TSINGHUA SCIENCE AND TECHNOLOGY
ISSN 1007-0214 15/15 pp216-224
Volume 16, Number 2, April 2011

Histogram of the Oriented Gradient for Face Recognition*

SHU Chang (舒 畅), DING Xiaoqing (丁晓青)**, FANG Chi (方 驰)

State Key Laboratory of Intelligent Technology and System, Department of Electronic Engineering, Tsinghua University, Beijing 100084, China

Abstract: The histogram of oriented gradient has been successfully applied in many research fields with excellent performance especially in pedestrian detection. However, the method has rarely been applied to face recognition. Aimed to develop a fast and efficient new feature for face recognition, the original HOG and its variations were applied to evaluate the effects of different factors. An information theory-based criterion was also developed to evaluate the potential classification power of different features. Comparative experiments show that even with a relatively simple feature descriptor, the proposed HOG feature achieves almost the same recognition rate with much lower computational time than the widely used Gabor feature on the FRGC and CAS-PEAL databases.

Key words: face recognition; feature; histogram of oriented gradient

Introduction

The intensity of an image contains discriminative information as well as noise, and in most cases, is the only source that can be used to still object recognition. However, what really matters is not the absolute value, but the relative value which reflects the structure information or texture variation of an object.

Various feature extraction and selection methods have been widely used[1-5]. Besides holistic methods such as PCA and LDA, local descriptors have been studied recently. An ideal descriptor for the local facial regions should have large inter-class variance and small intra-class variance, which means that the descriptor should be robust with respect to varying illumination, slight deformations, image quality degradation, and so on. Information theory was used to develop a criterion to evaluate the potential classification power of different features.

Among the variety of different descriptors for the appearance of image patches that have been developed by the texture analysis community, local binary pattern features yield some of the best results when used to represent facial images. The idea of using a local binary pattern for facial descriptions is that faces can be seen as a composite of micro-patterns which are well described by this operator[6]. However, sometimes there are too many micro patterns so in practice a system has to reduce the number of local regions or the number of possible scales to form a reasonable length feature vector.

The Gabor wavelet[7], whose kernels are similar to the 2-D representative profiles of the mammalian cortical simple cells, was first introduced by Gabor in 1946. The Gabor transformation simultaneously enhances facial feature magnitude and orientation and has been widely used as an effective element in image processing and pattern recognition tasks. The Gabor wavelet is the most popular and successful feature ever used for face recognition. For example, it is used for face recognition in the dynamic link architecture

Received: 2010-02-10; revised: 2010-10-19

* Supported by the National Key Basic Research and Development (973) Program of China (No. 2007CB311004) and the National High-Tech Research and Development (863) Program of China (No. 2006AA01Z115)

** To whom correspondence should be addressed.
E-mail: dingxq@tsinghua.edu.cn; Tel: 86-10-62772368

framework by Lades et al.[8] and in the elastic bunch graph matching method developed by Wiskott et al.[9]

The use of orientation histograms also has many precursors. Freeman and Roth[10] used orientation histograms for hand gesture recognition, Dalal and Triggs[11] presented a pedestrian detection algorithm with excellent detection results using a dense grid of HOG. The HOG provides the underlying image patch descriptor for matching scale invariant keypoints when combined with local spatial histogramming and normalization in Lowe's scale invariant feature transformation (SIFT) approach to wide baseline image matching[12]. However, few publications can be found which show a successful application of this feature to face recognition.

1 Histogram of Oriented Gradient

1.1 Basic theory

The basic idea of HOG features is that the local object appearance and shape can often be characterized rather well by the distribution of the local intensity gradients or edge directions, even without precise knowledge of the corresponding gradient or edge positions. The orientation analysis is robust to lighting changes since the histogramming gives translational invariance. The HOG feature summarizes the distribution of measurements within the image regions and is particularly useful for recognition of textured objects with deformable shapes. The method is also simple and fast so the histogram can be calculated quickly.

As used in SIFT or the EBGM method, the original HOG feature is generated for each key point of an image. The neighboring area around each key point is divided into several uniformly spaced cells and for each cell a local 1-D histogram of gradient directions or edge orientations is accumulated over all the pixels of the cell. The histogram entries of all cells around one key point form the feature of that key point. The combined histogram features of all key points form the image representation. The whole process is shown in Fig. 1.

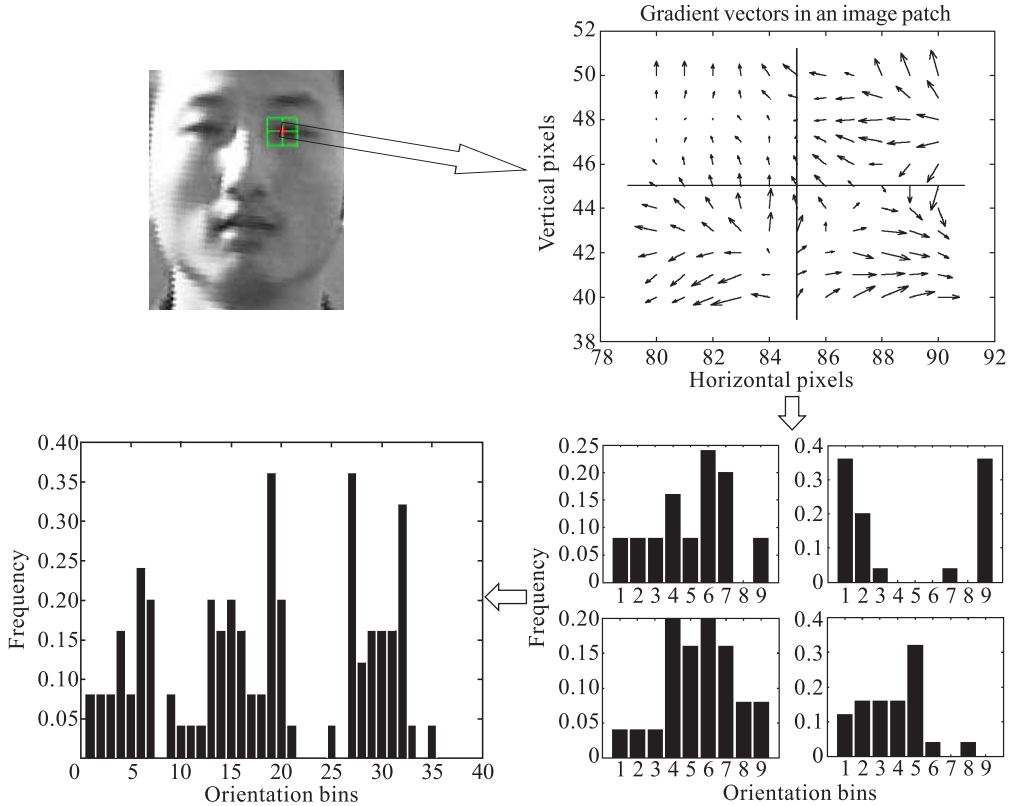

Fig. 1 Image window divided into small spatial regions ("cells"). Local 1-D histograms of gradient directions or edge orientations are accumulated and concatenated to form the final histogram feature.

1.2 Orientation representation

Orientation can be represented as a single angle or as a double angle[13]. A single angle treats a given edge and a contrast reversed region as having opposite orientations. A double angle representation maps these into