Real-time Face Recognition System with Dynamic Training and Enhanced Multi-Algorithm Face Recognition

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ABSTRACT
In today's world, the scope and applications of face recognition systems either as standalone or as an integrated module into a larger system cannot be belittled. Remarkable face recognition algorithms have been proposed in last decade offering towering levels of accuracy and precision. However, the flexibility and robustness of the existing systems remain highly questionable. To further intricate these problems, most of the face recognitions systems are designed under strict background constraints, conveniently ignoring variations in illumination and at the apex of the predicament, lies the intricacy involved in the creation and maintenance of training sets in the databases. Even the most sophisticated systems designed posed grave difficulties in deployment and required maintenance by skilled personnel, leading to poor response from the global market. With an objective to realize an intelligent, maintenance-free system with impeccable design, our research team developed an immaculate real-time face recognition system with dynamic training and enhanced multi-algorithm face recognition. The system would facilitate user-friendly, dynamic creation of training sets by means of an innovative approach which would make the need of skilled maintenance personnel obsolete. The proposed system has been comprehensively tested to achieve remarkable precision and accuracy of 99.9%. Proposed system archetype design would result in manifold applications in developing simplified face recognition systems (for enrolling masses) for institutions, business organizations, research labs, military applications, etc. for authentication and authorization purposes.

Categories and Subject Descriptors
I.4.9 [**IMAGE PROCESSING AND COMPUTER VISION**]: Applications

General Terms
Management, Performance, Design, Reliability, Human Factors

Keywords
Face, detection, recognition, dynamic, training, algorithm, image, processing, system, real-time, PCA.

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1. INTRODUCTION
Face recognition systems have been at the apogee of researchers' interest in the last few decades, the primary purpose being devising simpler methods for recognizing faces. Numerous profound algorithms and approaches have been proposed and developed for face recognition and have obtained outstanding results. However, researchers have continued to be uncertain about the design of face recognition systems, which varies based on the environment of deployment and the application. With a view to solve this dilemma, our research team modeled a real-time face recognition system operational in unknown environment. The paper puts forth state-of-the-art design of a novel system with automated dynamic training set generation using a specialized approach. A multi-algorithm face detection module was further incorporated in the system to achieve remarkable accuracy for detection of faces. Platform independent architecture would facilitate seamless deployment on any computer system, thereby, globalizing the use of the proposed face recognition system.

2. RELATED WORK
The popular approaches for face recognition proposed by prior researches comprise of skin segmentation under changing lighting conditions, model based face recognition, DCT based face recognition, PCA, feature extraction and many more. Popular algorithms incorporated by such modules include Viola-Jones object detection framework - Viola & Jones (2001), Schneiderman & Kanade (2000), Rowley, Baluja & Kanade: Neural Network-based Face Detection (1998), Principal Component Analysis with Eigen Face, Linear Discriminate Analysis, Elastic Bunch Graph Matching fisher face, the Hidden Markov model, and the neuronal motivated dynamic link matching, DCT based face Recognition, Eigen faces, et al. Although extensive research has been carried out to exterminate the flaws in the existing system design, the highly flexible and robust system is yet to be realized. Furthermore, training set generation and maintenance requires skilled personnel but fails to accrue impressive results.

3. PROPOSED SYSTEM DESIGN
The research team developed an impeccable design of a platform independent, user-friendly face recognition system intended to offer maintenance-free robust functionality. The system eradicates the need of skilled personnel for training set generation by constructing its training set databases using a specialized automated approach. Once the training sets are built, the system uses combination of different approaches for face recognition prevalent today. The functionality of the proposed face

recognition system shall be segregated into two procedures as follows:

3.1 Automated Run-Time Training Set Generation for Enrolment

The training set is built dynamically to improve efficiency, user-friendliness and robustness of the system. For enrolment of each user, a short duration specialized video is captured and used for training purpose.

3.1.1 Innovative Training Set Generation Technique:

The training set of every individual is created in a specialized manner in which frames are captured by the camera while the face is rotated about a vertical axis passing through the center of frontal face. For enrolment, each user is only instructed to orient his/her head perpendicular to the axis of the capturing camera and rotate the face from right to left end. In simpler words, the user maintaining an erect posture, must gaze directly and straight forward into the camera and turn face from right to left end. The camera must be preferably positioned such that its axis passes through the center of the face and is perpendicular to the reference axis shown in Figure 1. In this manner, numerous training images of user's face in all possible orientations about vertical axis are obtained. This makes the training set self-reliant to recognize the face in almost all possible orientations. Figure 1 illustrates the reference axis considered with respect to the frontal face of a user.

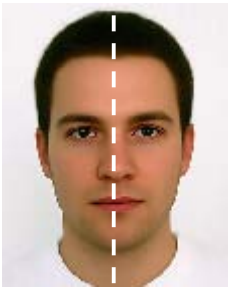

Figure 1. Reference axis with respect to frontal face

3.1.2 Capturing the Specialized Training Video:

This process involves obtaining a short duration real-time video captured by video capturing device like a standard web cam for 't' seconds which is dependant on the frame rate. At a constant frame rate of 'r' fps, total of (t x r) frames are captured. These frames are segregated to obtain 'm' frames (where m=t x r). Each video frame is enhanced using contrast stretching technique for image processing. The video capture may further be carried out against any unknown, random, non-plain, changing background environment by use of skin segmentation techniques. Figure 2 illustrates samples of video frames captured for 't' seconds.

Frame 1 Frame 12 Frame 27 Frame 38

Frame 49 Frame 63 Frame 78 Frame 93

Frame 112 Frame 123 Frame 132 Frame 143

Figure 2. Video frames captured using specialized approach

3.1.3 Face Detection:

Next, face detection is performed on each of the enhanced video frames [1][2][11]. This step is essential to verify the existence of a detectable face in each of the video frames. A video frame may have face oriented in an angle incomprehensible for face detection, may be subjected to extreme variation in illumination or may not contain a face at all. Such images if stored in the training set would act as redundant bulk data unnecessarily increasing the system load. Therefore, by using face detection using skin segmentation technique on individual frames, such insignificant frames are discarded to obtain 'n' resultant frames.

3.1.4 Feature Extraction and Updating the Training Set Databases

The training is performed by the means of these final 'n' frames, out of the initial 'm' frames captured. The system provides scope for either dynamically creating the training images for the training sets in the database or to pre-train the databases using feature extraction and model based approach [6][10]. Considering the user preference and system performance requirements, suitable action is taken. Either the 'n' extracted frames are dynamically saved to a directory on local hard-drive and logged with the name of user in the captured image or the database is pre-trained, resulting into dynamic creation of template finally saved onto the hard-drive, which concludes the training procedure. Pre-training the databases offers lesser response time during recognition phase in contrast to simply saving the training images into training sets.

3.1.5 Framework for Enrolment Procedure

As evident from the processing steps for enrolment, the system facilitates automated training set generation in a hassle-free manner without the need of any expert assistance. Consequently, it is no longer required to recruit trained personnel for enrolment and maintenance purposes thereby making the system easy to use and user friendly. Moreover, by capturing all possible face angles of an individual, the training set thus constructed is robust, powerful and very effective for face recognition.

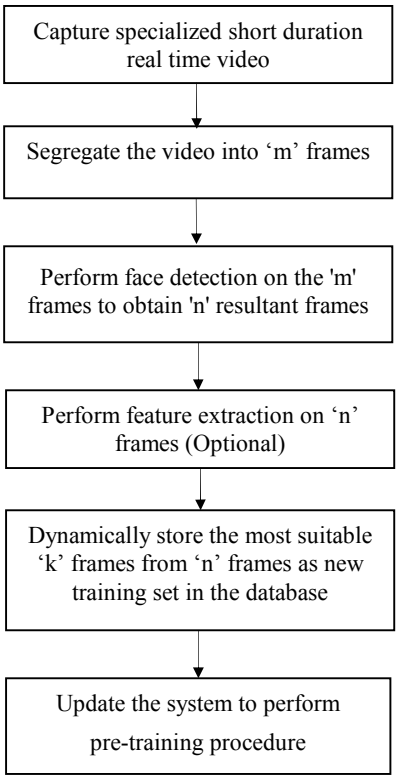

Figure 3. Framework developed for enrolment procedure

3.2 Enhanced Multi-Algorithm Face Recognition Module

This module is designed to recognize and thereby authenticate an individual by capturing a single video frame at a time from the real-time video input device. First and foremost, the video frame captured is subjected to face detection. Considering the possibility that input video frame may be captured in an unknown, random, non-plain, changing background environment, skin segmentation independent of light is performed to discard the complex superfluous background. In case the face detection procedure returns negative results, the system obtains another video frame from the real-time input. In case a face is detected in the video frame, the video frame is input to face recognition module which is based on a multi-algorithm approach. The system is configured by default to follow an approach designed and recommended by our research team which revealed best results during testing phase. The system is capable of performing face recognition using manifold algorithms. The different approaches have been appended into the processing sequence in decreasing order of their accuracy and precision. The highest preference is given to DCT based face recognition approach followed by skin segmentation based feature extraction model followed by principal component analysis (PCA) based face recognition. The system offers user the facility to re-sort the preference list of the face recognition algorithms to be used or use the default sequence of the algorithms. The system is designed in such a manner that if a higher preference algorithm returns negative result then the immediate lower preference algorithm shall be deployed for each frame. This concept allows a single frame to be tested using different approaches which is of prime importance in order to realize an overall functional system in any background and in varying lighting conditions [5][7][8][9][12]. Subjecting a single video frame to different approaches was a better solution than using the same approach for another sample of video frame, as there may exist a series of input video sequence frames (affected by intense/ unpredictable illumination) that may not be recognized using just a single approach repeatedly. Thus, the use of multi-algorithm based approach enabled the research team to design an infallible and fool-proof system.

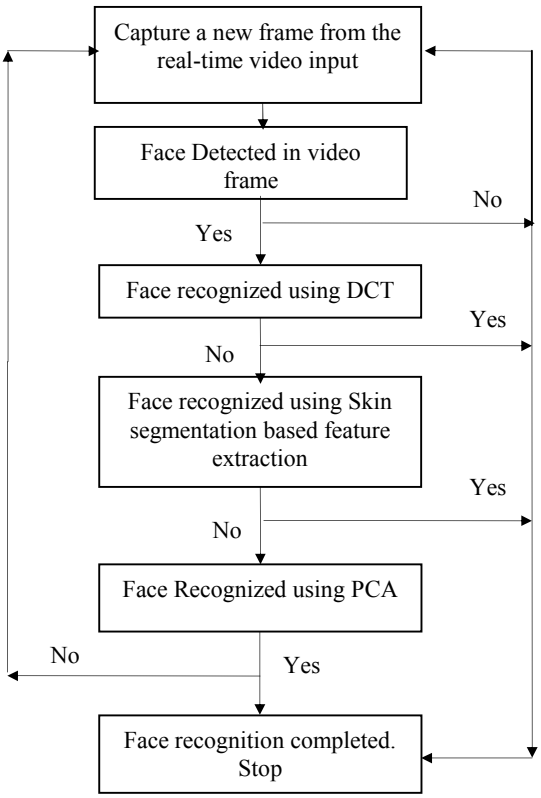

Figure 4. Framework developed for face recognition procedure

4. RESULTS :- ADVANCEMENT OVER EXISTING TECHNOLOGY

4.1 Automated and Dynamic Training Set Generation

Automated capturing of the short duration real-time video, processing and storage of training images into training sets at run-time enabled the researchers to realize a fully-automated system. Automated dynamic creation of training sets eliminates the intricacies involved in capturing the training images under supervision of skilled personnel.

4.2 User Friendly Design of System

A graphical user interface (GUI) has been provided for operating the system comprising of automated controls for dynamic training set creation and real-time face recognition. Thus, the proposed system with the user friendly interface can be effortlessly deployed and operated by amateur users.

4.3 Support for Multiple Algorithms for Face Recognition

A single algorithm may not suffice all the unpredictable conditions such as luminance variation and complicated background and fail to provide ideal accuracies for a face recognition system. Hence, the proposed system offers support to deploy multiple approaches while testing an input image (video frame) for flawless face recognition. A user may either seek the default configuration or may customize a novel approach pattern.

4.4 Extremely High Precision and Accuracy for Face Recognition

Face recognition using any single approach would result in 80-85% accuracy. However, a user definable, improved multi-algorithm face recognition module was integrated to assist the process of face recognition in case one algorithm does not yield satisfactory results making the system design infallible. By using the proposed combination of various approaches, the system can deliver an incredible accuracy of 99.9%.

4.5 Robust System Design

The paper proposes highly maintenance free design of a system that works even in light variant conditions. The system is designed to operate in unknown background making the system highly robust. Platform independent architecture, developed using MATLAB integrated with JAVA technology facilitates seamless deployment on any computer system, thereby, globalizing the use of the proposed face recognition system.

4.6 Applications

The primary objective of the system is to provide simplified enrolment procedure for face recognition systems thus promoting its usage in the global market. Design of the proposed system would result in manifold applications in creating mass enrolment systems (for registering huge number of people in face recognition system) for organizations, teaching centers, research labs, government services, personal home usage, etc. for authentication and authorization purposes [2][13].

5. CONCLUSION

The proposed system design for real-time face recognition system with dynamic training and improved multi-algorithm face recognition was implemented and found to possess remarkable precision. The highlight of the system being the specialized module for dynamic creation of training sets through the use of highly user-friendly GUI enabled the researchers to model an immaculate design of a flexible and robust face recognition system. The objective of designing the proposed system for simplifying the overall training procedure and creating easy enrolment systems for organizations was successfully accomplished. Recording various orientations of face from the video and performing face recognition using user-definable multiple algorithms enabled the system to achieve implausible accuracy of 99.9%. Deploying the multi-algorithm based approach for face recognition was a better solution than usage of any single algorithm as a single algorithm may not always yield ideal accuracy for all sets of real-time video input frames with unpredictable illumination, background or face orientation. Thus, the proposed system design is infallible and provides extensive future scope for customization and integration into larger systems currently under development.

6. REFERENCES

[1] Rob B, Ranjani B, 2006. *Real time 2-D face detection using colour ratios and K-mean clustering*. ACM-SE44 : Proceedings of 44th Annual Southeast Regional Conference

[2] Caroline M, Jean D, Florent P, Christophe G. 2005. *Online face detection and user authentication*. MULTIMEDIA'05: Proceedings of the 13th ACM Internl Conf on Multimedia

[3] Jeff. 2006. *Facial feature extraction for face characterization*. ACM-SE 44: Proceedings of the 44th annual Southeast Regional Conference

[4] S. C. Dass, A. K. Jain. 2001. *Markov face models*. In Proceedings, Eighth IEEE International Conference on Computer Vision (ICCV), pages 680–687, July 2001.

[5] Ognian B, Strahil S, Georgy G. 2007. *Combined face recognition using wavelet packets and radial basis function neural network*. CompSysTech '07: Proceedings of the 2007 International Conference on Computer systems and Tech.

[6] Ramesha K, K B Raja, Venugopal K, L M Patnaik. 2010. *Feature Extraction based Face Recognition, Gender & Age Classification*.(IJCSE) International Journal on Computer Science and Engineering, Vol. 02, No.01S, 2010, 14-23

[7] Zong X. L, Wei-Jyun Y, Chian C. H, Chin-Song W, 2009. *Fast Vertical-Pose-Invariant Face Recognition*, Proceedings of the Fourth International Conference on Autonomous Robots and Agents, pp. 613-617, 10-12 February 2009.

[8] Anil S, B.Yegnannarayna,2009. *Analytic phase-based representation for face Recognition*,7th International Conf on Advances in Pattern Recognition, pp. 453-456, 2009.

[9] P. N. Belhumeour, J. P. Hespanha, D. J. Kriegman. 1997. Eigenfaces vs. fisherfaces: *Recognition using class specific linear projection.* IEEE Trans. Pattern Analysis and Machine Intelligence, 19(7):711–720, July 1997.

[10] M. H. Yang, N. Ahuja. 1998. *Detecting human face in color images*. In Proceedings, IEEE International Conference on Image Processing, volume 1, pages 127–130, 1998.

[11] T. Leung, M. Burl, P. Perona. 1995. *Finding faces in cluttered scenes using labeled random graph matching*. In Proceedings, 5th Internl Conf on Computer Vision, pages 637–644, June 1995.

[12] B. Tacacs, H. Wechsler. 1998. *Face recognition using binary image metrics*. In Proceedings, 3rd International Conference on Automatic Face and Gesture Recognition, pages 294–299, April 1998.

[13] Guillaume H, Yann R, Sebastien M, 2006. *Local Binary Patterns as an Image Preprocessing for Face Authentication*, Proceedings of 7th International Conference on Automatic Face and Gesture Recognition, pp. 6-14, April 2006.