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An Adaptive-Profile Modified Active Shape Model for Automatic Landmark Annotation Using Open CV

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***Abstract*- Detection and tracking of face and facial features are the fundamental steps for many applications like Biometrics, human computer interface, video surveillance and expression analysis This paper addresses the challenges in current techniques and presents an adaptive-profile accurate method for facial feature detection and real time tracking. Face and facial features are detected by improved Active shape model (ASM), This application is developed by using Intel's Open source computer vision project, OpenCV, Microsoft's .NET framework and DLIB.**

***Index Terms*—Active shape model, Active appearance model, Facial landmark**

I. INTRODUCTION

Research work on face recognition system has been improved due to its wide range of applications in the fields of security, gaming, entertainment and psychological facial expression analysis. Our framework can simultaneously handle the unified model for face recognition; pose estimation, and landmark detection in real-world. Face detectors gives the resulting image in which the rectangular/square bounding box having face region. After locating face region, remaining facial parts like eye, nose tip, mouth corner and contour parts are detected. The resulting detection system is real-time on a standard personal computer (PC). Present authentication applications are not robust; they are limited for particular pose and illumination condition. Most of the algorithms are affected by changes in poses and illumination. A coarse-to-fine approach is adopted to find the whole face and restrict the search region for individual features. Then shape information is used to select the features that are used to form a plausible face shape.

Model-based object recognition [2] is the earliest approach of feature extraction. It uses Global feature method to trace the boundary of the object and uses hypothesis-verification procedure to locate the objects in the image. Matching of located objects is done by using parsing. Active contour model [3] locates the irregular boundaries of the objects in an image. This model uses greedy algorithm for contour detection but it has several drawbacks which cannot locate the irregular boundaries accurately. The Active Appearance Model (AAM) [4] and Active Shape Model (ASM) [5] are the two popular approaches for facial feature recognition; AAM uses the texture information of faces. These two methods give high accuracy and performance. Both ASM and AAM define number of labeled landmarks on the faces. Active shape model uses texture profile models to locate the landmark positions and it uses point distribution model (PDM) for estimation of object's boundary and to label the set of landmarks on object. Active appearance model uses whole face region for searching of face texture, after detecting the facial region it removes the remaining part of the image and extracts the shape free patch of the face. Due to many iterative steps in AAM the time duration for processing the images is more, but ASM results fast simulation of images and advantageous than AAM. Active appearance model is better in terms of facial textures meanwhile active appearance model is best for facial feature localization. ASM gives accurate results in order to detection and extraction of facial features.

A lot of literature has proposed for improvement of robustness and performance of active shape model. ASM is not robust under different pose, expressions and different illumination conditions. So to improve the accuracy of the ASM, the Genetic algorithm (GA) [6] is used for searching the best representation of facial images, but the disadvantage with this algorithm is, it uses man made constraints to represent the face features such as eyes, nose, lips, mouth and face contour. Two dimensional profiles [6] are used for locating the position of each landmark, 1D profile is not suitable because it doesn't captures the more information of each landmark. Hence 2D profile method is the efficient algorithm for existing landmark detection techniques; it's the main contribution for ASM. Further extended work on landmark techniques are used 2D profiles in [7] and [8]. The method in [7] uses both scale invariant feature transform (SIFT) and ASM combination to find the facial features, while [8] uses Principal component analysis (PCA) to find each landmark using 2D profile model. These methods are sensitive for variations in pose, expressions and occlusions.

In this paper, An Adaptive-profile Modified Active shape model for automatic landmark annotation using OpenCV is presented as shown in Fig. 1, the method includes Face detection, Facial features detection along with Mesh analysis, and Face tracking. The rest of the paper is organized as follows. In section II, active shape model and modified active shape model will be discussed. In Section III, experimental results are shown. Finally, in Section IV, conclusion of our work will be discussed.

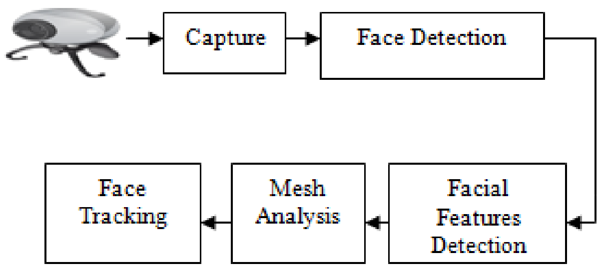

Fig. 1: An overview of the system

II. MODIFIED ACTIVE SHAPE MODEL

Active shape model

Active shape model applies the model to an image and follows these steps, 1) Searches the entire image around each point for accurate location of that point.2) for the accurate location of each point, the model searches for the strong edges. Classic Active shape model uses the Mahalanobis distance to locate the accurate location of each landmark points. ASM uses Point distribution model (PDM) to locate the object in an image, PDM extracts the profile which is perpendicular to the contour part at each landmark and new position of that landmark is estimated along extracted profile.

Although the active shape model is used in many applications, but there are still many problems exists with ASM like accuracy, speed and robustness of the algorithm. Thus this study sought to modify the drawbacks of classical ASM with some improvements applied on it.

***Profile Model*:**

Profile models are used for searching the position of each landmark using Template matching. Active shape model uses one-dimensional profile at each landmark and it samples the image pixels through one-dimensional line which is orthogonal to the boundary of the object shape. In our method, we used two-dimensional profile which allows for getting the accurate position of the point more rapidly. At each landmark, 2D profile is used to select a square of the side m (*m* x *m* size). The center of the square represents the present location point of its landmark. For each landmark n squares are obtained because of number of facial shape points are more in face image. To locate the accurate location of the each landmark, the distance (d_0) is calculated using the following equation;

$$d_0 = \frac{1}{m*m}\sum_{i=0}^{m-1}\sum_{i=0}^{m-1} abs(g^0_{(i,j)} - t^0_{(i,j)})$$

Where $g^0_{i,j}$ is the pixel value of gray-scale present in i^{th} row and j^{th} column of the 0^{th} landmark in respective with two dimensional profile and 0, $t^0_{i,j\ j}$ is the pixel value of gray-scale present in i^{th} row and j^{th} column of the sub-2D profile of the 0^{th} feature point. d_0 is the similarity between 2D profile and sub-2D profile. When the d_0 is minimum, the value of current feature point location will get update the center of sub-2D profile.

The query face image is placed at the placed at the center of the square which is located by the face detection algorithm of Viola and Jones [9].Several iterations are done to determine the cluster of profile model used in next iteration. The selected profile model would be more robust to the different poses and expressions of face, and hence the landmarks can be located accurately. The proceedings of algorithm are illustrated in Fig. 2. Methodology of landmark location is discussed in the following sub-sections.

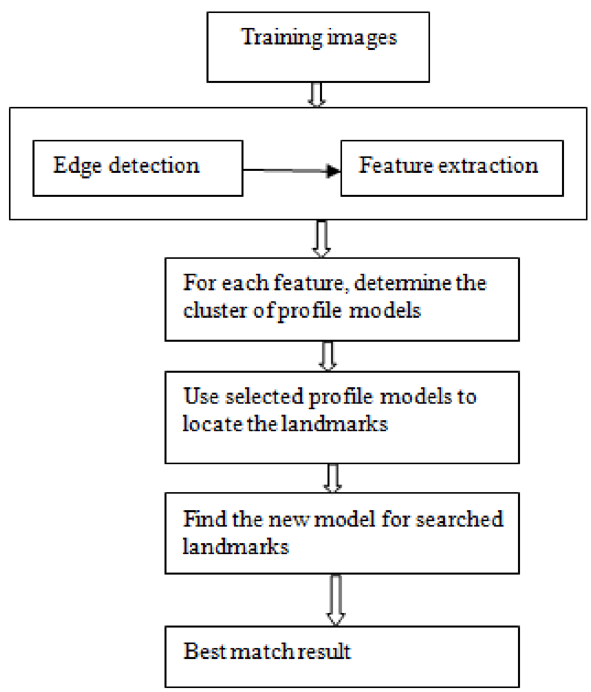

Fig. 2: Algorithm Architecture

Profile matching

Previous active shape model algorithms uses Mahalanobis distance to find the similarity between the testing profile and profile-model. But there are many drawbacks with this measurement, it is restricted to limited number of training samples and it has only one cluster for comparing two profiles but none of profiles within each cluster supports the multivariate normal distribution. Thus Mahalanobis distance is not suitable metric to find similarity between two profiles. Therefore in this algorithm, by considering two profiles we employ an efficient metric to measure the similarity by applying correlation between two profiles.

$$S(g1, g2) = g_1^{T} \cdot g_2$$

Compared to the Mahalanobis distance measurement, this dot product reduces the computation complexity and improves the accuracy.

Searching Window Shrinking

In our algorithm we employ multi-level profiling [10], it uses different size searching windows and avoids the rescaling of the image. While training the images, initially the searching window is set to 21*21 which contains 441 pixels each sample of profile is compared with the profile model. The comparisons are done for each detected landmark. The window size will get reduced to 17*17 after converging of the face model. These steps are repeated for several times until the window size should become 1*1. Down sampling is applied to reduce the computational complexity.

III. EXPERIMENTAL RESULTS

In order to do performance evaluation of our implemented algorithm we used IMM dataset [11] of images which includes the different facial expressions and poses.

Face and Facial Feature Tracking

Haar feature-based cascade classifier is well known object detection method proposed by Viola and Jones [9]. OpenCV comes with this detection method, which contains pre-trained classifiers for facial features like eyes, nose, lips and face. Fig. 3 shows result of facial features,

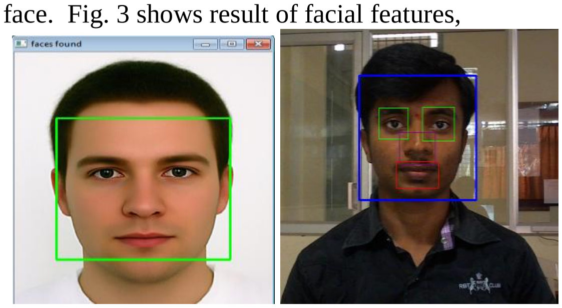

Fig. 3: Results of face and facial feature detection using OpenCV for frontal view.

This method is suitable only for frontal view and it fails when it applied under different poses and expressions of face. Hence in order to locate the accurate position of features we used original labeling scheme of active shape model for detecting landmarks on face. IMM face dataset [11] is used for locating landmarks;

Fig. 4: landmarks labeled for face under different poses and expressions.

Fig. 4 shows the re –annotated landmarks of a face under different pose variation and expressions.

Once the facial features are determined, the real time tracking of face is done by fitting an improved 2D profile model. We can achieve accurate tracking of face and its features by using our modified ASM under any expression and poses. Fig. 5 shows our localization results using undashed colored lines,

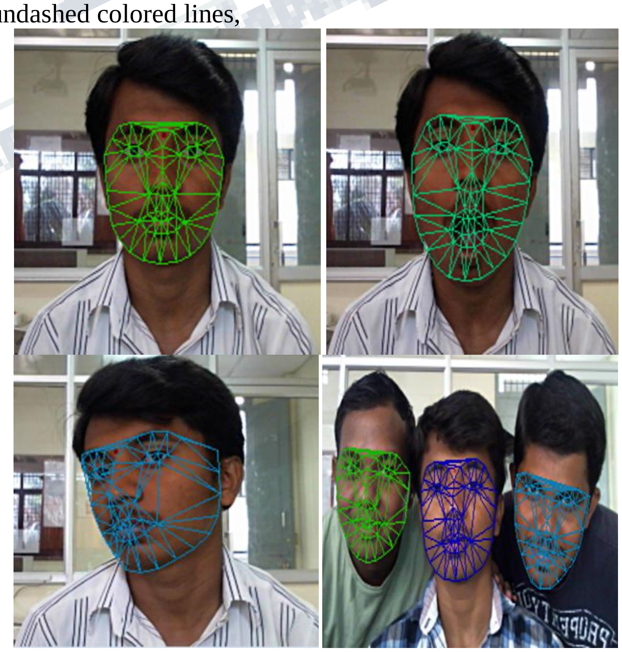

Fig. 5: Tracking results of faces.

By using dlib's computer vision library with OpenCV [12], we can achieve both face detection and facial feature

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detection. It gives fast and robust detection results under any variation in poses and expression along with number of faces in an image. Fig. 6 shows the results obtained using Dlib and OpenCV.

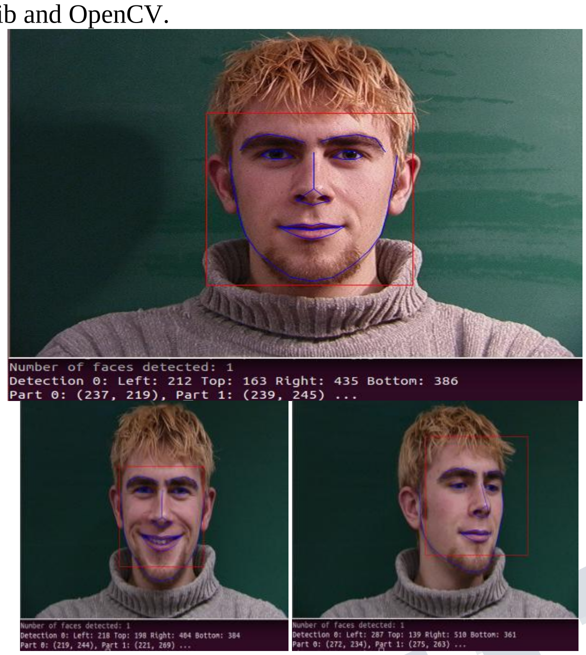

FIG. 6: DETECTION RESULTS USING DLIB AND OPENCV.

Conclusion

In this paper, a more efficient and complete automatic system for detection and tracking of face and its features is presented. Our approach concentrates on achieving high accurate location of landmarks on face. We developed a pipeline for face detection, facial feature extraction and real time tracking of face. The system is achieved high recognition rate and able to maintain accuracy under any poses and occlusion. This paper has achieved Accurate and Efficient face recognition method than the classic ASM. Extension of this work is to implement on android.

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