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ScienceDirect

Procedia Computer Science 87 (2016) 300 – 305

Procedia Computer Science

4th International Conference on Recent Trends in Computer Science &Engineering

Automatic Frontal Face Reconstruction Approach for Pose Invariant Face Recognition

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Abstract

Handling pose variations for face recognition system is a challenging task. The recognition rate is drastically decreasing with the images captured in uncontrolled environment having pose variations in yaw, pitch and roll angles. When the face image with frontal pose it is proved that the recognition system performs well. In this research an attempt is made to reconstruct frontal pose face images from non-frontal face images to improve the face recognition accuracy. By estimating the change in pose with respect to yaw, pitch and roll angles based on the landmark points best viewed side of the pose is identified. Using tilting, stretching and mirroring operation to the best viewed side, frontal pose is obtained. This approach is database independent, training free and no need to generate 3D model and not using any fitting approach, which is a complex task and handle any combination of roll, yaw, pitch angle up to ± 22.5 degrees only from the 2D landmark points. Experiments were conducted on FERET, HP, LFW, PUB-FIG data bases and the experimental result proves that our approach can handle the uncontrolled faces with arbitrary poses Experimental results on various controlled and uncontrolled poses proved the effectiveness of the proposed method.

Keywords: Face Recognition, Uncontrolled, Frontal, Non-Frontal, Landmark Points, Best Viewed, Tilting, Stretching, Mirroring, Reconstruction.

1. Introduction

Real World Face Recognition in an uncontrolled settings is the most challenge research topic in the past few years with enormous applications viz. surveillance, crime investigation, boarder control, military applications etc., handling pose variations between the probe and the gallery images acquired in the uncontrolled environment is still remains a challenge and needs lot of attention since the performance drops for such non-frontal images with large pose variations. Most of the face recognition algorithms yield satisfactory performance for the frontal faces. However matching the non-frontal faces directly is a difficult task. One intuitive solution is to reconstruct the frontal face from the non-frontal face for further processing. The pose invariant face recognition algorithms are mainly categorized into three categories such as invariant feature extraction based methods, multi-view based methods, pose normalization based methods [1-11]. The ultimate idea of pose normalization is by generating a novel pose of either the probe image as similar to that of the gallery image or by the reverse based on the 3D model. The other idea of pose normalization is by synthesizing the frontal view of gallery and probe image which is otherwise known as frontal face reconstruction.

Only a very few works explored the idea of frontal face reconstruction [10-11] to improve the accuracy of face recognition. The existing methods suffer from any of the drawbacks such as not fully automatic, not allow the combined pose variations, database specific, need lot of training, uses 3D model generation, uses huge landmark points methods and manual selection of required points, using fitting approaches etc, Chai et al [1]. Learn pose-specific locally linear mappings from patches of non-frontal faces to patches of frontal faces. Their method only handles a discrete set of poses and requires some manual labeling of facial landmarks. Similarly in the approach of Asthana et al [4] several non-frontal synthetic images are generated from frontal gallery images and this method has the limitation for discrete set of poses and required landmark point are manually selected. Gao et al. [8] use a single Active Appearance Model (AAM) to fit non-frontal faces but also require manual labeling. Du and Ward [3]. require a set of prototype non-frontal face images that are in the same pose as the input non-frontal face. Heo and Savvides [9]. use a similar approach to ours for locating facial feature points but use 2D affine warps instead of our more accurate 3D warps and rely on manual initialization. Blanz and Vetter [5] use a 3D Morphable Model to fit a non-frontal face image and then synthesize a frontal view of the face and uses manual marking of several facial feature points. Huy Tho Ho [10]. present a

Peer-review under responsibility of the Organizing Committee of ICRTCSE 2016
doi:10.1016/j.procs.2016.05.165

method for reconstructing virtual frontal face from non-frontal face using MRFs and BP algorithms. A lot of training is needed for aligning the input non-frontal face with that of the frontal faces available in the training database and it is not fully automatic. Maria De Marsico [11]. uses the Extended Active Shape Model called STASM algorithm for landmark point detection. out of 68 landmark points of STASM the points needed for frontal face reconstruction are selected manually. Since very long back itself it is proven that the face recognition accuracy is good for the frontal faces. However in the real time scenario the face images captured is not always frontal and has arbitrary pose variations comprising all possible directions. Hence it is a high demand for the face recognition methods that can able to handle such faces and it is proposed to reconstruct a frontal face from the non-frontal face to improve the recognition accuracy using very few 2D landmark points.

2. Proposed Approach

A novel approach is proposed for frontal face reconstruction from non-frontal faces captured in controlled, uncontrolled settings. The proposed Frontal face reconstruction method is capable of reconstructing a frontal face image from a single non-frontal image, fully automatic and the YPR 3-axis pose coverage of the uncontrolled faces without applying any 3D techniques and training methods.

The entire framework for frontal face reconstruction is shown in Fig. 1. In the first stage the landmark points are detected and in the subsequent stages better viewed half selection, approximation of other half based on the better half are discussed.

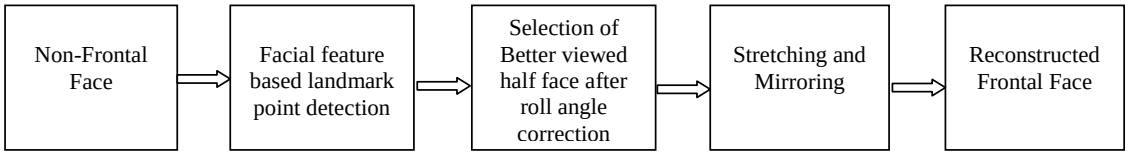

Fig. 1 Framework for Frontal Face Reconstruction

The process of reconstructing frontal face from non frontal face is depicted in Fig. 2, the fontal face reconstruction via TSM algorithm. From the non-frontal face by estimating the roll angle and from the salient landmark points the frontal face is reconstructed with stretching and mirroring operations. The facial components such as left eye, right eye, nose and mouth are detected using the object detection algorithm [12, 13]. The landmark points and subsequent division of face image into two halves depends on the quality of object detection process. Given a test image, our approach automatically detects the face and facial features such as eye(s), nose, mouth that will be the initial step for the landmark point detection. If no face or if both the eye features are not detected, a failure to acquire has occurred and for such images frontal face reconstruction is not possible. For all other images facial feature based landmark points can be detected and by using these points frontal face is reconstructed from the given non-frontal face. Similarly for the uncontrolled face images with occlusion in the eyes such as front hair covering eyes, sunglasses, closed eyes, large pose variations, high illumination, low resolution etc., the face or facial feature detection fails. In case of facial feature detection fails landmark point detection also fails since it relies completely on detection of facial features such as left eye, right eye, nose, mouth.

It has a advantage that, it does not require training process, head pose estimation, 3D model generation, landmark point fitting, manual selection of landmark points, necessity of frontal face availability in the gallery etc., In the case of face images has pose variations in the left direction from the viewer perspective, the some of the facial features are not detected correctly and hence accurate landmark point detection fails. However for the same image if we use the annotated landmark points then our proposed Frontal face reconstruction works promptly.

The rest of the paper is organized as given. Section 2 presents automatic landmark point detection, better viewed half selection, other half approximation based on the better half. Section 3 shows the results. Section 4 ends up with conclusion.

1.1. Automatic Landmark Point Detection Based on Facial Features

In order to attain the full automation, the proposed approach uses a novel method to detect the landmark points. The Viola Jones Cascade Object Detector using Haar features and Adaboost cascade classifiers [12-13] is used to detect the facial components such as left eye, right eye, nose, mouth. Based on the facial features four landmark points such as left eye center point, right eye center point, nose tip point, mouth point are detected by the finding the midpoint of the eye(s), nose, mouth rectangular features and the two other landmark points are derived from the mentioned four points. such as midpoint of the two eye centers, chin point. The chin point is derived from the nose tip and mouth point by placing a landmark below the mouth point with the distance of nose tip and mouth point as illustrated in fig. 3.