PCA as Dimensionality Reduction for Large-Scale Image Retrieval Systems

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ABSTRACT

Dimensionality reduction in large-scale image research plays an important role for their performance in different applications. In this paper, we explore Principal Component Analysis (PCA) as a dimensionality reduction method. For this purpose, first, the Scale Invariant Feature Transform (SIFT) features and Speeded Up Robust Features (SURF) are extracted as image features. Second, the PCA is applied to reduce the dimensions of SIFT and SURF feature descriptors. By comparing multiple sets of experimental data with different image databases, we have concluded that PCA with a reduction in the range, can effectively reduce the computational cost of image features, and maintain the high retrieval performance as well.

KEYWORDS
Dimensionality Reduction, Large-Scale Image Retrieval, Principal Component Analysis, Scale Invariant Feature Transform, Speeded Up Robust Features

INTRODUCTION

Nowadays, with the development of cloud computing and multimedia content creation and storage, a lot of applications exploiting image, and video content are daily used (Cheng, Zhuo, & Zhang, 2013). It is not uncommon to find multimedia databases containing thousands or even tens of thousands of images, videos and sounds, whether targeted for a professional field (medical, security, journalism, tourism, education, museums, etc.) or just for individuals which accumulate personal data such as: memories, travels, family, events, movie collections, etc. (Murray, Qiao, Lee, Fallon, & Karunakar, 2011). These applications generate a huge volume of multimedia data.

In order to quickly access to the desired images for users of these huge databases, efficient use, efficient access to multimedia contents has become a crucial task associated with Big Data fields (Patra et al., 2016).

Large-scale content based multimedia retrieval is one of most important technological fields using Big Data (Jain & Bhatnagar, 2016). Content-Based Image Retrieval (CBIR) presents now the most used method allowing to detect the visual characteristics of images by using processing techniques.

Each retrieval system generally computes visual functions from a given query and compares them to a set of image characteristics stored in the database. As result, a list of similar images are shown to the user.

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CBIR methods mainly include two phases: feature extraction and similarity measures. When the number of existing images in the database increases, the number of images features become very important and they are expressed in a high dimensional space. In this case, if we process the data directly, we can face to the “Curse of Dimensionality” phenomenon which cannot ameliorate the research algorithms performances (Belarbi, Mahmoudi, & Belalem, 2016).

One of the powerful methods used to solve these problems is the dimensionality reduction. The idea behind this approach is that image characteristics are pre-processed by reducing the characteristics sizes to a lower dimensional space. This method can play important and significant role to overcome the “Curse of Dimensionality”.

This method can be applied by using two kind of approaches: supervised and unsupervised methods. The unsupervised methods are used to reduce the loss of data information, where supervised methods are used when the information of inter-class can be maximized. The unsupervised methods generally used are PCA (Hotelling, 1933)(Kriti, Virmani, Dey, & Kumar, 2016), Multidimensional Scaling (MDS) (Brandes & Pich, 2007) and kernel PCA (KPCA) (Schölkopf, Smola, & Müller, 1998). The objective of PCA is to find the optimal projection matrix. The goal of MDS methods is to measure the Euclidean distance between original data after dimensionality reduction. KPCA method is based on an improved PCA. On the other hand, Fisher Linear Discriminant Analysis (FLDA) (Belhumeur, Hespanha, & Kriegman, 1997), and Local Fisher Discriminant Analysis (LFDA) (Rahulamathavan, Phan, Chambers, Parish, & others, 2013) are supervised methods.

In this paper, we explore a study of PCA as a method of dimensionality reduction when the volume data increases. Indeed, SIFT and SURF characteristics are computed, after that we apply the PCA as dimensionality reduction method in order to reduce the dimension of image features. PCA has been applied to SIFT and SURF features of different dimensionality. The performances of these descriptors were comparable to the original descriptors, with reduction ranges from 10% to 90% dimensions. We applied PCA to SIFT and SURF features with a dimension reduction in the range of 10% to 90%. The analysis of the performances of different compression ratio were conducted by using the recall-precision curves, and computing time.

This paper can be organized as following: section (2) presents some related works in the field of large scale images retrieval. Section (3) introduces SURF and SIFT features. In section (4) the exiting dimensionality reduction methods are described. Section (5) presents the evaluation metric used in this work. Section (6) analyses the performances of our experimental results. At the end, conclusions are in section (7).

RELATED WORKS

In (Cai, Wang, & Wang, 2011) Cai et al. have proposed a pattern scheme witch is robust and compact, and can be used to ameliorate the vector of locally aggregated descriptor (VLAD). also, they define another cluster by using another method called linear discriminant analysis (LDA) to minimize the dimension of the descriptor. This task was achieved by the optimization of the dimensionality in order to make the image more efficient to match. On the other side, each feature is associated to its nearest set of cluster centers. Especially, they choose the nearest set by using the calculated neighbor distance, in order to get more stable correspondence between the characteristics and the set. The two schemes allow to adapt features representation to both the distribution of feature classes in each cluster and to the distribution of cluster centers in the feature space.

The authors of (Bingham & Mannila, 2001) presented some experimental results related to random projection in dimensionality reduction. They compared different methods in this field. The criteria used in their work is the quantity of the contortion which caused by the complexity of this method. Their results show that random projection don’t decrease the system performances (Karaa & Dey, 2017). They also prove that even if the data are projected to moderate numbers of dimensions computing time still being fast.
Feature Selection for GUMI Kernel-Based SVM in Speech Emotion Recognition
www.igi-global.com/chapter/feature-selection-for-gumi-kernel-based-svm-in-speech-emotion-recognition/173367?camid=4v1a

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