IMAGE PROCESSING INTERFACE

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by

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JUNE , 2021

CERTIFICATE

Certified that **SAJAL CHANDRA**(04241802817) , **ROHIT KUMAR**(04214802817) , **OJAS**(35914802817) have carried out the major project work presented in this report entitled **"IMAGE PROCESSING INTERFACE"** for the award of **Bachelor of Technology** in **Electronics and Communication Engineering** from Maharaja Agrasen Institute of Technology affiliated to GGSIP University, Delhi under my supervision. The report embodies results of original work and studies as carried out by the students themselves and the contents of the report do not form the basis for the award of any other degree or to anybody else from this or any other university/institution to the best of my knowledge and belief.

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ABSTRACT

Digital image processing has unfolded itself in vast area of applications. It has proved itself beneficial in Medical field, Remote Sensing , Colour Processing ,Pattern Recognition etc. Image processing is a method to perform some operations on an image ,in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. The three general phases that all types of data have to undergo while using digital technique are pre-processing, enhancement, and display, information extraction.

ACKNOWLEDGEMENTS

First and foremost ,We wish to express our profound gratitude , MAIT for giving us this opportunity to carry out our project. We find great pleasure to express our unfeigned thanks to our training head Dr. R,K Choudhary and his useful suggestions at every stage of this project work. No words can express our deep sense of gratitude to our mentor ,without whom this project would not have turned up this way. Our heartfelt thanks to him for his immense help and support ,useful discussions and valuable recommendations throughout the course of our project work. We wish to thank our respected faculty for their support.
Last but not the least we thank the almighty for enlightening us with his blessings.
Most of all, I would like to thank God for everything especially His love and grace.

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CHPATER 01 INTRODUCTION

What Is Machine Learning?

Generally, to implement Artificial Intelligence, we use Machine Learning. We have several algorithms that are used for Machine Learning. For example:

- Decision trees
- Random forests
- Artificial Neural Networks

Generally, there are 3 types of learning algorithms:

1. Supervised Machine Learning Algorithms make predictions. Further, this algorithm searches for patterns within the value labels that were assigned to data points.

2. Unsupervised Machine Learning Algorithms: No labels are associated with data points. Also, these ML algorithms organize the data into a group of clusters. Moreover, it needs to describe its structure and make complex data look simple and organized for analysis.

3. Reinforcement Machine Learning Algorithms: We use these algorithms to choose an action. Also, we can see that it is based on each data point. After some time, the algorithm changes its strategy to learn better.

What is deep learning?

Then we will like to introduce “Deep Learning” as it is the base of our whole project. Deep learning is a branch of machine learning which has gained so much popularity in the last few decades for its capability to process data, develop abstractions and recognize objects visually.

When we researched more about “deep learning” we came across the term neural network which caught our attention . Neural network took biological inspiration from the smartest creator on earth i.e humans. The idea of human brain neurons inspired the scientists to create artificial neural network.

DEEP LEARNING VS MACHINE LEARNING

FACTORS	DEEP LEARNING	MACHINE LEARNING
Data Requirement	Requires large data	Can train on lesser data
Accuracy	Provides high accuracy	Gives lesser accuracy
Training time	Takes longer to train	Takes less time to train
Hardware Dependency	Requires GPU to train properly	Trains on CPU
Hyperparameter Tuning	Can be turned in various different ways	Limited tuning capabilities

CHAPTER 02 OpenCV

OpenCV is a huge open-source library for computer vision, machine learning, and image processing. OpenCV supports a wide variety of programming languages like Python, C++, Java, etc. It can process images and videos to identify objects, faces, or even the handwriting of a human.
It also plays a major role in real time operation which is very important in today's systems.

NUMPY
When it is integrated with various libraries, such as Numpy which is a highly optimized library for numerical operations, then the number of weapons increases in your Arsenal i.e. whatever operations one can do in Numpy can be combined with OpenCV.
Numpy is a highly optimized library for numerical operations. It gives a MATLAB-style syntax. All the OpenCV array structures are converted to-and-from Numpy arrays. So OpenCV-Python is an appropriate tool for fast prototyping of computer vision problems.

Benefit of OpenCV

1.Vast Algorithms
OpenCV gives access to more than 2,500 state-of-the-art and classic algorithms. By using this library, users can perform various tasks like removing red eyes, extracting 3D models of objects, following eye movements, etc.

2.Extensive Use

Big companies like IBM, Google, Toyota and even startups like Zeitera and Applied Minds are using OpenCV for multifarious tasks. This way, users are assured that they have access to a library that is being used by government institutions and enterprises.

In the vast community of OpenCV, users can ask for assistance and provide help to other developers. This gives developers access to insights of people about library and codes.

3.Efficient Solution

OpenCV provides algorithmic efficiency mainly to process real-time programs. Moreover, it has been designed in a way that allows it to take advantage of hardware acceleration and multi-core systems to deploy.

OpenCV VS MATLAB

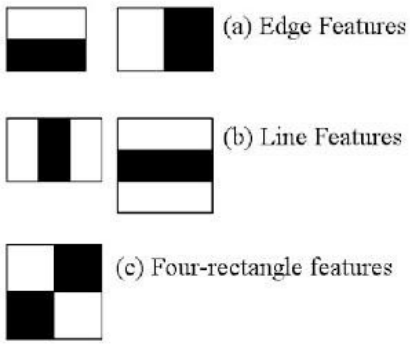
OpenCV	**MATLAB**
Faster in execution	Convenient in developing and data representation
Harder to learn	Comparatively easy to learn
Useful for rapid prototyping	Its program are not portable
it is open source	It is not an open source

CHAPTER 03 FACE DETECTION

Face Detection is a crucial step in the face recognition process because it helps localize and extract face regions from unwanted images or backgrounds. We evaluated two techniques for face detection: 1) Local Binary Pattern(LBP) and 2) Haar Like Features. In this project, Haar cascade classifiers are used.

Haar Cascade

Haar Cascade is a machine learning algorithm used to detect objects in images, videos, or live feeds. It is based on the concept of features proposed by Paul Viola and Michael Jones in their paper “Rapid Object Detection using Boosted Cascade of Simple Features”. It is based on the Haar Wavelet technique to analyze pixels in the image into squares by function. The contrast variances between the pixel groups are used to determine relative light and dark areas[25].



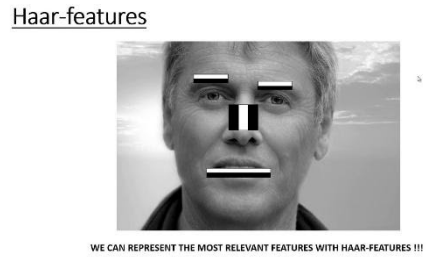
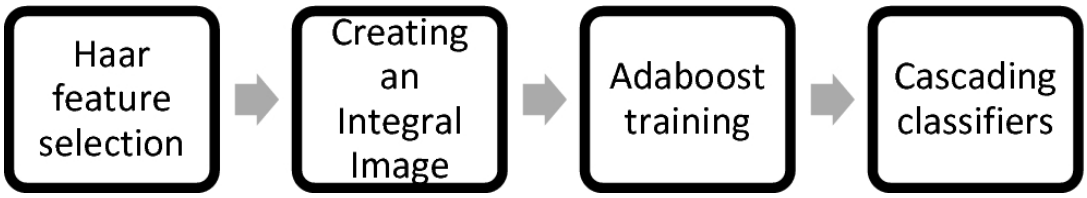


Fig: haar cascade features

This uses machine learning techniques to get a high degree of accuracy from the “training data”. This uses “integral image” concepts to compute the “features” detected. Haar

Cascades uses the **Adaboost** learning algorithm, which selects a small number of essential features from a large set to classify classifiers efficiently.

A flow chart of the Haar Cascade algorithm process is shown below:



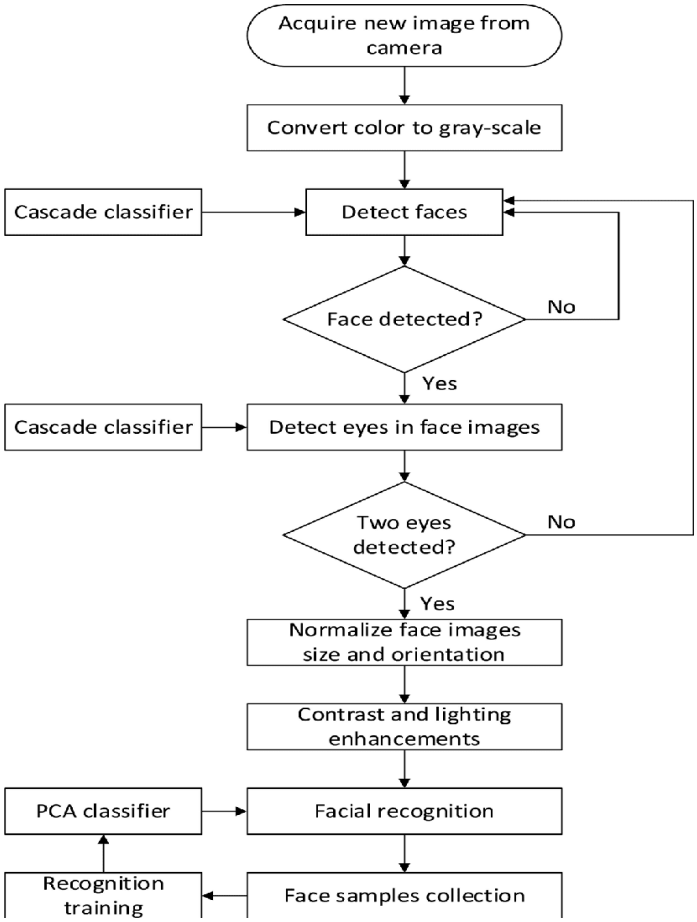
Open CV uses Haar Cascade to detect objects in an image. The list of objects that Haar Cascade can detect includes faces, cars, eyes, mouth, etc. It is widely used in face/body part detection, but it can be trained to detect other objects as well. For face detection, the algorithm needs to be trained with a large number of positive images(with faces) and negative images(without faces). The training phase is followed by feature extraction[22,23,24].

FACE RECOGNITION AND ITS APPROACH

After successful detection of the face in the image, now a face recognition system can be created. A proper procedure needs to be followed, which consist of the following steps-

1. *Input image /Video source*: An input source would be provided to the system. That input could be a still image or an image from a live feed.
2. *Face Detection*: It is a key issue as it involves the detection of the required object from images. In our case, it is the face. Also, all required translations, scaling, and rotational variations are performed in this phase only.
3. *Face Normalization*: Face normalization comes under image processing. It is a process that helps in changing the range of pixel intensity values. It is also known as contrast stretching or histogram stretching.
4. *Feature Extraction*: In this phase, the system tries to locate the approximate location of principal features such as nose, eyes, and mouth. This procedure needs to be repeated several times to predict the sub-features as well.
5. Face Classification
6. Face Recognition

A flowchart representing the facial recognition process is shown below.



We have learned about the different steps of a face recognition process. However, it is not necessary to stick to these steps only as it may differ when we follow different face recognition approaches [14].

Some popular facial detection approaches are examined below:

1. *Geometric /Template Based approaches*
   We can classify the methods as either template based or geometric based [2,3]. The template-based approach is a digital image processing technique suitable for locating small parts of an image that matches a template image. It compares the input image with a set of templates. Several statistical tools such as SVM [4,5,6],PCA [7,8,9] or LDA [10] can be used to construct the set of templates.

2. *Piecemeal/Wholistic approaches*
   This approach is made in separate stages rather than being planned as a whole. It follows the principle that the identification of faces is possible even from little information available. In simpler words, the relation of a feature with the whole face is not taken into account. Although characteristic processing is crucial in face recognition, the relation between features (configural processing) is also important. In fact, facial features are processed holistically. That's why nowadays, most algorithms follow a holistic approach[11].

3.Appearance- based /Model-based approaches

One classification of face recognition methods can be divided into appearance-based or model-based algorithms. An image is considered a high dimensional vector in an appearance-based approach, i.e., the face is represented in terms of several raw intensity images. Then statistical techniques are usually used to derive a feature space from the image distribution. Then the sample image is compared to the training set. On the other hand, the model-based approach tries to model a human face. The new sample is fitted to the model, and the parameters of the fitted model are used to identify the image.

4.*Statistical/Neural Network Approaches*

A similar separation of pattern recognition algorithms into four groups is proposed by Jain and colleges [12]. Face recognition methods can be classified into three main groups [13,14]–

- Template Matching: Patterns Template Matching: Patterns are represented by samples, models, pixels, curves, textures. The recognition function is usually a correlation or distance measure.

- Statistical Approach: Patterns are represented as features. The recognition function is a discriminant function.
- Neural Networks: The representation may vary. There is a network function at some point.

CHAPTER 06 IMAGE PROCESSING

Before applying the Face Recognition Algorithms mentioned above, it is essential to prepare the image first. Doing so will considerably improve the performance of the algorithm. This is the Image Processing step; it includes normalization, transformation, scaling, rotation, and other such steps. The general idea behind image pre-processing is to convert the image to a standard form to improve algorithms' performance. For example, algorithms that deal with non-uniform illumination in images typically attempt to normalize the lighting to a standard scale in order to reduce the negative impact of varying illumination on face recognition.

One of the most common methods used in image processing is grey-scale transformation. Face recognition algorithms are better at identifying facial features in grey-scale images due to the absence of the RGB color bands that hinder performance. Some popular methods of grey-scale transformation are as follows:

- Histogram Equalization: In this method, the original image histogram is changed into a constant histogram for all brightness values. This allows areas of low intensity to gain higher intensity and vice-versa. This method is handy when the background and foreground of an image are too bright or too dark. It is a straight-forward operation and is easily reversible, plus it is computationally inexpensive. However, this method is indiscriminate; i.e., it often increases the contrast of background noise-hampering the face recognition algorithm performance.
- Contrast Limited Adaptive Histogram Equalization (CLAHE): CLAHE is a modified version of Histogram Equalization. This method first uses a transformation function on the image and then applied contrast amplification, which is limited to reducing noise amplification.
- Gamma Intensity Correction (GIC): GIC corrects an image's brightness to a pre-defined value, thus weakening the effect of varying lighting.
- Discrete Cosine Transform (DCT): It is a normalization technique based on Fourier transform. The dynamic range of an image in grey-scale is adjusted to the interval [0,255], and then the ends of the image histogram are truncated. This operation allows distributed grey levels along an image, eliminating the problems of the presence of very bright values in the image that could dark the rest of the image after size changing.

For this project, after carefully examining all the methods, we have decided to use the CLAHE method because of its low complexity and high accuracy.

CHAPTER 07 COLOR DETECTION

Sometimes color detection is necessary to recognize objects, it is also used as a tool in various image editing and drawing apps.
Color detection is the process of detecting the name of any color. For humans this is an extremely easy task but for computers ,it is not straightforward. Human eyes and brains work together to translate light into color. Light receptors that are present in our eyes transmit the signal to the brain. Our brain then recognizes the color.
According to the color and luminance information in RGB color space, the dominant color is determined at first, and then color similarity can be calculated with the proposed calculation method of color component, which creates a color-class map.
We have studied various methods for color detection to enhance our capability of creating a efficient model methods[14,15]:

1)HSI Model

HSI model is more close to human eye perception of observing color. and the hue (H) parameter are more stable in different light conditions, so it is chose as the main parameters of this system. At the same time, In order to improve the accuracy of identification in different illumination conditions, based on the principle that the apple of human's eye have different reflection to the different illumination, so the value of the second parameter saturation threshold (S) is adjusted dynamically according to the brightness value (I), the run-length coding techniques is used in image fusion process.

2)YCbCr Model

YCbCr, Y′CbCr, or Y Pb/Cb Pr/Cr, also written as YCBCR or Y′CBCR, is a family of color spaces used as a part of the color image pipeline in video and digital photography systems. Y′ is the luma component and CB and CR are the blue-difference and red-difference chroma components. Y′ (with prime) is distinguished from Y, which is luminance, meaning that light intensity is nonlinearly encoded based on gamma corrected RGB primaries. Y′CbCr is not an absolute color space; rather, it is a way of encoding RGB information. The actual color displayed depends on the actual RGB primaries used to display the signal. Therefore a value expressed as Y′CbCr is predictable only if standard RGB primary chromaticities are used.

3) rg-chromaticity model

r, g, and b chromaticity coordinates are ratios of the of one tristimulus value over the sum the all three tristimulus values. A neutral object infers equal values of red, green and blue stimulus. The lack of luminance information in rg prevents having more than 1 neutral point where all three coordinates are of equal value. The white point of the rg chromaticity has one third red, one third green and the final third blue.

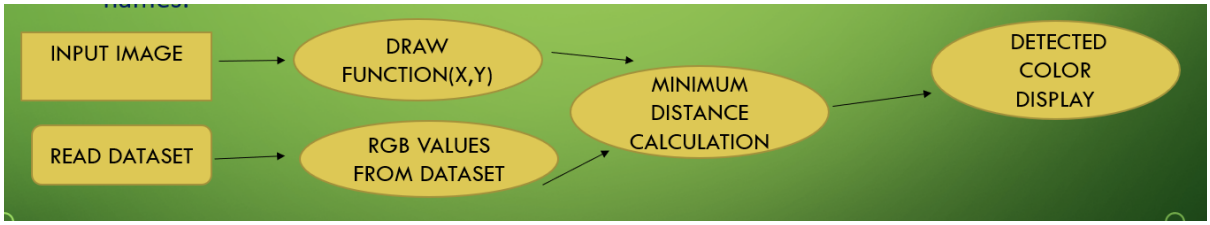
4)Naïve Bias based approach [16]

It is a classification based technique based on Bayes theorem. In simple terms, a Naïve Bayes classifier assumes that the presences of a particular feature . Class is unrelated to the presence of any feature . Calculate the prior probability for given class labels. Find Likelihood probability with each attribute for each class.

5)Research Methodology [16]

We have the r, g and b values. Now we need another function which will return us the color name from RGB value. To get the color name, we calculate a distance (d) which tells us how close we are to choose the one having minimum distance.

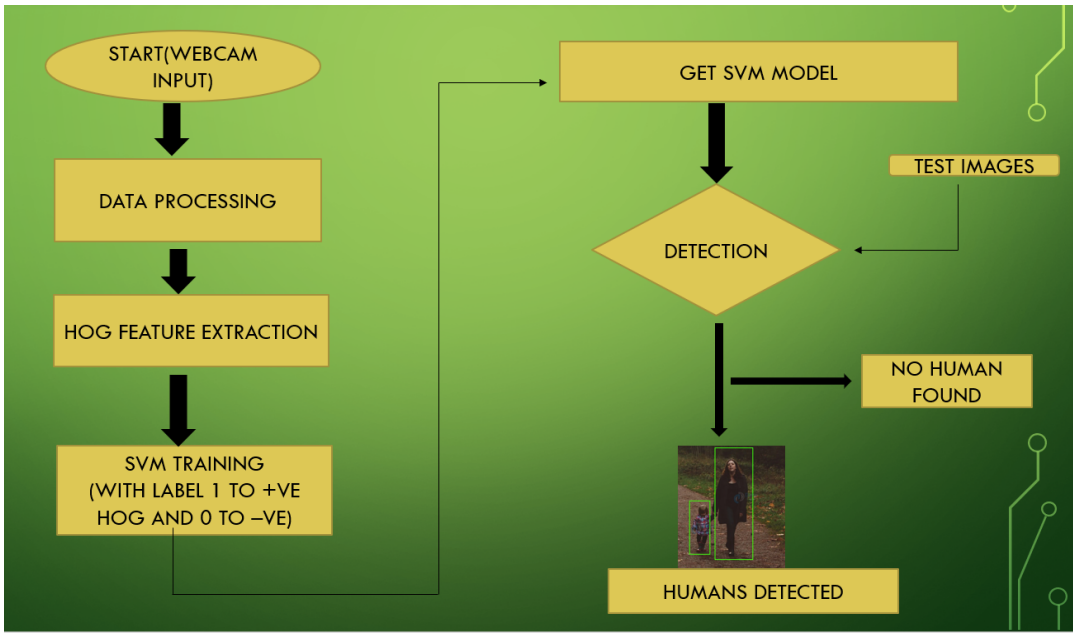
MODEL WORKING



CHAPTER 08 HUMAN DETECTION

Detecting human beings accurately in a visual surveillance system is crucial for diverse application areas including abnormal event detection, human gait characterization, congestion analysis, person identification, gender classification and fall detection for elderly people. The first step of the detection process is to detect an object which is in motion. Object detection could be performed using background subtraction, optical flow and spatio-temporal filtering techniques. Once detected, a moving object could be classified as a human being using shape-based, texture-based or motion-based features[30].

HOG FEATURE DETECTOR: HOG, or Histogram of Oriented Gradients, is a feature descriptor that is often used to extract features from image data. The HOG features are widely use for object detection. HOG decomposes an image into small squared cells, computes an histogram of oriented gradients in each cell, normalizes the result using a block-wise pattern, and return a descriptor for each cell[31].



The gradient orientation: Tells us the direction of greatest intensity change in the. neighborhood of pixel (x,y).

An image gradient is a directional change in the intensity or color in an image. Each pixel of a gradient image measures the change in intensity of that same point in the original image, in a given direction. To get the full range of direction, gradient images in the x and y directions are computed.

Additionally, these orientations are calculated in ‘localized’ portions. This means that the complete image is broken down into smaller regions and for each region, the gradients and orientation are calculated.

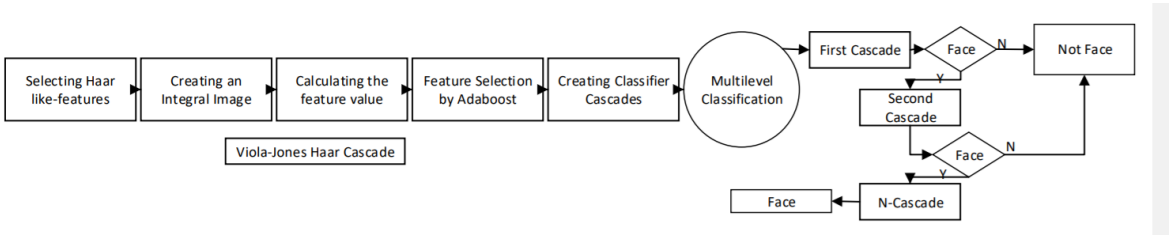
Finally the HOG would generate a Histogram for each of these regions separately. The histograms are created using the gradients and orientations of the pixel values.

we created the HOG features for the image ,the gradients of the image are sensitive to the overall lighting. We cannot completely eliminate this from the image. But we can reduce this lighting variation by normalizing the gradients by taking 16×16 blocks.

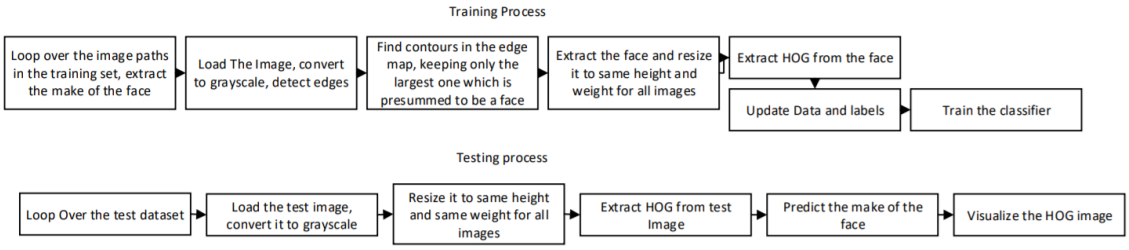
SVM: SVMs are set of related supervised learning methods used for classification and regression [32]. They belong to a family of generalized linear classification. A special property of SVM is , SVM simultaneously minimize the empirical classification error and maximize the geometric margin. So SVM called Maximum Margin Classifiers. SVM is based on the Structural risk Minimization (SRM). SVM map input vector to a higher dimensional space where a maximal separating hyperplane is constructed. Two parallel hyperplanes are constructed on each side of the hyperplane that separate the data. The separating hyperplane is the hyperplane that maximize the distance between the two parallel hyperplanes. An assumption is made that the larger the margin or distance between these parallel hyperplanes the better the generalization error of the classifier will be [32].

COMPARISON OF HAAR CASCADE AND HOG METHODOLOGY

In this study, we propose an application to detect the face by implementing Viola-Jones Haar Cascade and compared with the Histogram of Oriented Gradients. The following steps for image processing that have been done in both methods are shown in figures below[33].



(HAAR CASCADE)

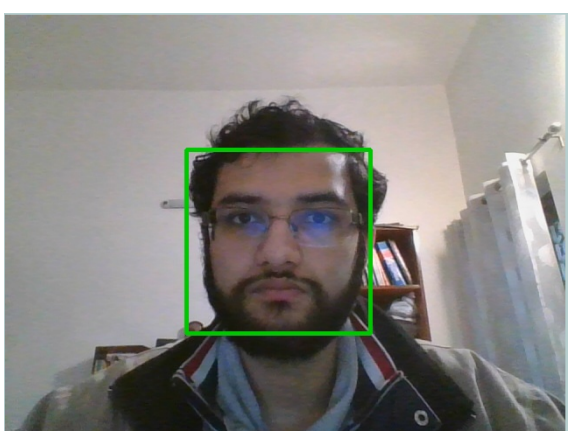


(HOG)

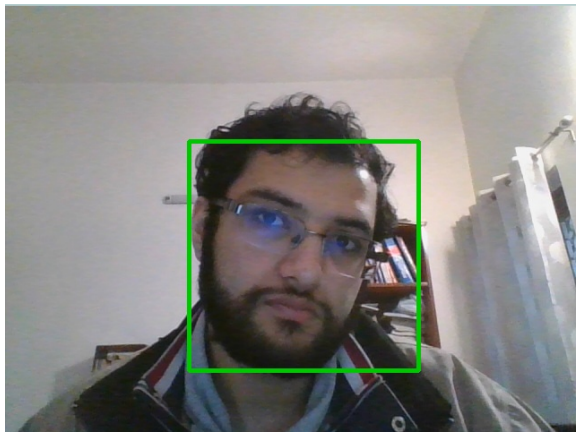
ANALYSIS MODEL OF IMAGE PROCESSING INTERFACE

In recent years, image processing has concerned much attention. It has numerous applications in computer vision communication and regular access control system. Image processing is an elementary yet essential step towards automatic face detection systems. We have tried to combine different functionalities at a single platform to see multi levels of image processing.

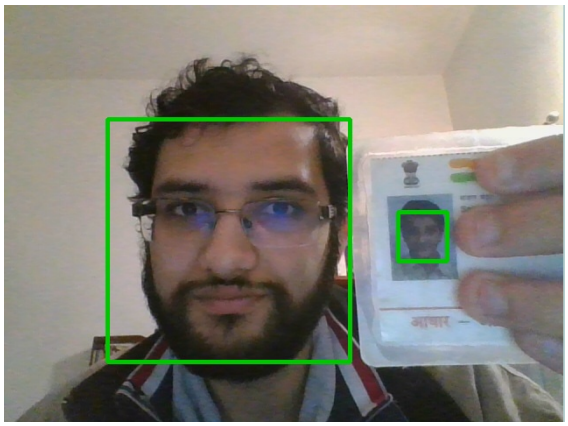
Image Outputs



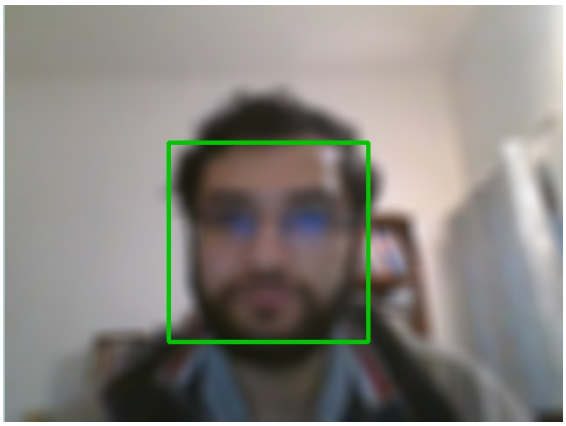
1



2



3



4

The four screenshots were taken from my webcam feed. The model's robustness and accuracy are clearly demonstrated by the fact that it could detect faces in a variety of settings. A brief description of the four images is given below:

1. This is a standard image without any filters. The model detected the face flawlessly, as expected.
2. The face is slightly rotated here, and it was still detected.
3. Multiple faces are detected accurately- one of them being on a printed document.
4. The blurred face is also detected accurately.

All of the above detections were performed on raw input data- without image processing. Now let us examine the model's performance after image processing.

Conclusion

In this paper, color detection , human detection techniques were discussed in detail. We also examined the various image processing algorithms that enhance the performance of those techniques. Further, we implemented one of the models(HOG +SVM) using Python's Open CV framework, and its results were satisfying. Although, there is scope for improvement. The model was unable to detect faces that were rotated beyond a certain angle, and it also struggles to detect faces in low-light conditions- severely limiting its applications. One possible solution to these obstacles is the use of Neural Network-based models. This was implemented in 2015 with the introduction of *FaceNet*- a new concept that achieved significantly improved results. [30]

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