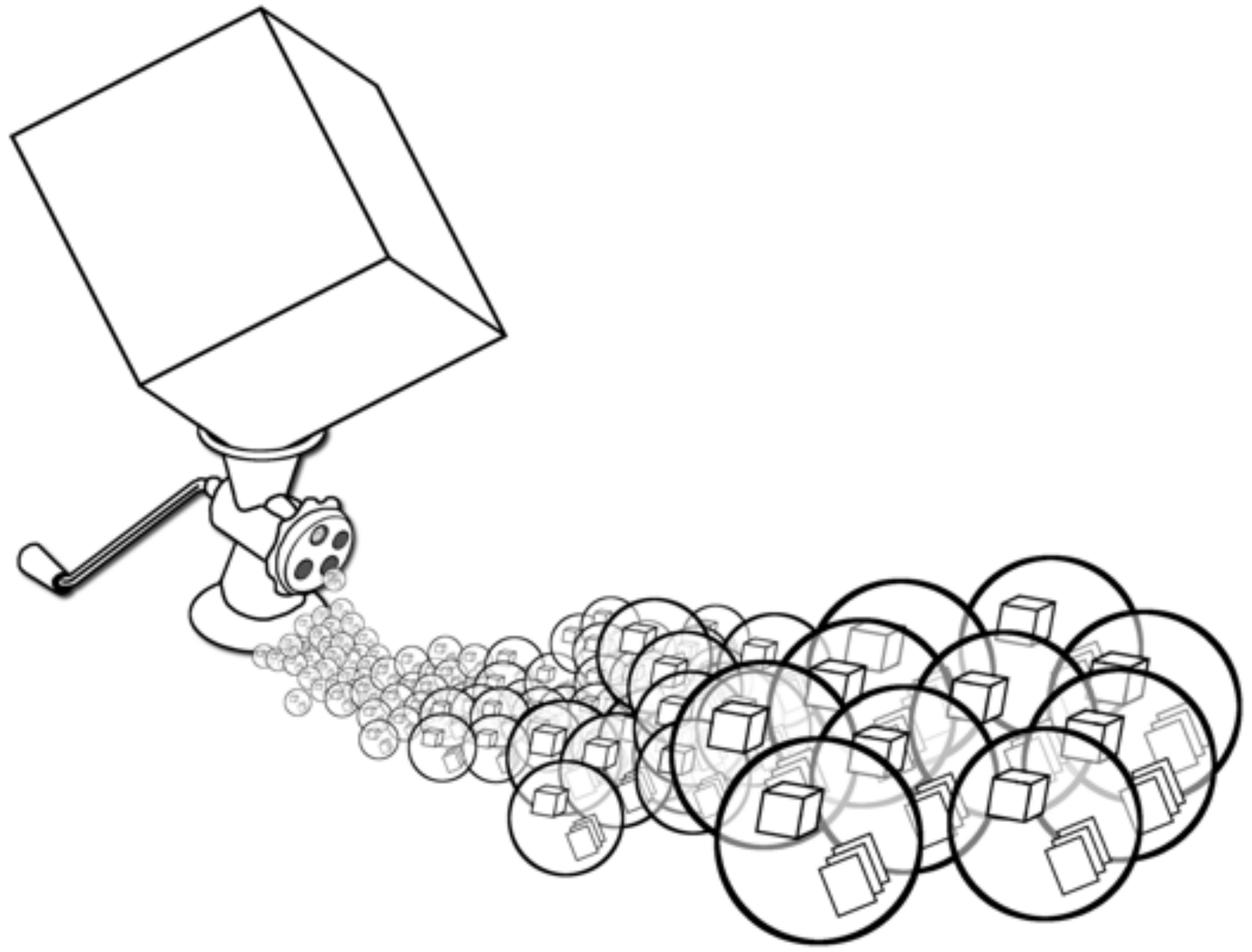
Tutorial: Tensor Approximation in Visualization and Computer Graphics

Introduction

Renato Pajarola, Susanne K. Suter, and Roland Ruiters



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Introduction

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- Roland Ruiters
  - PhD Student, Computer Graphics Group, University of Bonn

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 er- ror metric
  - Clustering and sparsity
  - Processing irregular and sparse input samples

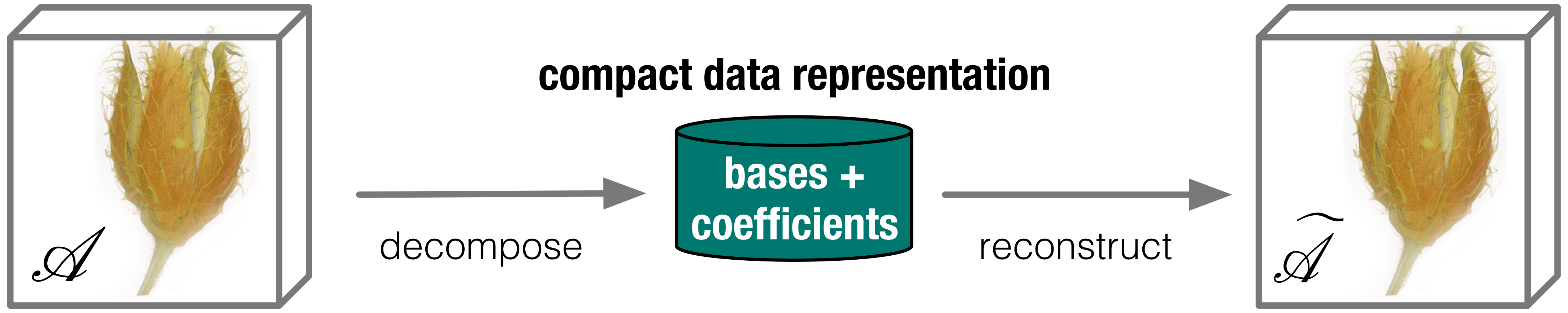
Tutorial Schedule

- **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)

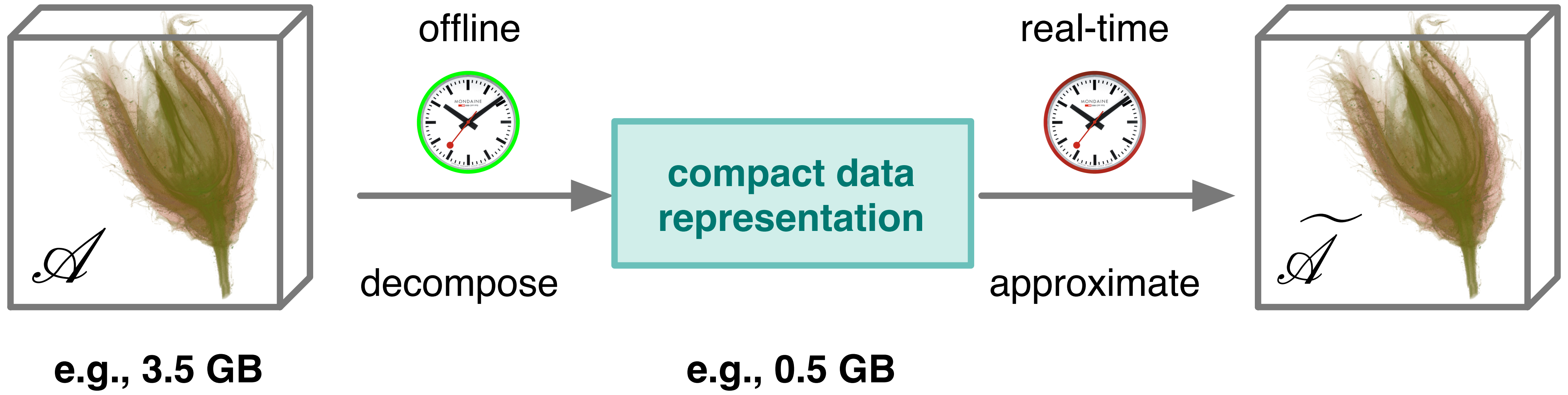
Motivation

- 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



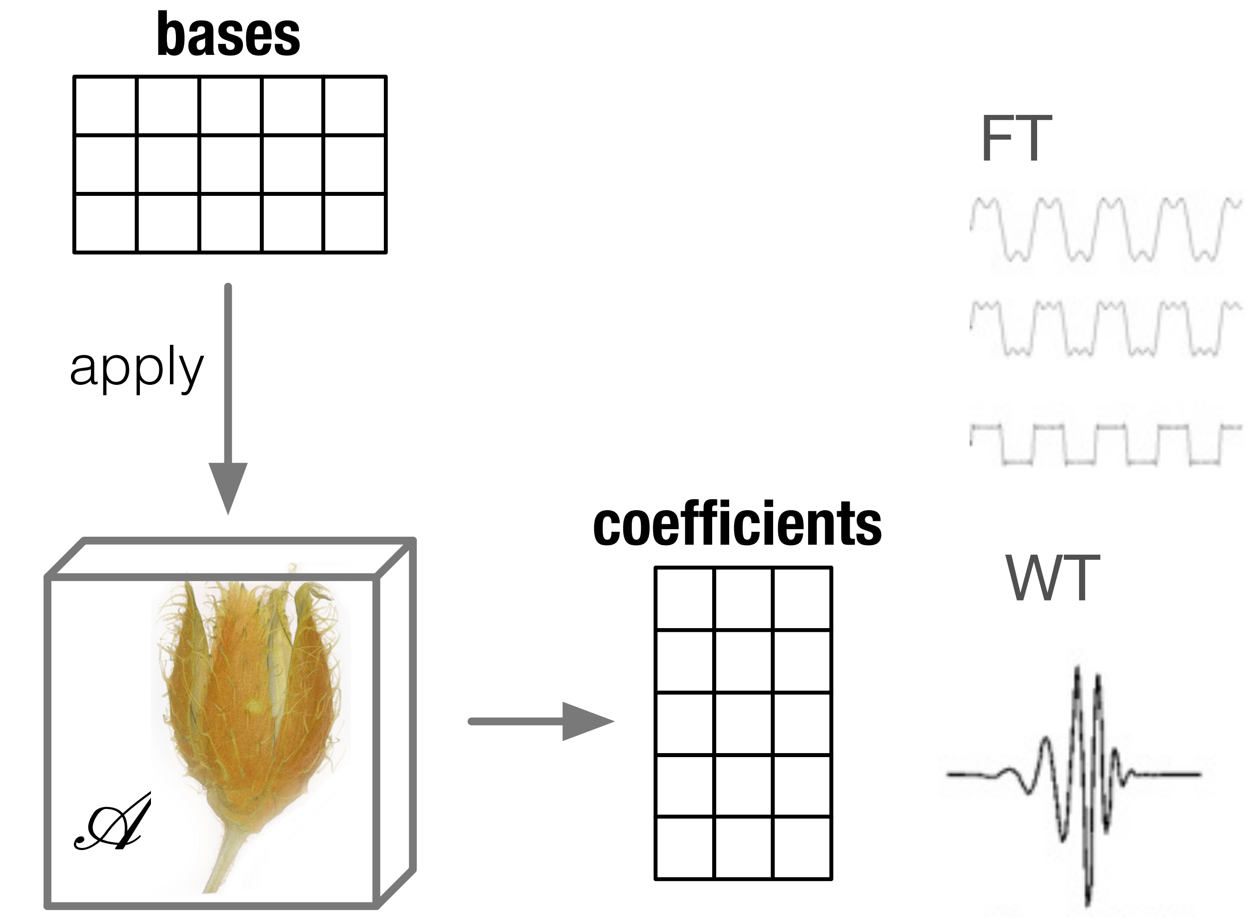
- Key features of a compact data representation:
  - effective decomposition
  - good data reduction
  - fast access and reconstruction

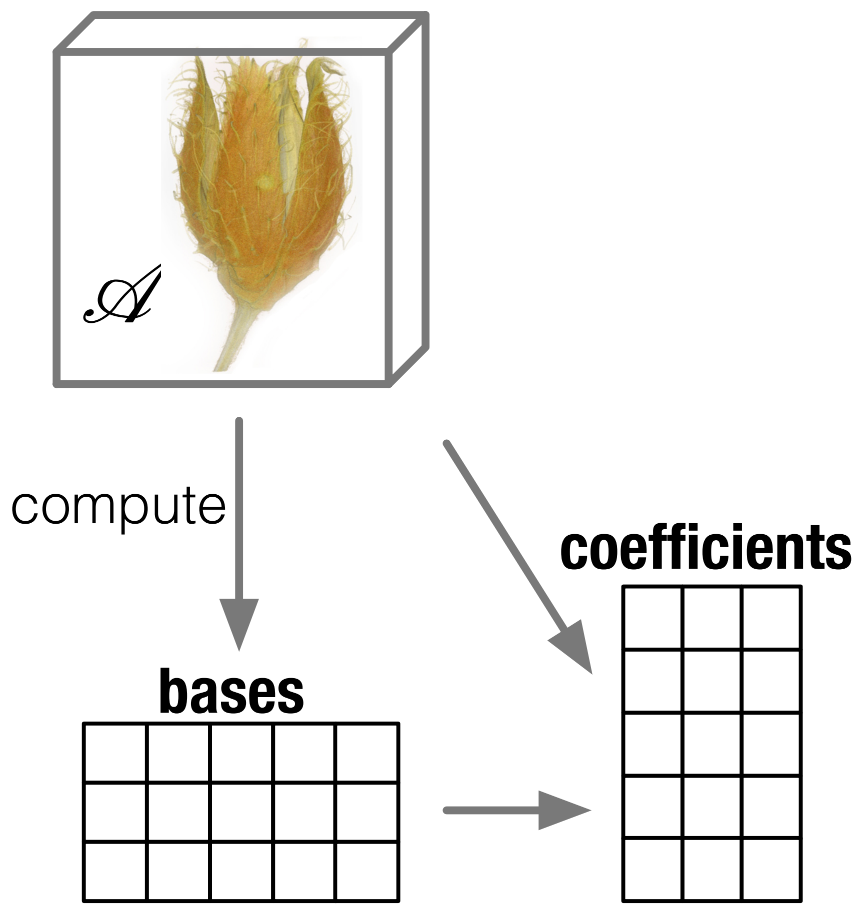


- Tensor approximation methods have shown to be a powerful and promising tool

Decomposition Bases

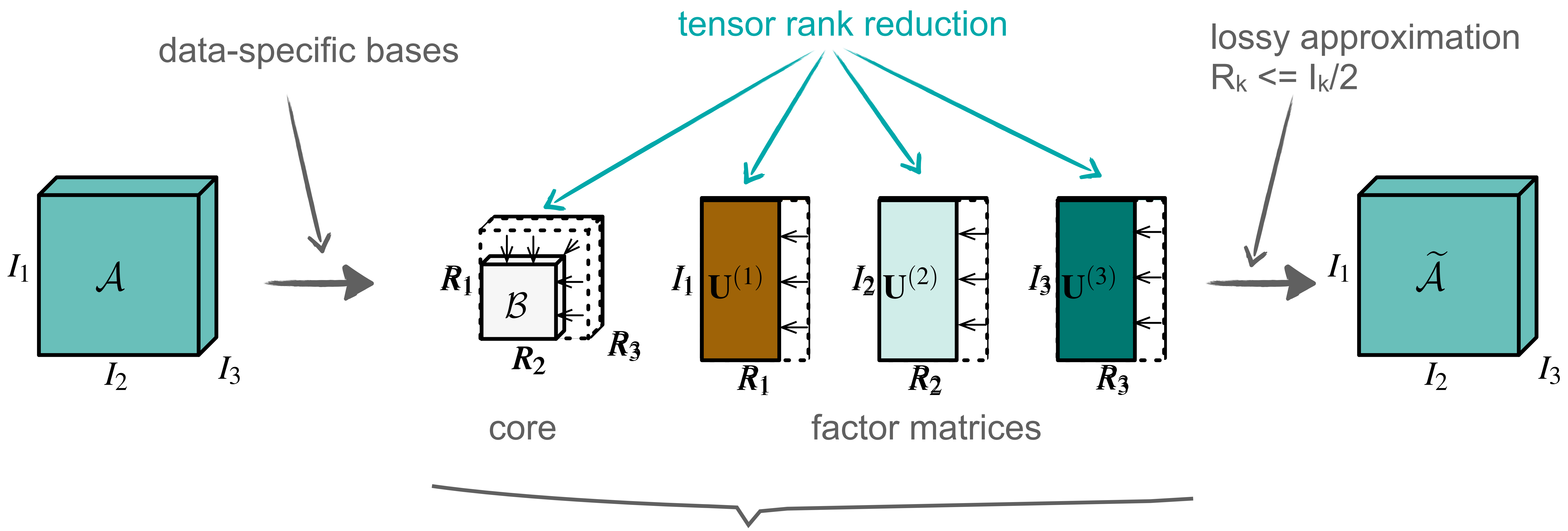
- Decompositions into bases and weight coefficients can either use a set of pre-defined fixed bases, or computed bases
- Pre-defined bases are given a priori, often represent some form of frequency analysis, and the decomposition may be fast to compute
  - e.g. Fourier, Discrete Cosine and Wavelet Transforms
- 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



$$\widetilde{\mathcal{A}} = \mathcal{B} \times_1 \mathbf{U}^{(1)} \times_2 \mathbf{U}^{(2)} \times_3 \mathbf{U}^{(3)}$$