommendations
Wait 5 minutes before driving the vehicle after exercising according to a study from the University of California.

Avoid calls and messages while driving the vehicle as this may cause concern or anger that alters the cardiac pressure.

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