Application of Active Appearance Model to Automatic Face Replacement

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Abstract

Active appearance models (AAM) are statistical model for capturing shape as well as appearance of deformable objects like human face. The power of AAM lies in the fact that it can synthesis or explain any given object shape and appearance with compact set of parameters. AAM is used widely in the application of face recognition and facial expression recognition. We present a novel method of using AAM to the application of Face Replacement. Face Replacement is process of replacing the face in an image with any face of our choice while retaining the original pose and expression intact. Face replacement of any two given images takes only few hundreds of milliseconds without compromising quality.

Categories and Subject Descriptors (according to ACM CCS): I.4.9 [Computer Vision]: Applications—Face Morphing

1. Introduction

Active appearance models (AAM) is proposed by Cootes et al. in 1998 [CET98]. It is a statistical model of shape and appearance of any given object. It has been widely used for modeling human face shape and appearance. In training phase, AAM takes a set of images and the corresponding landmark points as an input and produces model parameters as output. Landmark Points are represented by set of points in an image which captures shape and appearance of the object. Appearance is captured by pixels inside the convex hull of landmark points (see figure 1). AAM creates combined shape and appearance model rather than creating separate models. Power of AAM lies in the fact that it can explain any given object shape and appearance in compact set of parameters. During fitting phase, AAM finds the optimal model parameter for any given new image by synthesis. The state-of-the-art AAM fitting algorithms are almost real-time.

Face Replacement is process of replacing the face in an image with any face of our choice while retaining the original pose and expression intact. There are many tutorials available in the web for doing manual face replacement in Adobe Photoshop. We demonstrate the fully automated face replacement system in this paper. We call image in which face is to be replaced as template image and another image as user image. For example, Mona-Lisa image is called as template image and the another image with face as user image. Goal of Face Replacement system is to replace Mona-Lisa face with user face. Note that pose and skin tone of the template image and user image can be totally different. We also want to capture the facial expression of the template image. For example, if the face in template image is sad, it should not only result in replacing the template face with user face but also modify user face expression to sad. So effective face replacement system should take care of pose, face skin tone and expression. Although this paper deals with face replacement in images, ultimate goal is to do face replacement in videos where we not only want to capture expressions but also want to capture lip movements. Application of face replacement can vary from printing the result in personalized products like t-shirts, mugs etc to movie productions.

2. Related Work

The closest work to this paper is [BKD*08]. But the problem studied in that paper is different from this paper. They have database of nearly 30000 faces crawled from internet. Given an image, their system find the closest faces from the database. This results in set of faces which are close to the given image in terms of pose and appearance. Then face is replaced with the faces from the database with lighting and illumination changes. Their system does not handle face replacement which can capture face expression and also wide difference in pose between template face and user face.

Other works on face replacement requires either manual intervention or 3D models of face. We use AAM to efficiently capture both pose and expression of the face in a few parameters. In this paper, we propose a novel method of using AAM to the application of fully automatic Face Replacement. The proposed method takes few hundreds of milliseconds without compromising quality.

3. Proposed Method

In this section we describe the proposed method. Even though we will not describe AAM in this paper, the details of it can be found in [CET98]. Firstly we train the AAM with set of training image along with landmark points. Landmark points are such that it can capture variety of facial expression. Now given any two images, template image I_t and user image I_u, we run AAM fitting to find the corresponding optimal landmark points S_t and S_u. The way AAM Fitting works is that it first internally uses face detection algorithm to detect faces in the image, and then it starts with random landmark points and finally it arrives at optimal landmark points after several optimization steps. Remember that landmark points from the previous step captures face pose and expression.

Next step is to find the optimal warping of user face in template face. Warping is process of finding the pixel correspondence from user face to template face. Aim of warping is to find a function $f(x_i) = x_i^{'}$, where $x_i \in S_u$ and $x_i^{'} \in S_t$. We use piece-wise affine warp [GM98] to find the function f. After warping, we want to match skin tone of user face to that of template face. Each pixel in user face is converted such that overall skin tone of user face matches with template face. Both the images are partitioned into small grids (say 20x20) around each pixel and we calculate the mean of RGB values of the grid in both the images. Then pixel is modified as, $p_i = p_i + (m_i^{'} - m_i)$, where $p_i \in I_u$, m_i and $m_i^{'}$ are the mean of pixels around p_i in user image and template image respectively. Finally, user face which is replaced into the template face is smoothened along the boundary to get better quality. The method is illustrated in figure 1. First two images in figure 1 is the output of AAM. Affine warping result is shown in next image. Next image shows change of the skin tone of user face. Final image shows smoothening of replaced face along the boundary for better quality.

4. Results

Some of the face replacement results are given in the figure 2. The system takes 200 to 400 milliseconds (3GB RAM with 2.4GHz Processor) for face replacement with any two given images. Note that final output captures the facial expression of original template face. For example in first image, user face expression is modified to wide smile as in template face. Similarly in second image, user face expression is modified to sad. Also note that pose of template and user faces are different in some examples. Note that in all the images, skin tone of user face is changed so that output looks very realistic.

Figure 1: *First image depicts landmark points. Other images illustrates Face Replacement Procedure using AAM.*

Figure 2: *Example results of face replacement for first image in figure 1 as the input user image. Each row are in order of user image, template image and output image*

5. Conclusions

We proposed the method of face replacement using AAM which can capture face skin tone, pose and expression. The proposed face replacement system can perform in few hundreds of milliseconds without compromising the quality. We feel this work is the starting step for video face replacement.

References

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