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Human Posture Recognition from an Eigenspace

M. Masudur Rahman, Kazuya Nakamura, Seiji Ishikawa
Department of Mechanical and Control Engineering, Kyushu Institute of Technology
Sensuicho 1-1, Tobata, Kitakyushu 804-8550, Japan, email: rahman@is.cntl.kyutech.ac.jp

Abstract

This paper addresses a novel approach to recognizing several humans' postures from just a single eigenspace and investigates a practical problem associated with dress changes in recognizing human postures automatically employing an eigenspace technique. A single eigenspace is prepared employing an ordinary man's several orientations and various humans' postures are recognized from it. The dress effect in the eigenspace arises when a man/woman wears different dresses in the recognition stage employing a conventional parametric eigenspace method. This paper proposes to employ blurred-edge images with proper designing of the parameter of Gausian variance for overcoming the dress effect. We have conducted experiments using several humans' wearing various dresses in a laboratory environment and the approach has shown a satisfactory result.

1. Introduction

Due to some basic similarities with a biological recognition system and not to consider object's geometrical shape to its recognition, appearance based eigenspace (*ES*) methods are recently being investigated for the recognition of non-rigid objects. In biological recognition system, a human can recognize easily anybody's posture by just observing its appearance. So, a biological recognition system can identify a man/woman's present situations where a machine based recognition system is quite unable to do it. In some cases, medical treatment for example, intelligent agents are used for recognizing human behaviors/present situations. Automatic recognition of human behavior in computer vision is still under developing. The present approach proposes such a recognition technique where an intelligent agent can recognize human postures or behaviors using just its appearance. The original *ES* technique was first applied to the recognition of a 3D object from its 2D images in the works of Murase and Nayar [1]. Besides, we concentrate this study on recognizing human postures creating an eigenspace from just a single man instead of developing separate eigenspaces of all men/women. Since a human's various postures are very correlated with each other, we use this correlation to reach our goal. However, we find some difficulties to recognize a human posture along with some sort of practical situations. The difficulty arises from the fact that various kinds of human dresses cause individual creation of *ES* in the conventional technique. Although there are some other limitations like styles [4], occlusions, cluttered background [3] problems, *etc.*, in order to recognize a human posture employing *ES* technique, we concentrate only on dress problem in this particular paper.

This study creates a single *ES* from an ordinary man and a number of various orientations from different men are projected into this *ES*. A set of recognition rates for each man is obtained in the result. Besides, the paper proposes the employment of Gausian-blurred edge images for reducing dress effect in the *ES*. The present paper also considers a new recognition strategy for performing this special issue. The proposed approach gives us better result, which is shown in the experimental results.

2. Conventional *ES* Approach

We employ a conventional appearance based parametric *ES* technique in this paper proposed by Murase and Nayar [1] in order to recognize a human posture along with investigating dress problem. In their developed *ES* method, it has two stages called training and recognition stage. In training or offline stage, an image set is used with different orientations or different illuminations for constructing the eigenspace. In both stages, they use just original images without any pre/mid-level processing. The images in the set are usually highly correlated and they can efficiently be compressed employing Karhunen-Loeve (K-L) technique [5], resulting in a low-dimensional eigenspace. In recognition stage, a new unknown image is projected into the eigenspace database and assures the image nature by assigning the label of the closest model point.

In notation, $\boldsymbol{y} = (y_1, y_2, ..., y_{N\times N})^T \in \Re^{N^2}$ is an individual template with N^2 number of reading pixels brightness values in a raster scan manner. $\boldsymbol{Y} = \{\boldsymbol{y}_1, \boldsymbol{y}_2, ..., \boldsymbol{y}_P\}$ denotes a set of P images after taking the normalization. We define a covariance matrix $Q = \boldsymbol{YY}^{\mathrm{T}}$ and determine its eigen vectors $\boldsymbol{e_i}$ with corresponding eigen values $\boldsymbol{\lambda}_i$ using an eigen equation. The K-L method is used for compressing the $N^2 \times N^2$ dimensional space of Q, and only k eigenvectors are chosen. Using these eigenvectors, we calculate a set of discrete points $\boldsymbol{g}_p = (g_1, g_2, ..., g_k)^{\mathrm{T}}$ by projecting $\boldsymbol{Y}$, and $\chi = (\boldsymbol{e_1}, \boldsymbol{e_2}, ..., \boldsymbol{e_k})^{\mathrm{T}} \boldsymbol{I}_u$ by projecting the unknown image $\boldsymbol{I}_u$. Recognition result is assured as the closest one by calculating the minimum distance between the stored postures and the unknown one. **Figure 1** shows an ordinary *ES* created by taking several orientations of a man, H_1. An arrow indicates the direction of pose variations in the eigenspace database. A total of 36 poses are used to creating this *ES*.

3. Proposed Approach

The major novelty of our approach is to employ a single *ES* for recognizing a variety of human postures. We propose the usage of Gaussian blurred and Sobel-edge images for overcoming the dress effect [2] instead of using original images. So we make development of this technique beyond the conventional *ES* method by extending it in the following way. We first propose some image processing techniques, *i.e.*, two stages Gaussian blurring with proper designing of the parameter σ values for all images and Sobel-edge transformation is applied in between. The edge images are prepared to develop a parametric *ES* as well as using in the test stage according to the established *ES* method. Finally, we take a strategy for the recognition in case of pose-to-pose identification. In notation, the gray scale image is first given blurring (by Gaussian filter) $G_{\sigma 1}$ to yield a blurred image $\hat{\boldsymbol{y}}_{G1} = G_{\sigma 1} * \boldsymbol{I}$. Differentiation D (using Sobel mask) is applied to this image to obtain an edge image $\dot{\boldsymbol{y}}_{SE} = D(\hat{\boldsymbol{y}}_{G1})$. Gaussian with parameter

σ_2 is again convoluted to finally yield a double Gaussian blurred image $\hat{y}_{G2} \equiv G_{\sigma 2} * (\dot{y}_{SE})$. This double blurred edge image is proposed for creating the eigenspace database.

An experimental setup is conducted using a video camera (see **Fig. 2**), and eight different men wearing different dresses randomly to verify the dress effect. A man with 36 different orientations (*i.e.*, H_1) is considered to make an *ES* for creating an eigen-database, whereas other 252 images from different seven men are

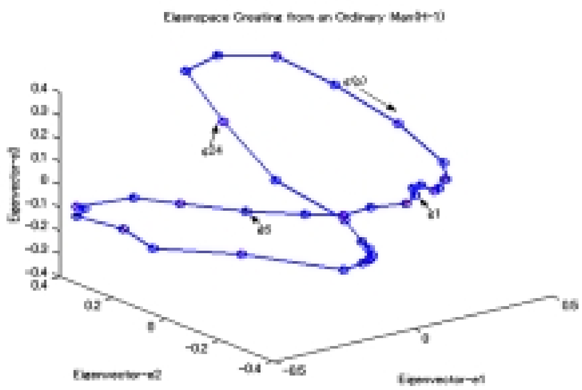

Figure 1. An ordinary eigenspace representing the learning samples of Fig. 2. Some of feature points represent the corresponding posture's locations. Only the three most prominent dimensions of the eigenspace are displayed here.

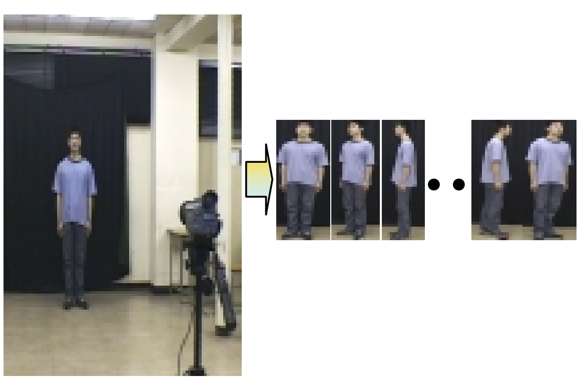

Figure 2. Setup used for acquisition of several human orientations. Images are taken from a video camera in order to produce an *ES* and for recognition samples.

considered for the recognition purposes. **Table 1** summarizes the experimental activities *i.e.*, number of human, number of training and recognition samples used in the experiment. The table also summarizes the number of images used in the experiments to satisfy the conditions, poses used to acquire the image sets in the experiments, *etc*. Only 36 images of different orientations from H_1 were used for learning the system in each experiment while a large number of different postures were employed for the recognition. To evaluate the recognition rate, we consider the percentage of test images for which particular learning images are correctly identified by satisfying the following equation;

$$P_{true} \in \left\{ P^* \pm i; i = 0, \pm 1, \ldots \pm T \right\} \qquad (1)$$

where T is a tolerance factor.

4. Experimental Results

In this section, we report on the extensive testing that we performed to prove the effectiveness of the proposed technique. The performances of the present approach were figured out based on the acquired recognition rates reducing the dress effect and the requirements of less eigen dimensions. The goal of this research is to recognize correctly of different postures employing an ordinary single *ES*. We have developed an *ES* from the model H_1 and investigated the recognition rates using

Table 1. Summary of used images in the experiment for training and recognition purposes.

Nos. of Samples	Learning/Training Sample	Recognition/ Test Sample
Eight different men	H_1 for Learning	H_2 to H_8 for Recognition
Total	36 Images	252 Images

the model from H_2 to H_8. In table 1, we have summarized the total number of images used in this experiments. In case of investigating the recognition rates, 252 different images of seven sets have been projected to the basic eigenspace. As a result 70% of average recognition rate was achieved by using all the recognition samples given T=1 in Eq. (1), which is shown in **Table 2**.

5. Discussions

This approach exploits several new techniques, *i.e.*, usage of image pre-processing, recognition strategy, estimation of the Gaussian variance, *etc*., in order to achieve the goal in this particular study. In this section, we briefly discuss several points related to the experimental activities that may be referred as advantages while some of others as disadvantages leading to open up the research in advance. The discussions depend mainly on the selection of human model, dress category, the blurring and differentiation effect on the dress textures, achieving the advantages in case of using less eigen dimensions, *etc*.

Selections of Human Model and Their Dresses: A large variety of human being in a daily life along with their different choices of wearing dresses creates tremendous effect to use this technique. The study has chosen only eight men randomly from our department wearing some of common varieties of dresses. A large difference of recognition between proposed method and the conventional method has appeared when we attempted to recognize a human posture wearing a textured dress with same/different color. We have found that, if a man wears a course-textured dress, the recognition rate abruptly decreased using conventional method (recognition rate is less than 25%) while our method has shown an expected result (see reference 6). In the present paper, we received an average 70% recognition rates that we consider a satisfactory result using just an ordinary human *ES*. However, the present research is in preliminary level and we employed only some of common standing man's orientations. We expect to employ this method against people of different body shapes, with considering different styles and with different attire such as the adornment of a hat in the future study.

Table 2: Result of recognition rates (H_1 as learning sample).

	Human Models						
	H_2	H_3	H_4	H_5	H_6	H_7	H_8
Recognition Rates (%)	64	80.5	69.5	61.1	72.2	69.5	73

Image Pre-processing Effect: Both learning as well as recognition were done using double Gaussian blurring and Sobel edge differentiation in between after thresholding the images like a conventional method. This is a strong contrast to the conventional *ES* method where this method requires some image pre-processing techniques as well as designing an appropriate σ for the Gaussian filtering. Obviously, the effect of this processing minimizes the dress problems in the *ES*. We have investigated that the recognition rates is higher when a man/woman wears a light textured dress. If a man/woman wears a coarse textured dress, the *ES* technique cannot recognize it properly. A trial and error strategy has been maintained in this study to select the magnitudes of σ. Further study in these issues can find some other techniques that could be more reliable than the technique we used.

Eigen Dimensions: The selection of eigen dimension

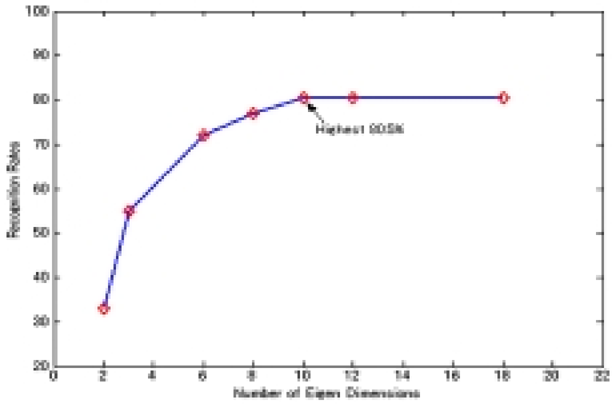

Figure 3. Number of eigen dimensions plotted with respect to the recognition rates of H_3. 96% of object's characteristics are appeared during the highest recognition rates.

depends on the appearance characteristics of the model, and the number of objects of interest to the recognition system. We also found that it also depends on the dress category, *i.e.*, if the textures are coarser, a large eigen dimensions may be required. On the other hand, if the dimensions are larger, the process time of the recognition will be higher. In the proposed approach, we had to use only six eigen values which cover 95% of image data variance in this experiment.

6. Conclusion

The contribution of this paper stands on using blurred and edge-detected versions of human body images to detect pose from one typical eigenspace of poses, regardless of the individual. So, we need not to develop each and every human *ES* separately to recognize its postures. The present study also addressed a practical problem associated with dress changes to recognize human postures, and proposed to use Gaussian blurred edge images for overcoming the dress effect. The proposed technique achieves robustness to the texture on clothes and results are shown for a set of 8 persons and a set of 36 poses. However, we recommend using some more variations of selecting human, postures and clothes to achieve ultimate effectiveness of this method.

7. References

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