Recent Advances in the Analysis of 3D Shapes

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What You Will Learn in the Seminar

Get an overview on state of the art research in 3D shape analysis

Be able to read and understand scientific publications

Prepare and give a talk

Write a scientific report
Preparation

Please do not work on your topic completely alone

Meet at least twice with your supervisor

Deliver the report and discuss the slides with your supervisor
Presentation

Recommended structure

1. Introduction, problem motivation, outline
2. Approach
3. Experimental Results
4. Discussion
5. Summary (of scientific contributions)

30 – 40 slides (ca. 1-2 minutes per slide)

Do not put too much information on the slides
Overview and main contributions of the assigned topic

Latex template available on the web page
Evaluation Criteria

Attendance at each appointment is necessary

Notice that many papers are not completely self-contained

It may be important to check related articles or text books

Report should be more detailed than original paper

Own implementations and graphics (where feasible) are appreciated
Typical Problems in 3D shape analysis
Typical problems

- Correspondence
- Partial similarity
- Symmetry
- Representation

Analysis of 3D shapes

Preparation Meeting

26.01.2015
Typical problems

Analysis of shape collections

Feature detection

Segmentation

Description
Tools

Linear algebra

Metric spaces

Optimization

Differential geometry

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Overview of Available Topics
Laplace-Beltrami Operator

- One of the key tools for 3D shape analysis
- Mathematical Background and Discretizations
- Two talks

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Robust Region Detection via Consensus Segmentation of Deformable Shapes

- Detection of regions that are stable under many deformations
- Semantically meaningful segmentation
- Based on unsupervised learning
Global symmetry detection in 3D shapes

Theoretical guarantees to find the best (approximate) symmetry

Uses a volumetric representation of the shapes
Global intrinsic symmetries of shapes

- Global symmetry detection when the shapes are allowed to deform
- Based on properties of the Laplace-Beltrami operator
- Formulated as a matching problem between the shape and itself
Pointwise feature descriptor

Invariant to big class of deformations

Based on heat diffusion and Fourier transform of the descriptor space
A method to compute geodesic distances based on heat diffusion

An order of magnitude faster than state of the art

Applicable to polygonal meshes, point clouds, as well as other representations
Biharmonic Distance

- Intrinsic metric (distance function)
- More robust to noise than geodesic distance
• Consider correspondences as linear operators
• Compact representation
• Related to Fourier analysis on manifolds

\[ \alpha_1 + \alpha_2 + \alpha_3 + \ldots \]
Coupled quasi-harmonic bases

- Interclass matching
- Learning the “best” functional bases for a given pair of shapes
Compressed manifold modes for mesh processing

- Locally supported quasi-harmonic bases
- Allows to identify key features of the shape
- Shapes as collections of parts
- Enables several applications (segmentation, etc.)
Dense non-rigid shape correspondence using random forests

- Apply random forests to perform shape matching
- Allows faster matching times
- General framework for inter-class matching
Supervised learning of bag-of-features shape descriptors using sparse coding

- Dictionary learning for shape retrieval (supervised learning)
- Provides a global shape descriptor that is fast to evaluate and compare
- State of the art retrieval
• Analysis of shape collections
• Consistently matching all shapes in a given collection starting from input maps
• Theoretical guarantees in presence of noisy input
Cross-Collection Map Inference by Intrinsic Alignment of Shape Spaces

- Analysis of shape collections
- Given two shape collections with similar structure, match the two collections
- Uses functional maps

Analysis of 3D shapes
Bilateral Maps for Partial Matching

- Define shape descriptors for pairs of points instead of individual points
- Allows to do partial matching
- Robustness to topological changes

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Optimal Intrinsic Descriptors for Non-Rigid Shape Analysis

- Supervised learning of optimal point descriptor
- Optimizing in infinite-dimensional space
- Best possible parametrization for existing descriptors
Exploring the geometry of the space of shells

- Shapes as points in a “space of shapes”
- Geodesics in this space correspond to deformations between shapes
- Possible to interpolate / extrapolate shapes by walking on geodesics
A Low-Dimensional Representation for Robust Partial Isometric Correspondences Computation

- Partial isometric matching
- Matching points and local coordinate system
- Robust to topological noise
- State of the art on real world data