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SAX2FACE: Estimating Facial Poses with Peano-Hilbert Curves and SAX Symbolic Time Series

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Abstract

In recent Human Computer Interaction (HCI) applications, pose estimation has emerged as an important field in computer vision. Even if a lot of the existing methods have provided acceptable classification results, they are often complex to implement and computationally very expansive. Starting from these bottlenecks, we propose in this work, SAX2FACE, a simple and efficient alternative solution which suggests the use of a time series dimensionality reduction method (SAX) to address the problem of facial Pose estimation. We start by converting a face image into one-dimensional vector as a time series using Peano-Hilbert space filling curve, then we convert these numerical vector-based series to a symbolic sequence. Using different training databases, we produce for each image, its symbolic sequences, then we calculate distance matrices between the pairwise symbolic series, to generate classifiers of frontal vs profile faces' poses. The proposed method is evaluated with three public datasets. The preliminary results have shown that the proposed approach is able to achieve a correct classification rate exceeding 97% and up to 100%.

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Keywords: Machine learning, Data mining, Facial Pose Classification, Time Series, Peano-Hilbert space filling curve.

1. Introduction

Computer vision has became an important field in computer science due to ubiquitous system proliferation. One example of computer vision systems is face identification and recognition. Due to their importance for many biometric applications, facial feature analysis, face identification, and pose estimation may be used to enhance the performance of face recognition system so that the selection of the frontal view minimizes the search space of similarity between the input detected facial image and the gallery images. Through these points, many works have been performed in

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this area in order to improve the efficiency of biometric systems to estimate the pose. A good overview of various approaches for head pose estimation are described in [1], which are categorized depending on the type of data.
Manipulating the image in their initial representation is complex, and computationally expensive. Moreover, some environmental conditions decrease seriously the efficiency. To overcome these problems we propose a new approach based on the exploitation of the representation of time series for building a model in order to classify and estimate poses. The main idea of our approach is to represent as time series the image of the face, in order to simplify the computation. As this linear representation of the image allows us to consider this sequence as time series and thus apply their properties: dimension reduction, similarity measurement and classification. To achieve this linear representation hence going from the 2D image to a 1D representation, we have chosen to use the Peano-Hilbert space filling curve. It is a transformation from the multidimensional space to one-dimensional space that preserves as much as possible the neighborhood of points. The similarity measures between time series sequences are used to generated classifiers and thus estimate the pose of the face a frontal or profile view, using KNN and SVM classifiers.
The rest of this paper is organized as follows. Section 2 presents the related work of faces poses estimation. Section 3 and 4 describes technical details of the proposed face estimation method. Section 5 shows the experimental results on public databases. Section 6 concludes the paper.

2. RELATED WORK

Recently, a great attention has been given to head pose due to its diverse applications in face recognition, driver monitoring and human computer interaction. Many factors prevent the process of pose estimation accurately such as pose, illumination, facial expressions, and subject variability. The current literature includes a variety of different strategies and algorithms to solve the problem and the challenge of the rotation of the head. These strategies can be classified into two main approaches: the appearance-based approach and the approach based on facial features.

2.1. Appearance-Based Approaches

These approaches treat the problem of the pose estimation as a multi-class classification problem; and seek to find the similarity between the characteristics of the entire facial area and a template of a facial pose. This wide category of approaches includes three subcategories: appearance template methods, detector array, and non-linear regression methods. In the appearance template methods The detected face is compared with a set of facial templates labeled with a discrete poses in order to find the similarity between them. Typically, this method assumes that the head region has already been detected and localized, and localization error can degrade the accuracy of the head pose estimate. They might suffer from estimating discrete pose and their computation time [2] ,[3]. While Detector Array Methods,training multiple face pose detectors is the technique that is used to evaluate the pose estimation system, each pose is considered as detector for different discrete pose. These systems afford excellent accuracy, but due to the non-uniform sampled training data, they have been limited to fewer discrete poses [4],[5]. Non-linear Regression Methods,the purpose of these methods is to reduce the space search:

- Either by building a model of head pose, as a function which determines the relationship between the appearance of a face and its poses. Several methods are proposed to project the image of the face directly on the space of poses, such as Support Vector regressors SVRS method [5] Progress Gaussian Regression (GPR) [6]. JI et al employ Convex Regularized Sparse Regression (CRSR).
- Or by using an alternative strategy to model the continuous variation of the pose of the face, based on dimensionality reduction techniques or manifold embedding method. These methods seek to find a low dimension which represents the continuous variation of the pose in a set of images, and a projection is tested on a subspace by integrating the functions of supervised or unsupervised learning. Principal Components Analysis (PCA) [8] and the nonlinear kernel KPCA [9], Locally Embedded Analysis (LEA) [11] have been used as dimension reduction techniques. In a more recent work, Wang et al. [12] used Isometric feature mapping (Isomap) to increase the level of oversight of traditional methods by the implementation of a Fisher Local Discriminant Analysis. Huang et al. in [13] proposed Supervised Local Subspace Learning (SL^2) that builds local linear models from a sparse and non-uniformly sampled training set.