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Design and Implementation of Automotive Security System using ARM Processor

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Abstract*—.Automotive theft has been a persisting problem around the world and greater challenge comes from professional thieves. Modern security can be deceived by professional thieves therefore a need of biometric authentication technology arises in automotive vehicles. Traditional automotive security systems rely on many sensors and cost a lot. When one vehicle is really lost, no more feedback could be valid to help people to find it back. In this paper, we present an immobilizer automotive security system that disables an automobile when lost. The system automatically takes photos of driver and compares his or her face with database to check whether he is an authenticated driver or not. He can have access to the vehicle only if he is an authenticated driver. If he is not an authenticated driver access to the vehicle will not be provided. Also, the owner of the vehicle gets an image of the theft via MMS (Multimedia Messaging Services) which is an additional feature of the given system. It hence deters thieves from committing the theft.

Index-Terms—**Face Recognition, PCA, ARM, GPS, GSM, MMS.**

I. INTRODUCTION

With the development of automobile industry, motor vehicle theft has increasingly become prominent issues. According to National Insurance Crime Bureau (NICB), National wide in 2010, there were an estimated 1.2 million motor vehicle thefts, or approximately 416.7 motor vehicles stolen for every 100,000 inhabitants. Property losses due to motor vehicle theft in 2010 were estimated at $7.6 billion [1].

Currently, automobile manufacturers use computer chips and other common security methods to ensure that even complete copy of the original vehicle mechanical keys, can only open the door, but cannot start the vehicle. However, there is a variety of vehicles decoder on the market, and the thieves can use the decoder to replicate the electronic chip keys, which can start the vehicle, in just a few minutes. Such as the decoder, which used the latest intelligence decoder chip developed by the United States, can unlock the most electronic locks of Mercedes Benz, BMW, Audi, Ferrari and other high-end models. Thus, it will be the sticking point of vehicle alarm to lock or unlock engine, through authenticating the identity legality.

There are different biometric technologies which are unique and invariant for a very long time, such as fingerprint, iris, palm print, palm vein, hand vein, finger vein, face, knuckle creases, hand-type and so on, which all can be used as the basis of authentication and the various biological characteristic have their own advantages and disadvantages. Compared to other biometric techniques advantages of face recognition includes

1) It doesn't require physical interaction.
2) It allows passive identification.
3) It doesn't require expert to interpret the comparison.

Thus, we have chosen Face Recognition as a biometric technology for security purpose.

II. SYSTEM OVERVIEW

The hardware implementation of automotive security system was done by making use of ARM 7. The block diagram for the hardware is shown in Figure1. A webcam will be placed in front of the driver seat. When the driver inserts key into the lock, the ARM 7 generates an interrupt signal which starts the image processing application on PC. After a fixed time interval, the web camera will take the photo and that photo will get processed in the application. Finally, the application will detect whether the driver is authorized or not. If he is not authorized, the ARM 7 will disable the access to vehicle by disconnecting the battery connections and ignition unit. The GPS module finds the exact location of the vehicle. Also, the MMS modem will send the snap of theft and the location co-ordinates to the owner's registered mobile.

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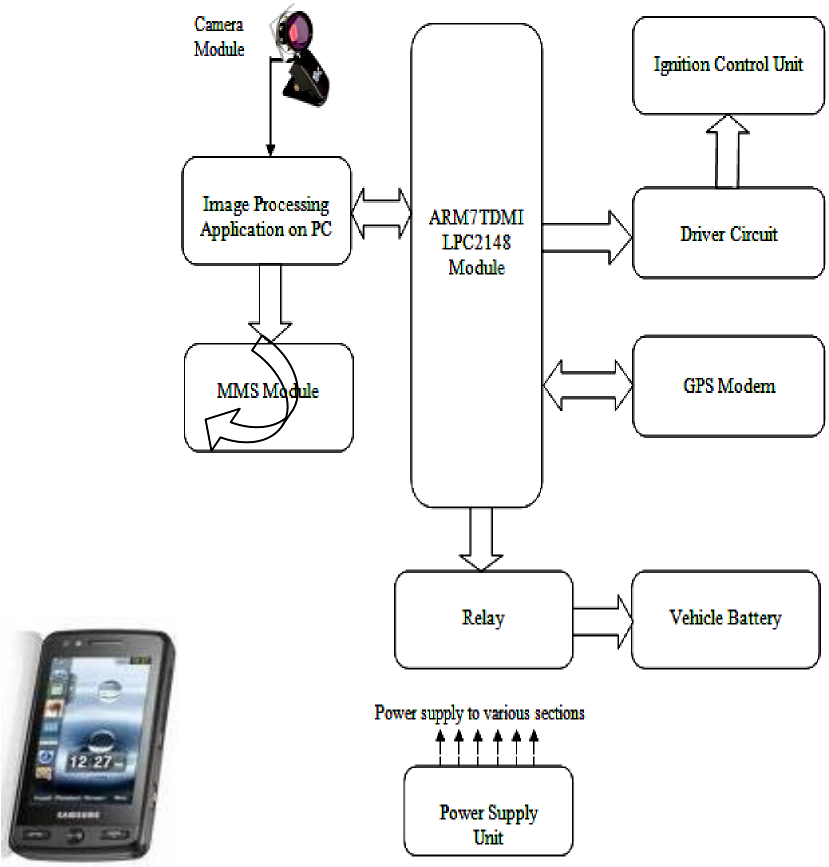

Fig 1. Block Diagram of Automotive Security System

III. IMPLEMENTATION

A. Face Detection Subsystem

The Face Detection Subsystem (FDS) involves,

Image Acquisition Subsystem

Image understanding starts with image acquisition. The purpose of image acquisition is to acquire the video images of the driver face in real time. A camera installed in the vehicle, which capture image and sent it to face detection and face recognition stage. The acquired images should have relatively consistent photometric property under different climatic ambient conditions and should produce distinguishable features that can facilitate the subsequent image processing. In real vehicles, a moving vehicle presents new challenges like variable lightening, changing background and vibrations that must be haven in mind in real systems. The image data is transmitted to the Face Detection System by USB channel.

Face Detection

The process of face detection used for the system presented in this paper is robust and rapid. Face detection algorithm extracts face portion alone from the photo taken by a webcam. At first, we get the location of the eye pair easily due to brighter pupil effect. After the location of eye pair, we can easily clip the face area from the input image according the spatial relationships between eye pair and face.

Face Recognition

In face recognition, validation of the input image is done .i.e. it involves comparing the input face with the faces in the database. Photos in the database is called training images and the photo taken during authentication phase is called as test image. Human face recognition belongs to a general classification problem with the characteristics limited spanning space. A lot of different approaches were present in the last years in the field of face detection methods development in recent years. The state of the art techniques are appearance based methods which includes also a lot of different approaches for face recognition. These methods cover Hidden Markov Models (HMM),

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Neural Networks (NN), Support Vector Machines (SVM), and Principal Component Analysis (PCA). We give a comparison over the above methods in the Table1.

Table1. Comparison of different Face Recognition approaches [5][6].

Sr. No.	Technique	Accuracy
1.	HMM	≈ 84.00%
2.	PCA	≈ 98.50%
3.	Neural Networks	≈ 95.60%

We can conclude from it that the PCA Eigen faces algorithm can give a high accuracy. Again it costs less time than the other two algorithms that is very important in real time embedded applications. In our embedded automotive security system, the PCA Eigen faces algorithm is used for driver's real time face recognition.

B. MMS Module

An MMS message can contain any combination of graphics, photographic imagery and audio. MMS makes it possible for mobile users to send these multimedia messages from MMS-enabled handsets or modems to other mobile users and to e-mail users. It also makes it possible for mobile users to receive multimedia messages from other mobile users, e-mail users and from multimedia enabled applications. The WAVECOM's Fastrack M1306B MMS Module is used in this system. This modem is used in the GPRS mode to send images of the driver. So the owner and the police can be informed at the first time.

C. Embedded Module

The embedded module is the heart of this system. All process is controlled by the embedded control central module ARM 7; include initiating the Face Detection System, achieving GPS information sending SMS messages and communicating with Engine Control Unit (ECU).
The Advanced RISC Machines (ARM) LPC 2148 is used in this system. It is a general purpose 32 bit microcontroller which offers high performance for very low power and consumption and cost. This has made them dominant in the mobile and embedded electronics market as relatively low cost and small size.

D. GPS Module

The Global Positioning System (GPS) modem is the receiver that collects data from the satellites and computes its location anywhere in the world based on information it gets from the satellites. It provides reliable positioning, navigation and timing services to worldwide users on a continuous basis in all weather, day and night.
We have chosen MT3318 GPS Module to offer the location of the vehicle in time. It has UART (Universal Asynchronous Receiver/Transmitter), which is used to communicate with many other embedded devices.

E. Engine Control Unit

An Engine Control Unit (ECU) is a type of electronic control unit that controls a series of actuators on an internal combustion engine to ensure the optimum running. The embedded module ARM 7 is responsible for switching ON/OFF the ECU.

IV. PRINCIPAL COMPONENT ANALYSIS (PCA)

A. Algorithm

The PCA algorithm is based on an information theory approach that decomposes face images into a small set of characteristic feature images called "Eigen faces," which may be thought of as the principal components of the images in database. Recognition is performed by projecting a new image into the subspace spanned by the Eigen faces ("face space") and then classifying the face by comparing its position in face space with the position in face space with the positions of known individuals. The flowchart for PCA algorithm is shown in Figure2. Each individual face can be represented exactly in terms of a linear combination of the Eigen faces. Each face can also be approximated using only the "best" Eigen faces—those that have largest Eigen values, and which therefore account for the most variance within the set of face images. The best M Eigen faces span an M-dimensional subspace—"Face space"—of all possible images.

B. Flowchart

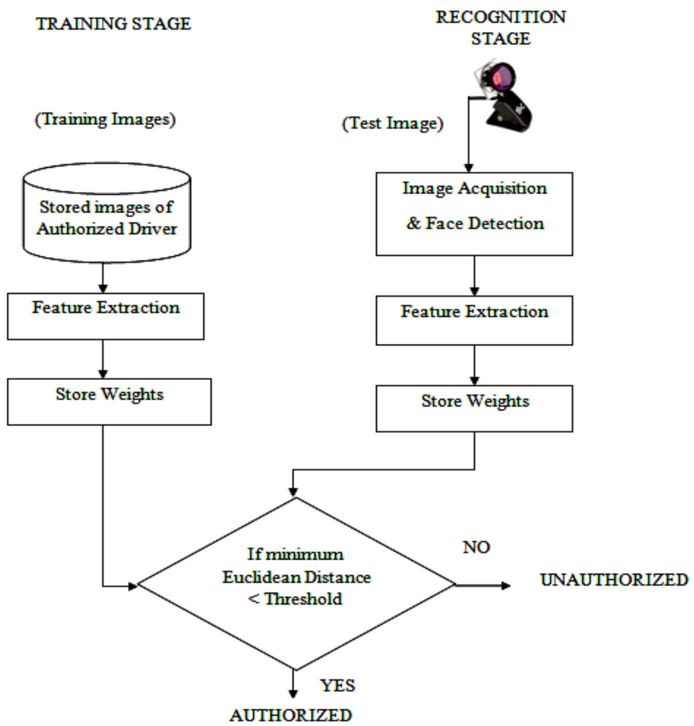

Fig 2. Flowchart of PCA Algorithm

C. Steps for PCA Algorithm

1. Acquire an initial set of face images as shown in Figure3 i.e. the training set.

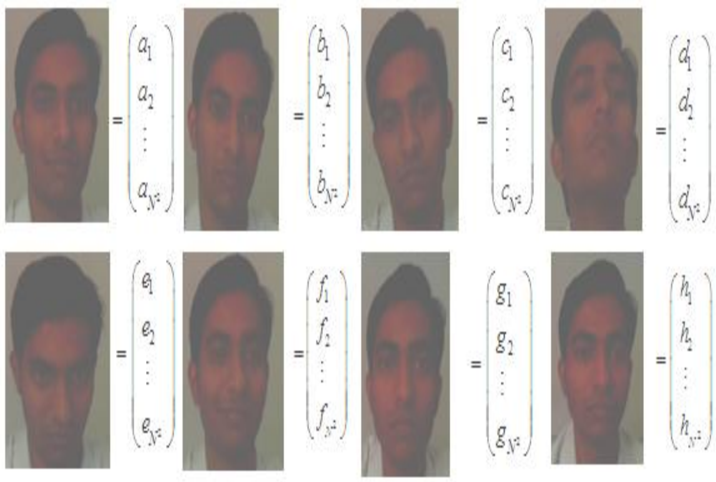

Fig 3. Database images

2. Compute the average face.

$$\vec{m} = \frac{1}{M}\begin{pmatrix} a_1 & +b_1 & +\cdots+h_1 \\ a_2 & +b_2 & +\cdots+h_2 \\ \vdots & \vdots & \vdots \\ a_{N^2} & +b_{N^2} & +\cdots+h_{N^2} \end{pmatrix}, \quad Here,\ M = 8 \qquad (1)$$

Where, M = Number of images in the database.
N = Size of an image.

3. Subtract the average face from training faces.

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$$\vec{a}_m = \begin{pmatrix} a_1 - m_1 \\ a_2 - m_2 \\ \vdots \quad \vdots \\ a_{N^2} - m_{N^2} \end{pmatrix}, \quad \vec{b}_m = \begin{pmatrix} b_1 - m_1 \\ b_2 - m_2 \\ \vdots \quad \vdots \\ b_{N^2} - m_{N^2} \end{pmatrix}, \quad \vec{c}_m = \begin{pmatrix} c_1 - m_1 \\ c_2 - m_2 \\ \vdots \quad \vdots \\ c_{N^2} - m_{N^2} \end{pmatrix}, \quad \vec{d}_m = \begin{pmatrix} d_1 - m_1 \\ d_2 - m_2 \\ \vdots \quad \vdots \\ d_{N^2} - m_{N^2} \end{pmatrix}, \tag{2}$$

$$\vec{e}_m = \begin{pmatrix} e_1 - m_1 \\ e_2 - m_2 \\ \vdots \quad \vdots \\ e_{N^2} - m_{N^2} \end{pmatrix}, \quad \vec{f}_m = \begin{pmatrix} f_1 - m_1 \\ f_2 - m_2 \\ \vdots \quad \vdots \\ f_{N^2} - m_{N^2} \end{pmatrix}, \quad \vec{g}_m = \begin{pmatrix} g_1 - m_1 \\ g_2 - m_2 \\ \vdots \quad \vdots \\ g_{N^2} - m_{N^2} \end{pmatrix}, \quad \vec{h}_m = \begin{pmatrix} h_1 - m_1 \\ h_2 - m_2 \\ \vdots \quad \vdots \\ h_{N^2} - m_{N^2} \end{pmatrix},$$

4. Build the matrix,

$$A = \left[\vec{a}_m \; \vec{b}_m \; \vec{c}_m \; \vec{d}_m \; \vec{e}_m \; \vec{f}_m \; \vec{g}_m \; \vec{h}_m \right] \tag{3}$$

Size of matrix A will be N^2 x M.

5. Find the Co-variance matrix.

$$Cov = AA^{T} \tag{4}$$

Size of Co-variance matrix will be N^2 x N^2.

6. Find the Eigen values of the co-variance matrix.
   But, its size is large and hence, the computational efforts will be large.
7. Compute another matrix L.

$$L = A^{T}A \tag{5}$$

Size of matrix L will be now M x M.

8. Find the Eigenvectors of matrix L and build matrix V.
9. These vectors determine the linear combinations of the M training set face images to form the M Eigen faces.

$$U = AV \tag{6}$$

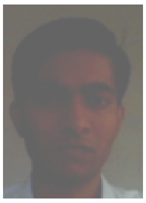
10. For each face, compute its projection onto the face space.

$$\Omega_1 = U^{T}(\vec{a}_m), \quad \Omega_2 = U^{T}(\vec{b}_m), \quad \Omega_3 = U^{T}(\vec{c}_m), \quad \Omega_4 = U^{T}(\vec{d}_m),$$
$$\Omega_5 = U^{T}(\vec{e}_m), \quad \Omega_6 = U^{T}(\vec{f}_m), \quad \Omega_7 = U^{T}(\vec{g}_m), \quad \Omega_8 = U^{T}(\vec{h}_m) \tag{7}$$

11. Compute the threshold θ.

$$\theta = \frac{1}{2} \max \left\{ \left\| \Omega_i - \Omega_j \right\| \right\} \quad for\ i, j = 1..M \tag{8}$$

12. Acquire an input image. The input image is shown in Figure4.



$$= \begin{pmatrix} r_1 \\ r_2 \\ \vdots \\ r_{N^2} \end{pmatrix} \tag{9}$$

Fig 4. Test Image

13. Subtract the average face from it.

$$\vec{r}_m = \begin{pmatrix} r_1 - m_1 \\ r_2 - m_2 \\ \vdots \quad \vdots \\ r_{N^2} - m_{N^2} \end{pmatrix} \tag{10}$$

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14. Compute its projection onto the face space U.

$$\Omega = U^{T}(\vec{r}_m) \quad (11)$$

15. Compute the distance in face space between the input face and all the known faces.

$$\varepsilon_i^2 = \|\Omega - \Omega_i\|^2 \quad for\ i = 1..M \quad (12)$$

16. Reconstruct the input face from the Eigen faces.

$$\vec{s} = U\Omega \quad (13)$$

17. Compute the distance in face space its reconstruction

$$\xi^2 = \|\vec{r}_m - \vec{s}\|^2 \quad (14)$$

18. The following conditions are checked and the results are derived from it.

Table2. Classification of image

Sr. No	Conditions	Results
1.	If, $\xi \geq \theta$	Not a face.
2.	If, $\xi < \theta\ and\ \min\{\varepsilon_i\} < \theta, (i = 1..M)$	Known face.
3.	If, $\xi < \theta\ and\ \varepsilon_i \geq \theta, (i = 1..M)$	New face.

V. EXPERIMENTAL RESULTS

In this project, the real time face recognition is achieved using PCA algorithm.
Figure5 shows the experimental result of MATLAB 7.10.0®, when the test image belongs to the database images as shown in Figure3.

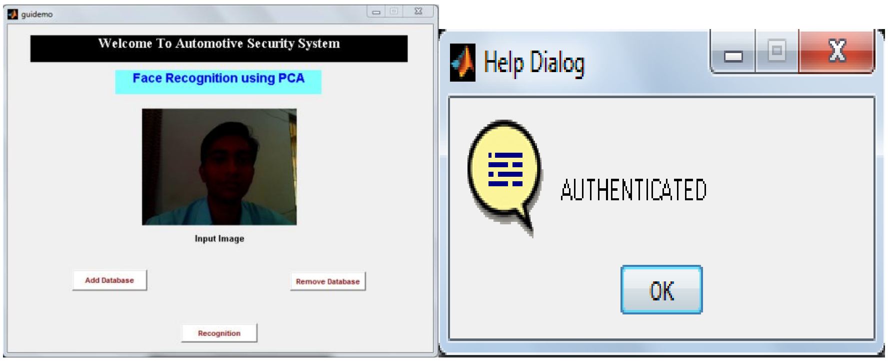

Fig 5. Recognition of Authorized Image

Figure6 shows the experimental result when the theft tries to start the vehicle.

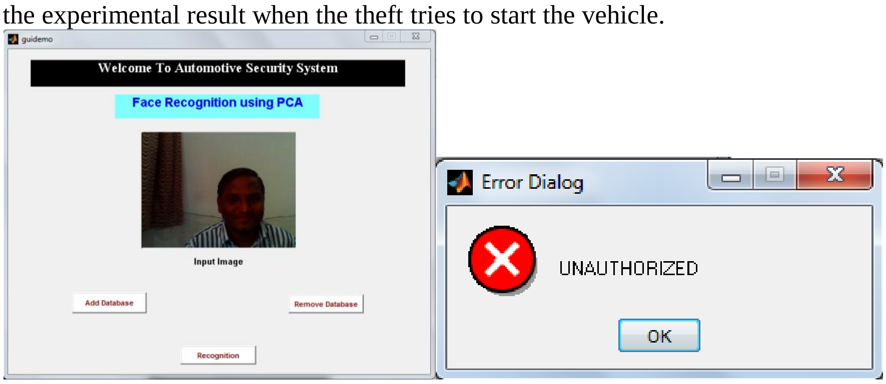

Fig 6. Recognition of Unauthorized Image

The figure7 shows the MMS structure which has been send to the owner's mobile from the vehicle.

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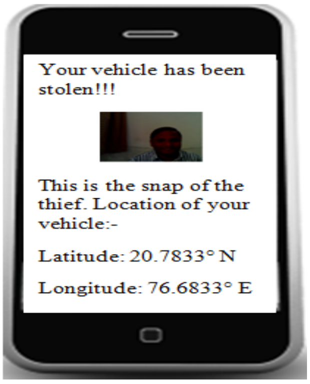

Fig 7. MMS Structure

VI. CONCLUSION

An embedded automotive security system is presented in this paper. Face recognition is a both challenging and important recognition technique. It has been shown that a proposed system can be implemented at any types of automobiles and can be used at any place where face recognition is needed. This system reduces increased amount of vehicle theft present today. Comparing with traditional automotive system, this system does not need any sensor, and thus it is highly reliable.

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