

EIGENFACES BASED FACE RECOGNITION DEVICE FOR VISUALLY IMPAIRED PERSONS

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Abstract - This paper proposes to develop an embedded system based instrument for visually impaired, it is a wearable device in the form of badge holder of the patent which is designed using Raspberry Pi in addition with visual and hearing sensor. This system works to detect the human faces. With this help user can identify the person in front of the vision sensor. Open CV computer vision and machine learning libraries were used to simulate a system that aids the blind person to recognize his family and friend's facial images that are stored in a database, and if a match is found in the database, the system will announce the name of the person via sound sensor to

the blind person. Further for this system modelling we used various algorithms. Viola-Jones object detection framework as known as Haar-features for face detection, Eigenfaces for face recognition and python text to speech library used for audio output. The simulation considered the recognition of a static facial image (photo) and a live facial image. This system is beneficial in terms of its portability, low cost, low power consumption.

Keywords - visually impaired, Computer vision, Haar features, Eigenfaces, Raspberry pi, Open CV

I. INTRODUCTION

It is estimated that 285 million people globally are visually impaired with 39 million blind and 246 million with low vision [3]. Visually impaired persons adapt to life by using various assistive methods such as the white cane, sensory substitution and electronic devices.

Electronic assistive systems use sensors or other methods to avail visually impaired users. They ordinarily focus on providing navigation in indoor, outdoor or both environments. Navigation is usually given through the frameworks which utilize some form of computer vision to recognize obstructions, paths and perform location determination. These frameworks frequently use Global Positioning System (GPS) gadgets and web-based location services while giving route in outdoor environments because of their high precision [4].

While there are several systems for availing the visually impaired people in navigation, there are couple of frameworks which enable them to locate and identify specific objects. Visually impaired persons can be assisted in object detection and recognition using electronic gadgets. These gadgets must be small enough to be easily portable and have the necessary hardware requirements of performing object detection and recognition.

At the point when object recognition is applied to faces, it can be utilized for identification. Face recognition is an appropriate technique for helping visually impaired people in identifying individuals compared to other technique, such as voice recognition [16]. However, this may be difficult or unfeasible in some circumstances Face recognition is the essential means by which people distinguish each other.

This project proposes to develop a wearable device which allows blind and low vision people to interact with society. Using face detection and recognition technology, the device will identify classmates, relatives and colleagues by giving some identity or name for new people. If the same

person appears in front of the user then the name of a person is given as message on earphone.

The remainder of this paper is organized as follows, section II and section III respectively describe system design and working principle. The system analysis and results are explained in section IV. Finally, conclusions are given in section VI.

II. SYSTEM DESIGN

Figure 1 shows the architecture of face recognition system for a visually impaired person. The system detects the face of the person approaching the blind person by a camera. The detected face will be processed by one of the face recognition algorithm Eigenface to find if it belongs to the database of friends and family or not. After the recognition process the system will announce to the blind person the name of that person

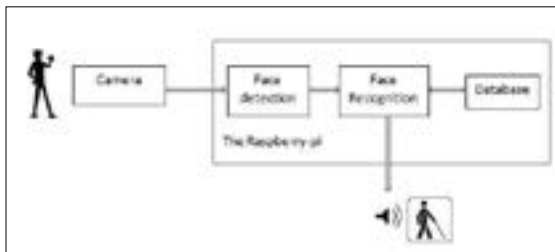


Figure 1. The architecture of face recognition system for a visually impaired person

The proposed face recognition system is designed to capitalize on the portability of mobile devices and provide a straightforward user interface that makes utilization of the system facile for the visually impaired. Key design requisites for a portable system include minuscule gadget size and low weight.

To achieve this goal, a raspberry pi, pi-camera and earphone are habituated to compose a compact and lightweight system. To give an advantageous software

experience to the compact framework, a clear application in an ideally recognizable working framework is required. The open source (Linux) based OS enables an easy to understand application to be produced using worked in accessibility features.

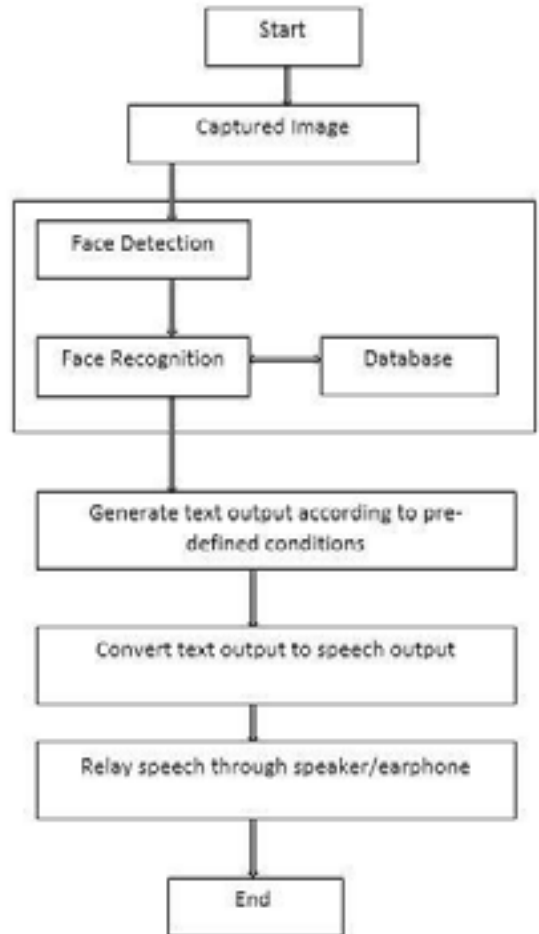


Figure 2. The proposed framework for face recognition system for a visually impaired person

III. WORKING PRINCIPLE

The process of the face recognition is divided into two parts; the training process and the testing process.

The training process starts by preparing the facial training database. This process converts the facial images in the database into matrixes [1]. The face vector will be then computed and the covariance matrix and the eigenvectors will be calculated from it. The eigenfaces with low eigenvalues will then be omitted [2]. From the remaining eigenfaces matrix, the feature weight of each will be calculated and stored as shown in Figure 3

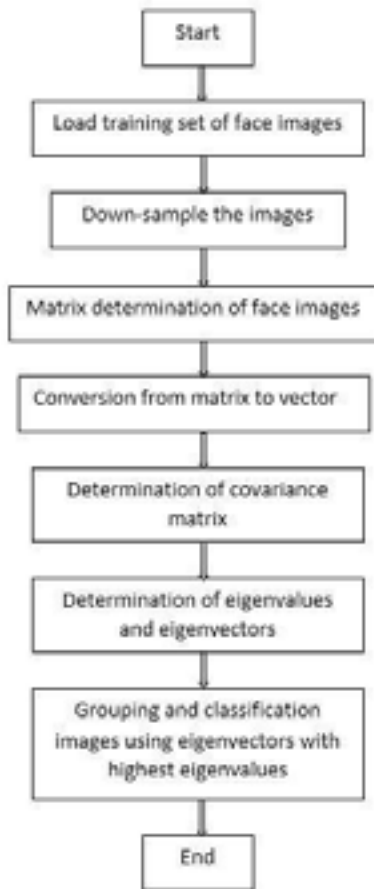


Figure 3. The Eigenface training process

In the testing process an image is captured and inserted into the system to find a match from the database. The eigenface, eigenvalues, and feature vectors of that face are then calculated. The Euclidean distance will then be calculated and the minimum Euclidean distance value will be found from it. The minimum Euclidean distance represents the matching value. The minimum Euclidean value together with a threshold will determine if the image is in the database or not [6] [7].

Developing a computational model of a face recognition is quite arduous, because faces are intricate, multi-dimensional and significant visual stimulant. In mathematical terms, we wish to find the principal components of the distribution of faces, or the eigenvectors of the covariance matrix of the set of face images. These eigenvectors can be thought of as a set of features which

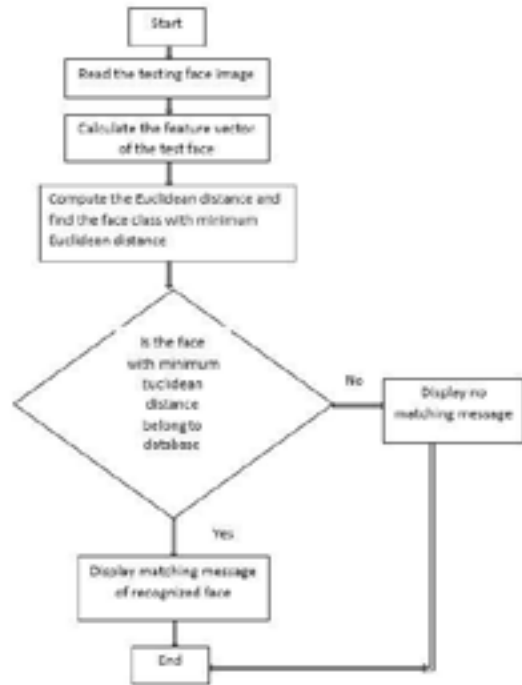


Figure 4. The Eigenface testing process

together characterize the variation between face images. Each image location contributes more or less to each eigenvector, so that we can display the eigenvector as a sort of ghostly face which we call an eigenface [5] [6].

The basic idea of eigenfaces is that all face images are similar in all configurations and they can be described in its basic face images. Based on this idea, the eigenfaces procedures are as follows [1] [2] [5] [6] [15]:

- a) We assume the training sets of images are $\Gamma_1, \Gamma_2, \dots, \Gamma_m$ with each image is $I(x, y)$. Convert each image into set of vectors and new full-size matrix $(m \times p)$, where m is the number of training images and p is $x \times y$.
- b) Find the mean face by:

$$\psi = \frac{1}{m} \sum_{i=1}^m \Gamma_i$$

- c) Calculated the mean-subtracted face:

$$\Phi_i = \Gamma_i - \psi, \quad i = 1, 2, \dots, m$$

$A = [\Phi_1, \Phi_2, \dots, \Phi_m]$ is the mean-subtracted matrix vector with its size A_{mp} .

- d) By implementing the matrix transformations, the

Vectors matrix is reduced by:

$$C_{mn} = A_{mp} \times A_{pm}^T$$

Where C is the covariance matrix and T is transpose matrix.

- e) Find the eigenvectors, V_{mm} and eigenvalues, λ_m from the C matrix using Jacobi method and ordered the eigenvectors by highest eigenvalues. Jacobi's method is chosen because its accuracy and reliability than other method.
- f) Apply the eigenvectors matrix, V_{mm} and adjusted matrix, Φ_m . These vectors determine linear combinations of the training set images to form the eigenfaces, U_k by:

$$U_k = \sum_{m=1}^m \Phi_m V_{km}, \quad k=1,2,\dots,m'$$

Instead of using m eigenfaces, $m' < m$ which we consider the image provided for training are more than 1 for each individuals or class. m' is the total class used.

- g) Based on the eigenfaces, each image has its face vector by:

$$W_k = U_k^T (\Gamma - \Psi), \quad k=1,2,\dots,m'$$

and mean subtracted vector of size (px1) and eigenfaces is U_{pm} . The weights form a feature vector:

$$\Omega^T = [W_1 \ W_2 \ \dots \ W_{m'}]$$

- h) A face can be reconstructed by using its feature, Ω^T vector and previous eigenfaces, U_m as:

$$\Gamma = \Psi + \Phi_f$$

Where

$$\Phi_f = \sum_{i=1}^{m'} w_i U_i$$

IV. SYSTEM ANALYSIS AND RESULT

A coloured face image (see figure 5) is changed over to grey scale image (see figure 6) as grey scale images are more facile for applying computational techniques in image processing



Figure 5. Captured coloured face image

A grey scale face image is scaled for a particular pixel size as 250x250 because many input images can be of different size whenever we take an input face for recognition [11].



Figure 6. Grey scale face image

With a specific end goal to make database, the viola jones algorithm is utilized to distinguish the face, which is captured image by means of web camera or pi-camera. For database distinctive arrangement of conditions must be kept up, for example, different expressions. Pivoted pictures in left and right course and diverse light conditions are additionally considered while influencing the preparation to training set. Measure varieties in an input face image can also change the output therefore input images by fluctuating their size are additionally taken for recognition.

A test image for recognition is tested by comparing to the stored data set. The eigenvectors corresponding to the covariance matrix define the Eigenface (see figure 8) which has a ghostly face like appearance and a match is found if new face is close to these images

In this study for the testing purpose, two database were designed for both static (The database of faces published by research AT&T laboratories Cambridge) and live facial



Figure 7. 4x3 Training set with different angle and expression



Figure 8. Eigenface

images. Figure (9) shows the static facial image database and figure (10) shows the live facial image database captured by pi-camera.



Figure 9. Static image database (The database of faces published by research AT&T laboratories Cambridge)

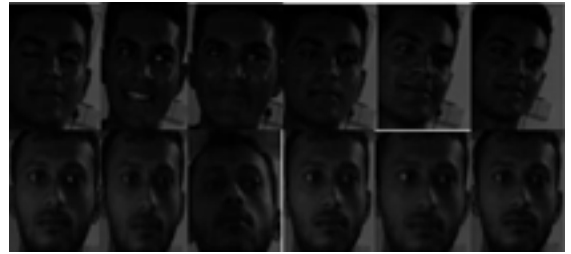


Figure 9. Live image database

The performance of the both live and static images were tested. A facial image was inserted to the system, to find a match from the database. It can be either live image or static image. Furthermore some simulated test facial images were initially used, they were consist of white, light grey, dark grey shaded and black backgrounds [16]. The test results obtained are shown in the table (1).

Table 1. Test result

Image type	Percentage predicted
Static images	64%
Live images	39%

V. CONCLUSIONS

This project helps visually impaired and blind individuals to identify persons in front of them and makes them independent to live in society. This device works in two modes of operations: Face Detection and Face Recognition. The device that includes face detection, regularized methods for training and testing of individuals in an unconstrained environment. While our device is functional, useful, and robust, there are still some improvements that could be made in the future. In real time atmosphere have more than one person. If all the faces are given same preference then the blind person finds it difficult to identify those faces, so each person has to be assigned some priority for easy recognition. Therefore, the face in front and close to the blind person is very essential rather than the other faces far away from the blind person.

In this project, one of the most requested features of this device was reduced size. With the current state of mobile computing, processors are not fast enough to perform the algorithms utilized by our device in real time. But in the future, several advances could be made to enable this. As technology progresses and mobile processors become more powerful, this could potentially be driven by a smaller device. This device will allow the visually impaired to greatly improve their social interactions with both sighted and blind people. This project puts the visually impaired one step closer towards equality with sighted people in conversation. New technologies will allow people with disabilities to improve their standard of living and put them closer to parity with people without disabilities. Here science, technology, and society intersect providing a better life for the visually impaired people.

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