Chapter 4

Gabor and Log–Gabor Wavelet for Face Recognition

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ABSTRACT

In practice Gabor wavelet is often applied to extract relevant features from a facial image. This wavelet is constructed using filters of multiple scales and orientations. Based on Gabor’s theory of communication, two methods are proposed to acquire initial features from 2D images that are Gabor wavelet and Log-Gabor wavelet. Theoretically the main difference between these two wavelets is Log-Gabor wavelet produces DC free filter responses, whereas Gabor filter responses retain DC components. This experimental study determines the characteristics of Gabor and Log-Gabor filters for face recognition. In the experiment, two sixth order data tensor are created; one containing the basic Gabor feature vectors and the other containing the basic Log-Gabor feature vectors. This study reveals the characteristics of the filter orientations for Gabor and Log-Gabor filters for face recognition. These two implementations show that the Gabor filter having orientation zero means oriented at 0 degree with respect to the aligned face has the highest discriminating ability, while Log-Gabor filter with orientation three means 45 degree has the highest discriminating ability. This result is consistent across three different frequencies (scales) used for this experiment. It is also observed that for both the wavelets, filters with low frequency have higher discriminating ability.

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INTRODUCTION

Face recognition research is important for both psychology and information science. How do we humans recognize faces and how faces are represented or encoded in our brain, are both long debated issues. Some of the theories of face recognition characteristics have been implemented in computer-based face recognition system. Following is a brief summary of the common approaches to face recognition.

An appearance based holistic approach to face recognition was introduced by Kirby & Sirovich (1990), and Turk & Pentland (1991) by representing facial images as eigenfaces. Subsequently, the concept of Fisher-Faces was introduced (Belhumeur et al., 1997; Etemad & Chellappa, 1997; Zhao et al., 1998). Liu & Wechsler (2001) introduced an enhanced Fisher classifier method for face coding and recognition. It relied on an enhanced Fisher Linear Discriminant model that used integrated shape and texture features (Liu & Wechsler, 2001). In a recent work, Vasilescu & Terzopoulos (2002) proposed a different type of facial representation named Tensor-Face.

In the actual practice of face detection, the image size can be quite small and Zhao et al. (1999) demonstrated that the image size could be very small for holistic face recognition. For example, a Linear Discriminant Analysis (LDA) system used 12×11 image for face recognition. Lin et al.’s (1997) Probabilistic Decision-Based Neural Network (PDBNN) system used 14×10, while neuropsychological research has shown that for human perception a minimum image of 18×24 is acceptable. Moreover, Zhao et al. (1999) insisted that there exists a universal face subspace of fixed dimension. For holistic recognition this means that the image size does not matter as long as it is larger than the subspace dimension. Zhao et al. also showed that smaller images perform slightly better perhaps due to the improvement of signal-to-noise ratio with the decrease in image size. More studies on the size of image and filter size were discussed in a recent paper by Zhang et al. (2006).

Lin et al. (1997) used a PDBNN method to create fully automatic face detection and recognition system. Shan et al. (2003) presented a method for lighting, expression and viewpoint independent face recognition by improving the eigenfaces method (Turk & Pentland, 1991). Bartlett et al. (2002) presented an in-depth analysis of the Independent Component Analysis (ICA) and its strength over the eigenface approach for face recognition. A comparative study on the effect of image compression techniques on the PCA, LDA and ICA was performed by Delac et al. (2007). Different ICA (Cao et al., 2004), two-dimensional (2D) PCA (Pang et al., 2008), and marginal fisher analysis-based face recognition approaches are also available in recently published works (Xu et al., 2005). Yan & Zhang (2008a, 2008b) proposed a method for face recognition based on correlation filter based class-dependence feature analysis.

Lades et al. (1993) applied Gabor wavelet for face recognition, using the Dynamic Link Architecture (DLA) framework. At first the DLA computes the Gabor jets and then it performs a flexible template comparison between the resulting image decompositions, applying graph-matching methods. In a later work Wiskott et al. (1997) expanded the DLA and developed a Gabor wavelet-based elastic bunch graph matching method that was used to recognize human faces. Lyons et al. (1999, 2000) proposed a two-class categorization of gender, race, and facial expression from facial image based on the 2D Gabor wavelet representation and the labeled elastic graph matching. Donato et al. (1999) have compared a method based on Gabor representation with other techniques, finding that the former provided better performance. In a series of work, Liu combined Gabor features with enhanced Fisher linear discriminant methods (Liu, 2002), kernel PCA with fractional power polynomial models on the Gabor features.