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*Original Article*

# Hybrid of Viola-Jones and Multi-Block Local Binary Pattern Based on Machine Learning Method for Multiple Angles Rotation Face Detection

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***Abstract -*** *Face detection is considered one of the most vital features in fields such as video surveillance, biometrics, and human-computer interfaces; the drawback is that these tasks require a huge computational and memory application resource. At the simplest level, this technology works by identifying features on a person's face and then using those features in identification from a digital picture of the person. Conversely, head rotation, low-quality pictures, and foreign objects in the detection area still pose big issues. This study examines our existing limitations in most Viola-Jones-based face detection methods, specifically their struggle against problems relating to head position recognition, black faces, and rotated images. The MB-LBP operator encodes image rectangle intensities, and a learning algorithm based on these features improves face detection. Studies indicate that MB-LBP-based classifiers outperform Haar features, making the enhanced Viola-Jones and MB-LBP methods preferred. The proposed method can detect frontal images rotated to 360 degrees, validated using datasets like Carnegie Mellon University, Labelled Faces in the Wild, and Face Detection Data Set and Benchmark. The results demonstrate a high detection accuracy of 100% in Detection Rate (DR), True Positive Rate (TPR), and False Positive Rate (FPR) for rotated images, highlighting MB-LBP features' superior detail capture and performance.*

***Keywords*** *- Face detection, Viola-jones algorithm, Multi-block local binary pattern, Machine Learning, Rotated Face Detection, Image Processing.*

## 1. Introduction

Biometrics, video surveillance, and human-computer interfaces all rely on face detection. Due to the intricacy of detection methods, detection systems necessitate a lot of computing and memory resources. Face detection, often known as face recognition, identifies a person from a digital image, primarily for safety. A biometric system uses a digital image to extract facial characteristics, including the eyes, mouth, nose, and face area. The process of recognizing a human face becomes much easier with the use of a face detector. On the other hand, the facial recognition algorithm has a 100% identification rate only when the images processed by the system are full-face images of adequate standard. Uncontrolled acquisition circumstances (blur effect, lighting, significant changes in face position, blocking effects) obstruct picture analysis and cause performance to plummet. Even though millions of video security cameras are added each year, the real-time information produced is underutilized or lost due to the lack of an effective automated identification system. The image becomes blurry whenever the shutter is released or the camera is out of focus and the subject moves. Most face recognition algorithms are insufficiently robust under such situations, resulting in a relatively low recognition rate. Many fuzzy images cannot convey any information about a face, which is a common difficulty in video surveillance. Various algorithms have been reviewed, such as Viola-Jones, SNOW Classifier, SMQT Feature, Support Vector Machines-Based Face Detection, Neural Network-Based Face Detection, and Local Binary Pattern or Multi-Block Local Binary Pattern in the face detection area to produce high detection accuracy with low false detection. Image-based and feature-based face detection [1, 2]. Head rotation is the critical factor contributing to a significant increase in the inaccuracy in identifying the brightness indicator with the most meaningful facial regions [3]. Face identification is problematic since a person's facial features, such as the mouth, nose, and eye, differ substantially from ordinary objects. Although the Viola-Jones method has numerous benefits for face identification, it also has significant drawbacks, such as the inability to recognize head posture and the failure to identify black faces. It faces crowds, low picture quality, and an excessively long training period.

The objective is to study and identify the requirement for a Viola-Jones feature-based face detection method for rotated images. Then, to design and develop an enhancement of the Viola-Jones and Multi-Block Local Binary Pattern face detection method on rotated images to increase the accuracy detection rate. Finally, to test and evaluate the performance using PSNR and MSE. The research aims to enhance the detection rate accuracy and reduce false positive occurrences in face detection for rotated images, which are crucial in many applications, such as information security, banking, ID cards, and medical records. The proposed approach's effectiveness and efficacy are essential for further research and can be implemented in real-world situations. As a result, face detection technology is progressively becoming a research focus in current pattern detection and Artificial Intelligence.

## 2. Literature Review

The Viola-Jones algorithm used a cascade of classifiers, and Haar-like features to introduce an effective real-time face detection method. Although it works well with frontal faces, rotated or partially obscured faces cause it to perform less well. This was addressed by developing the Multi-Block Local Binary Pattern (MB-LBP) technique, which enhances feature extraction by identifying local texture variations between image blocks. Achieving high detection accuracy for rotated faces is still a major research challenge despite MB-LBP improving robustness to rotation and lighting variations.

### *2.1. Face Detection Methods*

The progression of research in a particular area of face detection has been briefly observable in each algorithm's working procedure, history, advantages, and drawbacks [4, 5]. Face detection algorithms have progressed in recent years, moving away from traditional computer vision approaches and onto advanced machine learning techniques.

Finding the region in an image where a face or face is located is one of the most critical tasks in face detection technologies. Face detection is complicated by lighting, occlusion, and complex background. A variety of techniques have been developed to handle these problems. The existing algorithms are primarily classified into two categories: image-based and feature-based techniques. Image techniques rely heavily on image scanning, which depends on windows or sub-frames. In contrast, feature-based plans locate features (corners, image edges, or other structures properly located in two dimensions). According to [2, 5], the development of the feature-based approach has been further separated into three sections, as shown in Figure 1, and Figure 2.

**Table 1. Comparative evaluation of face detection algorithms**

| Methods | | Subcategory | Strength | Weakness |
|---|---|---|---|---|
| Feature-based Approaches | Active Shape Model | Snakes | Easy to manipulate | Must be initialized close to the feature of interest |
| | | Deformable Template Matching | Accommodative with any given shapes | Sensitive to initialized position |
| | | Deformable Part Model | Works well with different viewpoints and illuminations | Slow |
| | | Point Distribution Model | Provides a compact structure for the face | The line of action is linear |
| | Low-Level Analysis | Motion | Fast-tracking | Produces false positives due to beards, glasses, etc |
| | | Colour Information | Faster | Sensitive to luminance |
| | | Grey Information | Less complex | Less efficient |
| | | Edge | Requires a minimal number of scanning | Not suitable for noisy images |
| | Feature Analysis | Feature Searching | High detection accuracy | Sensitive to lighting. conditions and rotations |
| | | Constellation Analysis | Handles problems of rotation and translation | Difficult to implement |
| Image-based Approaches | Neural Network | Artificial Neural Network | Able to work with incomplete data | Computationally expensive |

| | | | | |
|---|---|---|---|---|
| | | Decision-Based Network | Provides a better understanding of the structural richness | Restriction on face orientation |
| | | Fuzzy Neural Network | Higher accuracy | Requires a linguistics rule |
| | Linear Subspace | Eigenfaces | Simple and efficient | Sensitive to scaling of the image |
| | | Probabilistic Eigenspace | Handles a much higher degree of occlusion | Performs well on only rigid faces |
| | Statistical Approaches | Principal Component Analysis | Performs very well in the constrained environment | Scale variant |
| | | Support Vector Machine | The risk of over fitting is quite less | Works poorly with a noisy data set |
| | | Discrete Cosine Transform | Computationally less expensive | Require quantization |
| | | Locality Preserving Projection | Fast and suitable for practical applications | Sensitive to noise and outliers |
| | | Independent Component Analysis | Iterative | Shows difficulty in handling a large number of data |

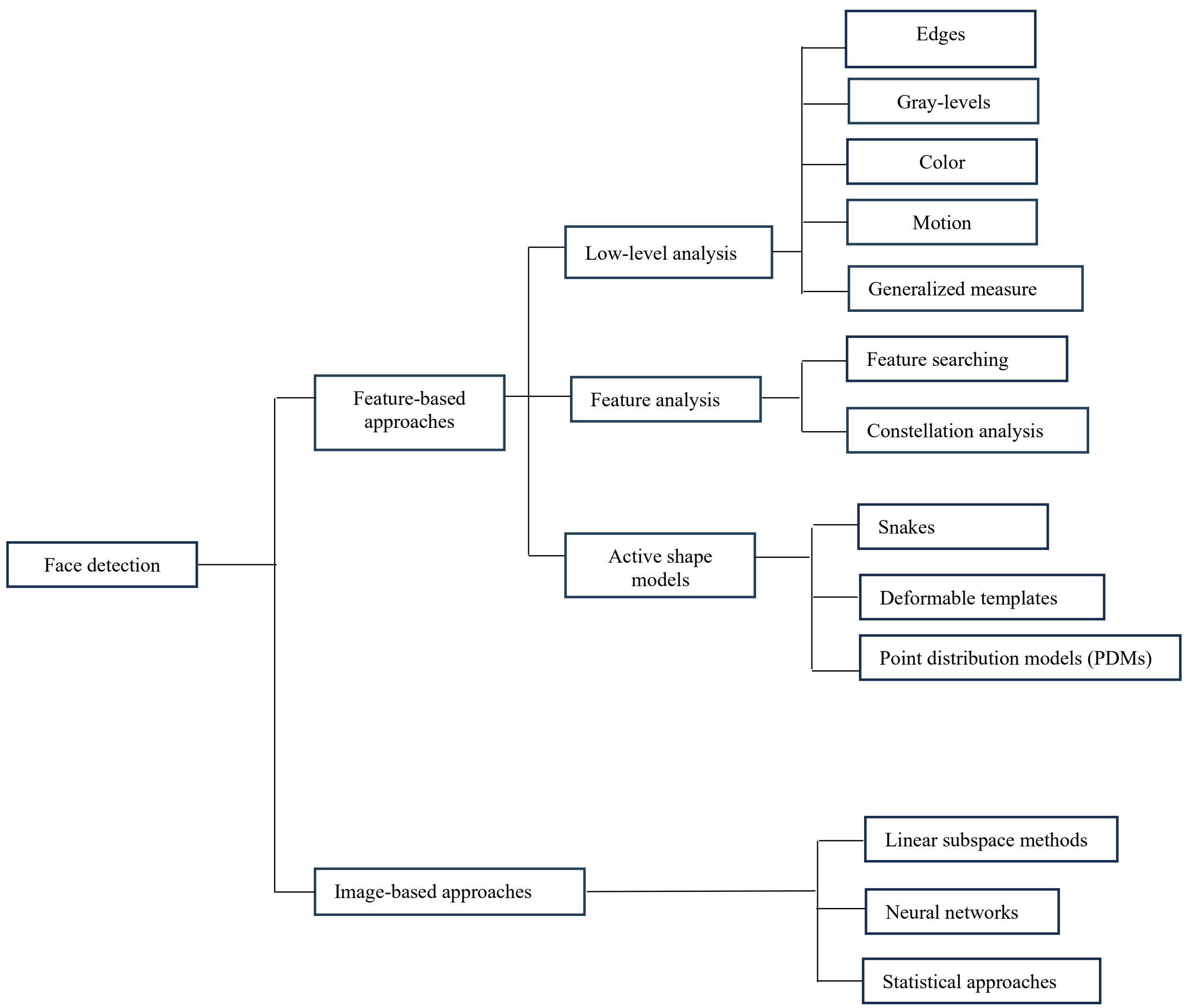


**Fig. 1 Face detection methods [4]**

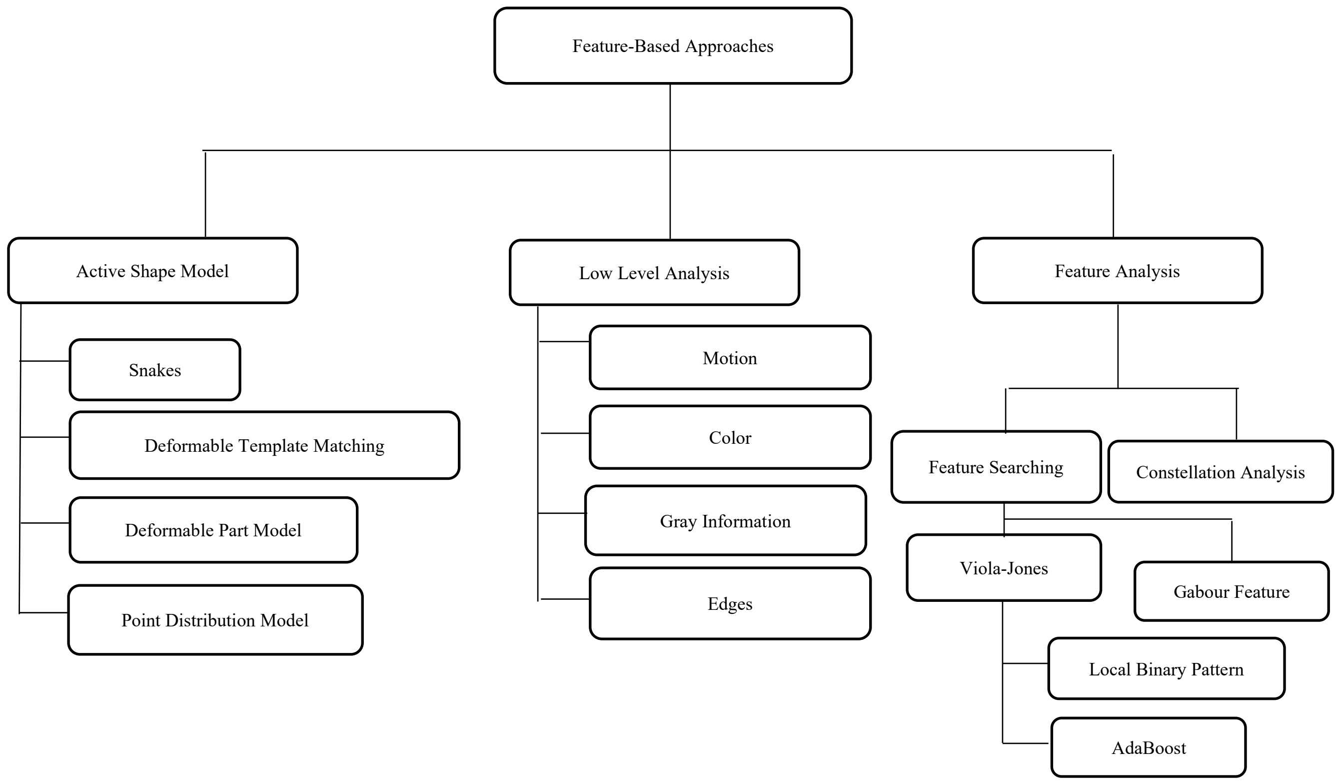


**Fig. 2 Feature-based approaches for face detection [5]**

**Table 2. Analysis of face detection algorithms**

| Method | Advantage | Limitation |
|---|---|---|
| The specific features, which are combined using both prosody and spectral data, are subjected to Principal Component Analysis (PCA). Mel Frequency Cepstral Coefficients (MFCC) is part of the feature combination Principled Frequency (f0), Pitch Chroma, and Formants characteristics. These are then applied to testing and the Gaussian Mixture Model (GMM) as a model [6] | When compared to the LPCC and the features of MFCC, the LFPC has a higher reaction rate. | There are ambiguities among the prosodic and spectral features that do not overlap. |
| Comparison between Viola Jones and YOLO v3 algorithm [7] | YOLO v3 algorithm obtained 90% accuracy rate mean while Viola Jones obtained 45% accuracy rate | YOLO v3 was slower detection compared to Viola Jones detection |
| Viola Jones with Haar Cascade [8] | The algorithm correctly recognizes faces and recognizes their features using sub-windows within rectangular boxes. | Detected basic or standard database of images |
| Comparative LBP, CF, SIFT, HOG and SURF[9] | LBP and VLC outperformed compared to others method. Each method is the best to implement and apply in real time detection | The availability of high-quality data for training and validation purposes can be a limitation, especially in domains where large datasets are required. |
| Multi-Block Local Binary Patterns (MB-LBP) [10] | MB-LBP provides a novel approach to capturing intricate facial details. | Not explicitly mentioned in the provided information, potential |

A critical finding of this study is that virtually all face detection algorithms produce false positives. While face healthcare, security, payment verification, and criminal identification, where false positives can have serious consequences. To fully harness the potential of face detection technology, it is essential to understand these critical procedures and develop more accurate face detectors.

## 3. Methodology

The implementation of a variety of methodologies is a crucial part of achieving the objectives of the study. The procedure for designing the instrument and collecting the data is briefly described. In general, this research consists of five main phases: literature review, research methodology, development of face detection, result analysis, and conclusion.

In every stage, there are some specific tasks to be performed. The details of the research phase and the tasks for each phase are shown in Figure 3. Figure 3 shows that this research was carried out by reviewing some literature as a starting point. Some tasks need to be reviewed in the literature review phase, and the first is the background of feature-based face detection and the study of artificial intelligence methods that can be used for detecting faces on rotated images. The next step is the research methodology that will lead this research overall. The construction of a framework to enhance multiple angles rotation face detection based on Viola-Jones and the multi-block local binary pattern approach must be considered during the research methodology phase. The problem of image rotation and motion blur, which severely distort facial features and lower detection accuracy, was considered when creating the framework. Traditional edge-based detectors have trouble localizing important landmarks when faces are photographed from non-frontal angles because the patterns are distorted or blurred.

Pre-processing methods like contrast enhancement, image resizing, and greyscale conversion were used to improve feature clarity and solve this problem. Then, robust local texture features that hold up even when slightly blurred or rotated were extracted using the Multi-Block Local Binary Pattern (MB-LBP) technique. Accurate face detection and localization across rotation angles and blurred conditions are further strengthened by integrating MB-LBP with the Viola-Jones detection algorithm. Then, with the development of enhanced face detection, the data collection of the rotated image will be gathered. The next step in this research is to display and analyze the validation of accuracy detection face on the rotated image. Finally, the discussion and conclusion are summarized with suggestions for further improvement.

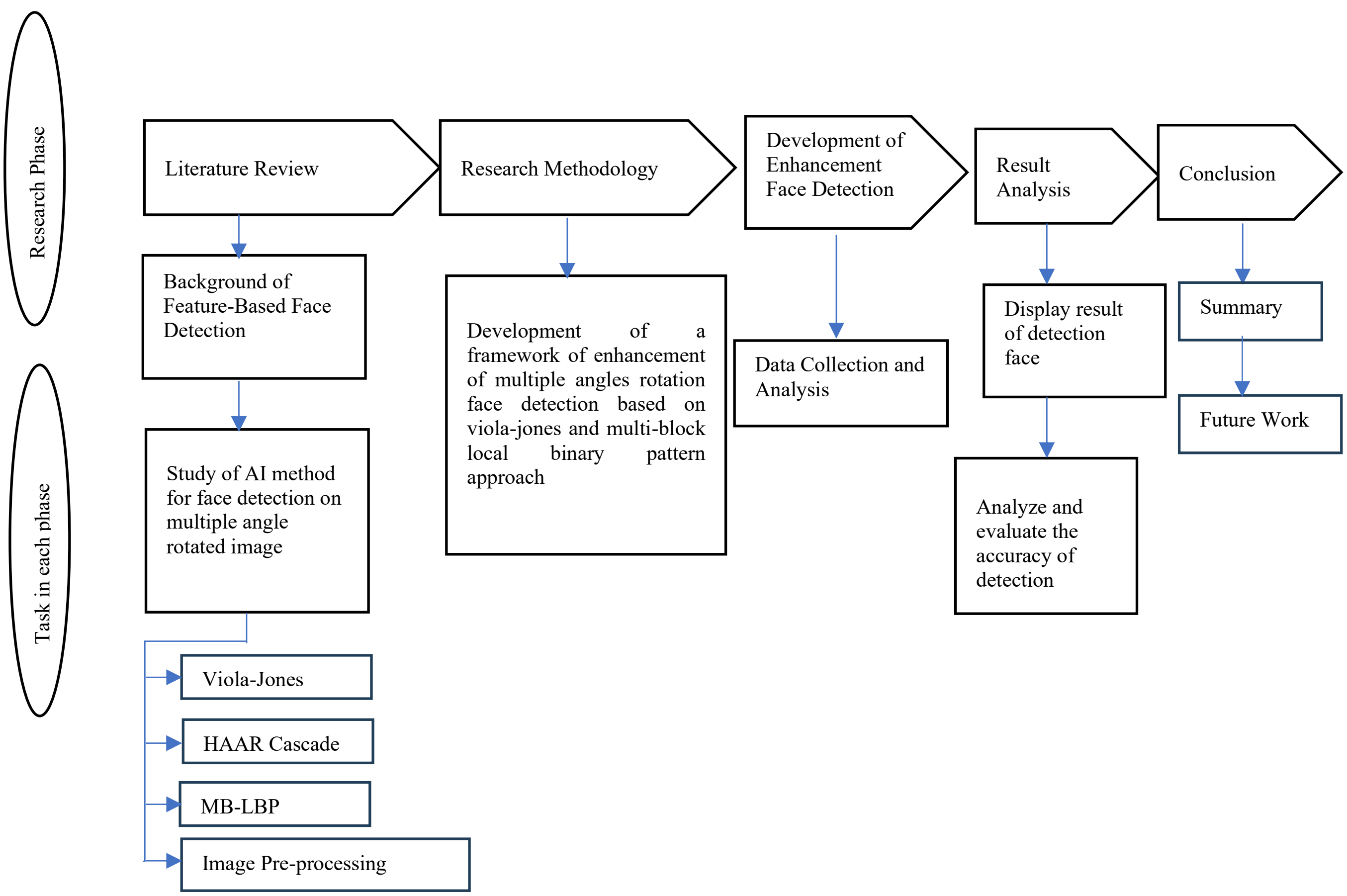


**Fig. 3 Research phase, task in each phase and chapter**

## 4. Development of Multiple Angles Rotation Face Detection

Face Detection: The basic purpose discusses implementation techniques, the Viola-Jones and Multi-Block Local Binary Pattern, in face detection of rotated images that lead to redundancy when trying to identify a face at different angles of orientation correctly. The discussion describes the employment of the histogram and feature value technique of MB-LBP (PSNR) as a peak noise ratio indicator and the movement indicators in the development of the face detection method. Apart from that, a detailed calculation of these implementations provides a clear perception of the implementation process. The Viola-Jones and MB-LBP were integrated to create a robust face detection system. The Viola-Jones algorithm swiftly detects objects, making it an effective first-phase method for this face detector. The MB-LBP features will boost the discriminative power of the model in capturing fine-grained texture information. It enables the system to detect faces with different poses more effectively, improving overall detection accuracy. The histogram and features of MB-LBP are crucial in characterizing facial texture and pattern, hence distinguishing the facial features from the background. PSNR is a technique that is applied to estimate the quality of the detected face relative to the original image and then details how well that detection process approximates fidelity to the facial details. Movement indicators assess the invariance of the face detection algorithm to face orientation motion and show performance again in detecting moving faces.The intricate details of implementing face detection techniques using Viola-Jones and MB-LBP have been elaborately covered, coupled with PSNR and indicators for movement, histogram, and feature values of MB-LBP to develop a reliable face detection system for rotated images. The diagram of multiple-angle rotation face detection is shown in Figure 4.

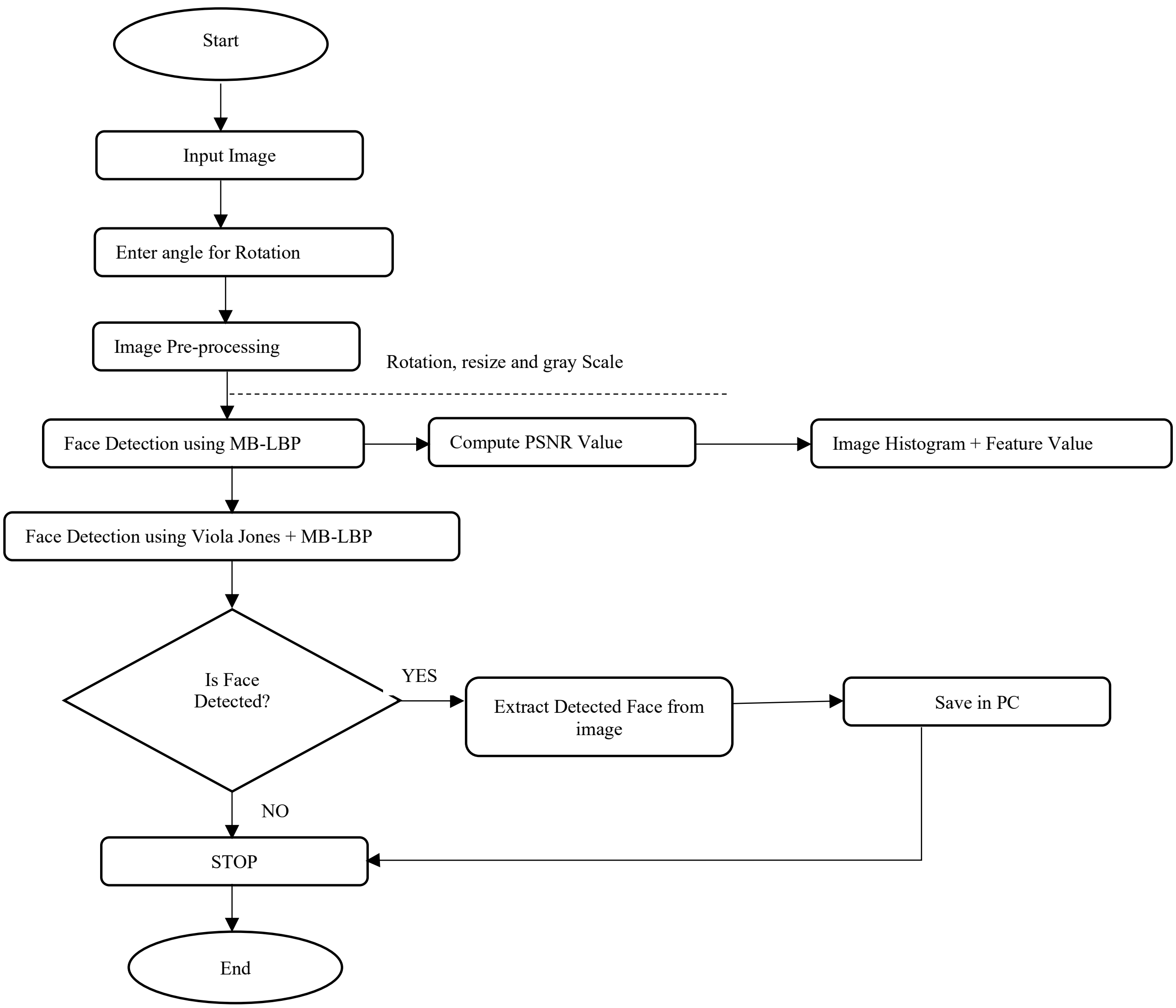


**Fig. 4 Framework diagram multiple angle rotation face detection**

Improving face detection accuracy by pre-processing is a very initial process when the input data is prepared before using detection algorithms. The first step is to set the orientation angle of images correctly so that the faces with various orientation angles can be detected effectively. This step is crucial in solving the problem of detecting faces at different angles.

Secondly, the process normalizes image size, allowing uniform steps in processing input to detection algorithms. Additionally, images can be converted into grayscale for noise reduction, simplifying the data. At the same time, information regarding very important facial features is retained for the purpose of accurate detection. The enhancement of the detection method means that the Viola-Jones algorithm is combined with (MB-LBP) features. This combined approach is intended to improve accuracy in detecting face location by combining the strengths of both approaches.

The Viola-Jones algorithm fast-tracks the very first object detection. Additionally, MB-LBP features strengthen discriminative power by extracting highly detailed texture information. These methods will allow the detection system to identify faces in different conditions and orientations precisely.

Face detection accuracy is the performance indicator that shows how well the method performs. The metric quantifies correct face detection as a percentage. It is due to assist us in evaluating how well the system would be able to detect a face in any event. High accuracy suggests the system can detect a face under varying orientations and qualities. This feature will prove the system effective and reliable in tasks related to face detection. This is shown in Figure 5, the MB-LBP process that this method uses. A step-by-step process is meant to show the processing of image blocks for accurate face detection and feature extraction.

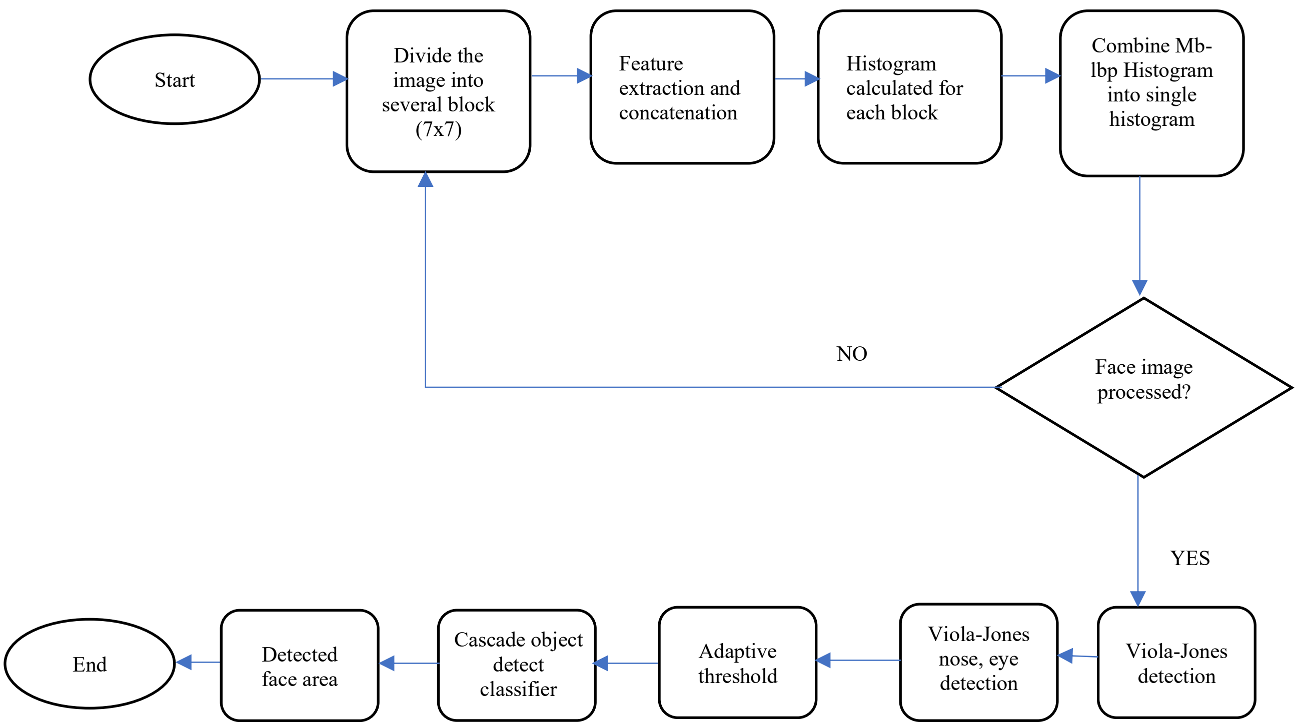


**Fig. 5 Flowchart of MB-LBP and Viola-Jones process**

After applying MB-LBP, the sequential cycle of procedures for any face detection system would carry the Viola-Jones algorithm. This is one of the more successful strategies in face detection and recognition. A cascade object detector is used to fulfil this detection process. Viola-Jones is quite effective in facial detection for images with a frontal face view. It might not work well for faces at other angles, such as facing up, sideways, or downwards. The vision.CascadeObjectDetector is the principal function that can be applied to accessing the Viola-Jones library for face detection. This function detects faces within images using its face-detection capability.

## 5. Result and Discussion

MB-LBP feature extraction and the Viola-Jones algorithm for detecting rotated images have been explained in the previous chapter. The chapter's results illustrate the performance of the face detector designed with MB-LBP and Viola-Jones. The chapter also involves testing selected images, their analysis, and the discussions made to answer the research problem. Table 3 shows the result of the face detection method using MB-LBP and Haar-like features. Figure 6 below shows the sequence of steps in the face detection process, from resizing and conversion to grayscale and rotation, followed by extraction of MB-LBP features applied to the Viola-Jones algorithm. The process outlined above adds value at every step to improve accuracy and efficiency in face detection, ending with the Viola-Jones algorithm as a pivot in the final detection stage. The spikes found in the histograms of Multi-Block Local Binary Pattern (MB-LBP) could possibly explain very different features or features that range diversely in the different area regions of the image. It is useful for tasks involved in detecting textures with different characteristics. The histogram spikes would suggest many different classes or categories in the image, giving more representational power differences. Therefore, a histogram with characteristic spikes could represent complex and varied textures or object appearance. Although this kind of detailed representation may capture fine-grained features, it is challenging for model training and generalization. It is more so when spikes are caused by noise or irrelevant features.

**Table 3. Result of face detection method using MB-LBP and Haar-like feature**

| No | Degree Rotation | Peak Signal-to-Noise Ratio | | Mean Square Error | |
|---|---|---|---|---|---|
| | | MB-LBP | Haar | MB-LBP | Haar |
| 1 | 1 | 24.1316 | 17.0313 | 253.1 | 7939.6 |
| 2 | 2 | 21.1453 | 14.0450 | 503.4 | 8189.9 |
| 3 | 3 | 19.1689 | 12.0686 | 793.5 | 8480.0 |
| 4 | 4 | 17.9435 | 10.8614 | 1052.3 | 8738.8 |
| 5 | 5 | 17.0102 | 9.9281 | 1304.5 | 8991.0 |
| 20 | 20 | 13.4225 | 6.3404 | 2980.1 | 10666.6 |
| 21 | 21 | 13.3789 | 6.2968 | 3010.2 | 10696.7 |
| 22 | 22 | 13.3291 | 6.2470 | 3044.9 | 10731.4 |
| 23 | 23 | 13.2885 | 6.2064 | 3075.4 | 10761.9 |
| 24 | 24 | 13.2456 | 6.1635 | 3104.0 | 10790.5 |
| 25 | 25 | 13.2456 | 6.1635 | 3104.0 | 10790.5 |
| 60 | 60 | 12.9511 | 5.8132 | 3321.8 | 11110.7 |
| 61 | 61 | 12.9821 | 5.8442 | 3298.2 | 11087.1 |
| 62 | 62 | 13.0192 | 5.8813 | 3270.1 | 11059.0 |
| 63 | 63 | 13.0570 | 5.9191 | 3241.7 | 11030.6 |
| 64 | 64 | 13.0907 | 5.9528 | 3216.7 | 11005.6 |
| 65 | 65 | 13.1294 | 5.9915 | 3188.2 | 10977.1 |
| 90 | 90 | 16.0194 | 8.8815 | 1638.9 | 9359.9 |
| 91 | 91 | 15.6833 | 8.5454 | 1770.7 | 9491.7 |
| 92 | 92 | 15.3837 | 7.9608 | 1897.2 | 9618.2 |
| 93 | 93 | 15.0987 | 7.6758 | 2025.9 | 9746.9 |
| 94 | 94 | 14.8474 | 7.4245 | 2146.5 | 9867.5 |
| 95 | 95 | 14.6075 | 7.1846 | 2268.4 | 9989.4 |
| 230 | 230 | 12.7771 | 5.2747 | 3457.6 | 107151.80 |
| 231 | 231 | 12.7988 | 5.2964 | 3440.3 | 107134.58 |
| 232 | 232 | 12.8151 | 5.3127 | 3427.4 | 107121.66 |
| 233 | 233 | 12.8358 | 5.3334 | 3411.2 | 107105.44 |
| 234 | 234 | 12.8524 | 5.3500 | 3398.1 | 107092.31 |
| 235 | 235 | 12.8722 | 5.3698 | 3382.6 | 107076.89 |

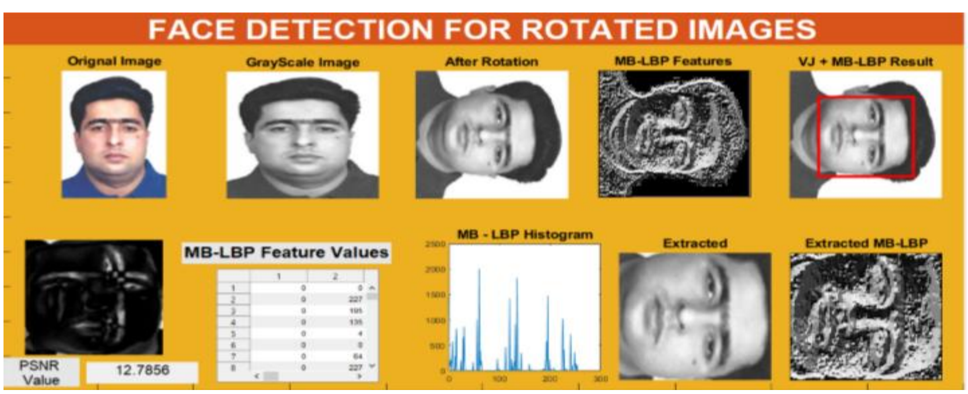


**Fig. 6 Result of VJ-MBLBP, Extracted Image and MB-LBP Histogram**

## 6. Conclusion

The findings of this research are taken to find the right way to use face detection on rotated images. Methods to develop face detection in rotated images form the nucleus of research on improving the efficiency of this process. The main contributions were from image processing and artificial intelligence in increasing accuracy in face detection in rotated images. A theoretical contribution is made by designing and evaluating a new method for face detection on rotated images. This research is an important step in improving the feature-based accuracy of face detection in images from different rotation angles, thereby moving the field of computer vision forward.

It identifies the limitations of previously used approaches and introduces a combination of Viola-Jones with Multi-Block Local Binary Pattern (MB-LBP) to increase detection accuracy. Practically, the research is almost a practical approach to realizing a real-world face detection method. The enhanced Viola-Jones feature-based method for face detection is quite applicable in various industries such as security, surveillance, biometrics, image processing, and many others. The research shall thus evaluate the performance of the proposed technique in terms of Peak Signal-to-Noise Ratio (PSNR), Mean Squared Error (MSE), and detection accuracy rate at the received operating characteristic to provide benchmarks for other similar methods. The increase in real positive detections working with the enhancement in correctness for rotated faces has real-world implications in boosting application-level efficiency and reliability for face detection. The key contributions of this research paper lie in the new Viola-Jones and MB-LBP hybrid face detection that works well with rotated images at multiple angles. For future improvements, the performance analysis of the proposed technique over a large dataset covering a variety of poses and expressions will validate its robustness and effectiveness. The next studies may also address the method's performance, combining the proposed technique with other image processing techniques, such as denoising, illumination normalization, or feature extraction.

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