

Sketch-Based Shape Retrieval



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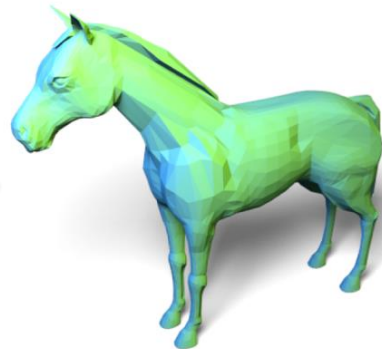
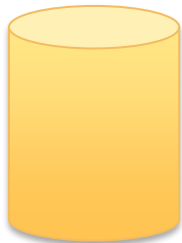
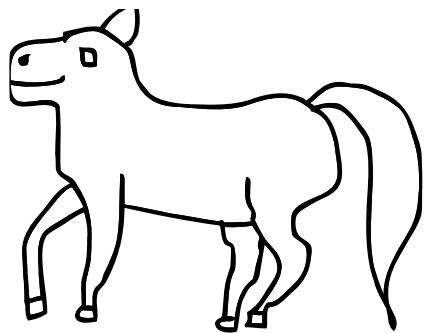
Kristian Hildebrand

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Overview



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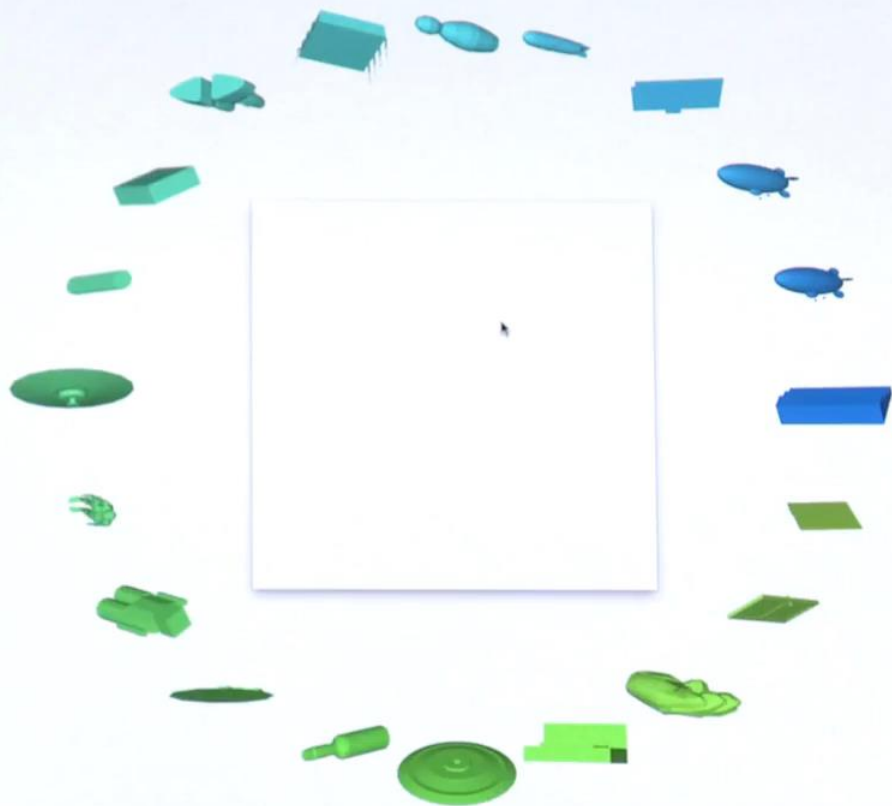


...



...





Why Sketch-Based?

3D warehouse

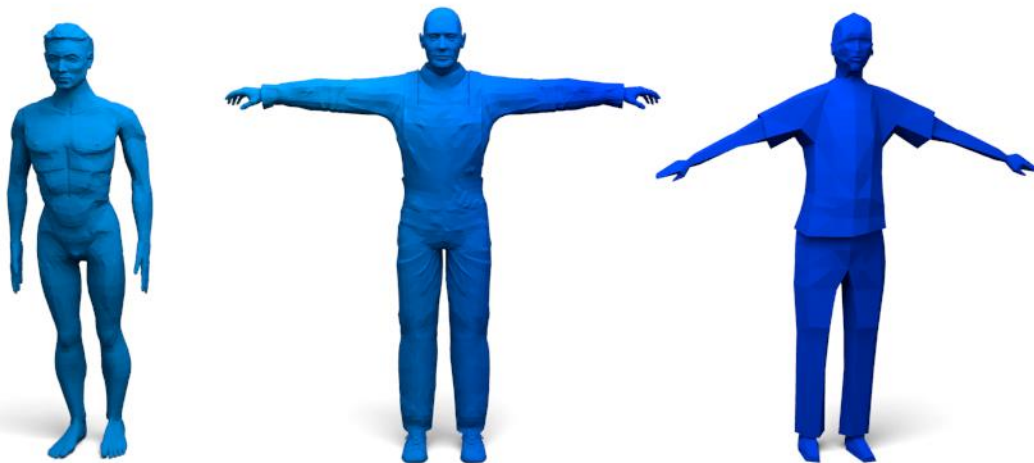
Search



- Problems:
 - vehicle, jeep, truck, pickup, ...
 - no keyword attached to model

Why Sketch-Based?

- Easy to sketch, difficult to describe

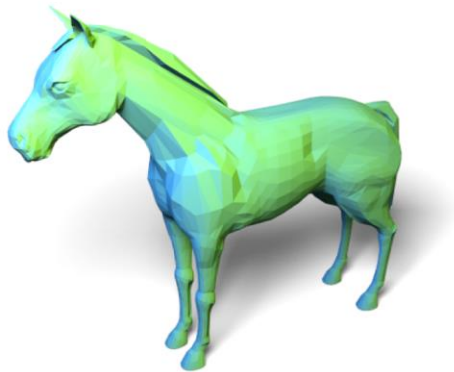
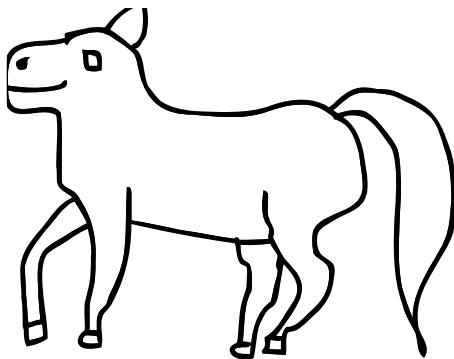


Why Sketch-Based?

- Easy to sketch, difficult to describe



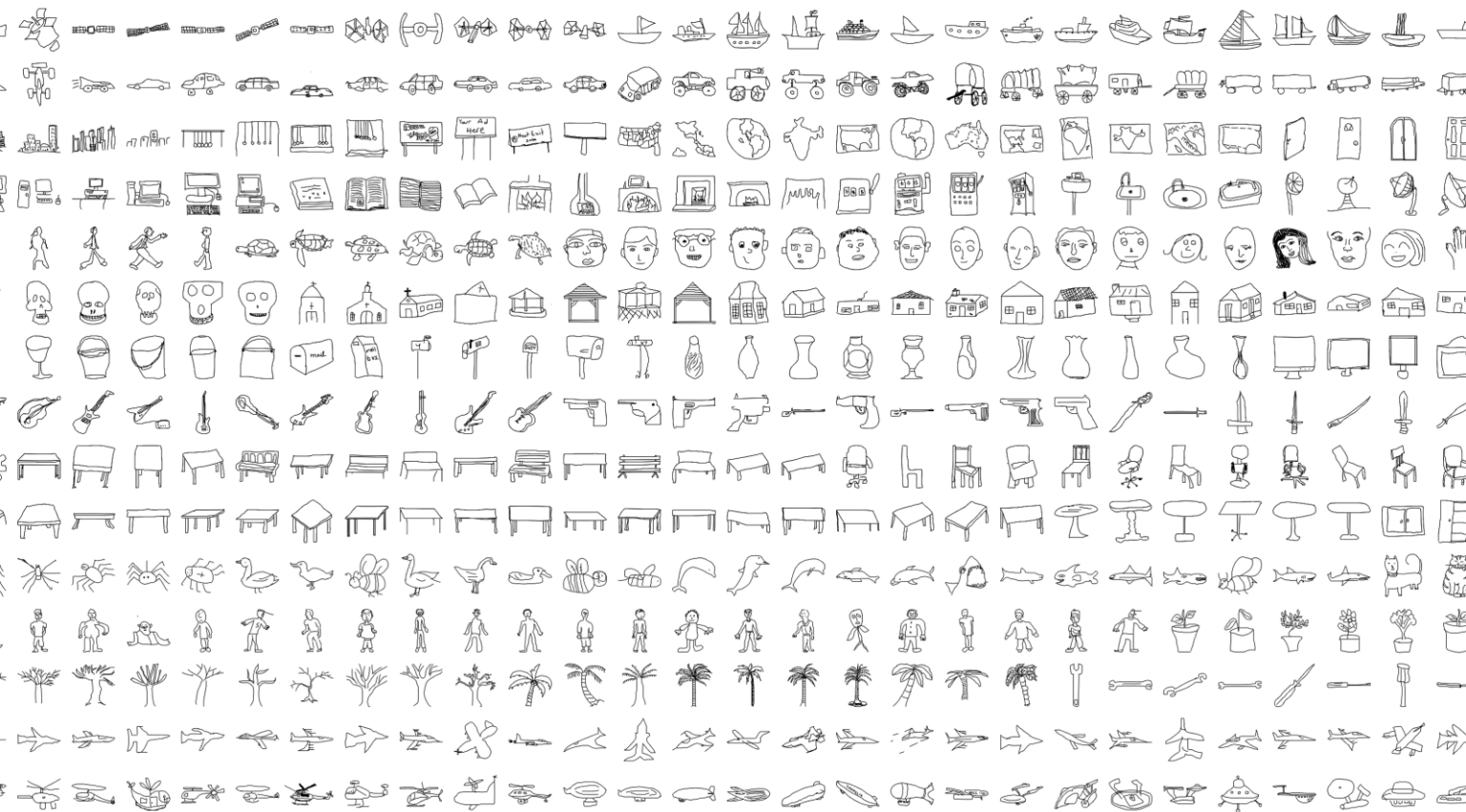
Challenges



- What to match the sketch lines against?
- Sketch is a projection, information lost
- Need to support all possible viewing directions
- Handle extreme abstraction/exaggeration

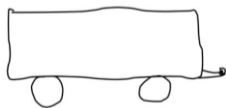
How Do Humans Sketch for Shape Retrieval?

- Questions:
 - Type of lines humans draw, are outlines enough? [Chen 2003]
 - Consistent quality?
 - Realistic/abstract?
- User study on Amazon Mechanical Turk
 - Interactive drawing tool
 - Asked for a total of ~2,000 sketches in 90 categories
 - Categories from Princeton Shape Benchmark [Shilane 2003]



How Do Humans Sketch for Shape Retrieval?

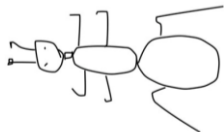
- Large variety of sketching styles:



outlines



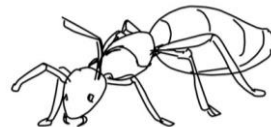
interior lines



abstract



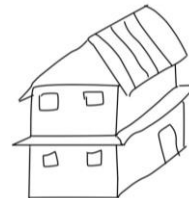
realistic



no perspective

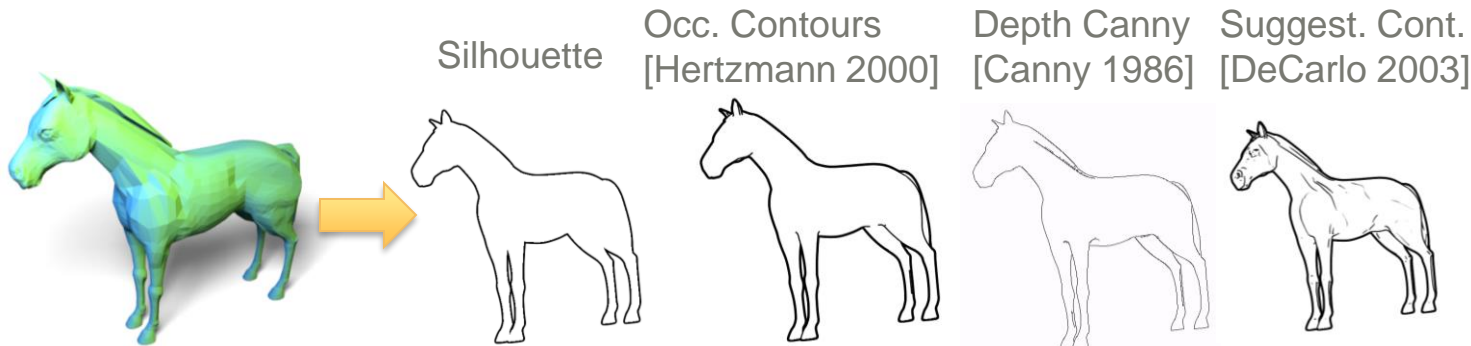
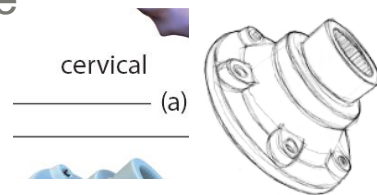


perspective

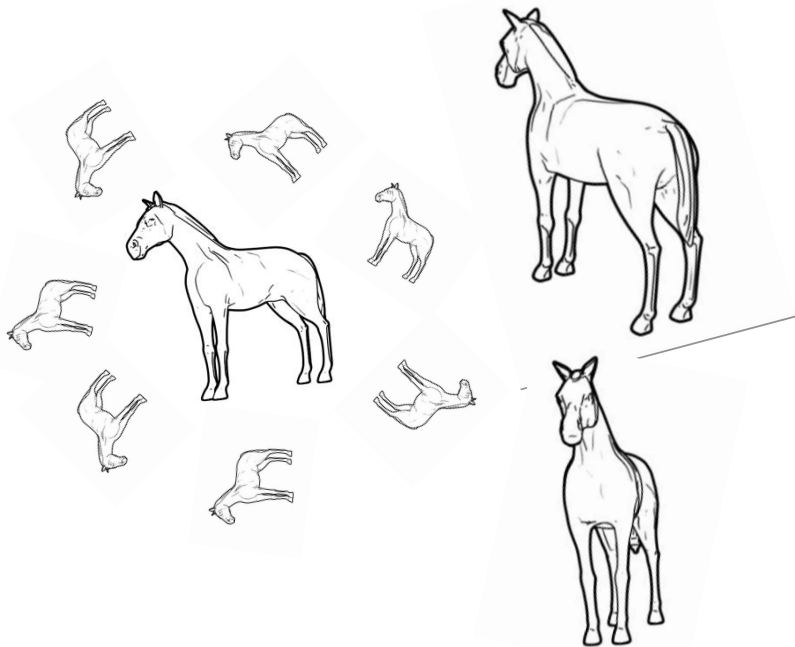
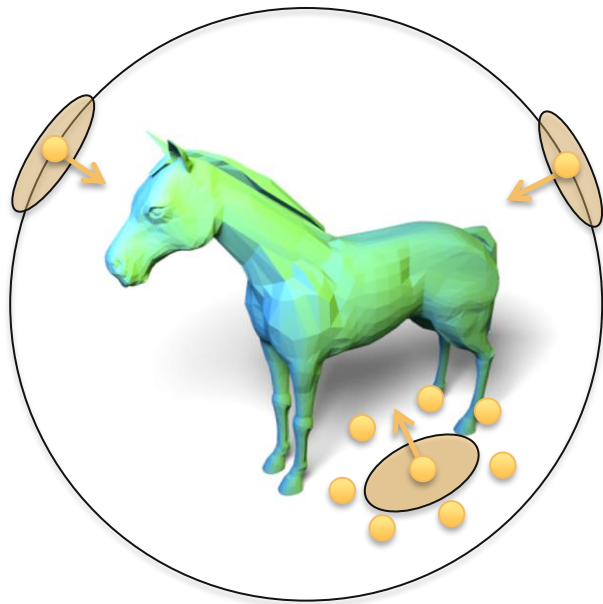


View-Based Approach

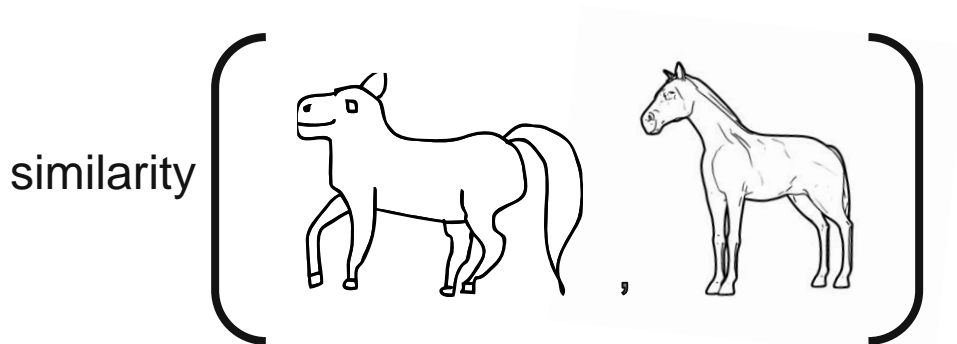
- View-based instead of direct matching to 3D shape
- [Bülthoff'92]: humans represent shapes using 2D views
- [Cole'07]: 90% of lines explained by NPR algorithms



View Generation



Similarity Measure



- Requirements:
- Tolerate local and global deformations
 - Support partial matching
 - Fast and efficient



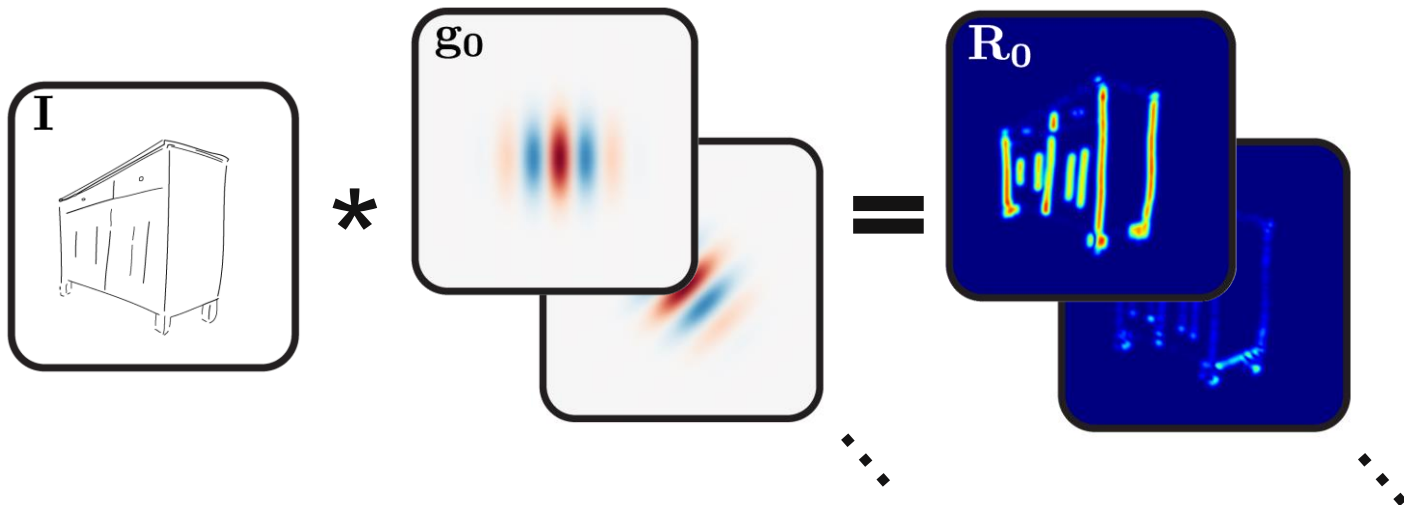
Need appropriate feature transform

Local Feature Extraction

sketch

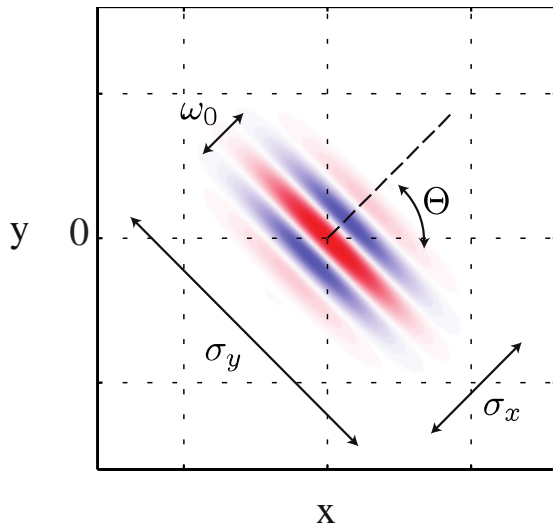
bank of Gabor filters

responses

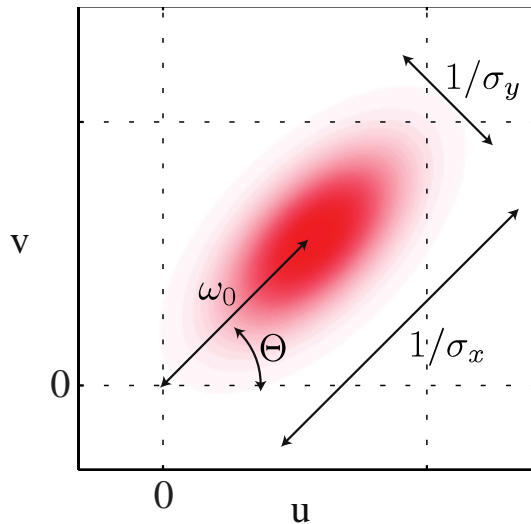


Local Feature Extraction: Gabor Filter

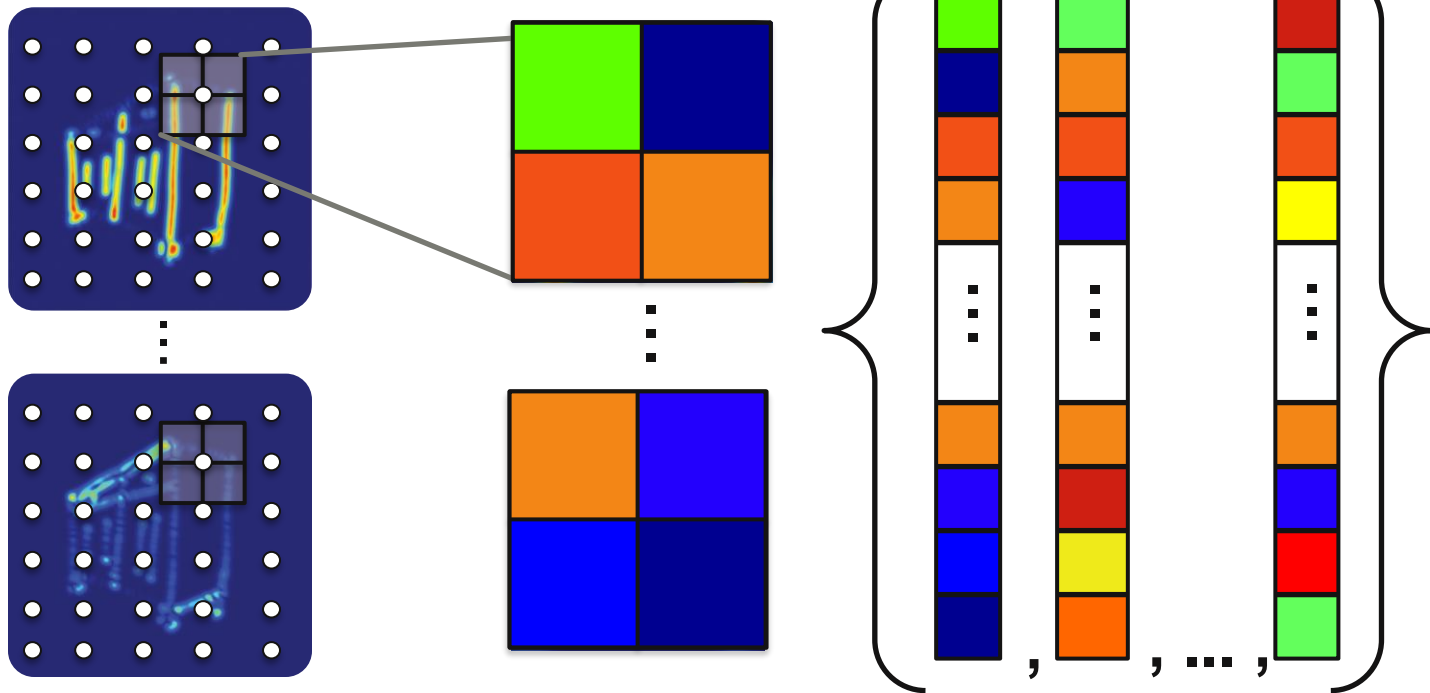
spatial domain



frequency domain

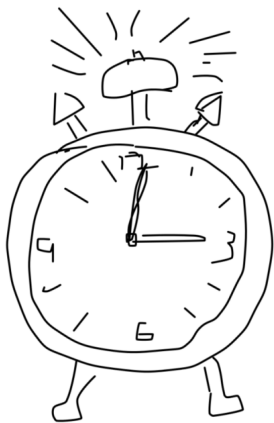


Local Feature Extraction

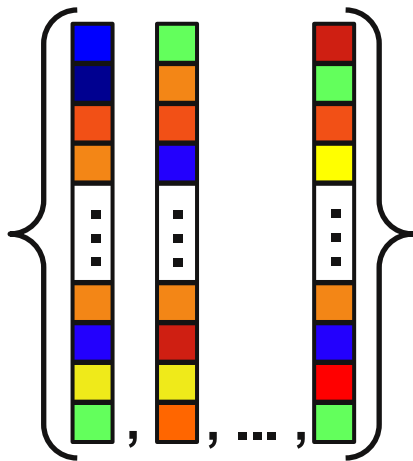


Quantization Using Visual Vocabulary

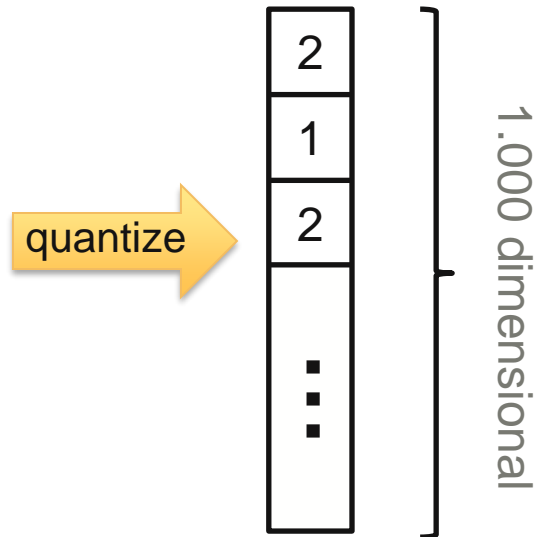
a) sketch



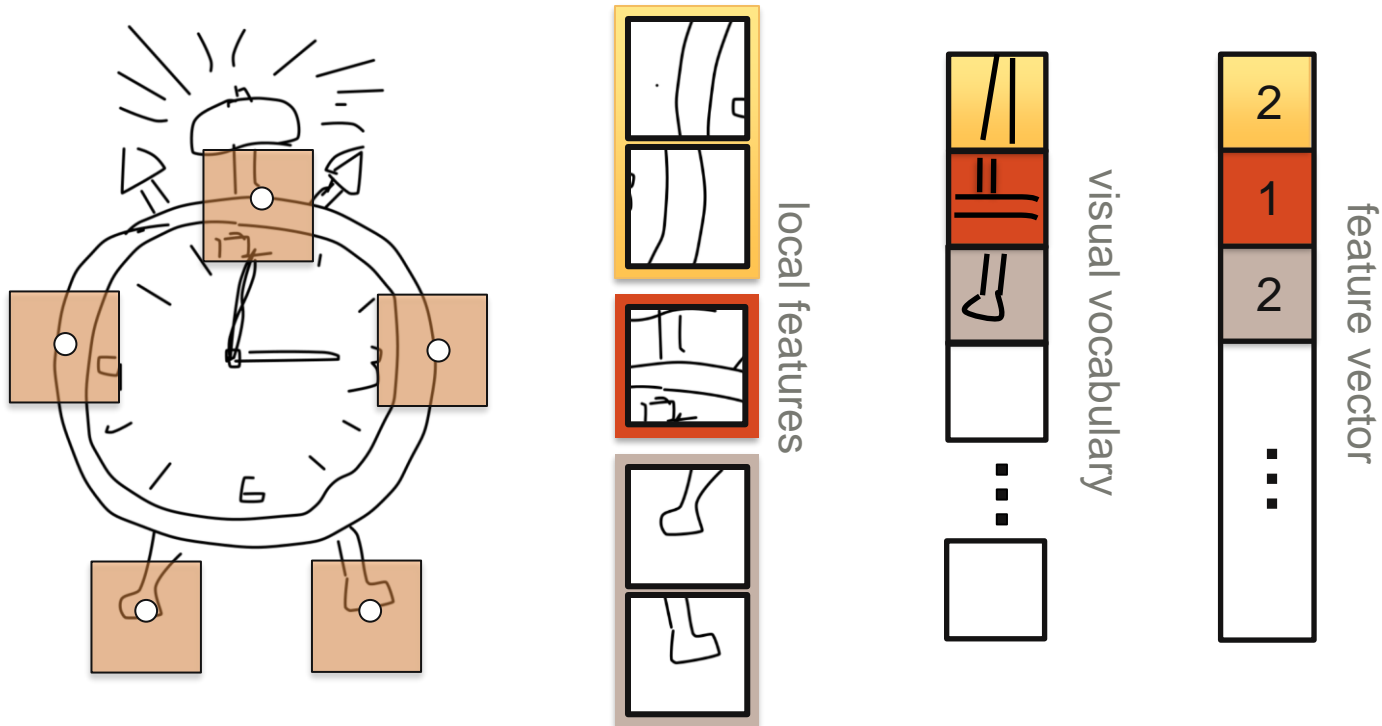
b) local features

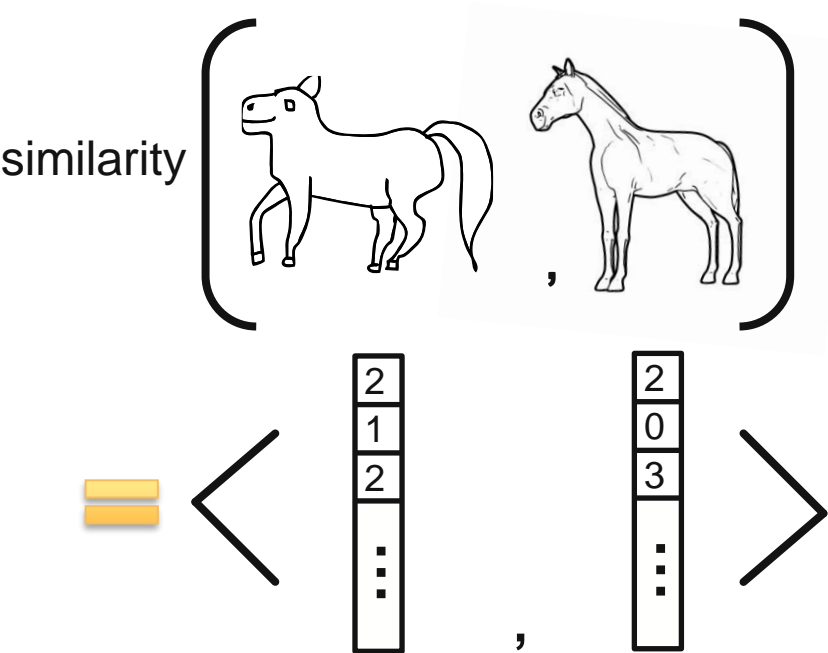


c) single feature vector



Bag-of-Features Representation

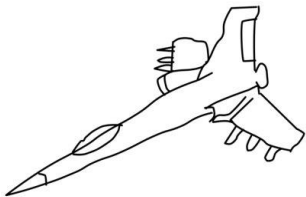




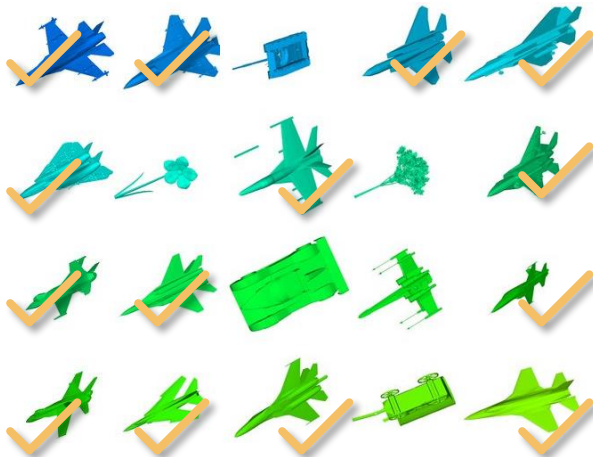
Establishing an Objective Benchmark

- First large benchmark for sketch-based 3d shape retrieval

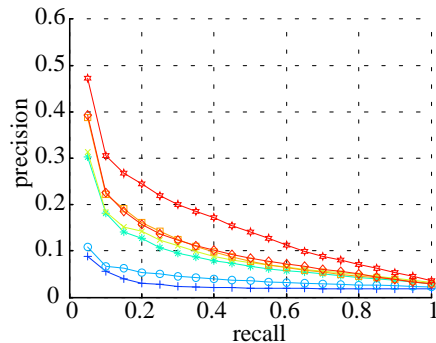
1) query:
„fighter jet“



2) count matches:
„fighter jet“

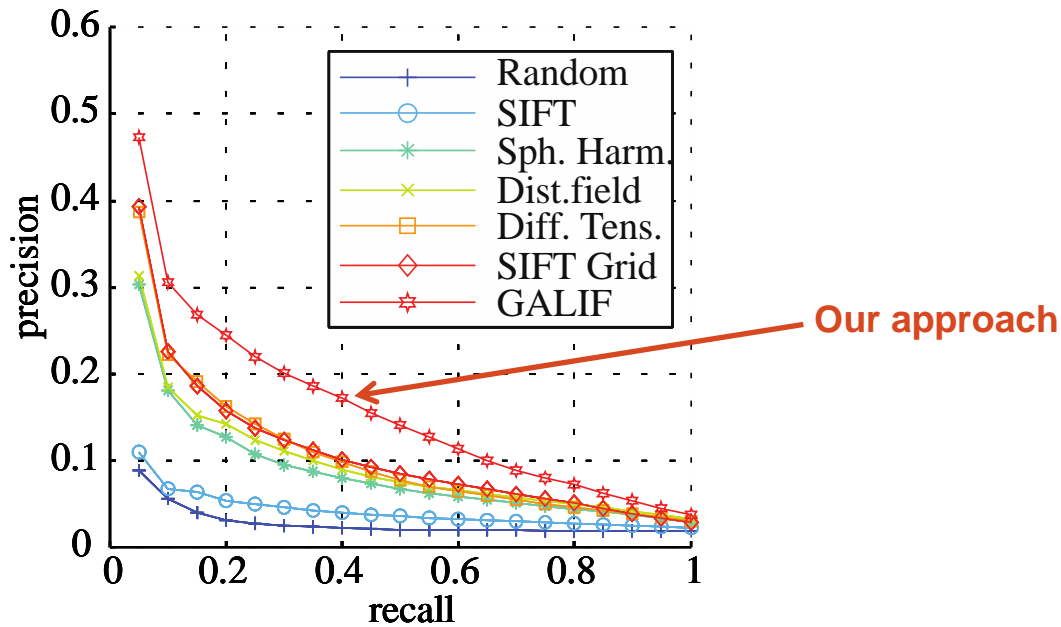


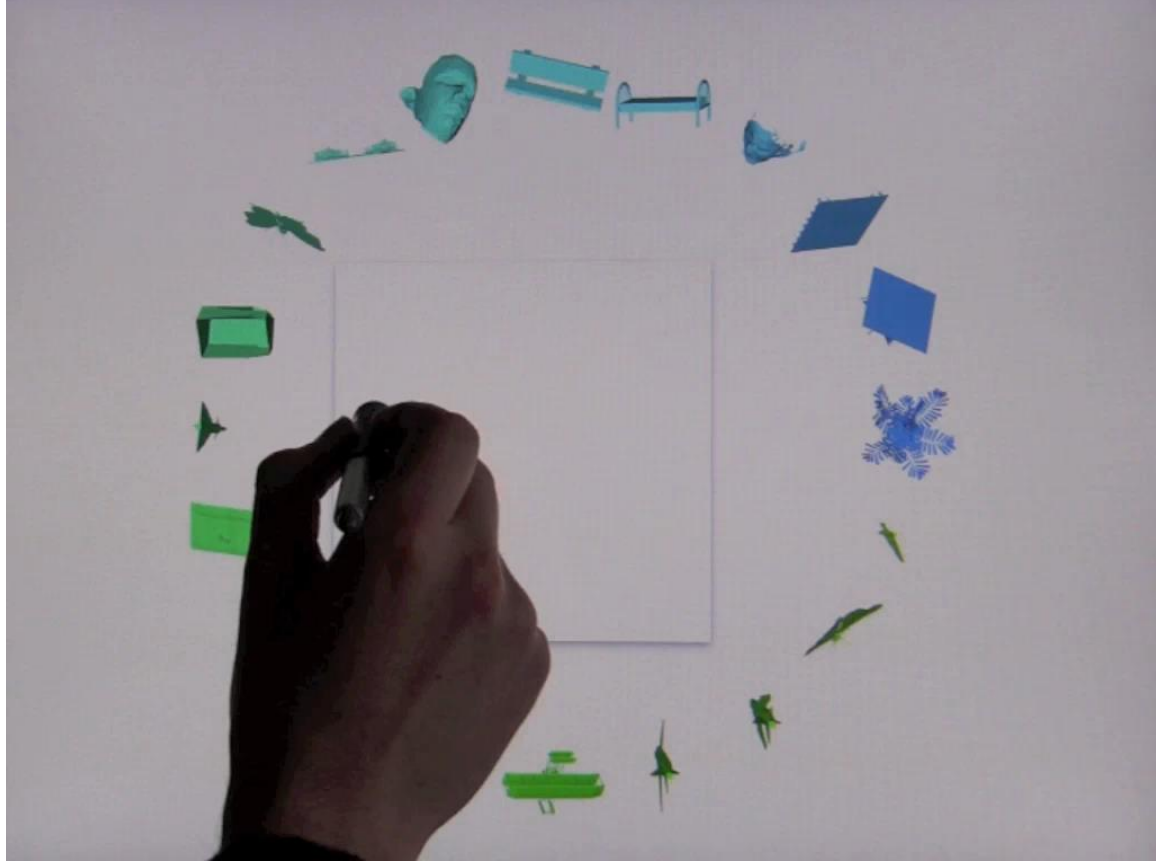
3) precision/recall

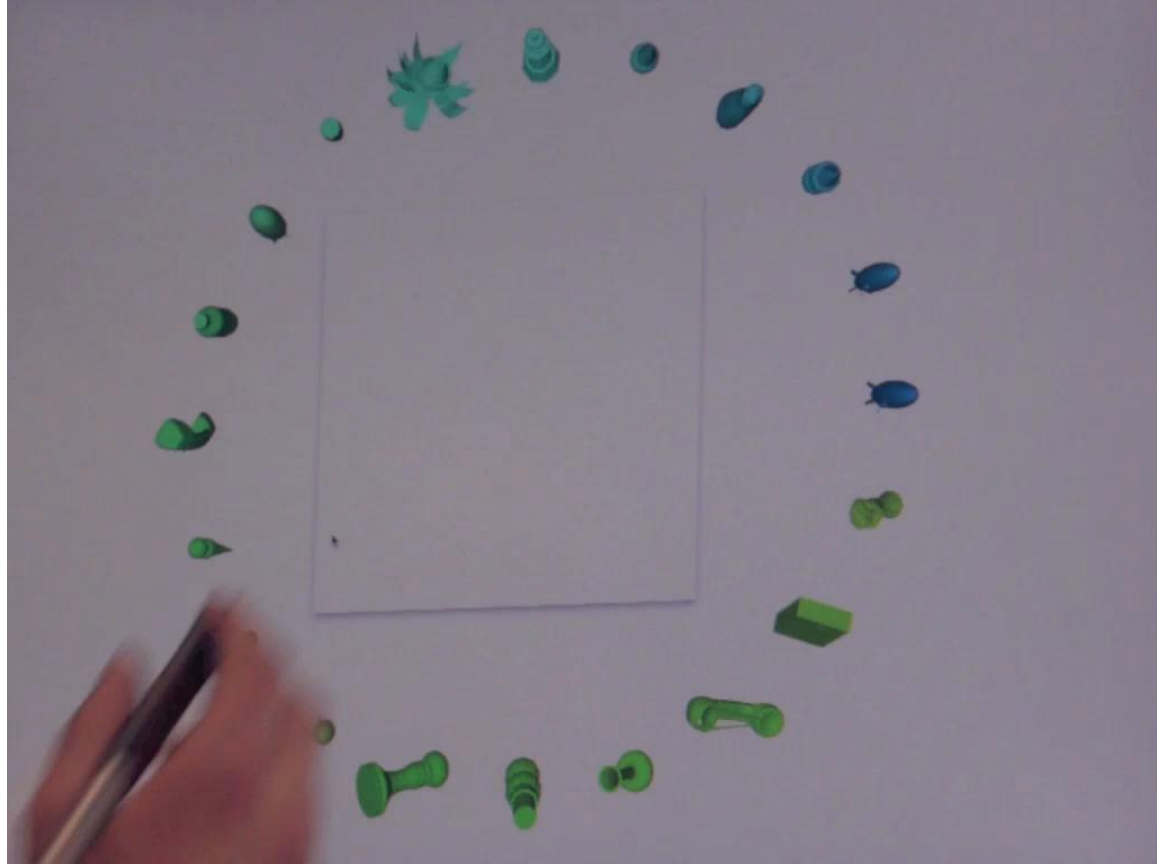


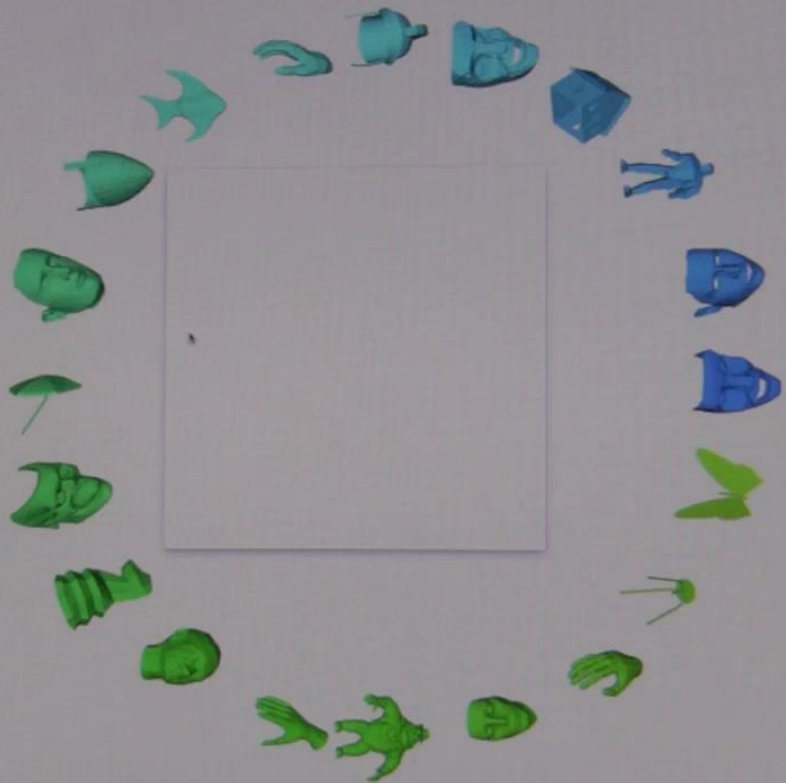
Comparison to Existing Systems

- Competing systems have been optimized as well!

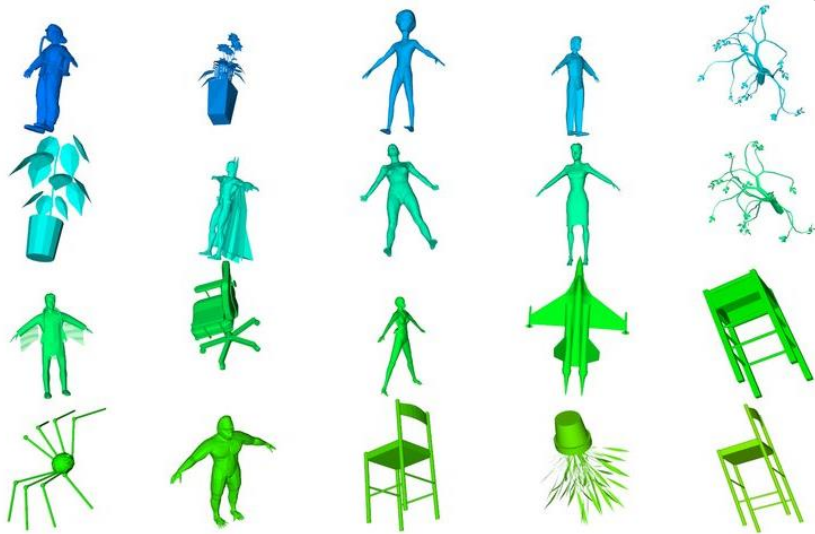
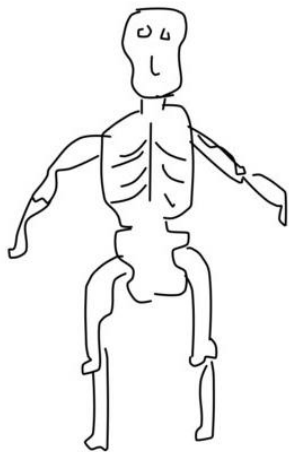




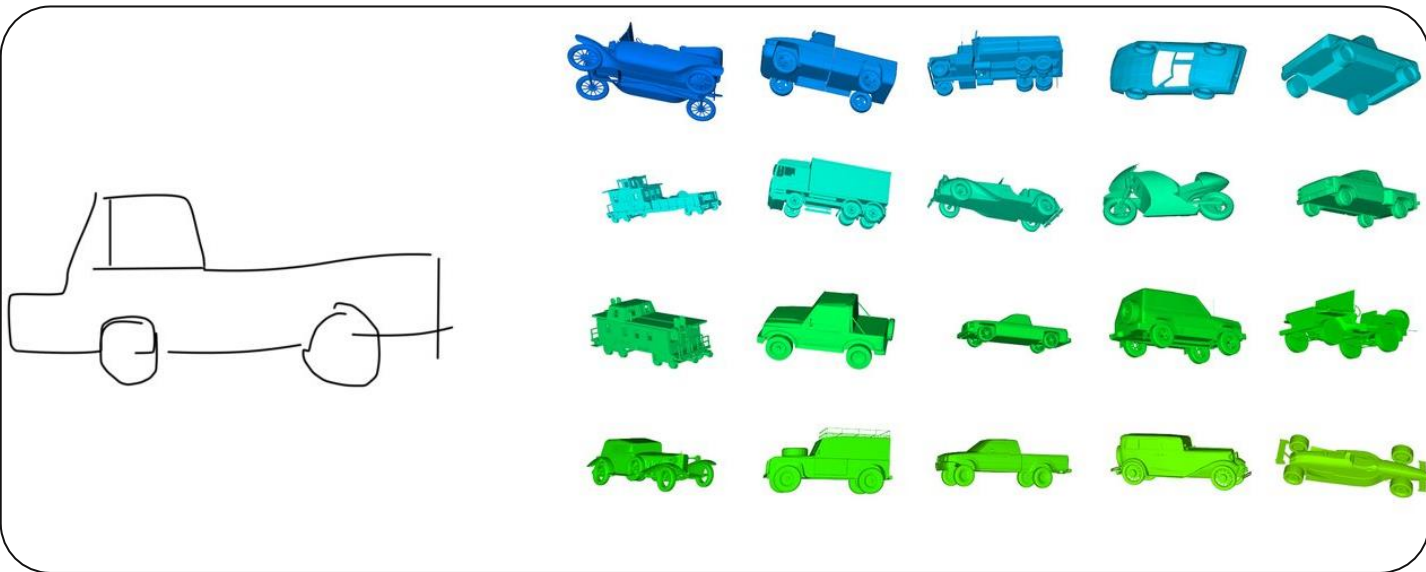




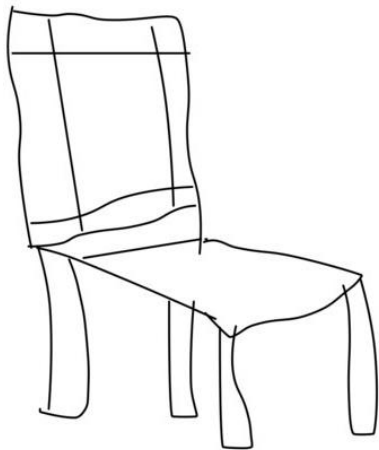
Failure Case



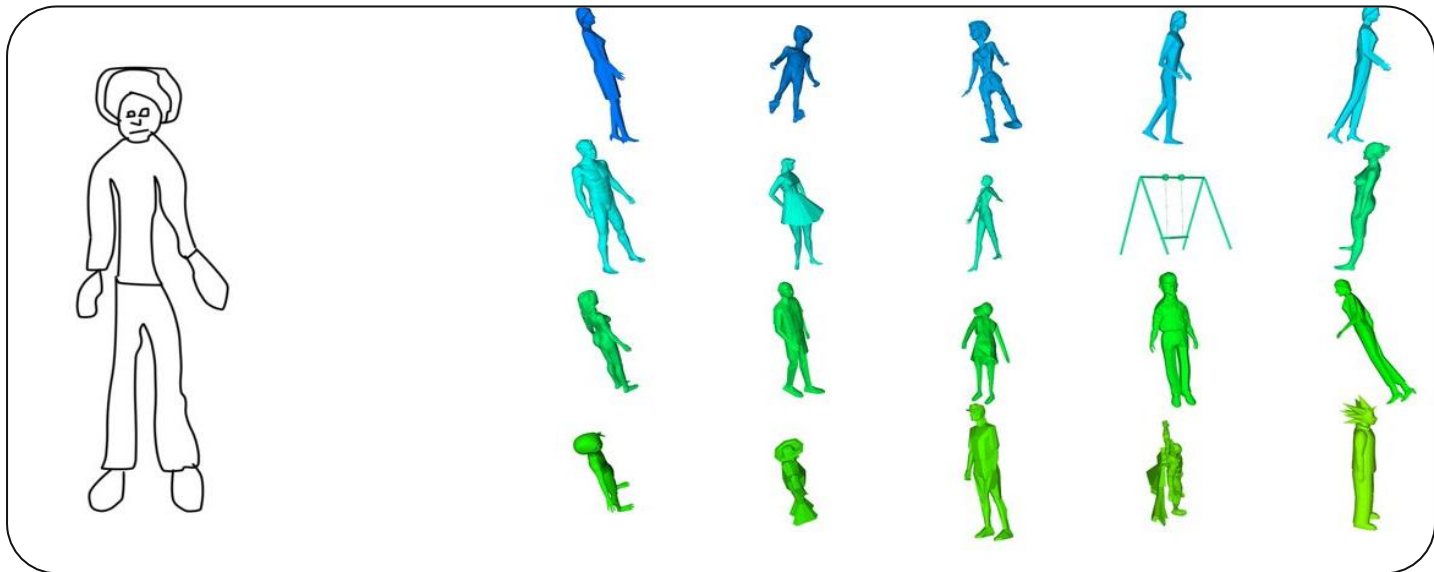
Partial Matching



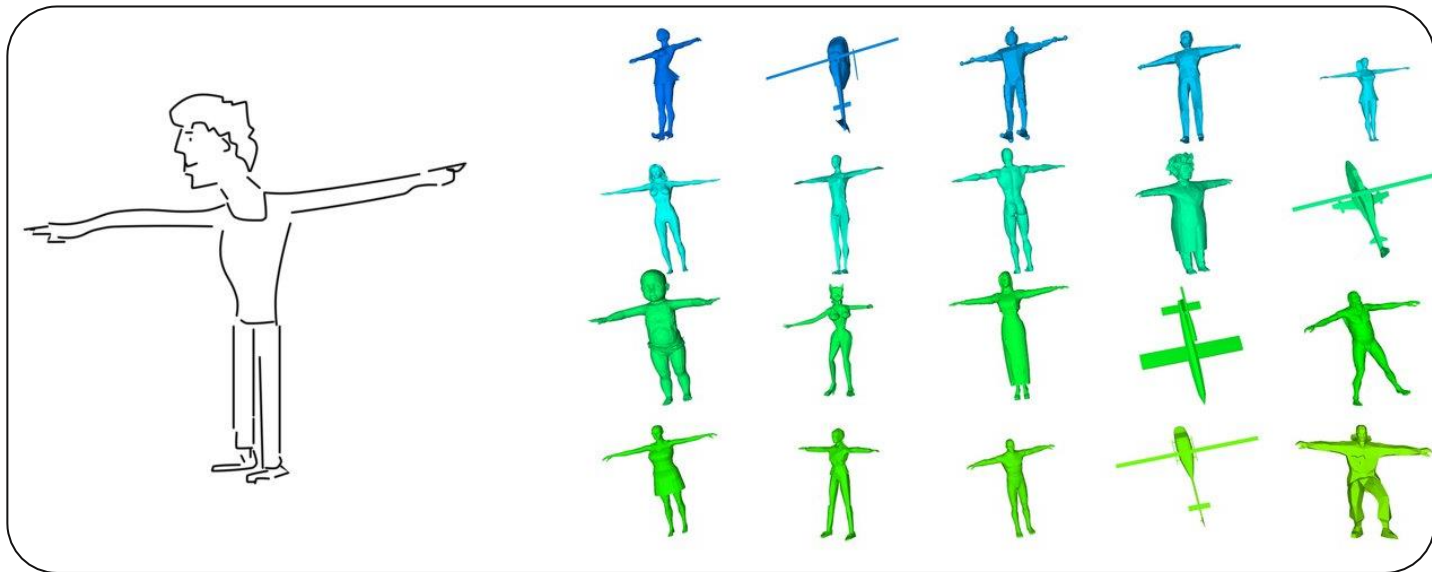
Partial Matching



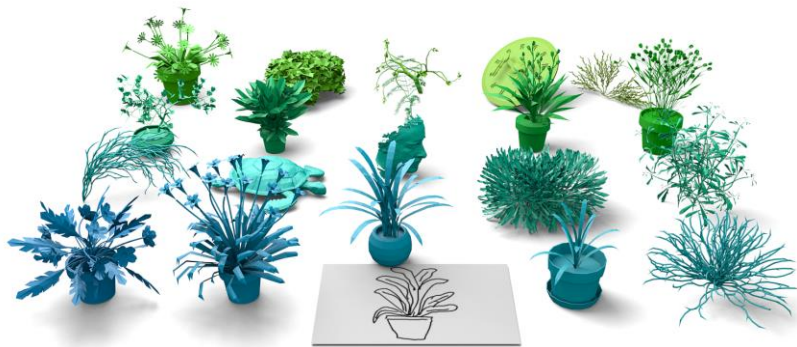
Easy to Sketch, Difficult to Describe



Easy to Sketch, Difficult to Describe



Conclusions



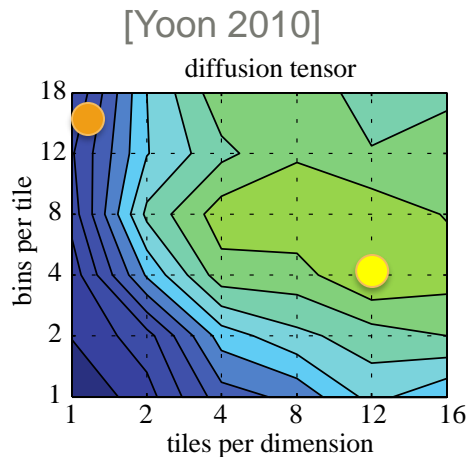
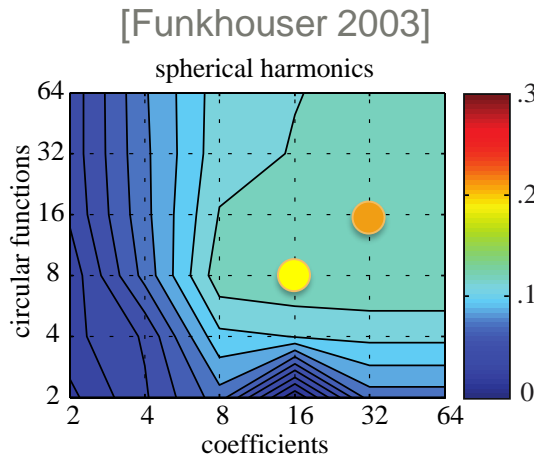
- Interactive sketch-based shape retrieval
 - First benchmark for 3d shape retrieval
 - New feature transform that outperforms existing approaches
 - Dataset released to encourage further research

Thanks

- Acknowledgements
 - AMT users for their sketches
 - James Hays for help with AMT
 - Princeton Shape Benchmark [Shilane'04]
 - RTSC tool by Doug DeCarlo, Szymon Rusinkiewicz
 - Cited authors for images from their papers
- See <http://cybertron.cg.tu-berlin.de/eitz> for:
 - Dataset
 - Demo

Parameter Optimization

- Can apply same method to existing descriptors

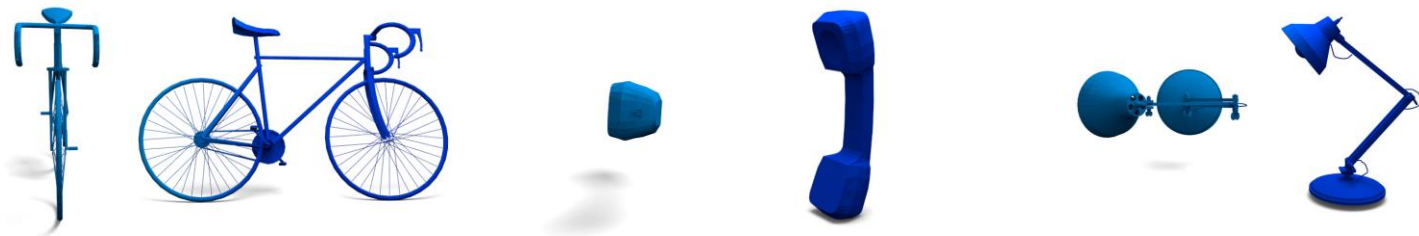


 original parameters

 optimized parameters

Best View Generation

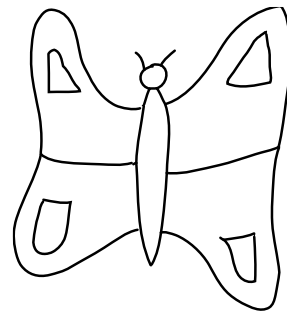
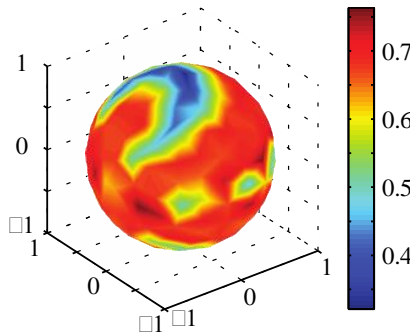
- Are all views equally likely to be drawn?
- Learn model of human viewpoint preference
- RBF SVM using the following features:
 - projected area [Plemenos 96], depth smoothness, silhouette length [Secord 11]



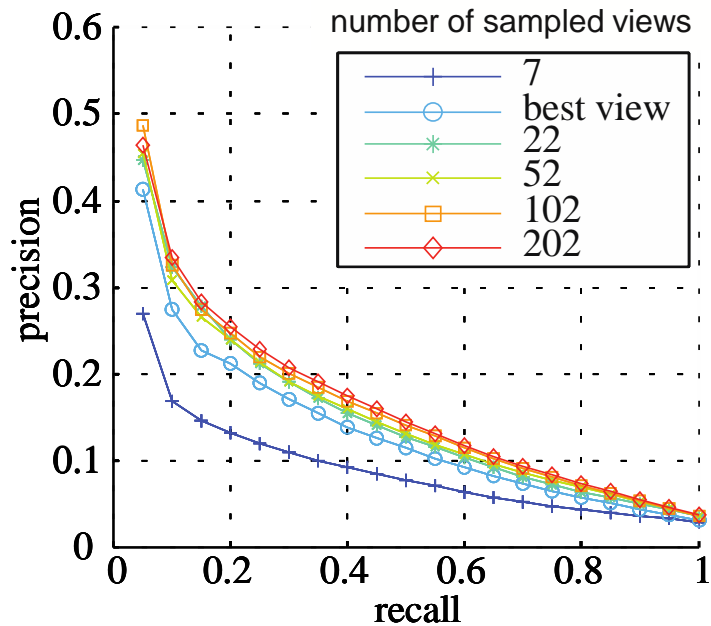
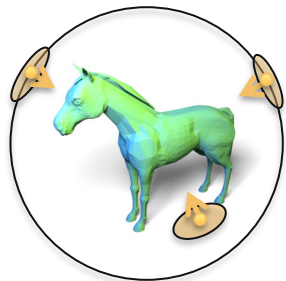
Best View Generation

- Predict best views for unknown model

a) probability map for model b) resulting best view c) user sketch



Comparison View Generation



Parameter Optimization

- Many parameters in our pipeline – best combination?
 - Feature transform: #orientations, Gabor filter parameters
 - Vocabulary size, feature size
- Sampling the whole parameter space is not an option
 - 6-dimensional space, 10 samples: 10^6 samples
 - Each sample takes one hour = 100 years
 - Our solution: choose two free parameters, fix remaining

Parameter Optimization

- Optimizing parameters of underlying GABOR filter
 - x/y axis: bandwidth
 - left to right: peak frequency

best parameter value

