The effects of Pose on Facial Expression Recognition

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Research into facial expression recognition has predominantly been based upon near frontal view data. However, a recent 3D facial expression database BU-3DFE [4] has allowed empirical investigation of facial expression recognition across pose. In this paper, the effects of pose from frontal to profile view on facial expression recognition is investigated. Experiments are carried out on 100 subjects with 5 yaw angles over 6 prototypical expressions. Expressions have 4 levels of intensity from subtle to exaggerated. Features evaluated include local binary patterns (LBPs) as well as various extensions of LBPs such as uniform LBPs (LBP^{u2}) and multi scale LBPs (LBP^{ms}). In addition, a novel approach to facial expression recognition is proposed using local gabor binary patterns (LGBPs). The combination of gabor and LBPs further enhances the power of the spatial histogram, and exploits multi-resolution and multi-orientation gabor decomposition. Multi class support vector machines (SVMs) [1] are adopted for classification, as they are well founded in statistical learning theory. The effects of image resolution and pose on facial expression classification using a variety of different features are investigated.

Recently, two studies have explored facial expression recognition with varying yaw angles on the BU-3DEF database [2, 3]. Hu et al. [3] focuses on facial expression recognition using LBPs, Histograms of Oriented Gradients (HOGs) and the Scale Invariant Feature Transform (SIFT) to characterize facial expressions over 5 yaw rotation angles from frontal to profile views. The main conclusion of [2] is that non-frontal views are better than frontal views for a computer to recognize facial expressions. As this contradicts many previous studies, an interesting question is if this conclusion is related to the geometric features used. In this paper, we explore this question using an appearance based approach.

Several different features have been applied to the area of facial expression recognition with success. However, most of these have been applied to frontal view only. In this paper we investigate the influence of pose on several different feature sets for expression recognition. We use an appearance based approach by dividing images into 64 sub blocks coarsely aligned over the face (see Figure 1). Feature vectors contain concatenated feature histograms built from each sub block.

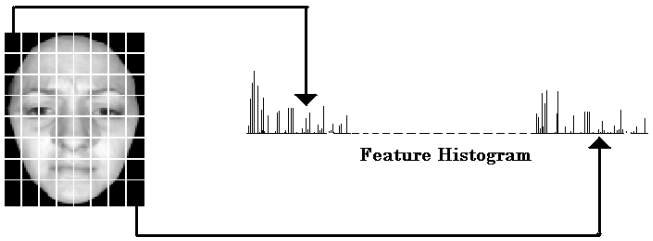

Figure 1: Face image is divided into sub blocks from which features are extracted and concatenated into a single spatial histogram

Another important question is how does yaw variation effect individual expression recognition performance. Figure 2 shows the performance of each expression over 5 yaw angles for LBP^{u2}, LBP^{ms} and LGBP over 4 resolutions. It does not follow that because frontal view is optimal for overall expression recognition, that individual expressions are optimal at frontal view. This is confirmed by figure 2. *Sadness* performs remarkably well at profile view (yaw 90) over all three features, often outperforming other views. For the LGBP feature over all 4 resolutions, *sadness* is consistently classified best at non frontal view. Another interesting finding is the performance drop of the expression *joy* as the yaw angles increases for the LGBP feature. This suggests that important discriminatory information is lost as the yaw angle increases for the *joy* expression. This finding is only evident for LGBPs and not the other features, suggesting that complementary information between different features exists. Also, from these results it is clear that LBP^{u2} suffers because of its inability to

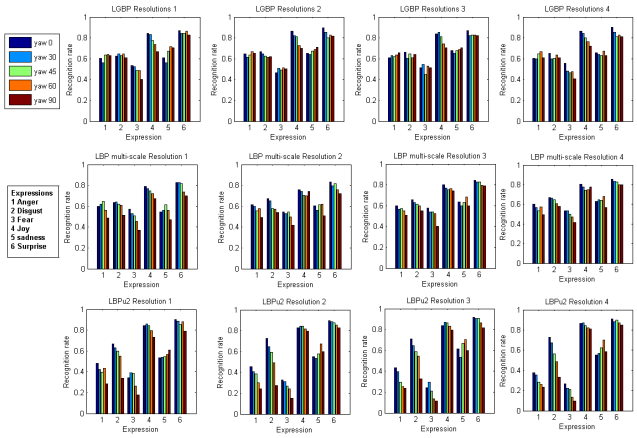

Figure 2: Performance of individual expressions for each yaw angle

classify the expressions of *anger* and *fear*.

Feature method	Results
Geometric based [2]	66.5
LGBP/LBP^{ms}	71.10

Table 1: Comparison of features methods

Our results show frontal pose is the optimal view over all resolutions for features *LGBP*, LBP^{ms} and LBP^{u2}. However, results show that performance does not decrease significantly due to yaw variation. Our results show that *LGBPs* outperform other features. *LGBPs* utilize multi-resolution spatial histograms combined with local intensity distributions and spatial information. Our results also show the strong performance of LBP^{ms} and when combined with *LGBPs* a recognition rate of 71.1% is achieved. Table 1 shows a comparison of geometric and appearance feature based approaches. Both approaches use a SVM as the classifier and are tested on similiar yaw variations. However the geometric based method [2] requires manually labeled feature points of the mouth, eyes and eyebrows. Our conclusions are that frontal pose is optimal for facial expression recognition, however this is dependent on feature selection. We investigated how individual expressions performed over a range of poses. We also found that some expressions performed better at non frontal views.

[1] Koby Crammer, Yoram Singer, Nello Cristianini, John Shawe-taylor, and Bob Williamson. On the algorithmic implementation of multiclass kernel-based vector machines. *Journal of Machine Learning Research*, 2:2001, 2001.

[2] Yuxiao Hu, Zhihong Zeng, Lijun Yin, Xiaozhou Wei, Jilin Tu, and T.S. Huang. A study of non-frontal-view facial expressions recognition. *Pattern Recognition, 2008. ICPR 2008. 19th International Conference on*, pages 1–4, Dec. 2008. ISSN 1051-4651. doi: 10.1109/ICPR.2008.4761052.

[3] Yuxiao Hu, Zhihong Zeng, Lijun Yin, Xiaozhou Wei, Jilin Tu, and T.S. Huang. Multi-view facial expression recognition. *FG2008, 2008. ICPR 2008.8th International Conference on Automatic Face and gesture Recognition*, Sept. 2008.

[4] Lijun Yin, Xiaozhou Wei, Yi Sun, Jun Wang, and M.J. Rosato. A 3d facial expression database for facial behavior research. *Automatic Face and Gesture Recognition, 2006. FGR 2006. 7th International Conference on*, pages 211–216, April 2006. doi: 10.1109/FGR.2006.6.