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Neurocomputing 64 (2005) 497–503
NEUROCOMPUTING
www.elsevier.com/locate/neucom

Letters

Training support vector machines based on stacked generalization for image classification

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Received 28 July 2004; received in revised form 25 August 2004; accepted 29 August 2004
Communicated by R.W. Newcomb
Available online 19 January 2005

Abstract

This paper presents a two-level stacked generalization scheme composed of three generalizers of support vector machines (SVMs) for image classification. They are color, texture, and high-level concept SVMs. The focus of this paper is to investigate two training strategies based on two-fold cross-validation and non-cross-validation for the proposed classification scheme by evaluating their classification performances, margin of the hyperplane and numbers of support vectors of SVMs. The results show that the non-cross-validation training method performs better, having higher correct classification rates, larger margin of the hyperplane, and smaller numbers of support vectors.

Keywords: Image classification; Support vector machines; Stacked generalization

1. Introduction

Content-based image retrieval (CBIR) has been an active research area for a decade. Since the retrieval results are not usually satisfactory, the urgent need for future image retrieval systems is to allow them to understand visual content at higher semantic level for storage and retrieval. This is because humans recognize images

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doi:10.1016/j.neucom.2004.08.005

based on high-level concepts, but computers can only extract low-level image features [9]. This is called as the semantic gap problem.

One solution to bridge the semantic gap is to classify low-level image features into high-level conceptual classes based on some machine learning techniques during the image indexing stage [6,10]. However, it is still very difficult to allow computers to recognize and classify high-level concepts by learning low-level features directly. Therefore, the generalization performance of the learning classifiers is the main issue. A novel two-level stacked generalization scheme, called a two-stage mapping model (TSMM) [11], is proposed to minimize the semantic gap by reducing classification error. The aim of this paper is to investigate the generalization performance of using two different training methods based on two-fold cross-validation [3] and non-cross-validation for the proposed scheme using support vector machines (SVMs) [2,12] by evaluating their classification accuracies, margins of the hyperplane, and numbers of support vectors of the SVMs.

2. The approach

2.1. System architecture

Fig. 1 shows a block diagram of the indexing system composed of three modules of SVMs [2,12] based on the TSMM [11]. They are color, texture, and high-level concept SVMs. Note that the system is different from the SVMs ensemble described in [12].

SVMs provide a solution to two-class classification problems by mapping the input vectors into a high-dimensional feature space through some nonlinear mapping based on such as a polynomial kernel function and construct an optimal separating hyperplane in this space by determining the largest margin to separate the positive and negative classes [2]. Fig. 2 shows the hyperplane of an SVM with different margins [7]. An SVM with larger margin and/or a smaller number of support vectors is expected to have better generalization performance. (See [2,9] for further explanations.)

For multi-class classification in this paper, the one-against-all method [4] is used. That is, when the number of classes is C, this method constructs C SVM classifiers, and each of them is to classify one positive $(+1)$ and $C-1$ negative (-1) classes.

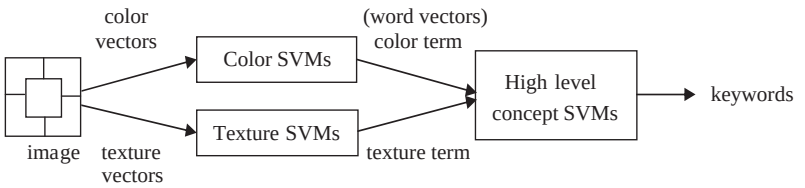

Fig. 1. The indexing system.