# 3D Model Retrieval

#### 05--Three-Dimensional Shape Searching: State-of-the-Art Review and Future Trends

#### 05--Feature-based Similarity Search in 3D Object Databases

#### 04--A survey of content based 3D shape retrieval methods

# Review

## ||Geometry-based techniques||

### Characterize the geometric information of a 3D model based on the distribution of geometric elements

### Two goals

##### Strong discriminative ability w.r.t various 3D models

##### Adequate generality w.r.t the robustness to different geometric representations, including surfaces

### Global

##### Shape Distribution

01--atching 3D Models with shape distributions

##### Shape Histogram

99--3D shape histograms for similarity search and classification in spatial databases

### Local

##### 3D shape context

04-ECCV-Recognizing objects in range data using regional point descriptors

05-CVPR-3D shape context based gesture analysis integrated with tracking using omni video array

03--3D shape matching with 3D shape contexts

##### Extended Gaussian Images (EGI)

84--Extended Gaussian Images

##### Conformal factor

08-3DOR-3D shape matching with 3D shape contexts

##### Spherical harmonics

03-SGP-Rotation invariant spherical harmonic representation of 3D shape descriptors

##### Poisson histogram descriptor

11-PRL-3D shape retrieval by Poisson histogram

#### 13-3DOR-Data-aware 3D partitioning for generic shape retrieval

##### Enhanced the traditional Bag-of-Feature framework for generic shapes with their data-aware partition approach

#### 14--A novel 3D model retrieval approach using combined shape distribution

##### Combined shape distribution descriptor based on principal plane analysis and group integration

### Zhang’s Modified Shape Distribution (MSD)

### Shell-Distance-Sum (SDS)

## ||Graph-based techniques||

### Perform matching among models by using their skeletal or topological graph structures

### Skeleton graph-based approaches

##### Abstract a 3D model as a low-dimensional graph, which visually preserves the global shape configuration and whose nodes and edges correspond to the geometric attributes of the shape components

###### 03--Skeleton based shape matching and retrieval

###### 14--Symmetry discovery and retrieval of nonrigid 3D shapes using geodesic skeleton paths

The geometry of a 3D mesh is coded as a sequence of radii of the maximal balls at the skeleton points

### Topology-based methods

##### Compare 3D models based on the difference in their global topological structures

##### Among the various topology representations, Reeb graphs, which are rooted in the Morse theory, are considered one of the most popular

###### 01--Topology Matching for Fully Automatic Similarity Estimation of 3D Shapes

typical example based on Reeb graph

###### 13--3D shape retrieval using Kernels on Extended Reeb Graphs

compared 3D models based on the kernel functions defined on extended Reeb graphs

##### Another direction relies on the theory of Topological Persistence

###### 02--Topological persistence and simplification

the concept of persistence diagram or barcode and builds on previous related work on size functions

The method provides a principled way to qualitatively visualize and measure the topological structures via the feature functions defined on the shape surface

###### 13--PHOG: Photometric and geometric functions for textured shape retrieval

###### 14-CVPR-Persistence-based structural recognition

## ||View-based techniques||

### A set of rendered views to represent a 3D model

### The visual similarity between the views of two models is regarded as the model difference

### Survey

###### 12--A Survey of Recent View-based 3D Model Retrieval Methods

### Two stages

###### Descriptive feature extraction from certain view images

###### Appropriate comparison between sets of visual features

### Descriptive feature extraction

##### Light Field descriptors

03-CGF-On Visual Similarity Based 3D Model Retrieval

##### Multi-view Depth Line Approach (MDLA)

07-ICIP-A New Descriptor for 2D Depth Image Indexing and 3D Model Retrieval

##### salient local visual features

08--Salient local visual features for shape-based 3D model retrieval

##### Compact Multi-View Descriptor (CMVD)

10-IJCV-A 3D Shape Retrieval Framework Supporting Multimodal Queries

##### View Context shape descriptor

11--View context based 2D sketch-3D model alignment

### appropriate comparison between sets of visual features

##### Bag-of-Features based approach and its variants

10--Visual Similarity Based 3D Shape Retrieval Using Bag-of-Features

10-Multimedia-3D object retrieval with bag-of-region-words

##### More accurate 3D model alignment-based methods

11-ICMR-3D model retrieval using accurate pose estimation and view-based similarity

### Recent methods

###### 14-TOM-Sphere Image for 3-D Model Retrieval

defined a view-based shape descriptor named Sphere Image that integrates the spatial information of a collection of viewpoints and their corresponding view features that are matched based on a probabilistic graphical model

###### 13--3D shape retrieval using viewpoint information-theoretic measures: 3D shape retrieval using viewpoint measures

Proposed a 3D shape descriptor of the Information Sphere and utilized mutual information-based measures for the matching

###### 13--Retrieving 3D Model Using Compound-Eye Visual Representation

Designed a feature named Spherical-SIFT to represent the salient local features on spherical images

###### 13--3D object retrieval via range image queries in a bag-of-visual-words context

Retrieved complete 3D pottery models based on the panoramic feature views of a partial range image query

### Evaluated methods

###### Aono’s KAZE local feature with the VLAD encoding scheme (KVLAD)

12-ECCV-KAZE Features

10-CVPR-Aggregating local descriptors into a compact image representation

##### Furuya’s Bag-of-Features of Dense SIFT (BF-DSIFT)

##### Per-View Matching of One SIFT (VM-1SIFT)

##### Manifold Ranking of BF-DSIFT (MR-BF-DSIFT)

##### Manifold Ranking of 1SIFT (MR-VM-1SIFT)

##### Manifold Ranking of D1SIFT (MR-D1SIFT)

##### Tatsuma’s Depth Buffered Super-Vector Coding (DBSVC)

##### Locally Constrained Diffusion Ranking of DBSVC (LCDR-DBSVC)

## ||Hybrid techniques||

### DESIRE

###### 05-ICME-DESIRE: a composite 3D-shape descriptor

### DSH

###### 08-3DOR-3D Object Retrieval using an Efﬁcient and Compact Hybrid Shape Descriptor

##### combines Depth buffer-based 2D features and Spherical Harmonics-based 3D features

### PANORAMA

###### 10-IJCV-PANORAMA: A 3D Shape Descriptor based on Panoramic Views for Unsupervised 3D Object Retrieval

##### Represents a 3D model based on a set of panoramic views and achieves state-of-the-art performance on several generic 3D model databases

### ZFDR

###### 13--3D model retrieval using hybrid features and class information

##### Comprising both geometric and view information

### Topology-based + View based

###### 13--Combining topological and view-based features for 3D model retrieval

##### combined the topological feature multi-resolutional Reeb graph (MRG) based features and modified BOF-based view features

### 

###### 14--Sparse Patch Coding for 3D Model Retrieval

##### Adopted several representative geometric features such as shape diameter function, average geodesic distance, and heat kernel signature, to characterize low-level semantic patches

### 

###### 14-CVPR-Covariance Descriptors for 3D Shape Matching and Retrieval

##### First sample a set of points on the surface of a 3D model

##### Then use the covariance matrices of multiple local features as shape descriptors for 3D face matching

##### Further apply an extended Bag-of-Words framework on the covariance matrix-based local shape descriptors for 3D model retrieval

### Aono’s Center-Symmetric Local Binary Pattern (CSLBP)

### Hybrid shape descriptor comprising several features including Surface-Roughness and DEpth-buffer (HSR-DE)

### Chen’s hybrid shape descriptor DBNAA\_DERE

##### Shape Distribution (D2)

02-TOG-Shape distribution

##### Bounding Box

##### Normal Angle Area

##### DEpth buffer

##### Ray Extend based features

04-PHD-3D Model Retrieval

### ZFDR hybrid shape descriptor

##### Zernike moments

##### Fourier descriptors

##### Depth information

##### Ray-based features

### Multi-Feature Fusion Based on Entropy Weights (MFFEW)

### Papadakis’ PANORAMA

###### 10-IJCV-PANORAMA: A 3D Shape Descriptor based on Panoramic Views for Unsupervised 3D Object Retrieval

## ||Non-rigid 3D model retrieval techniques||

### A review of non-rigid 3D retrieval techniques

##### Based on geodesic distance and spectrum analysis approaches, as well as different canonical form transforms for non-rigid models based on multidimensional scaling

###### 12--Non-rigid and Partial 3D Model Retrieval Using Hybrid Shape Descriptor and Meta Similarity

##### Recent survey of non-rigid shape retrieval is presented

###### 13--Spatially aggregating spectral descriptors for nonrigid 3D shape retrieval: A comparative survey

### The geometric analysis of non-rigid shapes, which relies on the Eigensystem of the Laplace–Beltrami operator

###### 06--Diffusion maps

###### 06—Laplace-Beltrami Eigenfunctions Towards an Algorithm that “understands” Geometry

### Shape DNA

###### 06--Laplace-Beltrami spectra as "Shape-DNA" of surfaces and solids

### heat kernel signature(HKS)

###### 09-CGF-Shape Analysis Using the Auto Diffusion Function

###### 09-CGF-A Concise and Provably Informative Multi-Scale Signature Based on Heat Diffusion

### wave kernel signature (WKS)

###### 11-ICCVW-The wave kernel signature: A quantum mechanical approach to shape analysis

### a general form of spectral descriptors(includes HKS and WKS as special cases)

###### 13--A multiresolution descriptor for deformable 3D shape retrieval

### Shape Google algorithm

###### 11-TOG-Shape google: geometric words and expressions for invariant shape retrieval

##### Aggregates spectral descriptors based on the Bag-of-Features framework

### An intrinsic spatial pyramid matching algorithm

###### 13--Intrinsic spatial pyramid matching for deformable 3D shape retrieval

## ||Semantics-based 3D model retrieval techniques||

### Incorporate high-level semantic information of the query and/or 3D models into the retrieval process to bridge the semantic gap existing in traditional content-based 3D model retrieval techniques

### A survey of three typical semantics processing techniques (relevance feedback, machine learning, and ontology)

###### 09--An Overview of Semantics Processing in Content-Based 3D Model Retrieval

### Relevance feedback

###### 05-VC-Semantic-oriented 3D Shape retrieval using relevance feedback

### Semantic labeling

###### 13-CAD-SVM-based Semantic Clustering and Retrieval of A 3D Model Database

### Neural networks

###### 07-ICIG-3D Shape retrieval integrated with classification information

### Supervised

###### 08--Supervised Learning of Salient 2D Views of 3D Models

###### 08--Supervised learning of similarity measures for contentbased 3D model retrieval

###### 10-3DOR- Semantics-driven approach for automatic selection of best views of 3D shapes

###### 10-3DOR- Learning the compositional structure of man-made objects for 3D shape retrieval

### Semi-supervised

###### 04-ICME-Using entropy impurity for improved 3D object similarity search

### Boosting

###### 07--A boosting approach to content-based 3D model retrieval

### Prototypes

###### 07--3D classification via structural prototypes

### Autotagging

###### 08--Autotagging to improve text search for 3D models

### Spectral clustering

###### 08-VC-Multi-fourier spectra descriptor and augmentation with spectral clustering for 3D shape retrieval

### Manifold ranking

###### 08--Ranking on semantic manifold for shape-based 3D model retrieval

### Semantic tree

###### 09--Semantic 3D Model Retrieval Based on Semantic Tree and Shape Feature

### Feature dimension reduction

###### 10--Squeezing Bag-of-Features for Scalable and Semantic 3D Model Retrieval

###### 10-3DOR-Distance metric learning and feature combination for shape-based 3D model retrieval

### Semantic subspaces

###### 11--A new framework for composing vectorial semantic labels in 3D model retrieval

### Class distances

###### 13--3D model retrieval using hybrid features and class information

### Semantics annotation of 3D models

###### 13--Clustering Analysis and Semantics Annotation of 3D Models Based on Users’ Implicit Feedbacks

### Semantic correspondences

###### 13-TOG-Geometry and Context for Semantic Correspondences and Functionality Recognition in Man-Made 3D Shapes

### Sparse structure regularized ranking

###### 14--Sparse structure regularized ranking

### Multiple shape indexes (attributes)

###### 11--3D model retrieval based on semantic and shape indexes

### Attribute-augmented semantic hierarchy

###### 13--Attribute-augmented semantic hierarchy: towards bridging semantic gap and intention gap in image retrieval

### Use attribute signature (AS) and reference set signature (RSS) to perform semantic 3D model retrieval

###### 13-Learning semantic signatures for 3D object

##### They selected 11 attributes including symmetry,flexibility, rectilinearity, circularity, dominant-plane, long,thin, swim, fly, stand with leg(s), and natural

### Aono’s machine learning-based method CSLBP

### Manifold ranking-based approaches, including Furuya’s MR-D1SIFT and MR-VM-1SIFT

### Tatsuma’s LCDR-DBSVC Query-by-Model algorithms

### Tatsuma’s SCMR-OPHOG Query-by-Sketch algorithms