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Facial Recognition System Using LBPH Algorithm and Raspberry Pi

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Abstract - *Face detection and picture or video recognition is a popular subject of research on biometrics. The idea behind this paper is to develop an efficient face recognition system. In this paper we proposed a system in which it captures images in real time. This system uses Haar-cascade classifier for detection of the face and then Local Binary Pattern Histograms (LBPH) to recognize the person from the local database created by the user during detection process. Security, monitoring and control to automation in real time are the key components of this system. Such a facial recognition system has many potential applications including crowd and airport surveillance, private security, etc. The hardware required to implement this system are Raspberry Pi 4 microprocessor, external web camera, Micro SD card.*

Key Words: **Face detection, Local Binary Pattern, Haar-cascade classifier, Histograms, Raspberry Pi 4, Web camera, LBPH**

1.INTRODUCTION

Facial recognition can be used in home automation which means it can be easily integrated in our houses. Face recognition is one of the few biometric methods that possess the merits of both high accuracy and low intrusiveness. Facial Recognition falls under the area of Image Processing. A facial recognition system is a technology capable of matching a human face from a digital image or a video frame against a database of faces, typically employed to authenticate users through ID verification services, works by pinpointing and measuring facial features from a given image. This system is very compact hence it can be integrated in our house without disturbing our daily lifestyle.The idea is to develop a face recognition system which recognizes only those faces which are stored in the database.Raspberry Pi is a low power device hence its power needs are very low. To build this system we will use a Raspberry Pi 4 microcontroller, an external camera is used. Raspbian operating system for Raspberry Pi will be used. For training of image database, around 100-150 images of each person would be stored. But before storing these images the images need to be detected and then captured. This detection of the faces is done using Haar cascades which is a method that was proposed by Paul Viola and Michael Jones's paper "Rapid Object Detection using a Boosted Cascade of Simple Features".

For face recognition part, Local Binary Pattern Histograms (LBPH) algorithm is used with feature extraction and Haar like classifiers as mentioned before. Local Binary Patterns are basically texture descriptor which was made popular by Ojala et al in their 2002 paper, Multiresolution Grayscale and Rotation Invariant Texture Classification with Local Binary Patterns. Since then, LBP is a very popular algorithm in facial recognition, so it is worthwhile, using it in our system. In [1] Harsha Prasad have proposed a system which mainly consists of subsystems namely image capture, face detection and recognition, email notification and automatic door access management. [2] This system which consists of a Raspberry Pi Zero connected to a Raspberry Pi camera module, Capacitive touch sensor and OLED display. This system uses Haar Cascade classifier for face detection in an image followed by Local Binary Pattern Histogram for facial Recognition (LBPH). The LBPH algorithm is implemented using OpenCV. Main [3] purpose is to be set as an alert for home visitors and provide information about the visitors in a dynamic website and phone application. Among the other bio-metric techniques, face recognition method offers one great advantage which is user friendliness.

2. ALGORITHM AND METHODS

The system proposed can be divided into 3 parts. Detecting Faces using the Haar like classifiers. After detection capturing of images of a person and creation of the dataset of those captured images. Second is to get the LBP of the images stored in the dataset and train the dataset. Obtaining Histograms from the trained dataset. Finally at the recognition step using the obtained histograms for comparison purposes to obtain a result. The two steps of obtaining an LBP of the image followed by its final step, which is histogram extraction, constitutes to the whole LBPH algorithm. For recognizing the faces, all computations are done locally.

2.1 Face Detection using Haar Cascade Classifier

A Haar cascade classifier is a classifier which trains a machine learning for detecting objects in a picture or a video. Haar belongs to Haar-like features which is a weak

classifierand will be used for the face recognition. A weak classifier is a classifier which is only slightly better than a random prediction. A Haar-like feature is a rectangle which is split into two, three or four rectangles. Each rectangle is black or white.

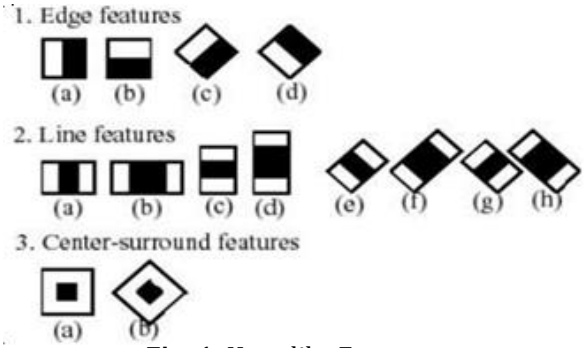

Fig -1: Haar-like Features

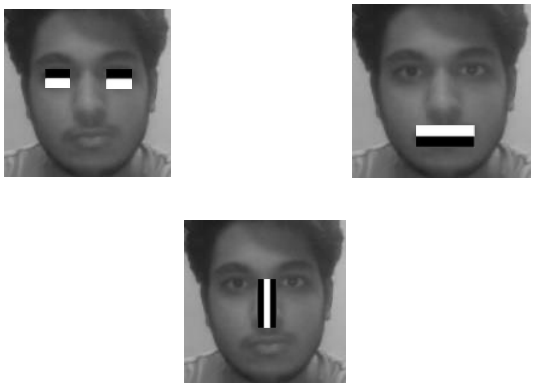

Fig -2: Haar Cascade Classifier Face View

The extracted combination of features will be used for detecting faces in pictures or a video. The features are tried to be matched only in a block of pixels defined by a scale. The scale can be a square of 232x232 pixels which is the dimensions of the image taken for feature extraction in our system. Each feature of the combination will be tried to be matched block by block. If one of the features does not appear in the block, the research in it will be stopped. The remaining features will not be tested because the machine concludes that there is no face in this block. Then, a new block is taken, and the process is once again repeated. This method tests all the blocks of pixels with the researched combination in cascade classifier. In the images shown above where features are placed.

2.2 Local Binary Pattern (LBP)

For facial recognition process LBP algorithm is used. A great advantage of LBP is that it is illumination invariant. If you change the lighting on the scene all the pixel values will go up but the relative difference between these values will be the same. Local Binary Pattern (LBP) is an efficient texture operator which labels the pixels of an image by thresholding the neighborhood of each pixel and considers the result as a binary number. When LBP is combined with histograms of oriented gradients (HOG) descriptor, it improves thedetection performance considerably on some datasets. Using the LBP combined with histograms we can represent the face images with a simple data vector. The LBP requires 4 parameters namely Radius, Neighbors, Grid X, Grid Y.

1. Radius: the radius is used to build the circular local binary pattern and represents the radius around the central pixel.

2. Neighbors: the number of sample points to build the circular local binary pattern. the more sample points you include, the higher the computational cost. For LBP 8 neighbors are used in our system.

3. Grid X: the number of cells in the horizontal direction. The more cells, the finer the grid, the higher the dimensionality of the resulting feature vector. It is set to 8.

4. Grid Y: the number of cells in the vertical direction. The more cells, the finer the grid, the higher the dimensionality of the resulting feature vector. It is set to 8.

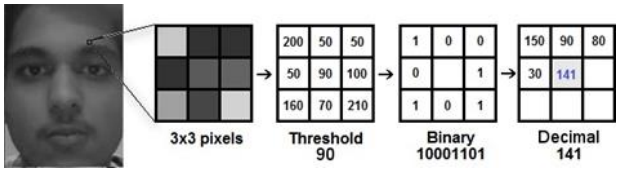

Fig -3: LBP algorithm for a face

After the parameters are obtained the first step is to convert the image to grayscale. Next is to obtain a window of 3x3 pixels for the image with intensity of each pixel denoted by any value from 0-255. A central value is then selected to be used as threshold value which will be used to define the new values from 8 neighbors as shown in the figure above. If the intensity of the center pixel is greater-t n we set the value to 1; $LBP(gp_x, gp_y) \sum_{p=0}^{P-1} S(gp - gc) \times 2^p$ his calculation is done by

$$s(x) = \begin{cases} 1 & if \quad x \geq 0 \\ 0 & if \quad x < 0. \end{cases}$$

In the given formula,

gc: intensity value of the central pixel

gp: intensity of the neighboring pixel with index p

The s(x) function which is shown above is known as threshold function which will determine the binary values for the 8 neighboring pixels.

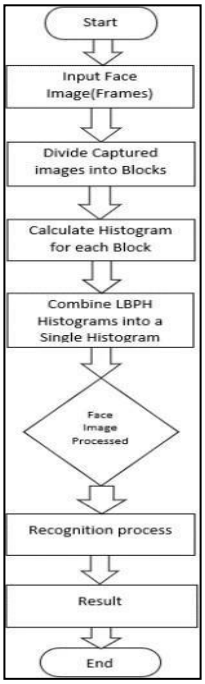

Fig -4: LBP algorithm flowchart

2.3 Histogram Extraction

At the end of this LBP process, we have a new image which represents better the characteristics of the original image. After this we extract the histograms of regions as shown below:

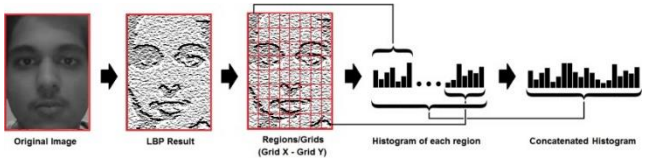

Fig -5: Histogram extraction and concatenation

As we have an image in grayscale, each histogram will contain only 256 positions (0~255) representing the occurrences of each pixel intensity. Then concatenation of each histogram creates a new and bigger histogram. After this step histograms are created for each image from the trained dataset. Now at the actual recognition step the input image we get the corresponding histogram for it by applying the steps mentioned above. The histograms can be calculated using Euclidean distance, chi-square, etc. We can then use a threshold and the 'confidence' to automatically estimate if the algorithm has correctly recognized the image. We can assume that the algorithm has successfully recognized if the confidence is lower than the threshold defined. The Euclidean distance formula for calculating the distance between histograms is given below:

$$D = \sqrt{\sum_{i=1}^{n}(hist1_i - hist2_i)^2}$$

Hist1: Value of histogram which is created from trained dataset images.

Hist2: Value of histogram which is obtained at the recognition step.

D: Distance between Hist1 and Hist2.

3. SYSTEM IMPLEMENTATION

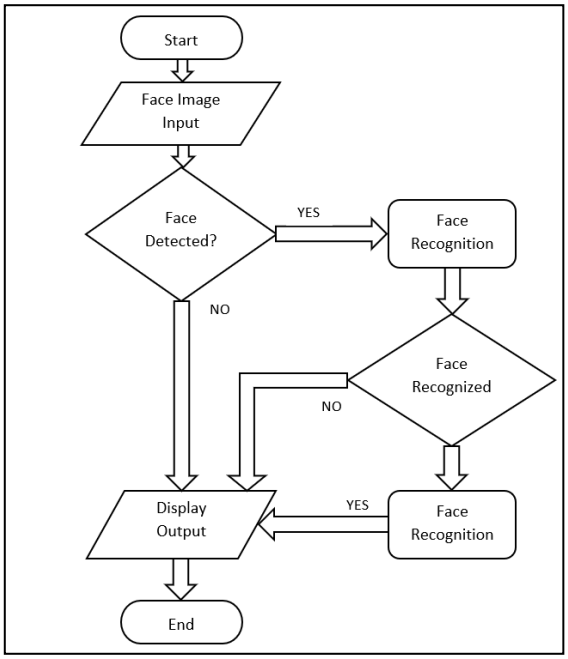

Fig -6: Base System Flowchart

The figure above represents the flowchart of the facial recognition system. The process starts from deciding whether the object that is put in front of the camera is face or not. This is done using the viola-jones algorithm based Haar-cascade classifier. Now if the object put forth is a face facial recognition part of the system which uses LBPH(Local Binary Pattern Histogram) will run. The first part would be capturing 100-150 images of a person with a unique ID and a Username which are required for the dataset. The dataset will be stored locally on the Raspberry Pi itself.

After the dataset of images is saved, the dataset is trained. Trained model is stored in .yml file format in a specific folder. The training is done such that at the actual recognition step the system can differentiate between a known and an unknown face. But if the face itself is not detected it will not save any images for the dataset to be processed further.

Fig -7: Hardware Setup

The above figure is the hardware setup for the facial recognition system. This simple setup consists of a Web camera which is connected to the Raspberry Pi development board's USB port.

4. RESULT AND DISCUSSION

Consider the following figure where the username and the ID of the person whose face is to be recognized is entered first.

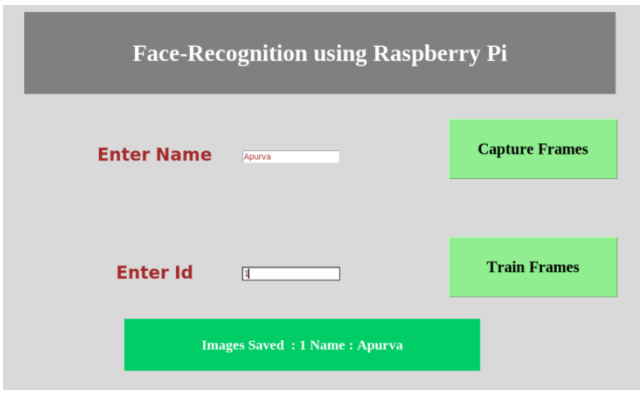

Fig -8: Entry of Name and ID

After entering the name and ID of the person, frames of the faces of that person are captured to store in the dataset. This process is shown in the below figure.

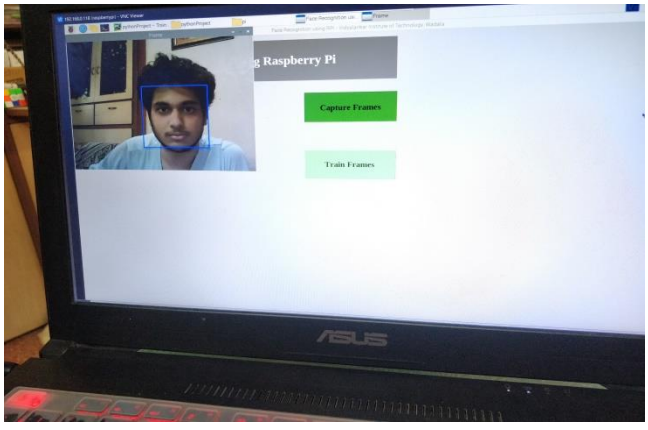

Fig -9: Capturing frames for the dataset

After storing the images in the dataset, the dataset is trained, and a model is obtained after training which stored locally in form of .yml file format. The figure below displays that the model is trained. This training of the model is done using the button provided in the GUI which is linked to the training function in the software.

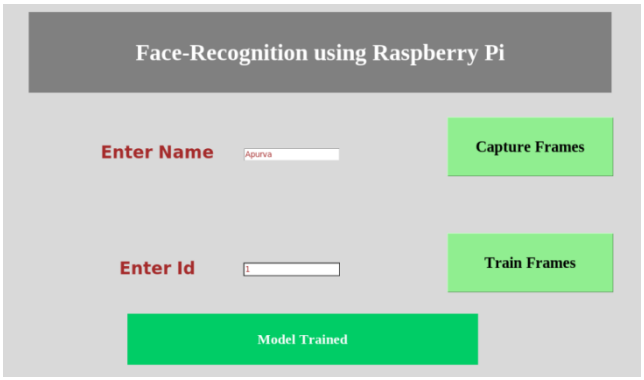

Fig -10: Model Trained notification

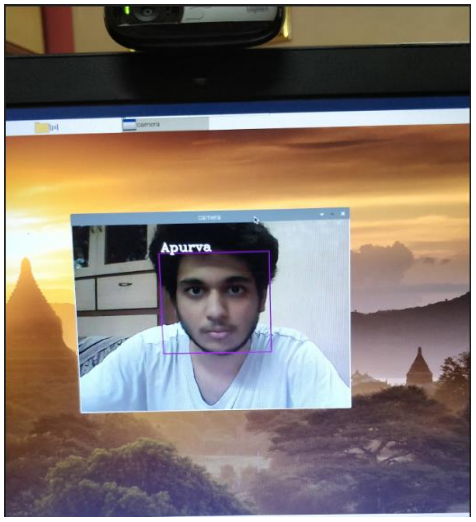

Fig -11: Displaying recognized face

As shown in the above figure, after training of the model when we obtain the output, it shows that the face of the person in front of the camera is recognized with the user's name displayed. This final recognition part is done by making the LBP of the image followed by the histogram extraction process and finally comparing the histogram of the face image in dataset and the histogram of the face image which is shown in real-time in front of the camera for recognition.

5. CONCLUSION

The Facial Recognition System uses Haar-cascade for face detection and Local Binary Pattern Histogram, a very efficient algorithm for face recognition. An image database is stored locally containing all the images of the known

persons. The system is cost efficient and even provides high security.

Facial Recognition is not only limited to home security but can also be applied to other applications like class attendance using facial recognition etc. Face recognition is more accurate than other biometric system, in this modern world, there are large number of systems using biometric. But the facial recognition turns out to be a better option as compared to other biometrics because of the high accuracy. lots of application in different fields the face recognition has received a lot of attention. System provides high level security as we all know that day – by – day technology is improving in every field. But the main focus of every company is on their security level. Because security plays a very important role in keeping their data safe & secure.

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