A Survey on Face Detection and Recognition Approaches

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Abstract

Face detection and recognition are major concerns in the area of biometric based security systems and purposes. These processes must ensure the recognition accuracy and minimum processing time. In this paper a review of existing face detection and recognition approaches is conducted to investigate the results of different approaches in terms of recognition accuracy and some of them are discussed for minimizing processing time point of view. The techniques for face detection and recognition are classified on the bases of their working domain as spatial, frequency, integrated and hardware support.

Keywords: Biometrics, security, FPGA, real-time surveillance.

Introduction

The task of searching faces from a source image or video is referred as face detection. The process of automatic identification or verification, of people from digital video frames or images, according to given database is called as face recognition. Face detection has become the most mature and important research topic, due to increase in security concerns and many other applications (human computer interaction, biometrics, surveillance etc). In the literature there are number of techniques are available for face detection and recognition. Some techniques have shown efficient results in achieving accuracy and reducing processing time1. In this survey, many face detection and recognition approaches are analyzed under recognition accuracy and processing time. Furthermore, it is investigated that which approach is based on which domain as spatial, frequency or integrated and which approach have better recognition accuracy. Also for speeding face recognition process a technique which approach performed better with and without hardware support.

Some contributors of this domain have presented their surveys on different issues as a survey2 on linear and non linear PCA based techniques for face recognition is presented. A survey3 on face recognition methods for tackling facial expression is presented. A survey is presented different face recognition techniques4, in which one of the approaches is based on the issue of partial occlusion dilemma, where faces are making unrecognized to cheat the security system. Similarly, a survey5 state of the art face recognition techniques is given. Therefore, in this survey some question are tried to explore that, which face detection and recognition approach have better detection and recognition accuracy. Also, which face recognition approach has minimum processing time?

Face Recognition Techniques

The author presented a 3D face recognition6, which is considered as a hybrid approach that is worked on horizontal vertical stripes and cloud conversion calculation method to achieve accuracy while tackling facial expression. Presented framework, first converted face model to point cloud, then by finding the nose tip face area is extracted and normalized. After this, average row column value is calculated by dividing face region into vertical horizontal stripes, this value used as a threshold to match faces from database. The results are tested on GAVAB database, presented method shows better recognition results as compare to previous approaches and the accuracy results are elaborated in table 1, where it achieve 95.08% accuracy on GAVAB data set. The presented method achieves robustness and provides an efficient feature extracting approach. Utilizing the spatial domain for improving face detection and recognition process a technique is presented by Sharif M. et.al7, which is based on Hexagonal image processing. The technique computationally less expensive and achieves averagely 98% accuracy on CVL, Indian and ORL face datasets.

A face recognition approach is presented by Sharif M. et.al8, which utilizes better edge based segmentation method to represent face images with enriched information. The purpose of edge based segmentation is to down sample image size. Furthermore for the representation of face images in low dimension space, DCT9 is utilized and this approach behaves well in changing illumination conditions. The approach achieves averagely 93.2% accuracy on different data set as shown in table 1. An approach is presented by Sharif M. et.al10 which works at face recognition preprocessing stage. The approach tackles illumination problems and it is tested on Yale data sets, where it shows significant improvement in facial recognition accuracy. An approach is presented by Zhu X. and Ramanan
D.\textsuperscript{11} which utilized local binary patterns operator for face recognition, which works in three stages i.e. face detection, localization and finally recognition. For face localization, LBP-based eye-pupil detection technique is proposed, that significantly reduce computational memory and power. All three stages are tested on the colour FERET database, where 77.8\% face localization and high match rank in face recognition is achieved successfully.

An Elastic Bunch Graph Map (EBGM) algorithm is presented\textsuperscript{12} for face recognition which utilized Gabor filters. In the approach, 40 different Gabor filters are applied on an image to be recognized, and then fiducial points are identified on Gabor filtered 40 images. The resultant fiducial points are optimized using distance formula. At last the optimized distance is compared with database for recognition. According to table 1 the approach achieves 94.29 \% accuracy on face 94 standard face database. A variant of SVD combined with DWT is utilized\textsuperscript{13} to develop a better face recognition method. The presented approach tackles several problems as single image per person problem, illumination and facial expression. As mentioned in table 1 the approach achieves 93.6\% recognition accuracy on different facial data sets. Tackling the problem of facial expression the author suggested an algorithm\textsuperscript{14} which is based on local directional pattern variance and the algorithm have better recognition accuracy in varying facial expression conditions. Gabor features based face recognition method is presented in literatures\textsuperscript{15,16,17} it works on the basic face points, like eyes, eyebrows, mouth and nose, which carry maximum, face information. The algorithm is tested using ORL and the Yale datasets, which performs well against disguised variations problems and system achieves 92\% recognition accuracy. Another approach is presented for tackling single image per person problem\textsuperscript{18}. The technique utilized laplacian of Gaussian and DCT and achieves 97\% accuracy. 3S and pose variation problems are dealt with\textsuperscript{19} as firstly, Linear Discriminate Analysis is considered to minimize the singularity problem that arises when small samples of individuals are available. In the next step, the framework utilizes global and local facial features and constructs a combined subspace using enhanced LDA. The approach is tested on different data sets where it shows improved facial recognition accuracy.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Techniques for face recognition</th>
<th>Working Domain</th>
<th>Additional Hardware Support</th>
<th>Face Data Bases</th>
<th>Hit</th>
<th>Miss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Horizontal and Vertical Marked Strips for 3D Face Recognition</td>
<td>Spatial Domain</td>
<td>No</td>
<td>GAVAB</td>
<td>95.08%</td>
<td>4.92%</td>
</tr>
<tr>
<td>2.</td>
<td>Face Detection and Recognition Through Hexagonal Image Processing</td>
<td>Spatial Domain</td>
<td>No</td>
<td>CVL, Indian and ORL</td>
<td>Avg 98%</td>
<td>Avg 2%</td>
</tr>
<tr>
<td>3.</td>
<td>Face Recognition using Gabor Filters</td>
<td>Integrated</td>
<td>No</td>
<td>Face94</td>
<td>94.29</td>
<td>6.3%</td>
</tr>
<tr>
<td>4.</td>
<td>Enhanced SVD Based Face Recognition</td>
<td>Integrated</td>
<td>No</td>
<td>Yale, PIE, and AR</td>
<td>Avg 93.6%</td>
<td>6.4%</td>
</tr>
<tr>
<td>5.</td>
<td>Disguised Variations Using Gabor Feature Extraction approach</td>
<td>Integrated</td>
<td>No</td>
<td>ORL and Yale</td>
<td>92%</td>
<td>8%</td>
</tr>
<tr>
<td>6.</td>
<td>Face Recognition Using Laplacian of Gaussian and Discrete Cosine Transform</td>
<td>Integrated</td>
<td>No</td>
<td>Yale, PIE, MSRA and ORL</td>
<td>97%</td>
<td>3%</td>
</tr>
<tr>
<td>7.</td>
<td>LDA algorithm based face recognition</td>
<td>Integrated</td>
<td>No</td>
<td>ORL data set</td>
<td>90.8%</td>
<td>9.2%</td>
</tr>
<tr>
<td>8.</td>
<td>Face recognition by independent component analysis</td>
<td>Integrated</td>
<td>No</td>
<td>FERET database</td>
<td>91%</td>
<td>9%</td>
</tr>
</tbody>
</table>

Table-1

Accuracy comparison of face recognition approaches on different data sets
A face recognition methodology is presented which utilized multiple techniques\textsuperscript{20}, the methodology is tested on FERET dataset where it achieves averagely 97% recognition accuracy. Hua et al presented\textsuperscript{21} a face recognition based on direct LDA algorithm for high-dimensional data. System is tested on 400 frontal face images from ORL data set, which successfully achieve average recognition accuracy of 90.8% as mentioned in table 1. A face recognition using Independent Component Analysis is put forward by Bartlett, Stewart\textsuperscript{22}. This framework use PCA and ICA algorithm on FERET database and tested on different architectures. System achieves best performance when classifier combined with two ICA and show overall 91% accuracy, as mentioned in table 1. An accurate face recognition approach is demonstrated\textsuperscript{23} by Georgiades et al that works under Variable Lighting and Pose conditions. Presented system is tested on Yale Face Database, containing 4,050 images and 405 viewing conditions. Face recognition is achieved by using Euclidean distance and approximated illumination cone, this approach gives almost error free results in extreme lighting directions. Furthermore, just recently M. Sharif et al presented a methodology for face detection, facial features extraction and face recognition\textsuperscript{24}. In the approach, the first phase is to detect faces and to extract region of interest from input source. In second phase, features are extracted i.e., eyes, nose and lips. In the last phase, face recognition is achieved by utilizing extracted left eye and combining features of Eigen features and Fisher features. M. Sharif et al demonstrated the data reductionality technique for the process of face recognition\textsuperscript{25}. In the technique, data reduction i.e., compression of image data, is achieved by utilizing through Discrete Cosine Transform (DCT) and PCA. In the work the author tried, to get the reduced dimensions of image without losing necessary information. The approach has brought significant improvement in traditional PCA working. Similarly, to assist preprocessing stage of face detection and recognition, the author suggested the enhanced image segmentation algorithms, which can improve facial recognition accuracy\textsuperscript{26,28}.

**Face Detection and Recognition approaches for videos**

For the detection of human faces in color images, an approach is presented by Sharif M. et.al\textsuperscript{29} which utilize HSV color space. In real time video this approach works in two steps. Initially statistical model to get H (Hue) and S (Saturation) ratios for skin region is applied. Secondly, to get approximation of face location in an image with respect to the detected skin is on the bases of defined ratios for scene width and height region. Finally to verify the face from the previous roughly detected skin region, an eye template matching algorithm is applied. With fairly acceptable performance, presented model has been tested in real time environment. A novel face detection technique is presented by Saleh and Muhittin, based on accelerated GPU object detection system which can successfully detect 90.8% faces from real time environment (high resolution video ranging from 640x480 to 1920x1080) without sacrificing accuracy\textsuperscript{30}. A real-time face feature detection based on conditional regression forests on low quality images is presented. The system is tested on Labelled Faces in the wild database which contain 5749 individuals facial images and achieve 87.5% accuracy, that show better results as compare to previously designed face features detection systems\textsuperscript{31}. Similarly, the contributors presented a human face retrieval frame work for video database, by applying fast Haar-like features based algorithm and Kanade-Lucas-Tomasi (KLT) tracker. The approach is implemented using Open CV and it achieves 94.17% accuracy\textsuperscript{32}.

<table>
<thead>
<tr>
<th>Sr. #</th>
<th>Approaches</th>
<th>Environment</th>
<th>Hardware Support</th>
<th>Hit</th>
<th>Miss</th>
<th>Speeds up face detection and recognition process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Skin Detection based</td>
<td>REAL TIME</td>
<td>No</td>
<td>90.8%</td>
<td>9.2%</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Modified Census Transform based</td>
<td>REAL TIME</td>
<td>Yes</td>
<td>87.5%</td>
<td>12.5%</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>Conditional regression forests</td>
<td>REAL TIME</td>
<td>No</td>
<td>94.17%</td>
<td>5.83%</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Face detection from video database</td>
<td>Video Database</td>
<td>No</td>
<td>97.5%</td>
<td>2.5%</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>Human Shape Analysis And Skin Colour Information based</td>
<td>Offline video</td>
<td>No</td>
<td>90%</td>
<td>10%</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Fusion and skin colour based</td>
<td>Video Datasets</td>
<td>No</td>
<td>99.9%</td>
<td>0.1%</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>Local Binary Patterns based</td>
<td>MultiPIE database</td>
<td>No</td>
<td>90%</td>
<td>10%</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>Face recognition from caption-based supervision</td>
<td>Video Database</td>
<td>No</td>
<td>95%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Adaboost and PCA based</td>
<td>REAL TIME</td>
<td>No</td>
<td>95%</td>
<td>5%</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table-2

**Accuracy comparison of different Face Detection and Recognition approaches for videos**
A novel approach for face area localization is proposed by Dibakar,33 proposed algorithm detect face based on analyzing human body shape characteristics and skin colour information, which successfully detects about 97.5% face correctly. A reliable face detection technique is proposed by Wei Ren et al which is based on skin colour detection in colour images,34, with 2D Gaussian modal and histogram, proposed system required no training that significantly reduces computational cost. To gain efficiency and robustness, fusion strategy is addressed, which gives accurate results with 0.904 probability on Stotinger dataset. Zhu, et al, suggested a Face Detection and Pose Estimation technique utilizing Tree structured and shape model, moreover system is trained under fully supervised circumstances. System is tested on multi-view point, illumination and expression conditions, with around 750,000 images of 337 people. System achieves 99.9% accuracy, when allowing ±15º error tolerance on MultiPIE database.35 Similarly, efficient face recognition technique is presented by Guillaumin36 by utilizing caption based supervision. The approach works in two stages: initially face retrieval from video frames is performed and then establishing correct association of face from database. The approach is verified on Wild database and it achieves 90% accuracy as mentioned in table 2. The human face recognition for a real time attendance system is proposed by Susheel, et al.37 Presented system works in two main stages: in first, face detection base on AdaBoost with Haar cascade is used and in second, face recognition based on fast and simple PCA and LDA is implemented. Presented system is tested on 500 images, after face detection, in JPEG format images are store in 100 x 100 matrix size for face recognition, this approach achieve accurate results for general purpose online attendance system. Wood et al presented a robust face detection based on lighting-variable adaboosting, which is adaptive for varying illuminations and depend on multiple features such as global and local intensities variations.38 System is tested on standard datasets Caltech-101, which successfully achieve overall 95% accuracy in different lighting levels, as mentioned in table 2.

**Techniques for speeding face detection and recognition process**

Recently, Jing and Chen proposed the probability based face mask pre-filtering and hierarchical feature ada-boosting,39 for complexity reduced face detection. Ada-boost classifiers are combination of weak classifiers that produce efficient and simple results as compare to Haar-like features, which require more training time in practical applications. The approach utilized MIT-CBCL data base for training. A speedy application specific processor design for face detection is presented by Jin S.40, using Xilinx Virtex-5 LX330 FPGA. The system with an operating frequency of 125.6MHz is able to detect standard VGA 307 fps.

From given database, a fast face image searching technique is presented. In this approach to speed up the searching process, recognized image is segmented in different parts and each part is searched in different nodes simultaneously. A face hashing technique for fast face recognition is presented by Sharif M. et.al.42 The technique employs the two existing algorithms, i.e., 2-D discrete cosine transformation and K-means clustering, which ultimately improves the speed of face recognition.43 A computationally low cost algorithm for recognition is presented which achieves better recognition rates at different standard facial data sets.44 Similarly a face detection and tracking algorithm is presented which is based on hybrid approach which offers trade off between hardware and computational software resources.45 The system is able to handle more complex set of classifiers more easily and detect faces from video at the rate of 30 fps.

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### Table-3

**Comparison of approaches for speeding face detection and recognition process**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Technique</th>
<th>Hardware Support</th>
<th>Environment or Data Set</th>
<th>Improves face detection and recognition time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Probability-Based Face Mask Prefiltering and Pixel-Based Hierarchical Feature Adaboosting</td>
<td>No</td>
<td>MIT-CBCL</td>
<td>Yes</td>
</tr>
<tr>
<td>2.</td>
<td>Pipelined datapath assisted high-speed face detection using FPGA</td>
<td>Yes</td>
<td>Video</td>
<td>Yes</td>
</tr>
<tr>
<td>3.</td>
<td>Using nose Heuristics36</td>
<td>No</td>
<td>Face Database</td>
<td>Yes</td>
</tr>
<tr>
<td>4.</td>
<td>Real Time Face Detection</td>
<td>No</td>
<td>Image</td>
<td>Yes</td>
</tr>
<tr>
<td>5.</td>
<td>Adaptive Margin Fisher’s Criterion and Linear Discriminant Analysis based</td>
<td>No</td>
<td>Face Database</td>
<td>Yes</td>
</tr>
<tr>
<td>6.</td>
<td>Advanced Hardware Real Time Face Detector</td>
<td>Yes</td>
<td>Video</td>
<td>Yes</td>
</tr>
<tr>
<td>7.</td>
<td>An FPGA-based real-time face recognition system</td>
<td>Yes</td>
<td>Video</td>
<td>Yes</td>
</tr>
<tr>
<td>8.</td>
<td>Haar classifiers based</td>
<td>Yes</td>
<td>Video</td>
<td>Yes</td>
</tr>
<tr>
<td>9.</td>
<td>Approach for detecting face from compressed video and monitoring environment</td>
<td>No</td>
<td>Video</td>
<td>Yes</td>
</tr>
<tr>
<td>10.</td>
<td>Real-time face detection and tracking</td>
<td>No</td>
<td>Video</td>
<td>Yes</td>
</tr>
<tr>
<td>11.</td>
<td>FPGA based Haar classifier based face detection algorithm</td>
<td>Yes</td>
<td>Video</td>
<td>Yes</td>
</tr>
</tbody>
</table>
An approach is presented by Matai et al works in real time; system is implemented on Virtex-5 FPGA. Initially, according to given scenario location of face is detected based on Viola-Jones algorithm, and then face recognition has done using Eigenface algorithm. Presented system achieves successful face recognition at 45 fps on VGA data. In table 2 the approaches which contribute to speed up face detection and recognition process are mentioned, where it is observed that the approaches can work in different environment as on facial data base and videos. Also some approaches have just better software support and some are required hardware support as well[5]. A fast FPGA-Based Face Detection approach is demonstrated by Cho et al[45], based on AdaBoost algorithm Using Haar Classifiers. This approach works on, parallel multi-classifiers to accelerate the face detection mechanism. System is implemented on Xilinx Virtex-5 FPGA using Verilog HDL, achieves 35 times better results over equivalent software implementation. A face detection approach from compressed video streams, are discussed respectively by Gorbenko. Presented approaches based on Haar cascades, which efficiently achieves 30 fps for standard quality JPEG images[48,49]. A real time face detection and tracking approach for the monitoring of crowded areas is presented by Mustafah et al. Input is acquired from high resolution smart camera, face detection is achieved using skin colour detection and Viola-Jones approaches, which significantly reduce computational load. System is implemented on OpenCV, which successfully achieve fast face detection[30]. A FPGA based face detection method is demonstrated by Gao, Changjian, and Shih , based on Haar-classifier[31]. This approach reduce computational load, successfully achieve real time performance by utilizing pipelined architecture and parallel arithmetic units. System is implemented on Xilinx XC5VLX110T FPGA chip, with16-classifier system achieve detection rate of 98 frames/sec.

Conclusion

The survey reflects the analytical comparison of different techniques in the domain of face detection and recognition. In the literature, the contributors have different goals in the domain of face detection and recognition, as some of the contributors have tackled recognition accuracy and some of them have approached improving processing time of face detection and recognition. On the bases of this survey, it is concluded that, in order to have better recognition accuracy and minimum computational cost, the trend of face detection and recognition is moving towards complexity reduced software and application specific processors along with integrated domain processing.

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