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Fast detection of human using differential evolution ☆

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ABSTRACT

Human detection is a significant and challenging task with applications in various domains. In real-time systems, the speed of detection is crucial to the performance of system, while the accuracy is also taken into consideration. In this work, a human detection approach based on Histograms of Oriented Gradients (HOG) feature and differential evolution (DE), termed as HOG-SVM-DE, is proposed to achieve both fast and accurate detection. The proposed method considers the problem of locating an objective detection window as a search problem, and speeds up the detection stage by solving the search problem with DE. DE is chosen as the optimizer as it is characterized by fast and global convergence. The proposed system trains only one linear-SVM, and allows tradeoffs between the detection rate and the detection time to satisfy different applications by simply tuning one parameter. Experiments are conducted on a set of images from the INRIA Person Dataset, and the results validate that the proposed HOG-SVM-DE is promising in terms of both speed and accuracy.

1. Introduction

Human detection is a significant and challenging task in computer vision. With the increased popularity of computer vision in areas such as video surveillance, smart vehicles, robotics, and ubiquitous system, technologies of human detection have drawn much research attention.

In many real-time applications, the detection of human is required to be both fast and accurate. The task is difficult since pedestrians are usually with various appearances, postures and backgrounds. There are mainly two directions for the development on human detection, i.e. feature and classifier. Methods such as Haar Wavelet features [1], Implicit Shape Models [2], edge templates [3], Adaptive Contour Features [4,5], and Histogram of Oriented Gradients (HOG) [6] have been proposed for extracting features. On the other hand, classifiers for human detection mainly include Support Vector Machines (SVM) [6–9] and cascade-structured boosting-based classifiers [10,11]. For methods that adopt SVM, there is a preference for linear SVM because it achieves higher speed and reduces the problem of overfitting compared with the non-linear SVM kernels [6].

Among the feature extraction methods, the Histograms of Oriented Gradients (HOG) proposed by Dalal and Triggs [6] is widely used for human detection for its robustness and fast speed. Working together with linear SVM, the HOG features are extracted in sliding window fashion for human detection in an image. The HOG-SVM approach scans the whole image

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in a sliding window in order to locate the objective detection windows. However, the time efficiency of the scanning strategy hardly satisfies the requirement of real-time applications for although the HOG feature extraction is faster than many counterparts. Later on, Zhu et al. [12] speed up the method by constructing cascade-of-rejectors with AdaBoost algorithm. Although their method performed favorably in terms of detection time, the training process is much time-consuming. An et al. [13] suggested using a particle swarm optimizer (PSO) for locating the detection window, but the enhanced speed is at the cost of accuracy. To compute the HOG features more efficiently, in the work of Pang et al. [14], the HOG-SVM based human detection was accelerated by reusing the features in blocks and cell-based interpolation. Furthermore, the Dominant Orientation Templates (DOT) [15,16] which is based on the idea of HOG is proposed to enhance the speed.

In this work, a human detection approach termed HOG-SVM with differential evolution (HOG-SVM-DE) is proposed. Aiming at both fast detection and training cost minimization, the proposed method focuses on locating an objective detection window quickly and accurately at real-time. To fulfill the task, the evolutionary computation technology differential evolution (DE) is applied instead of scanning the detection windows in sliding fashion. The DE is a simple and efficient population-based search algorithm proposed by Storn and Price [17,18] for global optimization. Characterized by its fast and global convergence, the algorithm has been successfully applied to various real-world applications in diverse domains [19,20]. In our proposed method, the DE algorithm works at the real-time detection stage and solves the non-linear search problem of locating the objective detection window. Individuals in DE are defined as detection windows on the image, and the fitness of individuals is assigned according to the output of HOG-SVM for the corresponding detection window.

The proposed method has following features:

- The proposed HOG-SVM-DE provides an approach for both fast detection at real time and at the same time requires minimum off-line training. Only a single linear SVM is required to be trained.
- A human detection framework based on solving the human detection problem as a search problem is suggested. In the proposed method, the feature extraction method and classifier are relatively independent of the search algorithm. Although HOG feature and linear SVM are adopted in this work, other developments of both feature extraction approaches and classifiers might be applied to the proposed framework. Examples are the simple graph-based method proposed in [21], the adaptive hypergraph learning method proposed in [22], and the multimodal features and classifiers like the multiview sparse learning methods [23] and the high-order multiview distance learning based classifier [24]. Besides, the information-reusing strategy in [14] can be utilized in the proposed framework to accelerate the computing of HOG features.
- The proposed algorithm is tunable, which means that the balance between the successful rate and the execution time can be adjusted by simply changing a parameter. In this way, the method can satisfy the requirement of different applications with little modification.

The remainder of this paper is organized as follows. Section 2 introduces the framework of HOG-SVM based human detection and the search problem defined in the framework. Section 3 describes the proposed HOG-SVM-DE in detail. In Section 4, the proposed algorithm is simulated in a set of experiments and the results are discussed. Finally, Section 5 concludes the paper.

2. HOG-SVM based human detection as a search problem

Characterized by relatively fast computation and favorable performance, the HOG-based human detection and its variants are widely used for human detection. A typical framework of the method is presented in Fig. 1, where the three modules of the system, i.e. HOG feature extraction, classifier training, and detection module are illustrated. This framework is explained as follows.

There are two stages in the human detection system in Fig. 1, i.e. off-line training stage and online detection stage. The training stage works only once, whereas the online detection stage works every time when a real-time image arrives for detection.

The procedure of HOG feature extraction is employed in both the training stage and the detection stage. Proposed by Dalal and Triggs [6], the technique extracts a feature set from a detection window. The extraction process is based on evaluating well-normalized local histograms of image gradient orientations in a dense grid.

In the off-line training stage, a classifier, typically linear SVM, is trained for human/non-human classification on a single detection window. For the training of classifier, a number of labelled sample images are fed to the HOG feature extraction module. The HOG features are then extracted and used to train the classifier.

In the online detection stage, real-time images arrive for human detection. The detection module is responsible for finding out the objective windows containing human

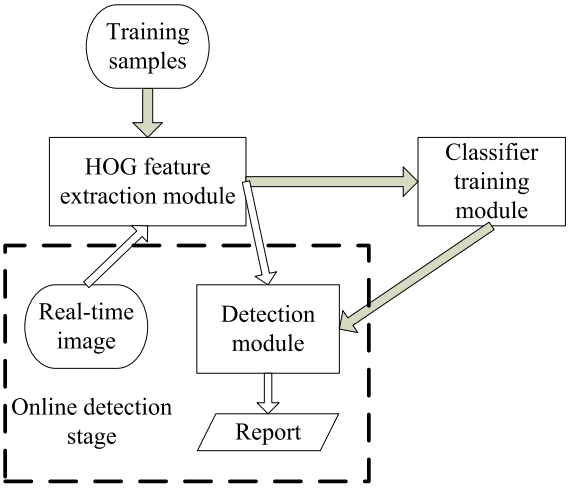

Fig. 1. Architecture of HOG-SVM based human detection.

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