主 論 文 要 旨

論 文 題 名　Tensor-Based Subspace Learning and Statistical Modeling for Multi-Dimensional Data Analysis

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主論文要旨

In computer vision and computer graphics, we often encounter multi-dimensional data (MDD), such as medical volume data, hyper spectral images, and so on. As the MDD contains huge information, how to extract core information appropriately and effectually is a key issue in MDD analysis. The principal component analysis (PCA) is a typical method for data analysis. But PCA requires that MDDs should be firstly unfolded into 1D vector. Since the dimension of the vector is huge, it suffers large-computation and low-generalization problems.

In order to solve above problems, our researches focus on tensor-based subspace learning and statistical modeling for MDD analysis. The MDD is treated as a tensor directly without unfolding. The main contributions in this thesis can be divided into three aspects:

1. We propose a tensor-based subspace learning algorithm (TSL) based on high-order tensor decomposition and apply it to facial pose synthesis. Facial images with multiple modes such as person, texture, pose are treated as a third-order tensor. The person-mode subspace, texture-mode subspace and pose-mode subspace can be generated by tensor decomposition. By using such mode-subspaces, we can synthesize any pose image with only a single input facial image.

2. The proposed tensor-based subspace learning method is a powerful technique for data analysis and feature extraction for MDD. But it lacks on efficient data representation capability since it is a unilateral projection. We propose to use a tensor-based generalized N-dimensional PCA (GND-PCA), which is proposed in our previous work and is a multilateral projection scheme, for statistical appearance modelling of MDD. The MDD is treaded as a higher-order tensor. We have successfully constructed statistical models for both facial images with multiple modes and liver volumetric images. We also show that the statistical liver appearance model can be used for computer-assisted diagnostics of liver disease.

3. As an extension of GND-PCA, we propose a linear tensor coding algorithm (LTC) for statistical modeling. In LTC, the MDD (tensor) can be represented by a linear combination of tensor-formed bases. Each base captures some specific variability such as illumination from left direction, and so on. Its coefficient can be used as a quantitative measure of the specific feature. It will be a useful technique for identification of specific components of disease in medical image analysis field.