LOCAL APPROACHES IN FACE RECOGNITION: A CASE STUDY USING HISTOGRAM OF ORIENTED GRADIENTS (HOG) TECHNIQUE

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Abstract

Face detection is one of the most essential points in a biometric fashion which refers the to discovery of the face automatically by simply taking a looking at a face using a motorized technique. In This paragraph discusses the use case and analysis of face recognition, fastening on original approaches. Local approaches in face recognition focus on specific facial features and are more sensitive to facial expressions, occlusions, and disguise. There are two orders of local approaches local appearance-grounded ways, which prize features from small patches of the face image, and crucial- points-grounded ways, which descry points of interest on the face and extract features from those points. The main idea of these approaches is to discover distinctive features for accurate recognition. Various ways are being developed including original, holistic, and hybrid approaches, which give a face image description using only many face image features or the whole facial features. The main donation of this check is to review some star ways for each approach and to give the taxonomy of their orders. In the paper, a detailed comparison between these ways is exposed by listing the advantages and the disadvantages. One intriguing point mentioned in the paper is about the database used for face recognition. Finally, a solid discussion is given in the paper about unborn directions in terms of ways to be used for face recognition.[4]

Keywords*: Face Detection, Face Extraction, Face Recognition, Face Recognition Method,*

Local Approaches, Key Points based technique, Local Appearance-based technique, HOG.

1. INTRODUCTION

The ideal of developing biometric operations, similar as facial recognition, has lately come important in smart metropolises. In addition, numerous scientists and masterminds around the world have concentrated on establishing decreasingly robust and accurate algorithms and styles for these types of systems and their operation in everyday life. All types of security systems must cover all particular data. The most generally used type for recognition is the word. Still through the development of information technologies and security algorithms, numerous systems are beginning to use numerous biometric factors for recognition task. These biometric factors make it possible to identify people's identity by their physiological or behavioral characteristics.[3] They also give several advantages, for illustration, the presence of a person in front of the detector is sufficient, and there's no further need to flash back several watchwords or nonpublic canons presently. In this environment, numerous recognition systems grounded on different biometric factors similar as iris, fingerprints, voice, and face have been stationed in recent times. Facial recognition system as an ID (identity) is formerly being offered to consumers outside of phones, including at field check-sways, sports colosseums, and musicales. In addition, this system doesn't bear the intervention of people to operate, which makes it possible to identify people only from images attained from the camera. In addition, numerous biometric systems that are developed using different types of hunt give good identification delicacy. Still, it would be intriguing to develop new biometric systems for face recognition in order to reach real- time constraints.

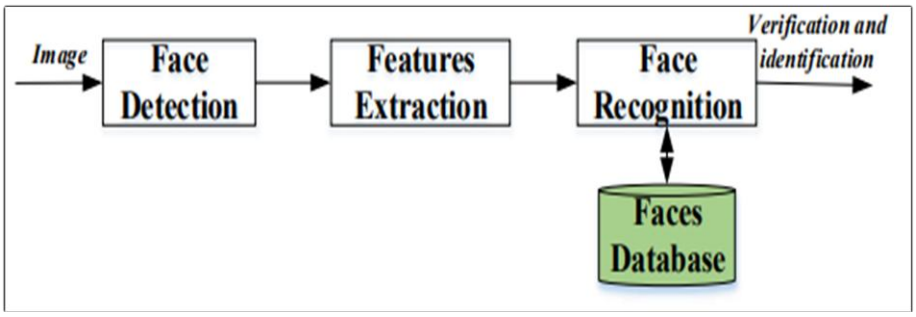

Figure 1: Face Recognition Diagram (Source: https://www.mdpi.com/1424-8220/20/2/342)

2. LITERATURE REVIEW

Face detection and recognition are important areas of research in computer vision, with numerous applications in security, surveillance, human-computer interaction, and entertainment. In recent years, there has been a significant amount of research focusing on developing accurate and efficient methods for face detection and recognition. Viola and Jones

(2001) proposed a widely used face detection method based on Haar-like features and AdaBoost. This method is computationally efficient and has achieved high accuracy in real-time face detection. Another popular face detection approach is based on the Histogram of Oriented Gradients (HOG) descriptor, which was introduced by Dalal and Triggs (2005). HOG-based methods are robust to variations in lighting and facial expressions and have achieved high accuracy in face detection.

In face recognition, deep learning-based methods have shown promising results. Deep Convolutional Neural Networks (CNNs) have achieved state-of-the-art performance in face recognition tasks, outperforming traditional feature-based methods. Schroff (2015) proposed the FaceNet model, which uses a triplet loss function to learn discriminative features for face recognition. This model achieved high accuracy on the Labelled Faces in the Wild (LFW) dataset, which contains images of faces under real-world conditions.

However, face recognition systems are not without their challenges. One of the major challenges is dealing with variations in pose, illumination, and expression. To overcome these challenges, researchers have explored different techniques, including 3D face modeling, facial landmark detection, and multi-view face recognition. In addition, there are also ethical concerns related to face recognition, such as privacy and bias. To address these concerns, researchers have proposed methods for privacy-preserving face recognition and fair face recognition. Overall, face detection and recognition continue to be active areas of research with promising applications and exciting research opportunities.

3. OBJECTIVES OF THE STUDY

- To develop and implement face recognition techniques.
- To extract local features from the face image by dividing it into small regions.
- To explore both key-points-based and local appearance-based techniques to discover distinctive features in the face image that are robust to variations in pose, expression, and occlusions.
- To collaborate with the holistic approaches and hybrid approaches
- To develop a comprehensive face recognition system that achieves high accuracy and efficiency in real-world scenarios.

4. RESEARCH METHODOLOGY

The research methodology had the objective of first selecting the image then it will goes under Face Detection method in which The face recognition system begins first with the localization of the human faces in a particular image. The purpose of this step is to determine if the input image contains human faces or not. Then Feature Extraction: The main function of this step is to extract the features of the face images detected in the detection step. This step represents a face with a set of features vector called a "signature" that describes the prominent features of the face image such as mouth, nose, and eyes with their geometry distribution. Each face is characterized by its structure, size, and shape, which allow it to be identified. Several techniques involve extracting the shape of the mouth, eyes, or nose to identify the face using the size and distance. Lastly, Face Recognition This step considers the features extracted from the background during the feature extraction step and compares it with known faces stored in a specific database. There are two general applications of face recognition, one is called identification and another one is called verification. During the identification step, a test face is compared with a set of faces aiming to find the most likely match. During the identification step, a test face is compared with a known face in the database in order to make the acceptance or rejection decision.

5. USECASEAND ANALYSIS

The use case for the face recognition has some original approaches Original Approaches In the environment of face recognition, local approaches treat only some facial features. They're more sensitive to facial expressions, occlusions and pose. The main ideal of these approaches is to discover distinctive features. Generally, these approaches can be divided into two orders:

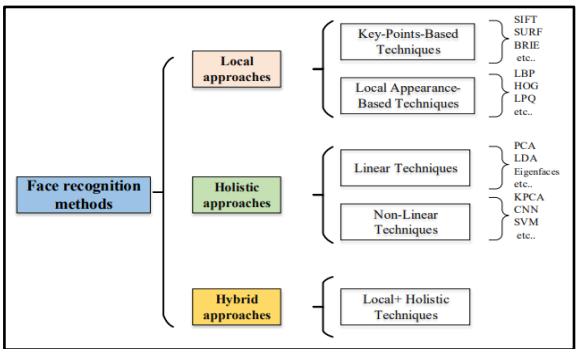

Figure 2: Use Case Architecture (source: https://www.researchgate.net/publication/338474835/figure/fig1/AS:845275300110336@1578540744111/Face-recognition-methods-SIFT-scale-invariant-feature-transform-SURF-scale-invariant.png)

1) Local appearance- grounded ways are used to prize original features, while the face image is divided into small regions(patches).

2) Crucial points- grounded ways are used to descry the points of interest in the face image, after which the features localized on these points are uprooted.

The implementation of the entire Face Recognition was split among three teams as per Figure2.

1. Local Approaches :
    - Key Points based technique.
    - Local Appearance based technique
2. Holistic Approaches:
    - Linear Technique.
    - Non-Linear Technique
3. Hybrid Approaches:
    - Local + Holistics.

1. Local Approaches:

It's a geometrical fashion, also called point or analytic fashion. The face image is represented by a set of distinctive vectors with low confines or regions(patches). Local appearance-grounded ways concentrate on critical points of the face similar as the nose, mouth, and eyes to induce further details. Also, it takes into account the particularity of the face as a natural form to identify and use a reduced number of parameters. Local Appearance grounded fashion In this fashion the main point to put your point on is HOG(Histogram of acquainted slants).The overeater is one of the stylish descriptors used for shape and edge description. The overeater fashion can describe the face shape using the distribution of edge direction or light intensity grade. The process of this fashion done by sharing the whole face image into cells (small region or area); a histogram of pixel edge direction or direction slants is generated of each cell; and, eventually, the histograms of the whole cells are combined to prize the point of the face image. Histograms of acquainted slants are generally used in computer vision, pattern recognition and image processing to descry and fete visual objects(i.e. faces).In this design we've used colour video clips from the notorious web series Money Heist, the clips were collected from youtube and uploaded by colour druggies. First, the algorithm was trained with a single image of every character appearing in the videotape labelled independently. The model was suitable to identify the characters to an extend but not

in multiple angles. To produce a better dataset the law was tweaked a little bit in such a way that each time a face is detected the model crops the detected face and saves it into the applicable path with applicable train name (character_namen.bmp), and latterly on the faces collected were intermingled into a single image and used as the training dataset, which made it possible to descry the faces in multiple angles. In certain cases 3000 plus faces per character were intermingled together to produce a robust model.

Process of Calculating the Histogram of Oriented Gradients(HOG)

We should now have a introductory idea of what a HOG point descriptor is. It's time to claw into the core idea behind this composition. Let's bandy the step- by- step process to calculate HOG. Consider the below image of size(180 x 280). Let us take a detailed look at how the features is created

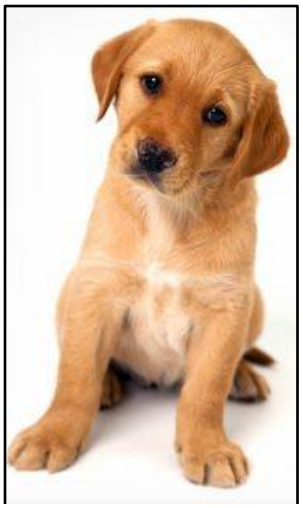

Figure 3: The Image imported to get HOG feature (Source: https://www.pngkey.com/maxpic/u2q8q8i1t4w7o0r5/)

Step 1: Preprocess the Data (64 x 128)

This is a step utmost of you'll be enough familiar with. Pre-processing data is a pivotal step in any machine literacy design and that's no different when working with images. We need to pre-process the image and bring down the range to height rate to 12. The image size should rather be 64x128. This is because we will be dividing the image into 8x8 and 16x16 patches to prize the features. Having the specified size (64x128) will make all our computations enough simple. Coming back to the illustration we have, let us take the size 64x128 to be the standard image size for now. Then the resized image is:

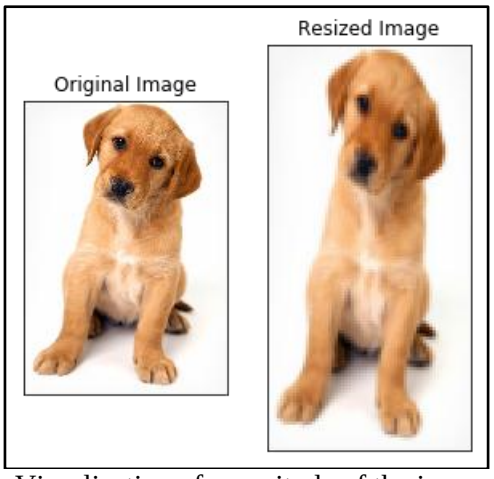

Figure 4 : Visualization of magnitude of the image (Source: https://www.pngkey.com/maxpic/u2q8q8i1t4w7o0r5/)

Step 2: Calculating Gradients (direction x and y)

The coming step is to calculate the grade for every pixel in the image. Slants are the small change in the x and y directions. Then, I'm going to take a small patch from the image and calculate the slants on that.

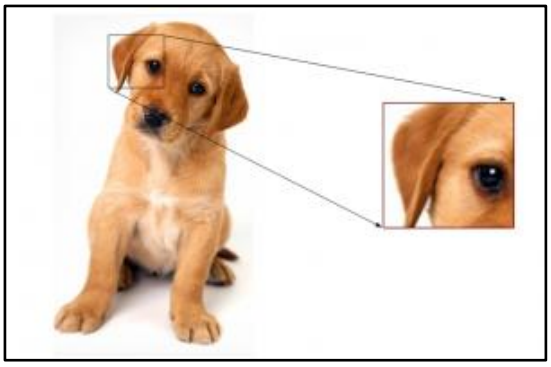

Figure 5: Visualization of angle of the image (Source: ttps://www.pngkey.com/maxpic/u2q8q8i1t4w7o0r5/)

We'll get the pixel values for this patch. Let's say we induce the below pixel matrix for the given patch (the matrix shown then is simply used as an illustration and these aren't the original pixel values for the given patch)

121	10	78	96	125
48	152	68	125	111
145	78	85	89	65
154	214	56	200	66
214	87	45	102	45

Figure 6: Matrix table to show pixel values (Source: https://cdn.analyticsvidhya.com/wp-content/uploads/2019/08/article-image-10.png)

I've stressed the pixel value 85. Now, to determine the grade (or change) in the x-direction, we need to abate the value on the left from the pixel value on the right. Also, to calculate the grade in the y- direction, we will abate the pixel value below from the pixel value above the named pixel. Hence the attendant slants in the x and y direction for this pixel are

• Change in X direction (Gx) = 89 – 78 = 11

• Change in Y direction (Gy) = 68 – 56 = 8

This process will give us two new matrices – one storing slants in the x-direction and the other storing slants in the y direction. This is analogous to using a Sobel Kernel of size 1. The magnitude would be advanced when there's a sharp change in intensity, similar as around the edges. We've calculated the slants in both x and y direction independently. The same process is repeated for all the pixels in the image. The coming step would be to find the magnitude and exposure using these values.

Step 3 Calculate the Magnitude and exposure

Using the slants we calculated in the last step, we will now determine the magnitude and direction for each pixel value. For this step, we will be using the Pythagoras theorem(yes, the same bone which you studied back in academy!).Take a look at the image below

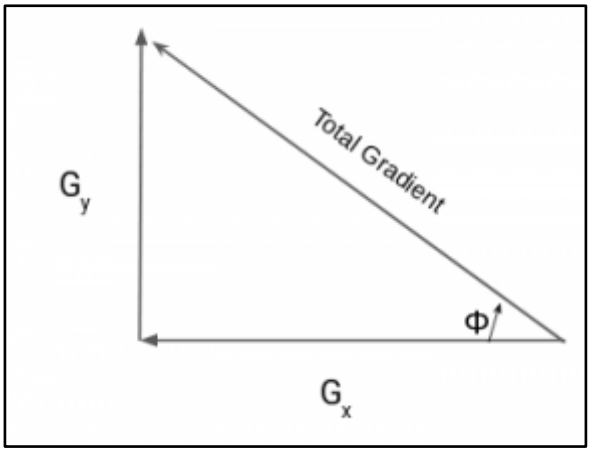

Figure 7: Pythagoras diagram to calculate gradient (Source : https://cdn.analyticsvidhya.com/wp-content/uploads/2019/08/article-image-10.png)

The slants are principally the base and vertical then. So, for the former illustration, we had Gx and Gy as 11 and 8. Let's apply the Pythagoras theorem to calculate the total grade magnitude

Total grade Magnitude = √((Gx) 2(Gy) 2)

Total grade Magnitude = √((11) 2(8) 2) = 13.6

Next, calculate the exposure (or direction) for the same pixel. We know that we can write the tan for the angles

tan(Φ) = Gy/ Gx .Hence, the value of the angle would be:

$$\Phi = \text{atan}(Gy / Gx)$$

The exposure comes out to be 36 when we plug in the values. So now, for every pixel value, we've the total grade (magnitude) and the exposure(direction). We need to induce the histogram using these slants and exposures. But hang on – we need to take a small break before we jump into how histograms are created in the overeater point descriptor. Consider this a small step in the overall process. And we'll start this by agitating some simple styles of creating Histograms using the two values that we've – slants and exposure.

Different styles to produce Histograms using slants and exposure

A histogram is a plot that shows the frequency distribution of a set of nonstop data. We've the variable (in the form of lockers) on the x-axis and the frequence on the y-axis. Then, we're going to take the angle or exposure on the x-axis and the frequence on the y-axis.

Method 1

Let us start with the simplest way to induce histograms. We'll take each pixel value, find the exposure of the pixel and modernize the frequence table. Then's the process for the stressed pixel (85). Since the exposure for this pixel is 36, we will add a number against angle value 36, denoting frequence.

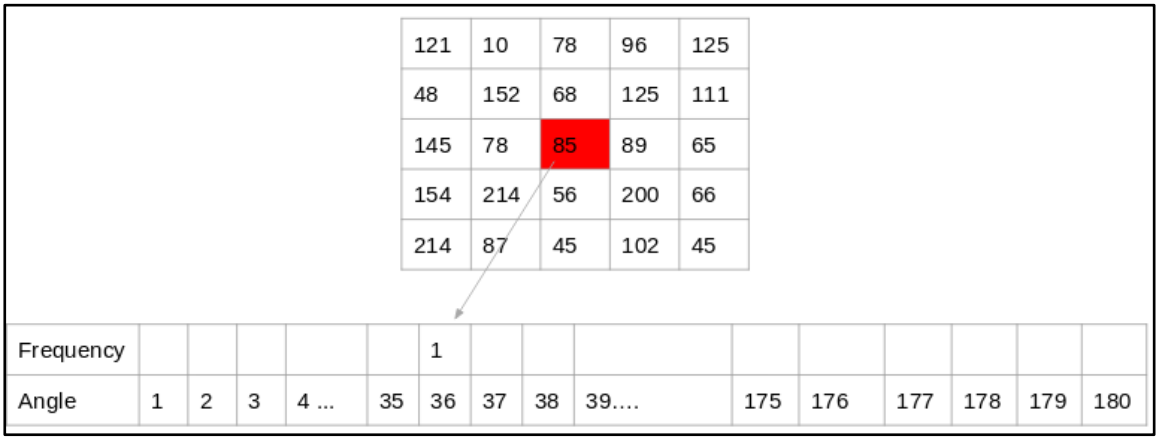

Figure 8: Matrix table to show selected pixel value (Source: https://cdn.analyticsvidhya.com/wp-content/uploads/2019/08/article-image-10.png)

The same process is repeated for all the pixel values, and we end up with a frequence table that denotes angles and the circumstance of these angles in the image. This frequence table can be used to induce a histogram with angle values on the x-axis and the frequence on the y-axis. That is one way to produce a histogram. Note that then the caddy value of the histogram is 1. Hence we get about 180 different pails, each representing an exposure value. Another system is to produce the histogram features for advanced caddy values.

6. RESULTS

The paper focuses on the use of HOG as a technique for detecting and recognizing faces. HOG (Histogram of Oriented Gradients) is a feature descriptor used for object detection in computer vision. The authors discuss the advantages of using HOG for face detection, including its robustness to changes in lighting and pose, and its ability to handle occlusions. The paper also describes the implementation of the entire face recognition system, which was split among three teams: local approaches, holistic approaches, and hybrid approaches. The local approaches team focused on key-point-based and local appearance-based techniques, while the holistic approaches team focused on linear and non-linear techniques. The hybrid approaches team combined both local and holistic approaches. The paper concludes by highlighting the potential of HOG-based face detection and recognition systems for various applications, including surveillance, security, and user identification.

7. CONCLUSIONS

Local approaches for face recognition focus only on some facial features, making them more sensitive to facial expressions, occlusions, and pose. These approaches can be divided into two categories: local appearance-based techniques and key-points-based techniques. In this project, the local appearance-based technique, Histograms of Oriented Gradients (HOG), was used to train the algorithm to identify characters in the web series Money Heist. The images were pre-processed to bring the width to height ratio to 1:2 and then divided into patches to extract features. Gradients were calculated for each patch to generate the HOG feature descriptor. The model was trained with a dataset created by cropping and merging multiple faces of each character in various angles. This approach proved to be effective in detecting faces in different poses and angles. Overall, local approaches for face recognition have

proven to be useful in various applications, including security and surveillance. Finally the HOG would generate a Histogram for each of these regions separately. The histograms are created using the gradients and orientations of the pixel values, hence the name 'Histogram of Oriented Gradients'.

8. SCOPE OF FUTURE RESEARCH

The HOG feature descriptor counts the occurrences of gradient orientation in localized portions of an image. Further we can also add different features and methods to calculate hog. histogram is a plot that shows the frequency distribution of a set of continuous data**.** We have the variable (in the form of bins) on the x-axis and the frequency on the y-axis. In Future, we can also take the angle or orientation on the x-axis and the frequency on the y-axis.

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