Tutorial: Tensor Approximation in Visualization and Computer Graphics

Introduction

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Introduction

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Overview

• **Part 1:** Introduction of the TA framework
  ‣ Tucker and CANDECOMP/PARAFAC (CP) tensor decompositions
  ‣ Rank-reduced tensor approximations, ALS methods
  ‣ Useful TA properties and features for data visualization
  ‣ Frequency analysis and DCT equivalence

• **Part 2:** Applications of TA in scientific visualization
  ‣ TA-based volume visualization applications
  ‣ Implementation details of tensor decomposition and tensor reconstruction algorithms
  ‣ Practical examples (MATLAB, vmmlib)

• **Part 3:** Applications of TA in rendering and graphics
  ‣ Examples for multidimensional datasets in rendering and graphics applications
  ‣ Influence of data organization, parametrization and error metric
  ‣ Clustering and sparsity
  ‣ Processing irregular and sparse input samples
Tutorial Schedule

- **Monday** May. 6 from **13:40 to 15:20**
  - Location: **Room B.1**
    - Introduction (Pajarola, 10min)
    - Tensor Decomposition Models (Pajarola, 25min)
    - Properties and Features (Pajarola, 25min)
    - Applications in Scientific Visualization (Suter, 30min)

- **Tuesday** May. 7 from **9:00 to 10:40**
  - Location: **Room B.1**
    - Implementation Examples in Scientific Visualization (Suter, 25min)
    - Graphics Applications (Ruiters, 30min)
    - Clustering and Sparsity (Ruiters, 25min)
    - Summary/Outlook (Pajarola, 10min)
Motivation

- Compact representation of large scale data sets important in many areas of scientific visualization and computer graphics

- Use a mathematical framework for the decomposition of the input data into bases and coefficients

- Key features of a compact data representation:
  - effective decomposition
  - good data reduction
  - fast access and reconstruction

- Tensor approximation methods have shown to be a powerful and promising tool
Decomposition Bases

• Decompositions into bases and weight coefficients can either use a set of pre-defined fixed bases, or computed bases

• Pre-defined bases are given a priori, often represent some form of frequency analysis, and the decomposition may be fast to compute
  ‣ e.g. Fourier, Discrete Cosine and Wavelet Transforms

• Computed bases, learned from the input data, may provide a better data fit, approximation and fast reconstruction
  ‣ e.g. SVD, PCA and Tensor Decomposition
Tensor Approximation – TA

• TA: Generalization of low rank SVD matrix approximation to higher order data collections
• Data analysis, bases computation via tensor decomposition followed by rank-reduced reconstruction and approximation
  ‣ data reduction achieved through reduced bases dimensionality

\[ \tilde{A} = B \times_1 U^{(1)} \times_2 U^{(2)} \times_3 U^{(3)} \]