Comparison of Paul Viola – Michael Jones algorithm and HOG algorithm for Face Detection

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Abstract. The computer technology which helps to find the face of a person in video and image is face detection. It is like a biometric application that finds a person by analyzing and comparing the person's face patterns. The face detection technique helps for security purposes, and also it has an rising interest in many fields. This technology has received good attention. It has some good applications based on law enforcement. For detecting face in an digital image, we have lot of algorithms. In this, Viola Jones algorithm and histogram of oriented gradients is used to detect the face of a person. The paper is proposed for a comparison between viola jones and Hog. By analyzing this we can find the gender, age and also emotions of the person. Here different type of images were used for detection. The Matlab tool and Jupyter is used for implementing this face detection process.

Keywords: Face detection, viola jones algorithm, image processing, matlab, Hog algorithm.

1. Introduction

Face recognition helps to make the world smart, safe, and convenient. It can be used to prevent crime, used in the phone as face lock, to find the missing person, help blind persons, for forensic works, helps to identify people in images on the social platform. Object detection has lot of good things and application. And also face detection is part of it. In the past, few years the image processing had a huge growth in its development. In Industries, Object detection plays a good role in manufacturing and packaging the products. In supermarket, with the help of barcode we can identify the items [1,2]. Like this there are a lot of good applications are present in object detection for the industries. Computer vision which enables the machine to find the objects and process only the required information. Camera is used for detecting the object and it is the source of the computer. The only main thing is detection and recognition of the object or face should be accurately correct. If it has perfect accuracy, there won’t be any problem in the process. And also it has some problems in individuals privacy, it will be major drawback in this technology [3,4].
2. Viola Jones algorithm

Before two decades, Paul and Michael have developed this algorithm to find objects which are present in a digital image or video. That algorithm is object recognition framework. Even though it might be an old method, but it is powerful and has more applications and also given better results in identifying objects in digital images or real time videos [5]. Although we can train to detect a variety of objects like gray scale images, object classes for face detection.

It is fast and most accurate method to find objects. To improve the focus in professional cameras and mobile phone, the manufactures use this algorithm. Within seconds we can detect face, which is present in an image by using Haar and adaboost ML features of the algorithm. This algorithm has very high - detection rate and very low - false positive rate [6].

![Figure 1. Flowchart of the Viola Jones algorithm.](image)

There are four concepts, which is followed in this algorithm:

2.1. Haar - like feature

Mostly all the human face are having similar property. Using Haar feature we can match their properties. In computer vision features of the input image is extracted. Instead of considering the intensity of the input image. This Haar - like feature has white and black regions. One value is produced by the addition of the intensities of the white region and that is subtracted by the additon of the intensities of black region. There are different types of Haar - like feature which helps to extract information from the input digital image namely edge feature, diagonal line feature and straight line feature. This helps to identify the persons face [7, 8].

![Figure 2. Haar – like feature.](image)

2.2. Integral Images

The intermediate representing of an image is called integral image. It can also be named as sum of the area tables. It also helps to do fast feature detection. The integral image is the border of the pixel value in the image. The rectangular region can be calculated fast by using intermediate representation. It is because, each and every feature of the rectangular area is for always adjacent to one or the other rectangle. The any 2 rectangular feature is computed in 6 array reference, any 3 rectangular feature is computed in 8 array reference and any 4 rectangular feature is computed in 9 array reference. Since the Haar - like feature involves the process of extracting information by calculating the sum of the white/black rectangular region, by introducing the integral image it excludes the time needed to process the task [9,10].

2.3. Adaboost ML

This adaboost ML is used for selecting or extracting only the best features among all the features which are available in the image. The Strong classifier is the outcome of this algorithm. The linear combinations of the weak classifier are used for making a strong classifier. From the highest level, weak classifier can be identified by the processing algorithm for a number of iterations. The number of
iterations depends upon the number of weak classifiers. For each of the iteration, the adaboost algorithm identifies error rates in all the features and it selects the feature with very low error rate for that particular iteration. This algorithm captures the small feature which is present in the image and it helps for very fast and easy computation. By excluding the unwanted background information it only gives the desired part or regions of the image. This method of learning is very quick and produces only the desired data of the image. That data is arranged in classes into classifier. This classifier has some small features which are used for pattern detection. The accuracy is high and speed of detection is good but it consumes a lot of time for training [11 - 13].

2.4. Cascade classifier
It is multi stage classifier, can do detection very fast and correctly. In each stage, it has powerful classifier which was generated by adaboost algorithm. In the strong classifier, number of weak classifier is increased by moving from one to another stage. The input image is computed stage by stage like a sequence basis. In the specific stage, if the classifier produces the result as negative then it rejects the input. Otherwise if the output is resulted as positive, then the input is sent to next stage. According to Paul and Michael, the multi stage classifier helps in building of simple classifier. It helps to exclude the negative inputs and it focus more on the positive inputs [14, 15]. Evaluating for each stage might take seconds but we need to do for each and every feature so it will consume more time. But the cascading increases the speed of the process and machine can produce the result very quickly.

Figure 3. Cascade Classifier.

3. Histogram of Oriented Gradients algorithm
The Hog algorithm is a feature descriptor whose main objective is detecting the objects. Hog algorithm is mostly used for people detection. The Histogram of oriented gradients depends on the object’s property in an image to have the distribution of edge directions or intensity gradients. The gradients are always calculated in an image per block. The pixel grid is known as a block where gradients are represented from the direction and magnitude of change in the pixel’s intensities within the block. The concatenation of histogram is called a descriptor. To improve the accuracy, in a block the larger region of an image is used for measuring the intensity across it. By calculating this, local histogram can be contrast normalized. This helps in increasing the accuracy. By using the value, all the cells are normalized in the block. The standardization helps in changing the illuminance and shadows [16].

Compared to other descriptor the Histogram of oriented gradients descriptor has some advantages. Since it is operating on local cells, it never changes for photometric and geometric transformation. But it changes for object orientation. These changes mostly occur at larger spatial areas. The histogram of oriented gradients is mostly suited for people detection in image.

3.1. Gradient computation
The initial action of feature detectors in image processing is to check whether the colour and gamma value are normalised. But this action can be excluded in Histogram of oriented gradients descriptor. It is because of the normalization of descriptor yields a similar result. By doing image processing, it gives a small impact on the performance. Computing the gradient values is the initial step of calculation. The common method was applying 1-dimensional coordinated derivative mask in a vertical direction or horizontal directions or in both the directions. This method need filtering of the color of the image using filter kernel like \([-1,0,1]\) and \([-1,0,1]^T\).

3.2. Orientation binning
Creating a cell histogram is the second step. The number of pixel in the cell consists of vote weight for the histogram channel depending on values which are available in gradient computations. The cells are in the shape of radial or rectangular. In the histogram channels, if the gradient is unsigned it spreads over 0
to 180 degrees. Otherwise, if it is signed it spreads over 0 to 360 degrees. The conjunction with unsigned gradients in nine histogram channels has performed exceptionally good in the human detection process.

3.3. 

Descriptor blocks
The gradient strength should be standardized to evaluate the changes in the lighting and contrast. The cells are grouped in a large area which is associated with the block. There are two important block geometry is present. R - Hog rectangular histogram blocks and C - Hog circular histogram blocks. Usually, R - Hog blocks are square grid type consisting of 3 specifications, the num of cells in each block, the num of the pixel of each cell, and also the num of the channel in each cell histograms. The C - Hog, Circular histogram blocks are 2 types. One is a signal cell and middle cell. Another one is a angular splitted middle cell. This block has 4 specifications, the num of angular bin and radial bin, the radii of the middle bin and also expansion factors of the radii of the extra radial bin[17].

4. Methodology and Result
The Matlab software and Jupyter is used for this work. The objective of this work is to detect face. The computer vision tool box of Matlab is required for this work. This tool box has cascade object detecting system which helps to find out the objects in the image or video, based on the algorithm. Viola Jones algorithm is implemented in Matlab and Histogram of oriented gradients is done by using Jupyter notebook.

4.1. Face detection using viola jones algorithm
In face detection, face was made as default object in the function. The face detection method was used to detect face in different types of images. The face detection was carried on a colour image, black and white image and group of people image. By seeing these figures we can find the face of the person, where a rectangle is placed over the image. Indicating the face of the person.

4.2. Face detection using Histogram of oriented gradients

5. Conclusion
The image processing has enormous applications in our daily life. It is used in medical, industries, satellites, bio-technology, forensics, CV, AR and lot more. With the help of MATLAB, we were able to detect the face through its image processing option. Computer vision tool box is one of the main function for object detection through different types of images. The face of the people were identified for the different types of images of Colour, black and white. The viola – jones algorithm was used in detecting the object. The haar – like feature and adaboost ML used to enhance the algorithm for detecting the object in seconds. Histogram of oriented gradients was fast and accurate in detecting the face of the
person in an image. We can conclude that histogram of oriented gradients is faster than the viola jones algorithm.

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References
[1] BahajathulFathema, AlamuriDedeepya Lakshmi, BandlamudiRavali and Raja RajeswariDokku 2018 Real Time Face Detection Using MatlabInternational Journal of Engineering Research & Technology7(02)
[2] GirishBelani 2020 Face Recognition with Feature Points Detection using MATLAB International Research Journal of Engineering and Technology07(04)
[3] RudrakshYagnik, Ashish Jangid and Sachin Jain 2014 A Practical Implementation of Face Detection by using Viola Jones Algorithm in MATLAB GUIDE International Journal of Engineering Research & Technology3(9)
[4] Aaron Don M Africa, AraJyllian A Abello, Zendrel G Gacuya, Isaiah Kyle A Naco and Victor Antonio R Valdes 2019 Face Recognition Using MATLAB International Journal of Advanced Trends in Computer Science and Engineering8 4
[5] Elena Alionte and Corneliu Lazar 2015 A Practical Implementation of Face Detection by Using Matlab Cascade Object Detector 19th International Conference on System Theory, Control and Computing 785–790
[6] Michel Owayjan, Roger Achkar and Moussalskandar 2016 Face Detection with Expression Recognition using Artificial Neural Networks 3rd Middle East Conference on Biomedical Engineering (MECBME),1 115–119
[7] Mridul Kumar Mathur and PriyankaBhati 2017 Face Objects Detection in still images using Viola-Jones Algorithm through MATLAB TOOLS International Journal of Innovative Research in Computer and Communication Engineering5 2
[8] Yang G and Huang T S 1994 Human Face Detection in Complex Background Pattern Recognition27(1)53–63
[9] Yi Qing Wang 2014 An Analysis of the Viola-Jones Face Detection Algorithm Image Processing On Line4 128–148
[10] Mehl K Dabhi and Bhavna K Pancholi 2016 Face Detection System Based on Viola - Jones Algorithm International Journal of Science and Research (IJSR)5(4) 62–64
[11] Vikram K and Padmavathi S 2017 Facial parts detection using Viola Jones algorithm 4th International Conference on Advanced Computing and Communication Systems (ICACCS) 1–4
[12] Viola P and Jones M 2001 Rapid object detection using a boosted cascade of simple features Proceedings of the 2001 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR) I 1–I
[13] Cuimei L, Zhiliang Q, Nan J and Jianhua W 2017 Human face detection algorithm via Haar cascade classifier combined with three additional classifiers 13th IEEE International Conference on Electronic Measurement & Instruments (ICEMI) 483–487
[14] E. Ramprashath, P. Manojkumar, P. Veena “Analysis of Direct Current Motor in LabVIEW”, World Academy of Science, Engineering and Technology, 2015.
[15] Nehru M and Padmavathi S 2017 Illumination invariant face detection using viola jones algorithm 4th International Conference on Advanced Computing and Communication Systems (ICACCS) 1–4
[16] Rahmad C, Asmara R A, Putra D R H, Dharma I, Darmono H and Muhiqiqin I 2020 Comparison of Viola-Jones Haar Cascade Classifier and Histogram of Oriented Gradients (HOG) for face detection IOP Conf. Series: Materials Science and Engineering 732
[17] Dalal N and Triggs B 2005 Histograms of oriented gradients for human detection IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR’05)1 886–893