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Facial Recognition using OpenCv

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ABSTRACT: Facial Recognition is fast becoming one of the most popular means of bio-metric identification. Its inherent efficiency and ease of use finds many applications in a myriad of real life scenarios today. We have explored the various techniques involved in the Facial Recognition process and have presented our findings by means of this paper. The Viola Jones, Principal Component Analysis and the Elastic Bunch Graph Matching algorithms were explored. The role of Support Vector Machines was studied. The applications and efficiencies of each of these aforementioned models were analysed. The pivotal role played by Cascading Classifiers and its relevance today was also studied and presented. It was found that Facial Recognition, when employed judiciously, can be implemented to enhance interactions between humans and technology, and would aid in developing systems that are sensitive to the moods and emotions of human beings. That said, Unexplored Application areas were pondered upon and potential implementations were presented.

KEY WORDS: Facial Recognition, OpenCv, Haar classifiers.

I. INTRODUCTION

"Besides black art, there is only automation and mecha- nization"

-Federico Garcia Lorca

We live in an era where efficiency, accuracy and speed are the most important facets of any system. This is manifested in the form of automation whenever and wherever possible to reduce human error and replace human intervention with trained models for faster, error-free and seamless computations. Bio-metrics are being used for identification in almost every field today. Fingerprints, iris scans and facial recognition play pivotal roles in the creation and maintenance of several important databases.

Facial recognition stands out and is gaining significant traction because of its affordability, ease of use and security.[1] It has been discussed and worked upon since the 1960s and has evolved greatly since. The first software that came out for facial recognition involved the usage of grid lines. Coordinates of each facial feature were recorded and were referred to when a picture needed to be identified. This could recognize up to 40 pictures an hour, which was considered very impressive at the time. Subsequent algorithms fared much better in so far as performance is concerned and are still improving, owing to the approaches introduced by Machine Learning and Artificial Intelligence.

Facial Recognition algorithms, as they exist today, can be divided into two, on the basis of their approach- Geometric and Photometric.[2] Geometric Algorithms focus on distin- guishing features- finding out areas of contrast and using that information to classify faces, or in other words, the main geometrical features of the face such as the eyes, nose and mouth are located first, and the face is then classified on the basis of the various geometric distances and angles between them.[3] Photometric Algorithms use a statistical approach, i.e, they convert the image into certain values and compare the values with standard pre recorded templates to eliminate discrepancies.

They can also be seen as belonging to one of the two broad categories- Holistic Models and Feature-Based Models. Holistic Models try to recognize the face in its entirety whereas Feature-Based models try to recognise the face after recognizing each facial feature. The popular algorithms today are Principal component anal- ysis using Eigenfaces, Linear discriminant analysis, Elastic Bunch Graph Matching using the Fisherface algorithm, the hidden

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Markov model, multilinear subspace learning using tensor representation, and the neuronal motivated dynamic link matching.[4]

This document is structured as follows: Section II briefly sheds light on the algorithms used for facial recognition, Section III explains the functioning of OpenCv and the associated Local Binary Pattern Histogram (LBPH) algorithm. Finally, Section IV elaborates on the application areas that have been identified for the efficient and judicious use of Facial Recognition.

II. SIGNIFICANCE OF THE SYSTEM

The paper mainly focuses on how machine learning techniques, various algorithms and Opencv libraries can be applied in the field of facial recognition by training the data. The study of algorithms is presented in section III, OpenCv and LBPH algorithm is explained in section IV, and section V covers the application areas of the study.

III. ALGORITHMS

A. The Viola Jones Algorithm

Edge detection is used for feature extraction. If there is a light area that is surrounded by dark areas, this light area is extracted as an edge. Dark areas may be the shadow regions on the face. These edges are extracted by means of convolutional kernels- A convolutional kernel is one in which a row representing the edge in a matrix has values of a higher magnitude as compared to the other entries in the matrix. Haar Features use a similar principle. A black region is represented by a +1 and a white column is represented by -1. Each feature results in a single value which is calculated by subtracting the sum of pixels under white rectangle from the sum of pixels under that black rectangle. Standard Haar features represent some region or the other of a face.

Viola Jones Algorithm uses a 24x24 window as the base window size to start evaluating these features in any given image.[5][6] However, if we consider all possible parameters of the Haar features like position, scale and type, we end up calculating 160,000+ features in this window. This would render real time face detection almost impossible.

Integral Images and AdaBoost now come into play. The summation of pixels for feature identification each time you come across an image is impractical and time consuming. In integral images, the image is stored in such a way that the value of a given pixel is the summation of all the pixels that have been covered within its rectangular perimeter. This way, Integral Images allow for the calculation of the sum of all pixels inside any given rectangle using only four corner values.

As mentioned before, since the number of features recognised is large and mostly consists of redundant and unwanted features, we use the AdaBoost Algorithm for filtering purposes. AdaBoost is a Machine Learning algorithm which helps in finding only the best features among all the features identified. After these features are found, a weighted combination of all these features is used in evaluating whether a given window has a face or not. Each of these features are deemed to be acceptable if they can outperform random guessing. Such features are called weak classifiers. AdaBoost constructs a strong classifier as a linear combination of weak classifiers.

Discarding non-faces as quickly as possible is pivotal to the Viola Jones Algorithm in so far as efficiency and usability are concerned. The same image is subject to scanning by the detector several times, each time with a new window size. A single strong classifier formed out of a linear combination of all the best features is not good for evaluation on each window because of the computational cost. Therefore, a cascade classifier is used which is composed of stages, wherein each stage has a strong classifier. The job of each stage is to determine if a given sub-window is definitely not a face or maybe a face. A given sub-window is immediately discarded if it fails in any stage.

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B. Principal Component Analysis using Eigen-Faces

Given a data set containing bitmap images, each of a K x K matrix format, we unfold the bitmap into a K squared dimensioned vector. This is done for every instance in the data set, after which you will have N image vectors on which Principal Component Analysis is to be performed.

Normalisation is then performed on these image vectors. Normalisation will result in the removal of any and every common feature that these vectors share, resulting in image vectors that are unique and distinct from each other. For normalisation, an average face vector is calculated, which is then subtracted from every vector. Eigen Vectors are calculated from the covariance matrix consisting of the updated image vectors.

$$cov(x,y) = \frac{1}{(n-1)} \sum_{i=0}^{n} (Xi - \bar{x})(Yi - \bar{y}) \qquad (1)$$

The need for dimensionality reduction arises because of the huge size of each EigenVector. To reduce the calculations and the effect of noise on the needed Eigen Vectors, calculate them from a covariance matrix of trimmed dimensionality. Select 'n' best eigenfaces, such that it can represent the whole training set. Represent each face image as a linear combination of all 'n' eigenfaces.

Given how we have found out the Eigenfaces for all the training images and have calculated the associated weights, if an unknown input face is to be recognised, the input image is converted into a face vector, normalised and projected onto the Eigenspace. Finally, the weight vector is calculated and this value is used to calculate the distance between the new input image and all the weight vectors of the training set. If this distance is greater than the assigned threshold, the image is recognised. An improvement on EigenFaces would be the usage of FisherFaces.[7] FisherFaces recognize that variation within each class lies within a linear subspace of the image space. It follows that classes are convex and thus linearly separable. It helps to perform dimensionality reduction while retaining linear separability. It thus achieves greater between- class scatter than Principal Component Analysis, which leads to a better classification performance and better accuracy.

C. Elastic Bunch Graph Matching

Elastic graph matching is a Facial Recognition Technique in which graphs are compared with images and new graphs are generated from it.[8] In its most rudimentary form, a single labeled graph is matched onto an image. A labeled graph consists of a set of jets arranged in a particular spatial order. Correspondingly, a set of jets is selected from the Gabor- wavelet transform of the image.

Gabor wavelets are defined mathematically as follows:

$$\psi_{\vec{k}}(\vec{x}) = \frac{\vec{k}^2}{\sigma^2} \exp\left(-\frac{\vec{k}^2\vec{x}^2}{2\sigma^2}\right)\left(\exp(i\vec{k}\vec{x}) - \exp\left(-\frac{\sigma^2}{2}\right)\right) \qquad (2)$$

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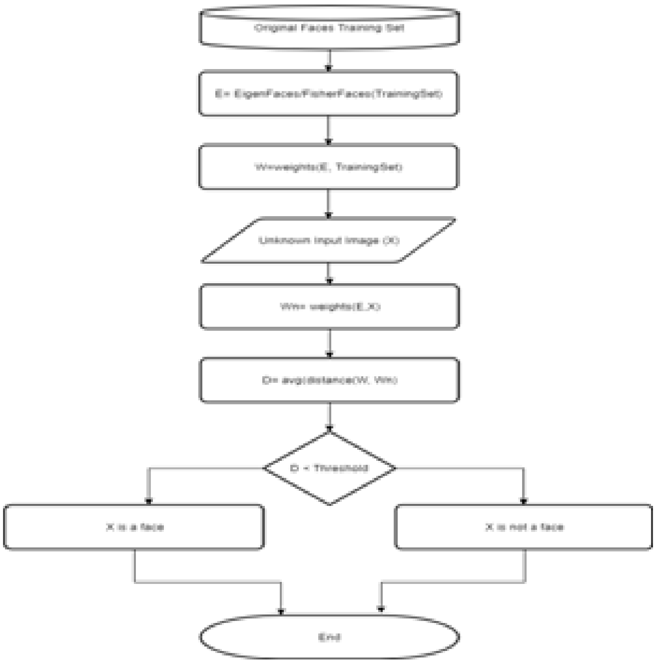

Fig.1 . PCA using eigen faces

They bear the shape of a cosine wave multiplied with a Gaussian Envelope Function.

The image jets have the same relative spatial arrangement as the graph jets initially, with each image jet corresponding to a graph jet. The similarity of the graph with the image is calcu- lated by taking the average jet similarity between image and graph jets. To increase the similarity, the graph is allowed to translate, scale and distort to some controlled extent, resulting in a different selection of image jets. Limitations and Penalties are imposed on distortion and scaling in the associated cost function. Finally, the image jet selection leading to the highest similarity with the graph is used to generate a new graph. In the Bunch Graph approach, similarity is maximized by selecting the best fitting jet in each bunch, in addition to selecting different image locations. This is performed indepen- dently for each bunch. This algorithm, at its crux, exploits the fact that all human faces share a similar topological structure, making it possible to represent the face as a labeled graph. The nodes and edges of the graph also contain crucial information, such as the distance from one node to another. Elastic Bunch Graph Matching treats one vector per feature of the face, in stark contrast to the Eigenfaces approach, the result being that changes in one feature do not particularly mean that the person is unrecognizable. It is also made possible by this algorithm to recognise faces up to a rotation of about 22 degrees.

Elastic Bunch Graph Matching uses features only at a key node of the image, and not the whole image, which reduces the noise taken from the background of the face images. It is relatively insensitive to the variations in facial position and expression.

As with any algorithm, the aforementioned algorithm also comes with its share of drawbacks. It is very sensitive to lighting conditions, and a lot of graphs have to be placed manually on the face for study and computation. In order to achieve a reliable system with high performance, a huge storage of convolution images is required.

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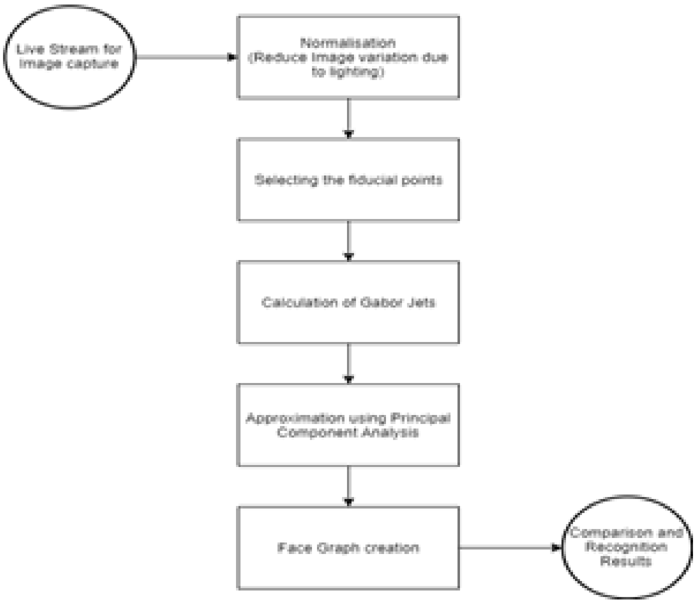

Fig.2. Elastic bunch graph matching

IV. OPENCV AND THE LBPH ALGORITHM

”Computer Vision is a field of deep learning that enables machines to see, identify and process images like humans.” OpenCv, or OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning soft- ware primarily used for Facial Recognition. OpenCV provides a common infrastructure for computer vision applications and accelerates machine perception.

The library has more than 2500 optimized algorithms, includ- ing a both classic and state-of-the-art computer vision and machine learning algorithms. Some of the applications of these algorithms include detection and recognition of faces, identi- fication of objects, classification of human actions in videos, tracking camera movements and moving objects, stitching images together to produce a high resolution image of an entire scene, finding similar images from an image database, recognizing scenery and establishing markers to overlay it with augmented reality, and so on.

The Machine Learning Library in OpenCV consists of Boost- ing Algorithms, Decision Tree Learning, Gradient Boosting trees, Expectation-Maximization and K-Nearest Neighbor Al- gorithms, Naive Bayes Classifiers, Artificial Neural Networks, Support Vector Machines and Deep Neural Networks.

OpenCv provides an all in all framework for facial recognition- beginning with detection, conversion into a desirable format, cropping and zeroing in on the regions of interests, training the associated classifiers, and finally, recognizing images. There are three facial recognition algorithms offered by OpenCV- Eigenfaces, Fisherfaces and the LBPH algorithms. The first fall within the purview of Principal Component Analysis and have been analysed in the previous section. The LBPH Algorithm is the predominantly used algorithm and is explored in detail below.

Local Binary Patterns Histogram (LBPH) Algorithm

Local Binary Patterns Histogram algorithm (LBPH) for face recognition. It is based on local binary operator and is one of the best performing texture descriptor existing today.

The LBPH uses 4 parameters-

Radius: It is used to build the circular local binary pattern and is representative of the radius around the central pixel. It is generally set to 1.

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Neighbors: This indicates the number of sample points needed to build the circular local binary pattern. You need to bear in mind that the more number of sample points you include, the higher the computational cost is going to be. It is generally set to 8.

Grid X: This indicates the number of cells in the horizontal direction. The more the number of cells taken, the finer the grid, resulting in a higher dimensionality of the feature vector. It is usually set to eight.

Grid Y: This indicates the number of cells to be taken in the vertical direction. This is again set to eight.

The algorithm is then trained. To do so, we need to use a dataset with the facial images of the people on whom facial recognition is to be performed. We need to associate an ID with each image. The algorithm will use this information to recognize an input image and give you a corresponding output. Images of the same person must mandatorily have the same ID for every picture involved in the training. The first computational step of the LBPH is to create an intermediate image that describes the original image in a better way, by highlighting the facial characteristics. To do so, the algorithm uses a concept of a sliding window, based on the parameters radius and neighbors.

The window/frame/image to be examined is divided into cells. For each pixel in a cell, its value is compared to each of its 8 neighbors (left-top, left-middle, left-bottom and right-top, and so on.) Strict order is maintained- clockwise or anticlockwise. If the center pixel's value is greater than its neighbor's value, then the neighbor pixel's value is replaced with a 1, 0 otherwise. This is repeated for every cell, giving rise to 8-digit binary numbers. Histograms are computed for each cell with regard to the frequency of occurrence of each number, and each combination of pixels with a magnitude smaller/greater than the center. Histograms of all cells are concatenated and normalised to give the feature vector of the window.

V. APPLICATION AREAS

A. Behavioral Science

Facial Recognition is going to play a critical role in Be- havioral Sciences in the years to come. It can be used to gauge the various facets of human behavior and to study the impulses involved in their response to various external stimuli. The results could then be studied to predict the manner in which certain people respond to events.

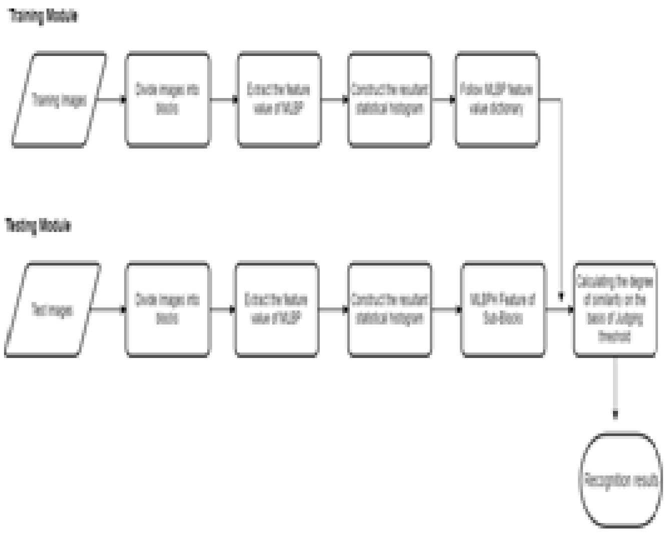

Fig.3. LBPH Algorithm

It could also be used to identify and record markers of poor mental or physical health, thereby facilitating quick and accurate diagnosis, and keeping the individual out of harm's way.

B. Sociable Robots

The one thing that has not been mastered in so far as Artificial Intelligence and Robots are concerned is the art of Human Interaction. Human Beings are complex creatures with distinctive behavioral patterns. No two human beings can be equated, and correspondingly, their interactions cannot be quantified.

Facial Recognition can play a significant role in mitigating the existent gap by providing AI devices with state-of-the-art Emotion Recognition capabilities for the study and simulation of Human Behavior, leading to very natural interactions between Humans and Robots.

C. Engagement Levels

Facial Recognition systems could be used in Educational Institutions to gauge the level of engagement of students.[9] Standard indicators of the lack of interest in students could be used to identify students who are lagging behind in the subject and in need of special attention

This system could also be used to rate the abilities of the lecturer in capturing the attention of students and making the course interesting.

D. Prevention of Road Accidents

Accidents on the road maybe caused due to a myriad of reasons- the most common ones being falling asleep on the wheel, driving when drunk and unexpected medical emergencies.

Facial Recognition could play a very important role if used judiciously in vehicles. It could be programmed to detect when the driver falls asleep, in which case emergency protocols such as sounding a loud alarm could be followed. Drunk and disorderly behaviour can be detected and the necessary parties can be intimated.

This can lead to a significant drop in the number of accidents and save lives on the road.

E. ATMs

ATM Machines, when enabled with efficient Facial Recog- nition, can provide an extra dimension to the verification and authorisation process. It could ensure that only the individual in whose name the card is registered, is able to access the pertinent banking facilities. This will prevent crimes involving impersonation and theft.

F. Smart Marketing

The world runs on data today. Data is almost reaching a weaponized state with companies battling it out to buy data to target customers by providing them with ads that are tailor- made to fit into their socioeconomic backgrounds.

Facial recognition can also be employed to effectively recog- nize, categorize and target groups of people with advertise- ments that are relevant, and would leave an impact on them. For instance- a person if identified as belonging to the student community and of the 18-25 age group, could be presented with advertisements on foreign universities for higher studies. This way, with smart utilisation, Facial recognition systems can revolutionise marketing strategies.

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REFERENCES

[1]Astro Teller, Manuela Veloso Algorithm Evolution for Face Recognition: What Makes a Picture Difficultn. Carnegie Mellon University Pittsburgh,PA 15213

[2]Keith Anderson, Peter W. McOwan A Real-Time Automated System for the Recognition of Human Facial Expressions Ieee transactions on systems, man and cybernetics- Part B: Cybernetic, Vol. 36, No. 1, February 2006

[3]Irfan A. Essa, Alex P. Pentland Coding, Analysis, Interpretation, and Recognition of Facial Expressions Ieee transactions on pattern analysis and machine intelligence, Vol. 19, No. 7

[4]Javier Galbally, Se´bastien Marcel Image Quality Assessment for Fake Bio- metric Detection: Application to Iris, Fingerprint, and Face Recognition Ieee transactions on Image Processing, Vol. 23, No. 2, February 2014

[5]Maja Pantic, Leon J. M. Rothkrantzl Facial Action Recognition for Facial Expression Analysis From Static Face Images Ieee transactions on systems, man and cybernetics- Part B: Cybernetic, Vol. 34, No. 3,
June 2004

[6]Thomas M. Murphy, Randy Broussard, Robert Schultz, Ryan Rakvic.Hau Ngo Face detection with a Viola–Jones based hybrid network IET Biometrics Volume: 6, Issue: 3,5 2017

[7]P.N. Belhumeur, J.P. Hespanha, D.J. Kriegman Eigenfaces vs. Fisherfaces: recognition using class specific linear projection IEEE Transactions on Pattern Analysis and Machine Intelligence (Volume: 19 , Issue: 7 , Jul 1997)

[8]L. Wiskott, Norbert Kru¨ger, N. Kuiger, C. von der Malsburg Face recognition by elastic bunch graph matching IEEE Transactions on Pattern Analysis and Machine Intelligence (Volume: 19, Issue: 7 , July 1997)

[9]Jacob Whitehill, Zewelanji Serpell, Yi-Ching Lin, Aysha Foster, Javier R. Movellan The Faces of Engagement: Automatic Recognition of Student Engagement from Facial Expressions IEEE transactions on affective computing, Vol. 5, No. 1, January-March 2014