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Development and implementation using Arduino and Raspberry Pi based Ignition control system

Fathima Jabeen A[1]
Research Scholar, Department of Instrumentation
S K University, Anantapur, Andhra Pradesh, India.

Dr. B. Ramamurthy[2]
Professor, Department of Instrumentation
S K University, Anantapur, Andhra Pradesh, India.

N.Anju Latha [3]
PDF. Department of Instrumentation
S K University, Anantapur, Andhra Pradesh, India.

Abstract

This paper proposes an ignition system for real time detection of driver's face recognition, finger print authentication as well as alcohol intoxication and subsequently alerting them. The main aim of this proposed system is to reduce the number of accidents due to driver's drowsiness and alcohol intake to increase the transportation safety as well as protect the vehicle from theft. This proposed system contains 8-megapixels digital USB camera, Raspberry-pi loaded. Face detection is the important part of this project will be done using Open CV. [2] [3].

Keywords: Drowsiness detection, Alcohol intoxication, face recognition, finger print authentication Raspberry pi, Open CV, Arduino UNO and GSM.

INTRODUCTION

A smart car is one which consists of several sensors which helps the driver to analyze the driving conditions such as terrain, environment conditions and engine temperature. These cars also have distance detection sensors to perform obstacle detection, and accelerometers for cruise control as well. Apart from this, cars also have a buttons to start the car, control the power windows, heads up display to play music and videos and the list goes on. With the dawn of Artificial Intelligence, automated cars have also gained importance [1].

Now-a-days, smart cars not only indicate luxury, but also have become a necessity. With the extreme competition between the automobile manufacturers, introducing new features in every edition of their cars has become the “success mantra”. Thus, many companies and universities around the world are working day and night to introduce new traits. One such attribute, which is most explored, is enhancing the security of the car. The usb camera used for face detection, the 8 MP camera capture the real time images and video. The captured frame is processed by Raspberry pi. Alcohol sensor (MQ-3) is used to detect the intake of alcohol in percentage if the intoxication matching fails GSM get triggered on and transmits warming message. The Raspberry-pi system board is serially interfaced with Arduino Uno. GSM, Bluetooth, relay circuitry and buzzers are interfaced with Arduino Uno. This will perform some task like the alarm notification and switching off the car power source.

LITERATURE SURVEY

The most commonly used security systems for a car namely steering wheel lock where locks are placed on the steering wheels. Hood Locks which locks the hood and can be opened only with a key. Tyre locks which are immobilizing locks for the tyres and are usually used by the policemen. Electronic immobilizers are electronic keys to ignite the engines of the cars these keys are usually driven by Radio frequencies (RFID). Kill switches are push buttons usually installed below the steering wheel of the cars. These get activated when the car is locked using electronic or RFID keys and shut down the ignition system completely. Car alarm systems can detect intrusions such as vehicle glass breakage, attempts to enter without a key and vibrations near the car. Once such invasion is detected, a huge alarm/noise is raised to alert the neighborhood.

Presently, Most of the cars have GPS systems installed which help the owners track their cars, all the time. Few tracking systems can be activated only by the police when the car is reported to be stolen. Apart from the above mentioned techniques, several other methods are also proposed. Using Internet of things to track the stolen car [2], installing keypad to enter the correct password to start ignite the engine [3], applying radio frequency technology to start the engine [4], drawing the right android pattern in air interface [5] can be few techniques that can be incorporated.

Biometric scans can be optional. Finger-print, Palm-print and finger knuckle print can be incorporated for enhanced security [6, 7]. Going a step ahead, face recognition algorithms can also be consolidated as an enhanced security feature. The present Paper [8, 9] proposes the principal Component Analysis by face recognition. The authors in [10] recommend Haar Transform for face feature extraction. Adaboost Technique is also proposed for face feature classification [11, 12].

The revolutionary algorithm for face detection, which combines both Haar Transform and Adaboost Technique, was proposed by Viola and Jones [13]. Further, the authors in [14] propose that skin tone colour in RGB and Viola-Jones algorithm can be implemented for a better face detection and recognition approach. These techniques are excellent algorithms when face recognition has to be done irrespective of variations in background. On the other hand, these techniques are computationally expensive. Thus, situations where in the background can be plain simple image processing techniques would suffice the need. The paper deals with two face recognition algorithms that can be implemented where the background variations in minimum, as in the case of car, behind the driver in the car.

Parameters included in the Smart Car

Face Recognition, Finger Print Authentication, Alcohol Detection

Face Recognition

[A] Mean based Face Detection Algorithm

A camera can be installed near the steering wheel in the car to capture the face of the driver. The face detection algorithm can be applied over the image captured to identify the driver is an authorised user or not. To perform the same, Mean Squared Error (MSE) method can be employed.

In MSE technique, the sum of the squared difference between two images is found out. The following pseudo code explains the working of MSE technique.

Step1: Read the **L**ive image (**L**)

Step 2: Read the **R**eference image (**R**)

Step 3: Convert both images to grayscale using the following formula [16],

$Gr = 0.299 R + 0.587 G + 0.114 B$

Step 4: Initialize the ‘error’ to be zero

Step 5: Subtract the pixels of L with pixels at same position of R and accumulate the squared errors obtained, i.e.,

Error = Error + [L (i, j) – R (i ,j)]^2

Where, i and j are represent the coordinates of the pixels.

Step 6: Calculate MSE by finding out the mean of squared differences, i.e,

MSE = error / (I*J),

Where I is total number of rows and J is total number of columns in the images.

If the MSE value obtained is zero, then it indicates perfect similarity between the live and the reference images. As the difference between both images increases, the similarity score, as assigned by MSE also increases.

As the MSE method works on the entire image, there arises a high chance of obtaining erroneous MSE value. This technique gives out absolute error. This method considers contrast or brightness changes between live image and reference image. Thus, Structural Similarity Index is considered to be the similarity score.

[B] Structural Similarity (SSIM) Index

Structural Similarity (SSIM) Index is a technique of understanding the perceived change in the structure of the image. Unlike MSE method, SSIM works on windows, wherein only few pixels of the image are considered and similarity score is estimated. Thus, changes in contrast or brightness between the live image and the reference image will be ignored. The algorithm for SSIM is as follows:

Step1: Read the live image (L)

Step 2: Read the reference image (R)

Step 3: Convert both images to grayscale.

Step 4: Place NxN windows on the images L and R.

Step 5: In image L, for the given window, find out mean (m_L) and variance (v_L) of the pixels lying within the window.

Step 6: In image R, for the given window, find out mean (m_R) and variance (v_R) of the pixels lying within the window.

Step 7: Calculate the covariance (v_{LR}) between both the windows of L and R.

Step 8: To stabilize the division with weak denominators, calculate the constants k_1 and k_2.

Where , $k_1 = 0.01 * (2^8 – 1)$ and

$k_2 = 0.03 * (2^8 – 1)$

Step 9: Calculate SSIM using the formula,

$$SSIM\,(L,R) = \frac{(2m_L\,m_R + k_1)(2\,v_{LR} + k_2)}{(m_L{}^2 + m_R{}^2 + k_1)((v_L{}^2 + v_R{}^2 + k_2)}$$

The SSIM score approaches 1, when the similarity between the images is high.

For enhancing the security of the system furthermore, biometric systems can be incorporated. In this work, a finger print authentication has also been added.

Camera Interface

The USB camera module (as shown in the Figure 4) used in this project . The camera plugs directly into the USB connector on the Raspberry Pi. It's able to deliver clear 8MP resolution image, or 1080p HD video recording

Fig 1: USB Camera

Finger Print Authentication

It is a well-known fact that the finger print of an individual is unique. Each print pattern includes two main features: ridges and minutia points. The former feature is found to be hereditary, thus individuals belonging to a family will have same ridge patterns. On the other hand, minutia features consider ridge endings, bifurcation of the ridges and short ridges, which are found to be unique. Thus minutiae based matching algorithm is applied for finger print authentication.

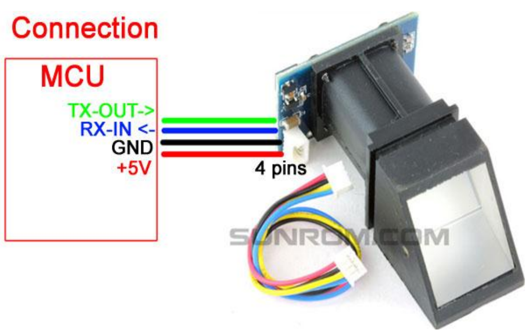

Fig 2: Fingerprint recognition (Biometry)

A fingerprint scanner system has two basic jobs, it needs to get an image of the finger, and it needs to determine whether the pattern of ridges and valleys in this image matches the pattern of ridges and valleys in pre-scanned images.

Alcohol Detection:

For the safety of the driver and passengers, an alcohol test can be performed. After two-stages, authentication of face and fingerprint recognition, the driver is requested to blow into a gas sensor. The MQ-3 gas sensor is used for alcohol detection. These are also known as Breathalyzer or Breathe content (BrAC). We can determine the driver consumed alcohol or not by the percent of BAC in blood of driver.

MQ BrAC values can be converted to

BAC.0.1% BAC = 1000 mg/L

If the sensor senses the value greater than a particular threshold, this implies that the driver is drunk. In such case, the car engine would not get ignited.

Fig 3: MQ-3 gas sensor

HC-05 Bluetooth Module

Bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz) from fixed and mobile devices and building personal area networks (PANs). Accessing range of HC-05 is approximately 10 Meters (30 feet). HC-05 is a capable module that can be set to be either Master or Slave. This HC-05 module runs on 3.3V power and interface to Arduino signal levels with interface technique of level shifting.

The HC-05 module includes the Radio and Memory chips, 26 MHz crystal, antenna and RF matching network. The right section of the BT Board has connection pins for power and signals as well as a 5V to 3.3V Regulator, LED and level shifting.

Fig 4 : HC-05 Bluetooth

Key, Forces AT Command Setup Mode for configuring the settings of Bluetooth, if the terminal is made high before powering the BT module, VCC (5V), GND, TXD (Transmit Serial Data from HC-05 to Arduino Serial Receive), RXD (Receive Serial Data from Arduino Serial Transmit) and STATE (Tells if connected or not).

The data rate of the module with Baud Rate of 9600 bps, 8 bit data, 1 stop bit, no parity, no handshake, Passkey is 1234.

Raspberry Pi

Raspberry Pi (RPi) 2 Model B is a credit card sized, single board computer 900 MHz quad-core ARM Cortex-A7 processor and has 40 General Purpose Input/output (GPIO) pins. It has a 1GB RAM. A 16GB microSD has the Linux (Raspbian) OS installed, which is inserted into the MicroSD card slot. A micro SDHC card can be inserted into the SD card slot of RPi, on which the OS (preferably Raspbian – Linux) is installed. Python is used for programming the RPi, which acts as the control system of the model. The device is powered by a 5V micro USB, with an ampere rating of 2A. A monitor with an HDMI port can be used as display and USB-based keyboard and mouse can be used to control the RPi. Since the monitor has touch interface, the USB cable for touch has to be connected to the USB port of RPi. Usually in order to work with RPi, the user has to be logged in. The default credentials are:

Username: pi

Password: raspberry

The RPi does not have inbuilt Bluetooth. Thus, a Bluetooth dongle has to be connected and configured. The HC-05 is then paired with the dongle to receive the data sent by the Arduino.

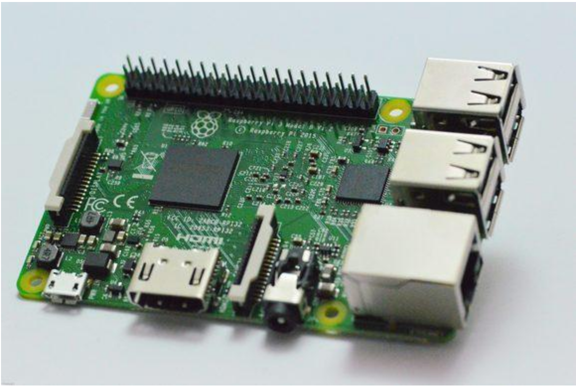

Fig 5: Raspberry Pi model

Arduino AT mega 2560

All the sensors and modules are connected to the micro controller board. An Arduino Mega micro controller board has been employed for the work conducted [7]. This micro controller is based on the ATmega 2560 processor. This has 54 input/output digital pins and 16 input/output analog pins.

This houses a 16MHz crystal oscillator. Flash memory up to 256 kB is available. The experimental set up as shown in fig.

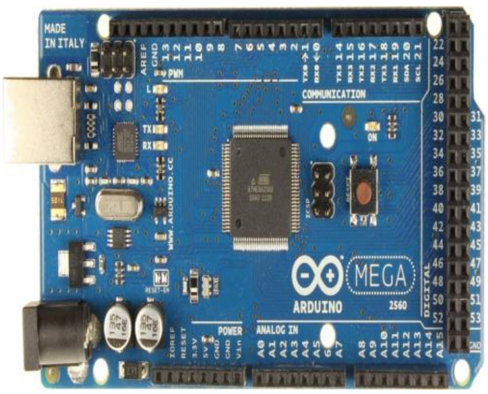

Fig 6: Arduino AT mega 2560

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GSM Module

The GSM-SIM900 module uses a Subscriber Identity Module (SIM) card issued by a network provider, which offers GSM/GPRS 900/1800MHz coverage. The GSM libraries have to be attached in the program for the Arduino, so that Arduino can communicate with the GSM shield/module. Here, dual band SIM900A is utilized.

Fig 7: GSM Module

Implementation and Results

The Raspberry Pi and Arduino Uno microcontroller board are used for the implementation of the flow mentioned above, as shown in Figure 2. The camera is connected to the Raspberry Pi 2 board. The algorithm was realized using Python 3.1 and Open CV package. The algorithm was tested was around 15 trials. Out of which 13 were successful. The position of the face plays an important role in this algorithm, thus the face should be placed at the same place every time for authentication. Table 1 showcases the average results obtained.

The fingerprint scanner and the alcohol sensor (MQ3) are connected to Arduino board. The Arduino board send the details of fingerprint and alcohol tests to the Pi through serial port. If all three tests are passed, then the display shows "Verified", else "Not verified" is displayed.

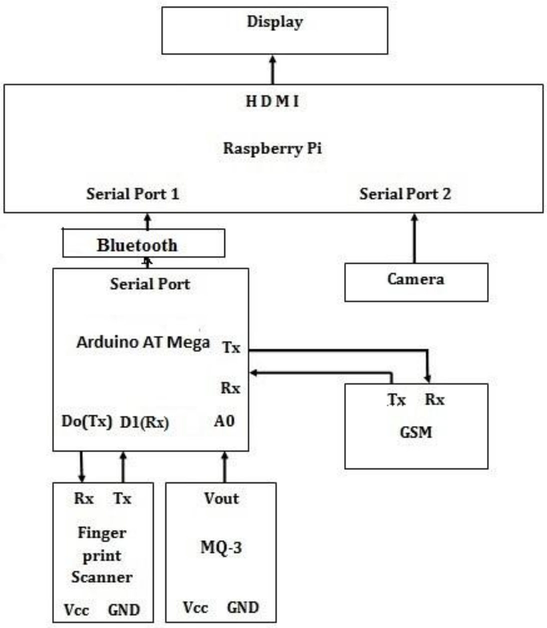


Fig 8: Implementation block diagram

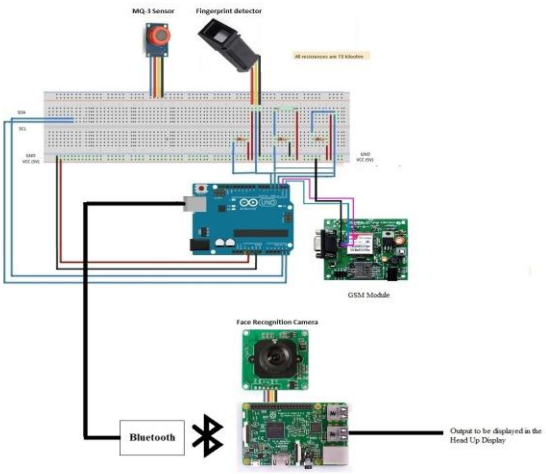


Fig 9: Experimental Set up

<u>Face Recognition</u>

Table 1: Face recognition results

Live Image	Reference image	MSE	SSIM
		2356	0.8679
		6581	0.2488

To perform our comparison, we made use of the Mean Squared Error (MSE) and the Structural Similarity Index (SSIM) functions. While the MSE is substantially faster to compute, it has the major drawback of (1) being applied globally and (2) only estimating the perceived errors of the image. On the other hand, SSIM, while slower, is able to perceive the change in structural information of the image by comparing local regions of the image instead of globally. In general, SSIM will give you better results, Not surpassingly, the original image is identical to itself, with a value of 0.0 for MSE and 1.0 for SSIM. Remember, as the MSE *increases* the images are *less similar*, as opposed to the SSIM where *smaller values* indicate *less similarity*.

<u>Finger Print Authentication</u>

The fingerprints captured for biometric use require further processing. This is not the case with those fingerprint capture for security vetting process which does not any process but saved directly into relational database together with personal details. Security vetting process requires the total in biometric system, input fingerprint image is processed to skeleton image levels and then features are extracted from the said thinned image. Biometrics fingerprint image processing (Digital image processing) stages includes fingerprint capturing, normalization, segmentation, enhancement, thinning and minutiae extraction as shown in figure

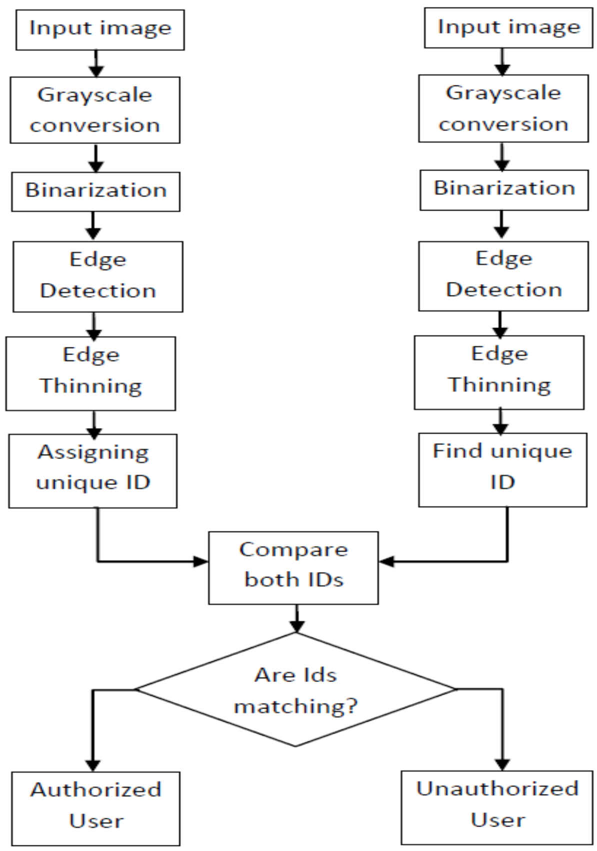


Fig 9: Flowchart of Finger Print Recognition

Only specific characteristics, which are unique to every fingerprint, are filtered and saved as an encrypted biometric key or mathematical representation. No image of a fingerprint is ever saved, only a series of numbers (a binary code), which is used for verification. The algorithm used cannot be reconverted to an image, so no one can duplicate your fingerprints

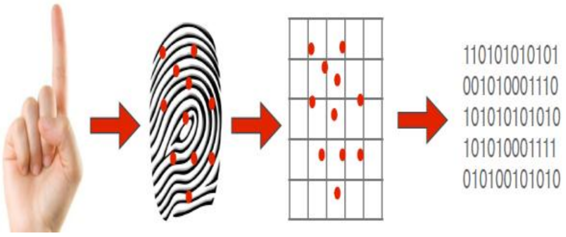


Fig 10 Optical Fingerprint Scanner

An optical fingerprint scanner has been utilized for this work. The image sensor within the scanner captures the image of the fingerprint. Initially, all the fingerprints are enrolled. In the enrolment stage, fingerprints of different individuals are stored. The image is converted to grayscale. Binarization of the image is carried out such that the ridges get converted to black and the furrows to white. For further enhancement, edge detection is performed. Next, the minutiae extraction is performed by image thinning process. The ridges are processed and marked with a unique identification number.

During the verification phase, the process from grayscale conversion till image thinning has to be performed. Based on the extracted minutiae, an identification number is obtained. If the obtained number corresponds to the unique identification number assigned during enrolment, then the finger print is considered to be authorized.

Alcohol Detection

The Alcohol sensor MQ-3 is selected in this system due to its high sensitivity in detection and has good resistance to disturb of gasoline, smoke and vapor. The sensor able to detect Blood Alcohol Content (BAC) with different concentration and classified to the range of BAC detected into a few level. Alcohol sensor MQ3 is suitable for detecting alcohol concentration just like our common breathalyzer. It has a high sensitivity and fast response time. Sensor provides an analog resistive output based on alcohol concentration which is given to inbuilt ADC of microcontroller.

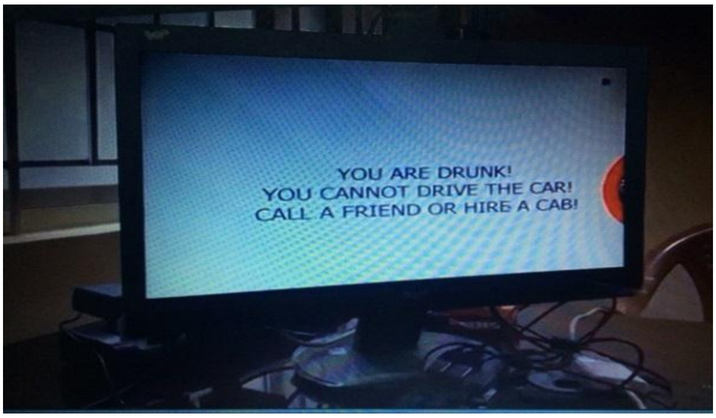
The system begins to operate when the alcohol sensor detected BAC level from the driver. Then it will send the signal to Arduino AT mega for further process which will involve the display, alarm and ignition system. BAC level detected by alcohol sensor is based on gas/ alcohol concentration in ppm (parts per million).

This system is tested by alcoholic drinks/after shave lotion as the input to the experiment. The alcohol sensor can sense an alcohol from human breath from 0 ppm until 1000 ppm. In this system is the alcoholic intoxication is displayed in the percentage, for that purpose we program as per our condition that voltage samples is converted into percentage using Mapping Concept. The result is categorized into three conditions of the driver with different value (in percentage) of BAC level which are intoxication, drunkenness and over limit drunk.

Table 2: Alcohol Detection

Output	Level of Drunkenness		
	0% - 25%	**26% - 50%**	**51% - 99%**
Dispaly	Intoxication	Drunkenness	Over limit Drunk
Ignition System	Enable	Enable	Disable
SMS by GSM	No	No	Yes

Fig 11: Alcohol Detection Output Display



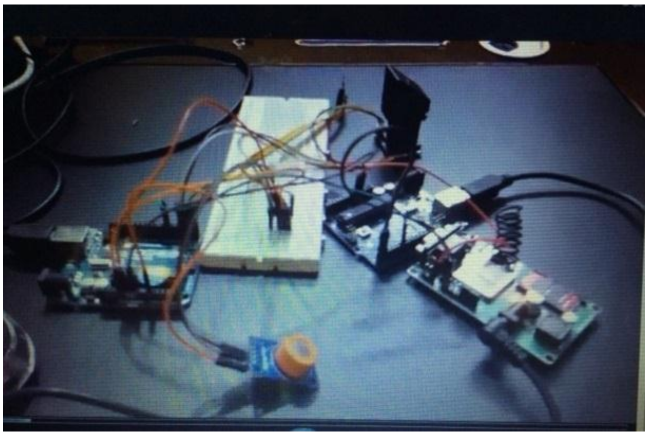


Fig 12: Output Display & Experimental set up

CONCLUSION

The prototype is successfully designed and tested. The objectives of the project are satisfactorily realized. Following are the major results obtained.

An advanced system is designed the protection of vehicles from theft and other hostile conditions becomes important due to insecure environment.

1. One level of ensuring authentication of driving is through finger print recognition system that authenticates a user being an authorized person to have access to the ignition system.
2. Real time vehicle security system based on computer vision provides a solution to this problem. The proposed vehicle security system performs image processing based real time user authentication using face detection and recognition techniques and microprocessor based control system fixed on board with the vehicle.
3. Automatic locking of vehicles on the alcohol detection.

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