IEEE 3DV 2014 talk slides:

Hashing Cross-Modal Manifold for Scalable Sketch-based 3D Model Retrieval

(Poster : 3-29)

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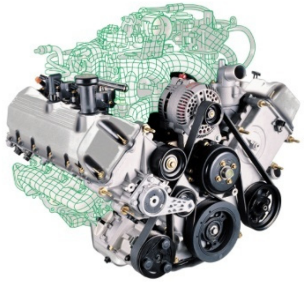
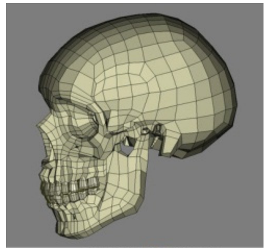
Introduction

- 3D models are widely used.
  - Mechanical CAD, Games,…
  - 3D range scanners, 3D printers,…
  - User generated.
    - Trimble 3D warehouse, ...
- 3D model retrieval is essential.
  - Ease of use.
  - Efficiency.
  - High retrieval accuracy.





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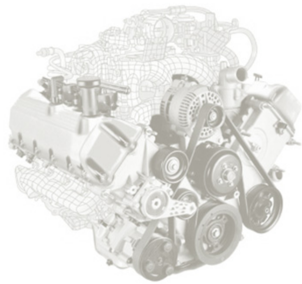
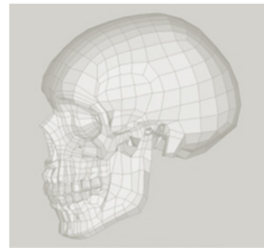
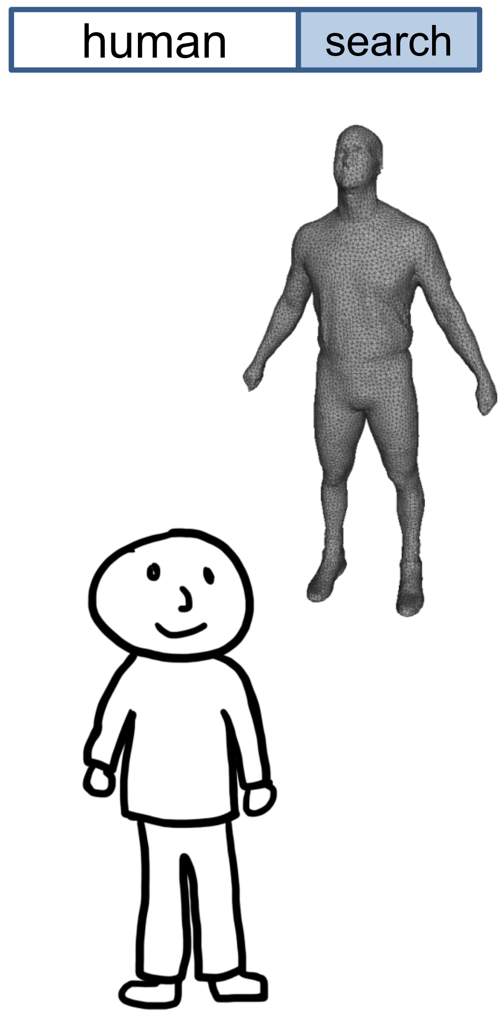



- 3D model retrieval is essential.
  - Ease of use. → Sketch-based query
  - Efficiency. → Binary features
  - High retrieval accuracy. → Better feature similarities

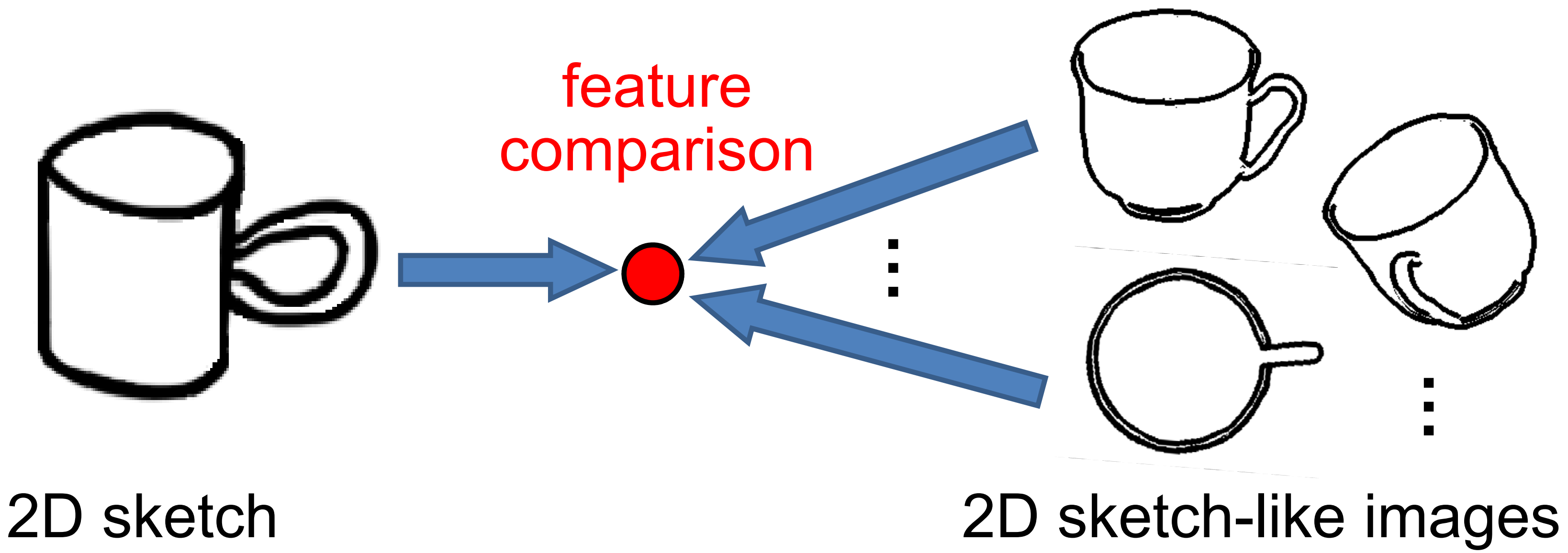
Why sketch-based ?

- Keywords
  - ✓ Accessible for most people.
  - × 3D models lack keyword tags.
- 3D model
  - ✓ Sufficiently accurate for certain applications.
  - × 3D models often unavailable.
- 2D sketch
  - ✓ Accessible for most people.
  - ✓ Intuitively specify 2D shape.
  - × Inaccurate.
  - × Inefficient.



Cross-modal matching problem

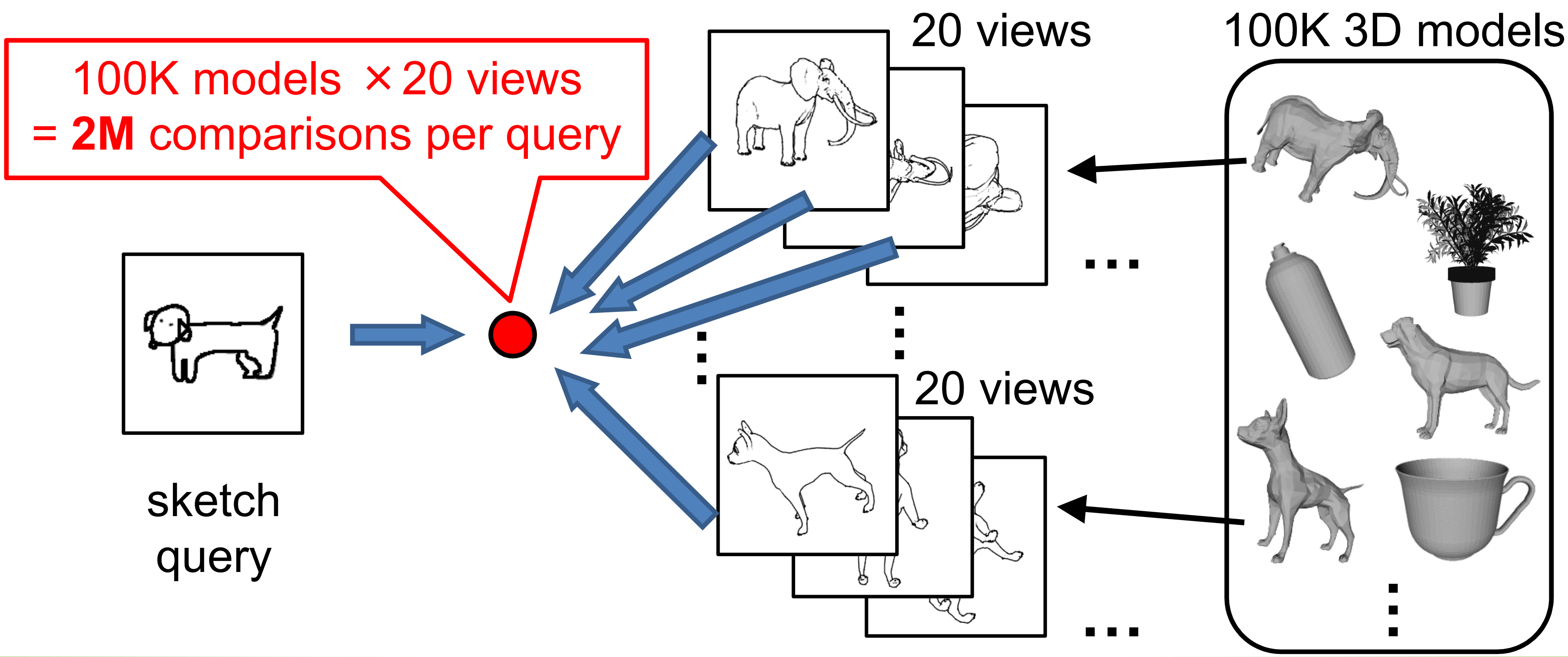
- Approach 1 : Image feature-based comparison.
  - Renders 3D models into lines.
    - e.g., Suggestive contour [DeCarlo03], …
  - Adopted by most ([Yoon10], [Shao11], [Eitz12], …).



Cross-modal matching problem

- Approach 1 : Image feature-based comparison.

Time-consuming for large-scale database.



Cross-modal matching problem

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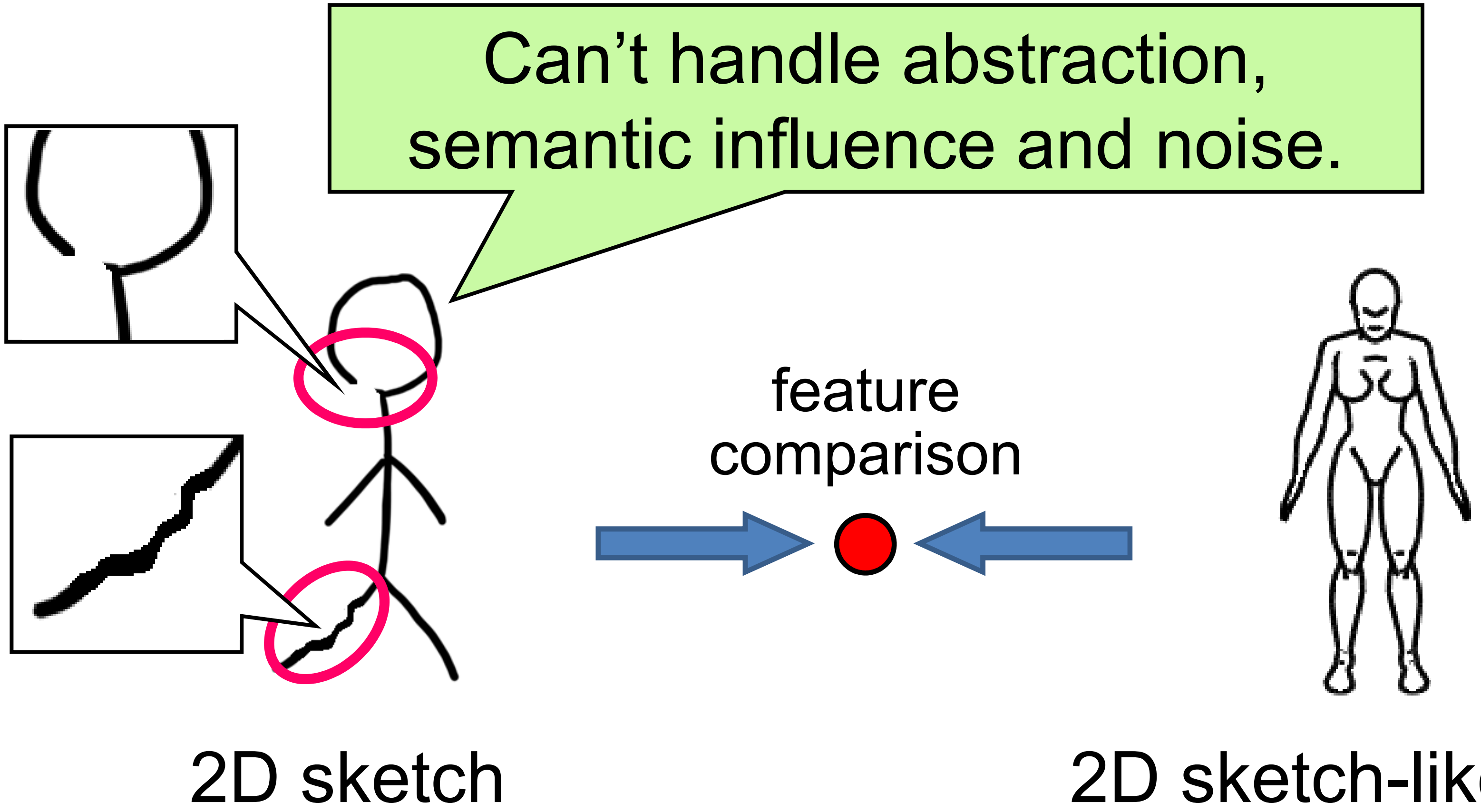
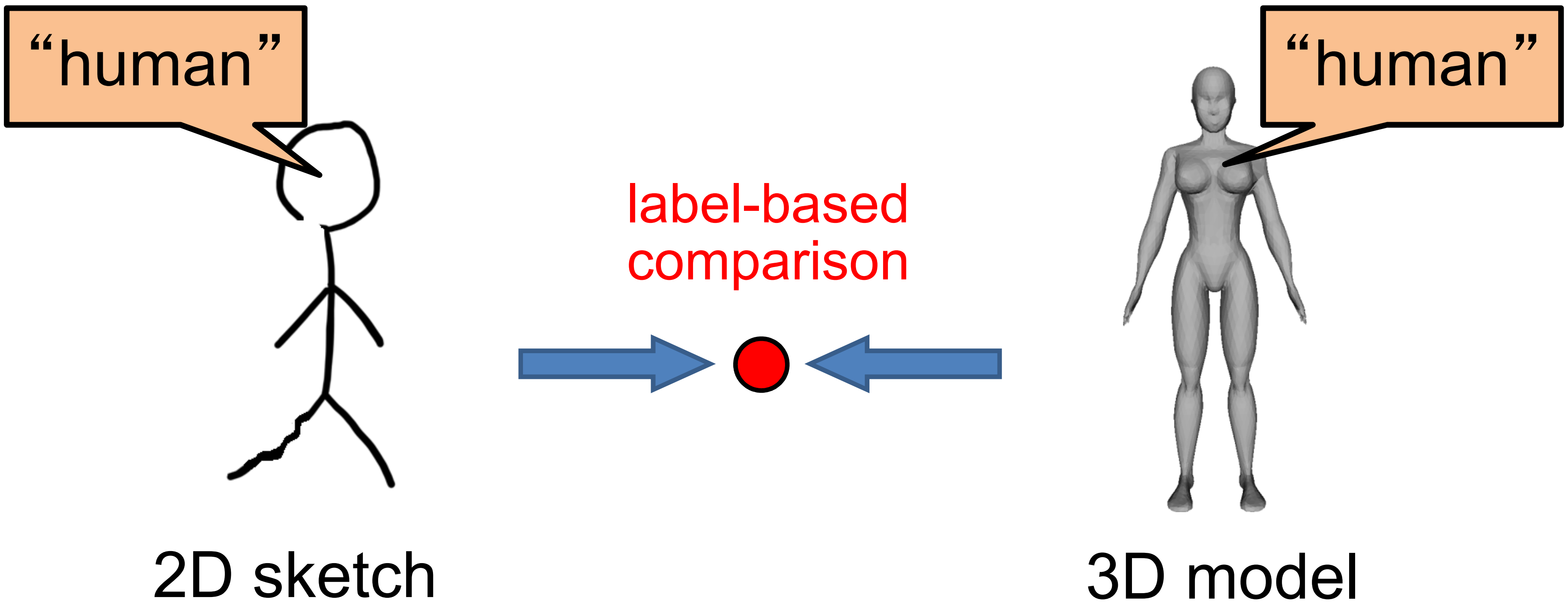


Cross-modal matching problem

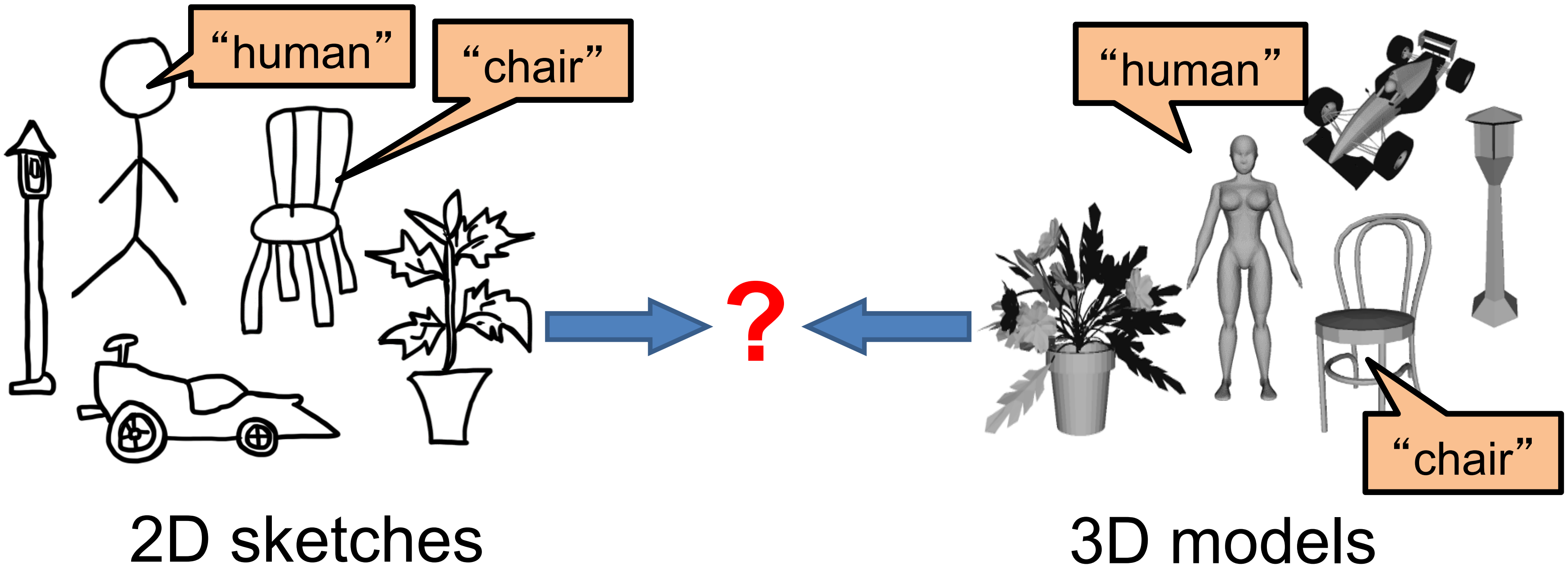
- Approach 2 : Semantic label-based comparison.



Cross-modal matching problem

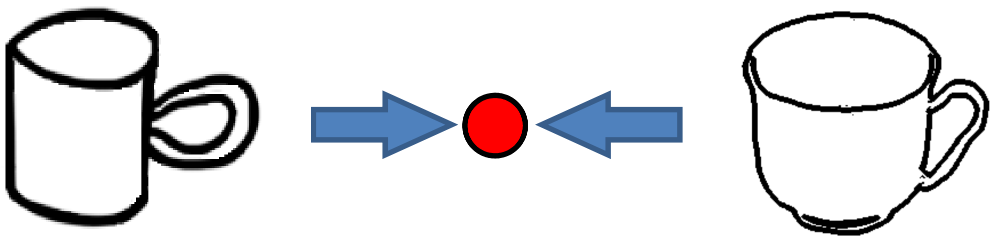
- Approach 2 : Semantic label-based comparison.

Learning sparse labeling is difficult.

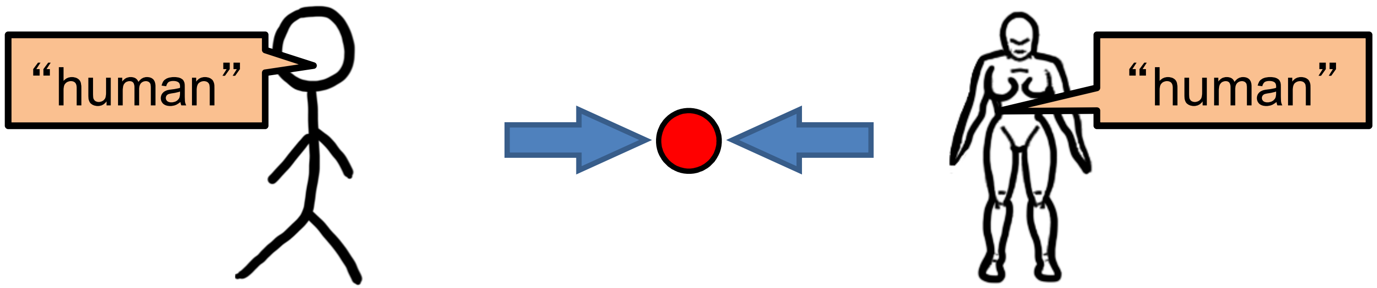


Our approach

- Efficiently & effectively combine features and labels.
  - ✓ Matching by image feature-based similarity.



  - ✓ Matching by semantic label-based similarity.

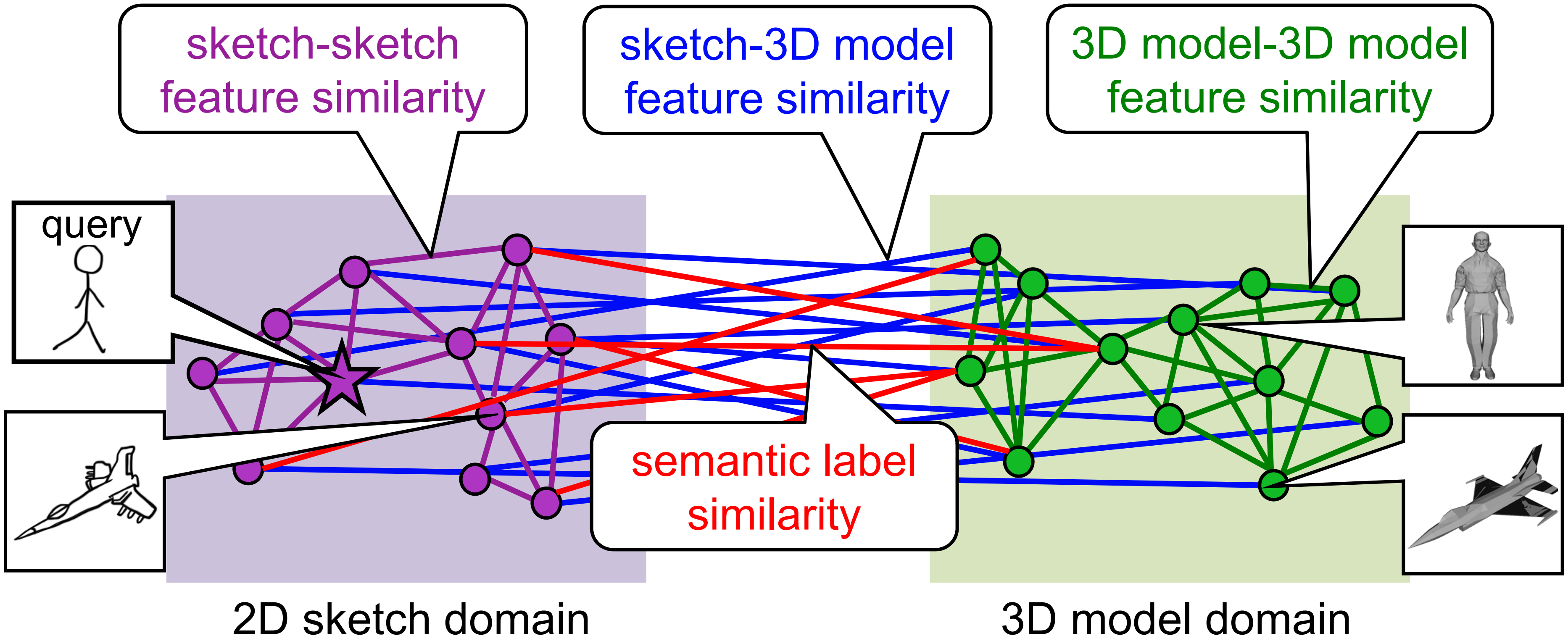


Outline

- Our previous work
  - Cross-Domain Manifold Ranking [Furuya13]
    - Algorithm for cross-modal similarity metric learning
- Proposed method
- Experiments and results
- Conclusion and future work

Our previous work :
Cross-Domain Manifold Ranking (CDMR)

- Ranking by diffusion distance on a Cross-Modal Manifold (CMM) [Furuya13].



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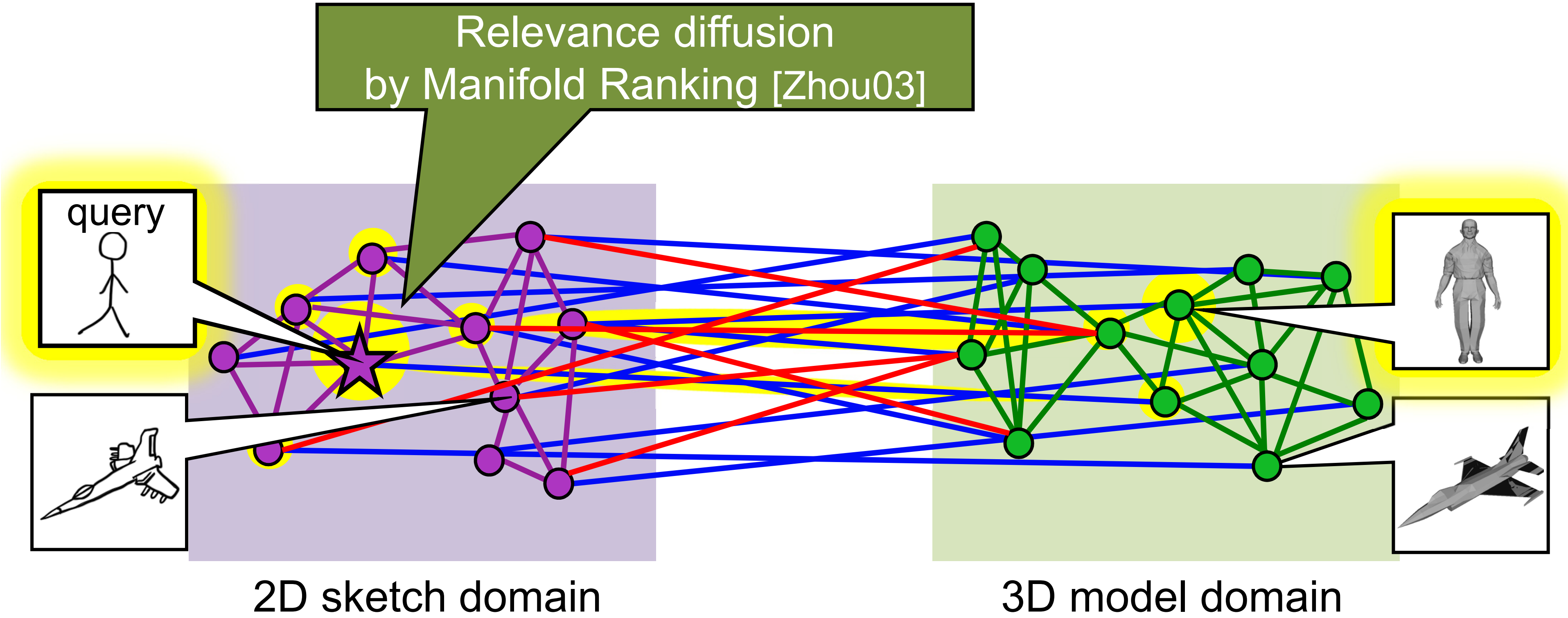


Our previous work :
Cross-Domain Manifold Ranking (CDMR)

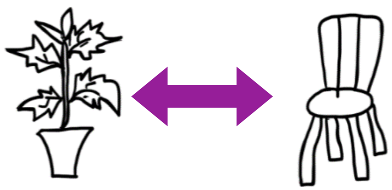
Lack of scalability.

Costly relevance diffusion per query.

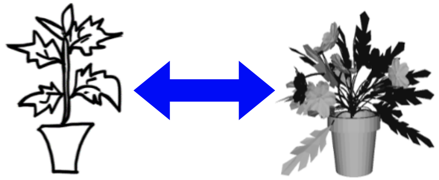
Insufficient accuracy.

"Outdated" visual features.

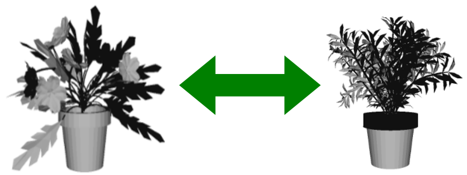
BF-fGALIF
[Eitz12]



BF-fGALIF
[Eitz12]



BF-DSIFT
[Furuya09]



Our previous work :
Cross-Domain Manifold Ranking (CDMR)

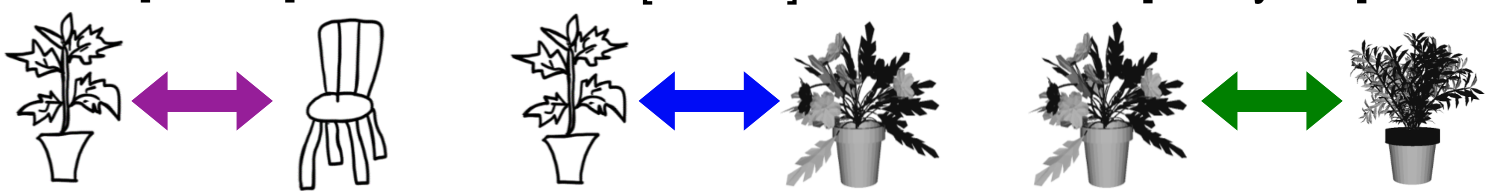
Lack of scalability. → **Hashing CMM (comparison by binary codes)**

Costly relevance diffusion per query.

Insufficient accuracy. → **Better features**

“Outdated” visual features.

BF-fGALIF [Eitz12] | BF-fGALIF [Eitz12] | BF-DSIFT [Furuya09]



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  - Cross-Modal Manifold Hashing (CMMH) algorithm
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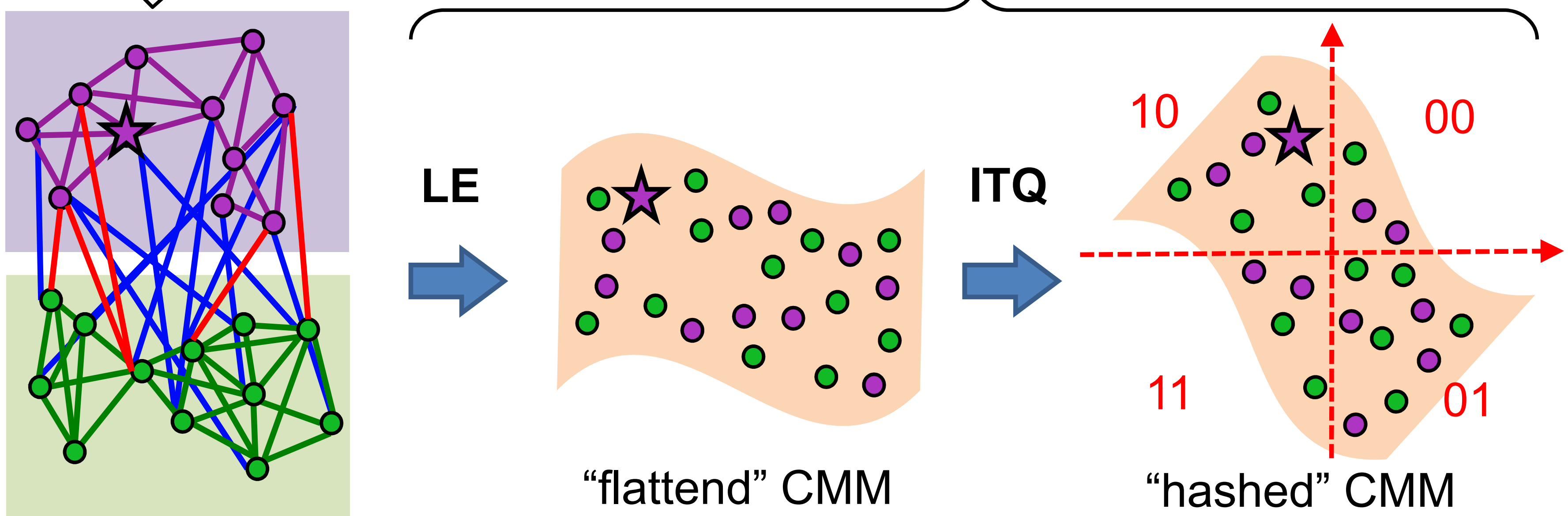
Proposed method
Cross-Modal Manifold Hashing (CMMH)

Accuracy: better features
- Improved visual features
  (efficient for large-scale CMM)

Efficiency: hashing CMM
- Manifold learning + hashing
  (Laplacian Eigenmaps (LE) [Belkin03]
  + Iterative Quantization (ITQ) [Gong12])



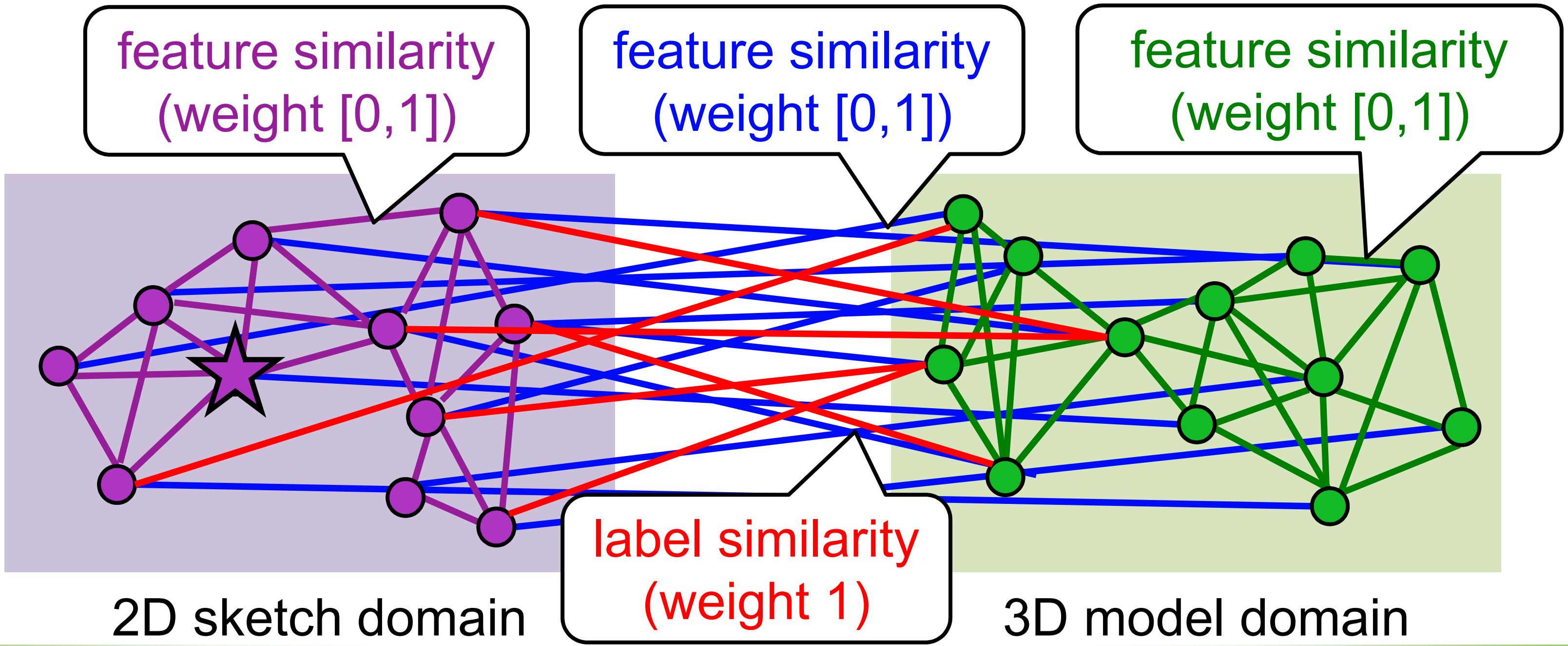
CMM

“flattend” CMM
(real-valued space)

“hashed” CMM
(Hamming space)

Cross-Modal Manifold Hashing (CMMH)

- Hashes the CMM to generate compact binary codes.
  1. Generates the CMM.
  2. “Flattens” the CMM by Laplacian Eigenmaps (LE).
  3. Hashes the flattened CMM by Iterative Quantization (ITQ).



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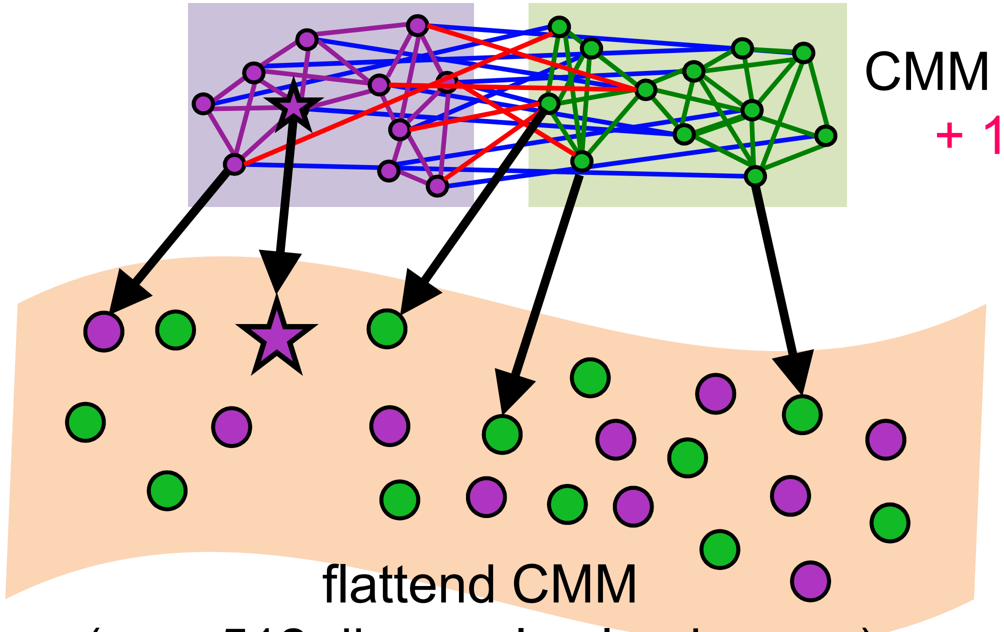

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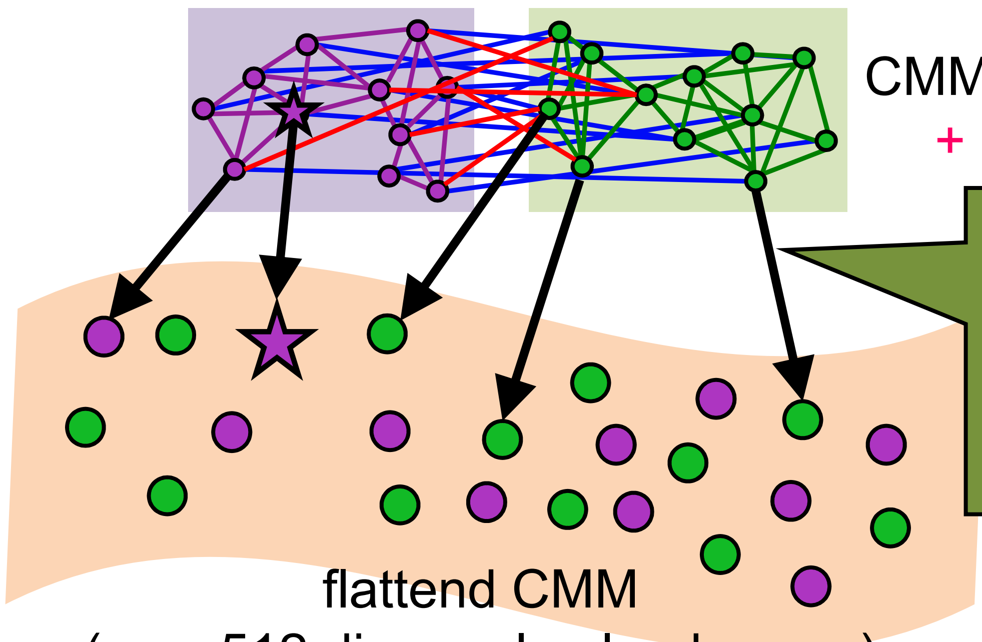

Proposed method

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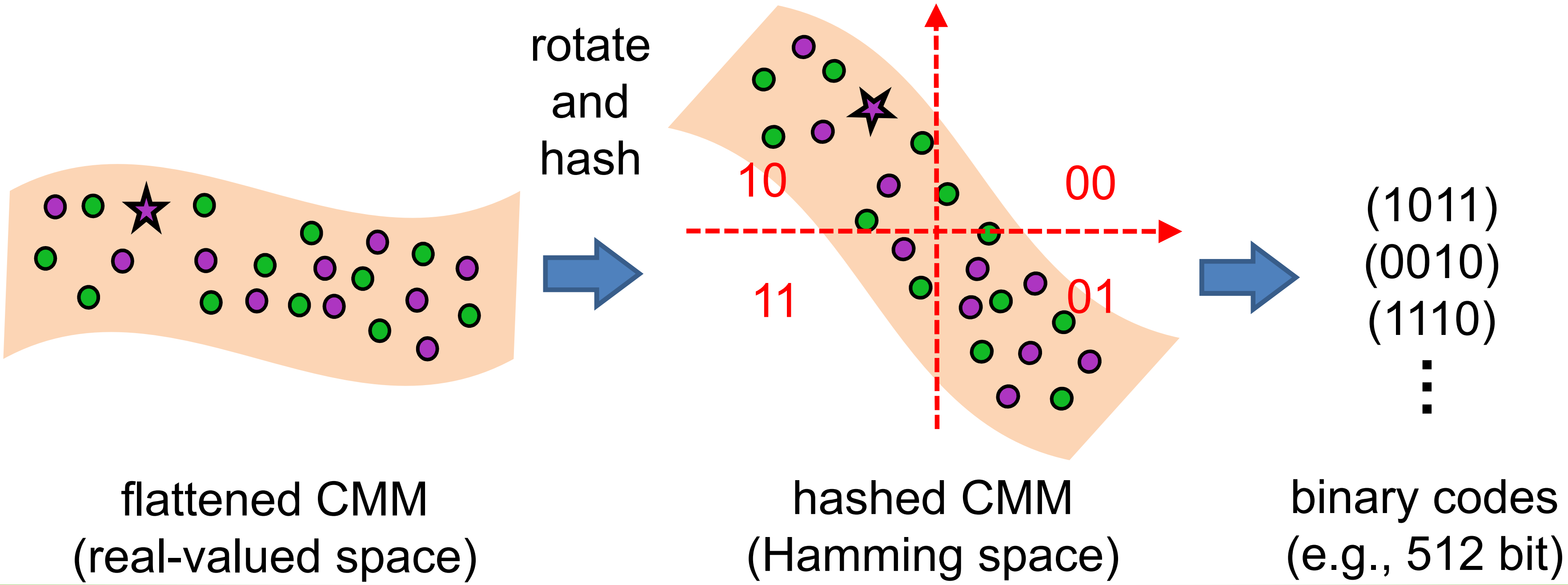
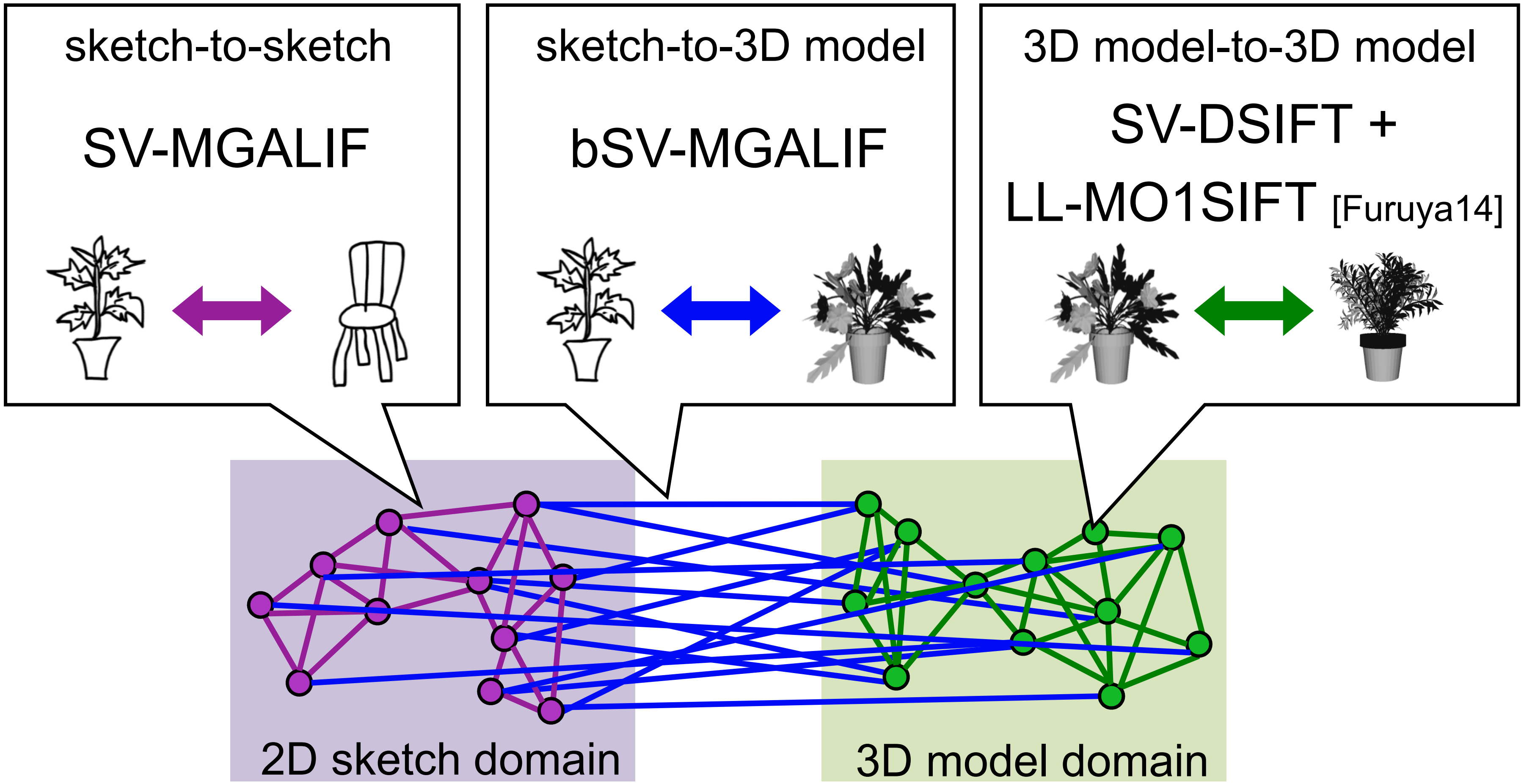


Proposed method
Improved feature similarity



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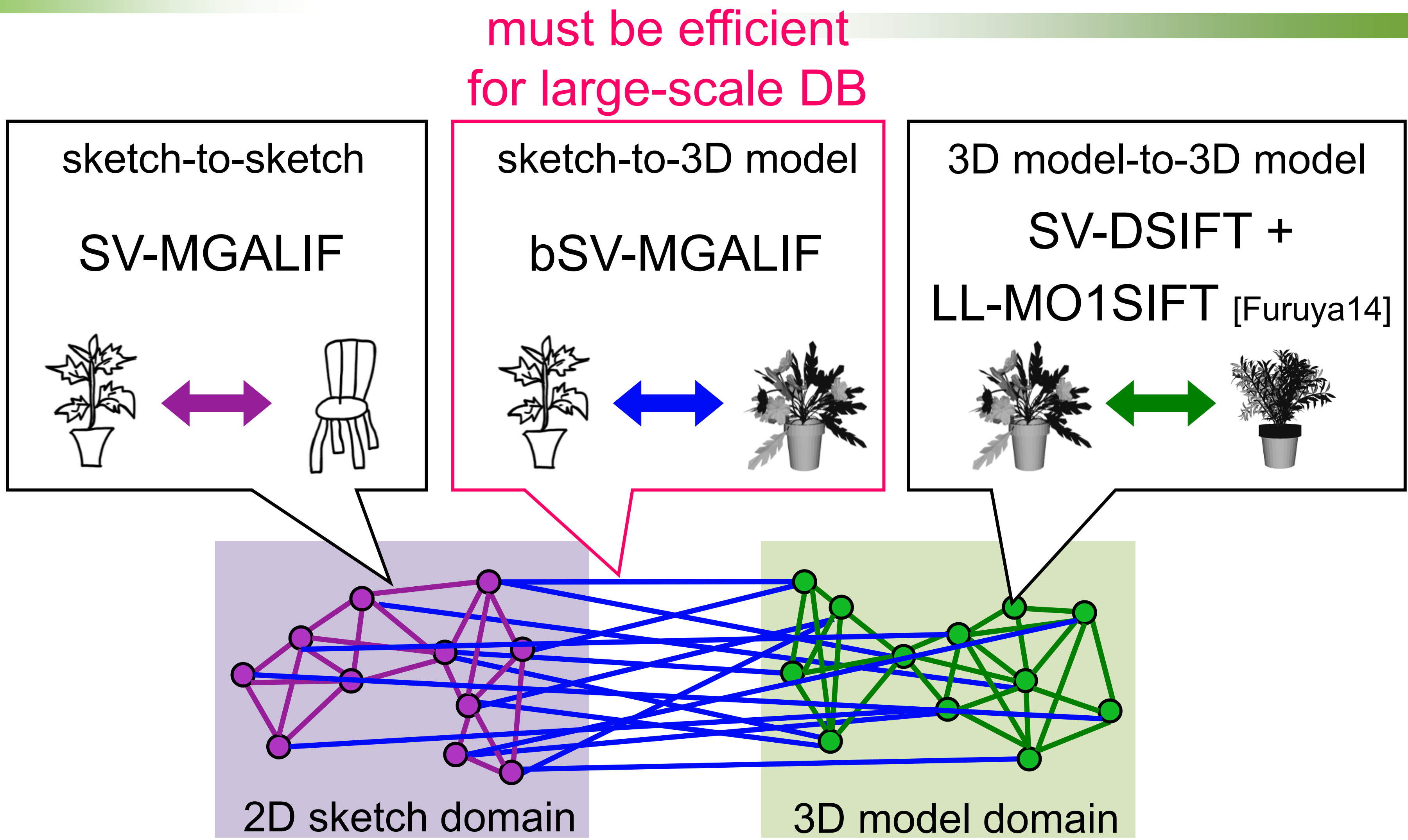
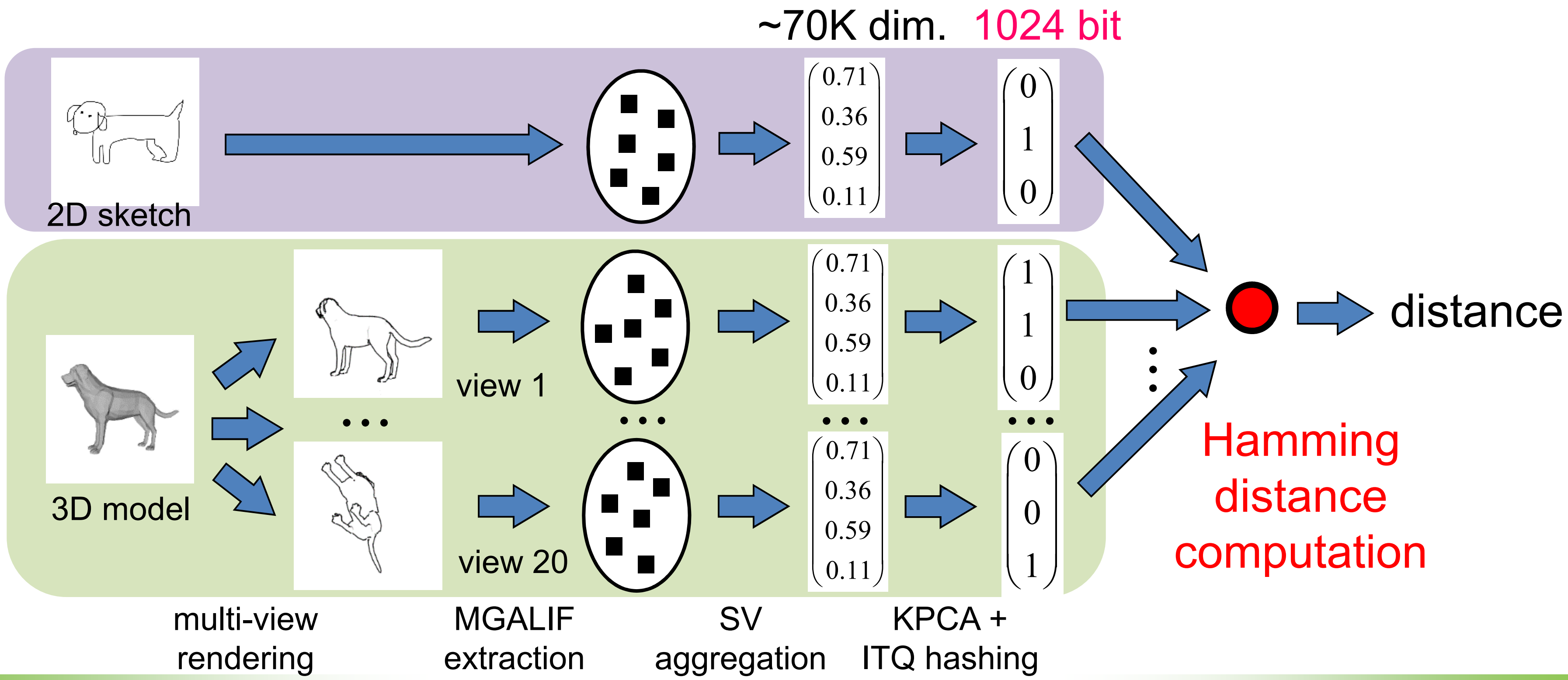


Proposed method
Improved sketch-to-3D-model similarity

- bSV-MGALIF
  - Multi-scale GALIF + Super Vector (SV) for accuracy.
  - ITQ hashing for efficiency.



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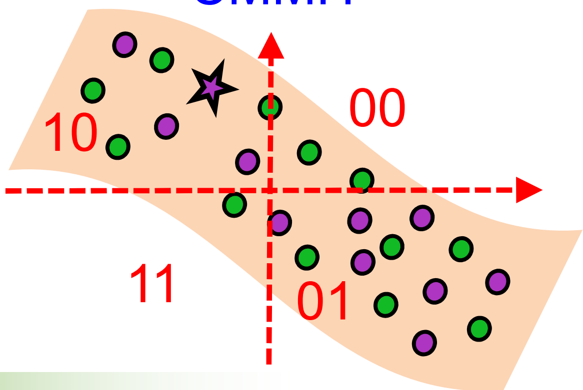
Experiments

- Evaluate accuracy and efficiency.
  - Visual features for CMM.

New Feature Set (NFS)		Old Feature Set (OFS) [Furuya13]
・SV-MGALIF ・bSV-MGALIF ・SV-DSIFT + LL-MO1SIFT	VS	・BF-fGALIF ・BF-fGALIF ・BF-DSIFT

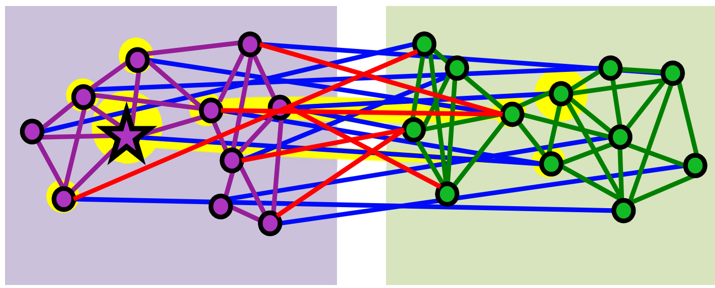
  - Cross-modal similarity metric learning algorithms.

CMMH



VS

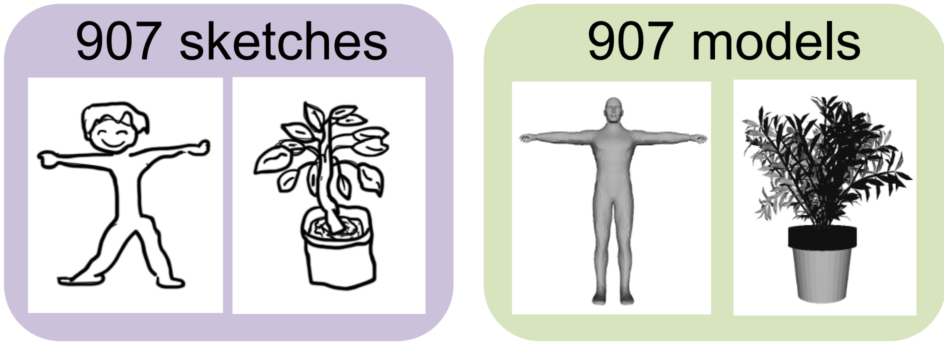
CDMR [Furuya13]



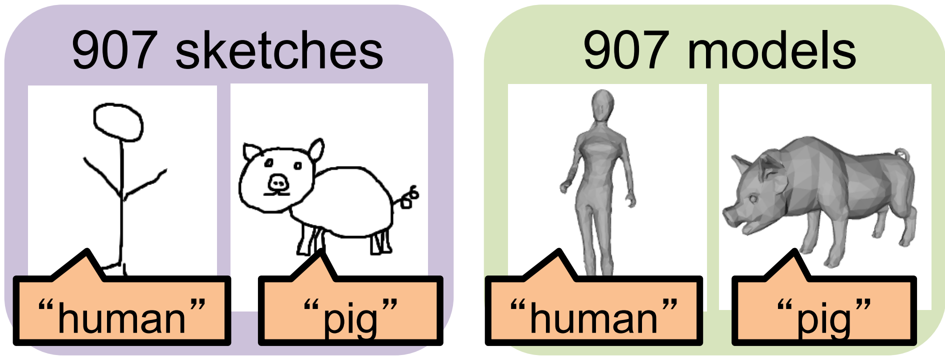
Experiments
Small-scale benchmark database

- S-PSB [Eitz12]

・Test set (90 categories)

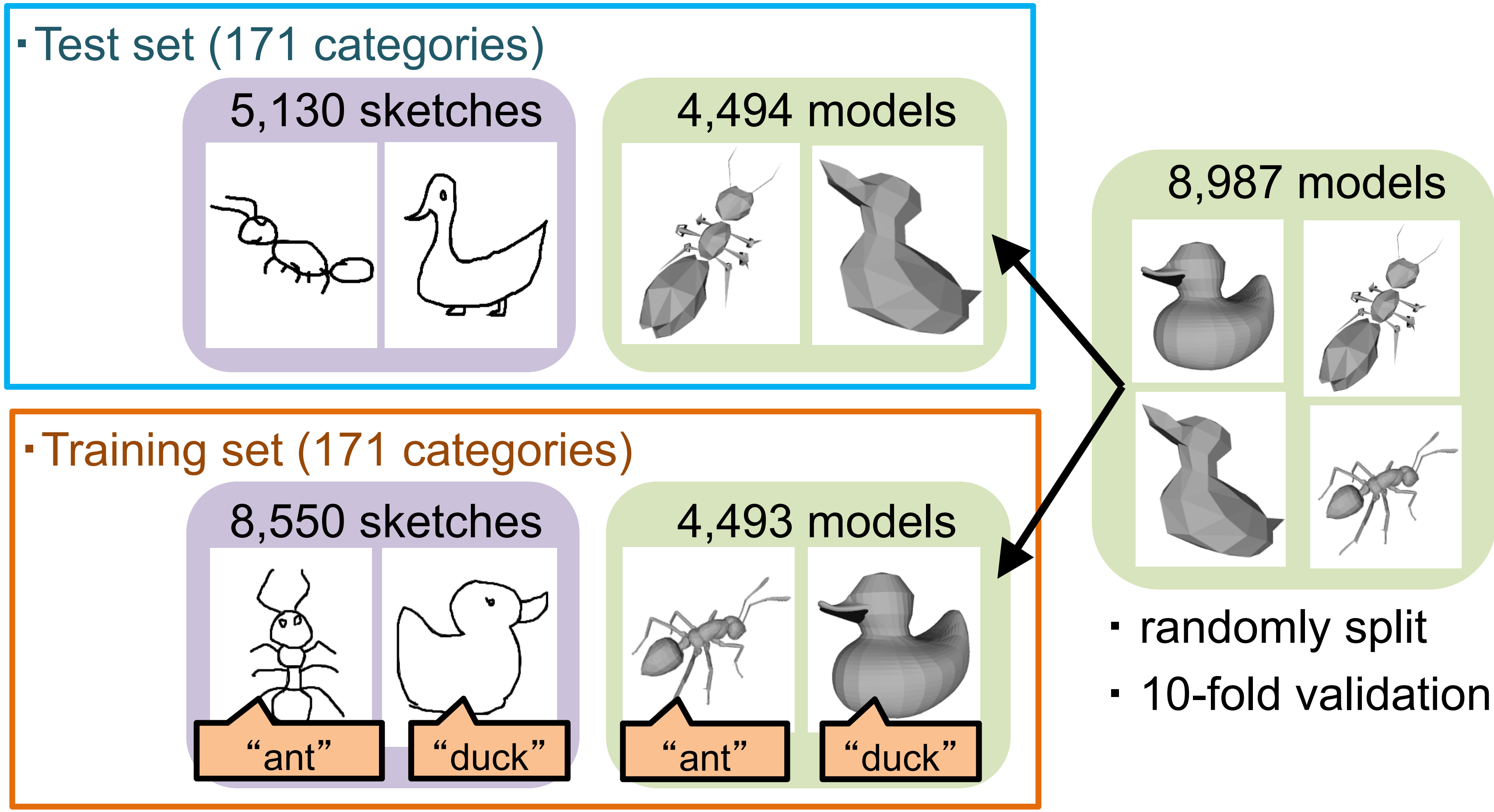


・Training set (92 categories)



Experiments
Medium-scale benchmark database

- SHREC2014 sketch-based 3D shape retrieval (SH14) [Li14]



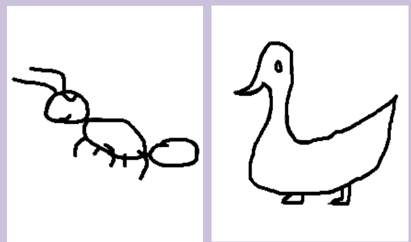
- randomly split
- 10-fold validation

Experiments
Large-scale benchmark database

- SH14X (100K 3D models)

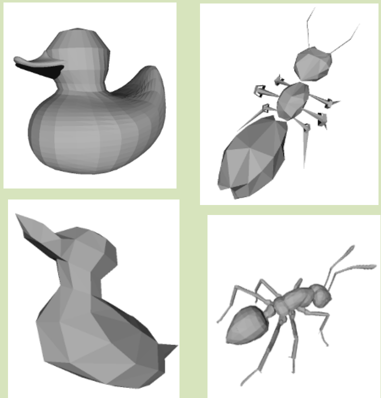
・Test set (171 categories)

5,130 sketches



(same as SH14)

8,987 models



(same as SH14)

＋

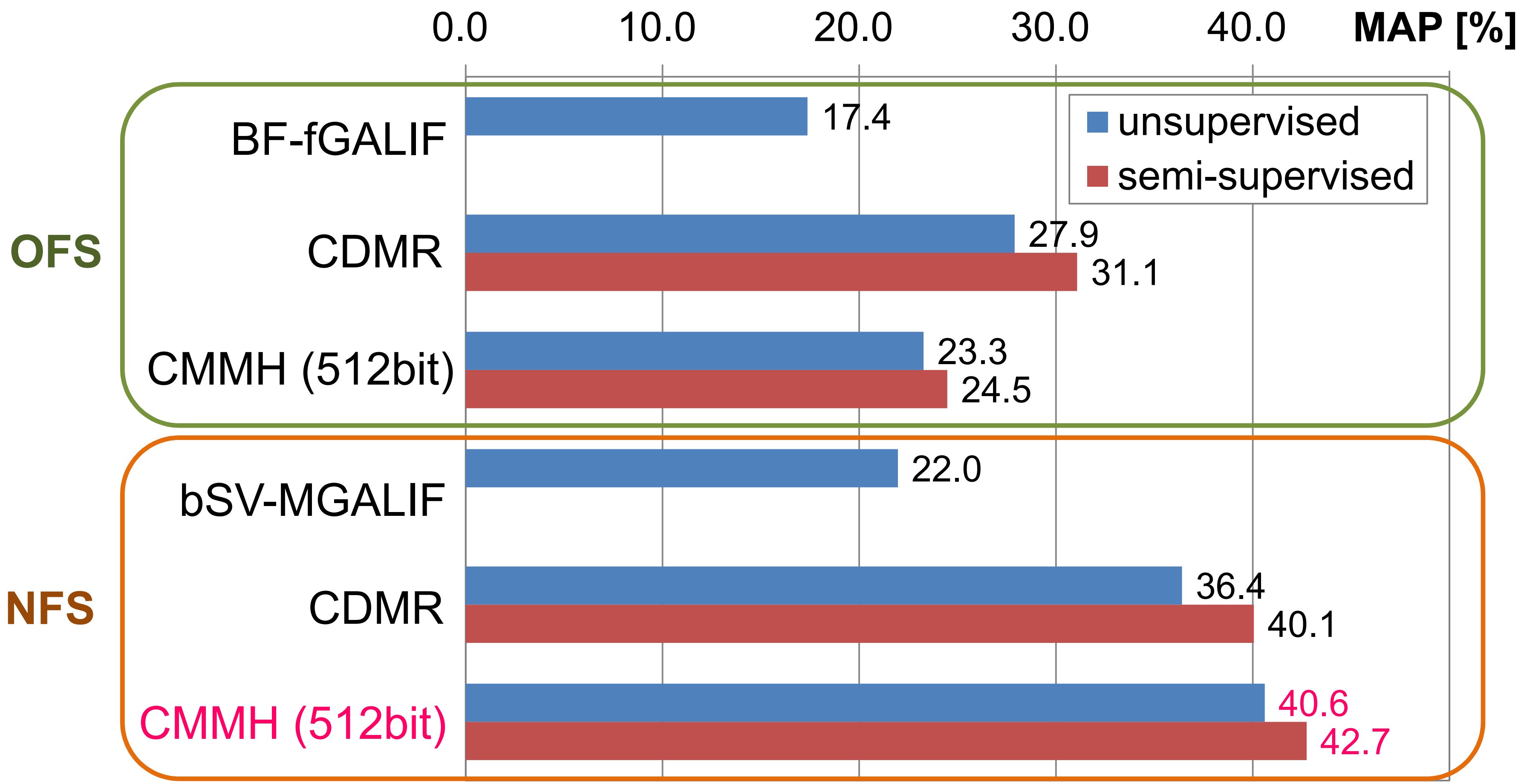
91,013 “imposters”

randomly transformed SH14 3D models

100K models

Experimental results
Effectiveness of new visual features (S-PSB)

- Proposed visual features (NFS) are more accurate.



Experimental results
Efficiency of CMMH

- CMMH is efficient even for 100K-model database.
  - About 1 second per query.
  - Less than 1 GByte memory footprint.
- CDMR has a large memory footprint.

Comparison of efficiency for SH14X.

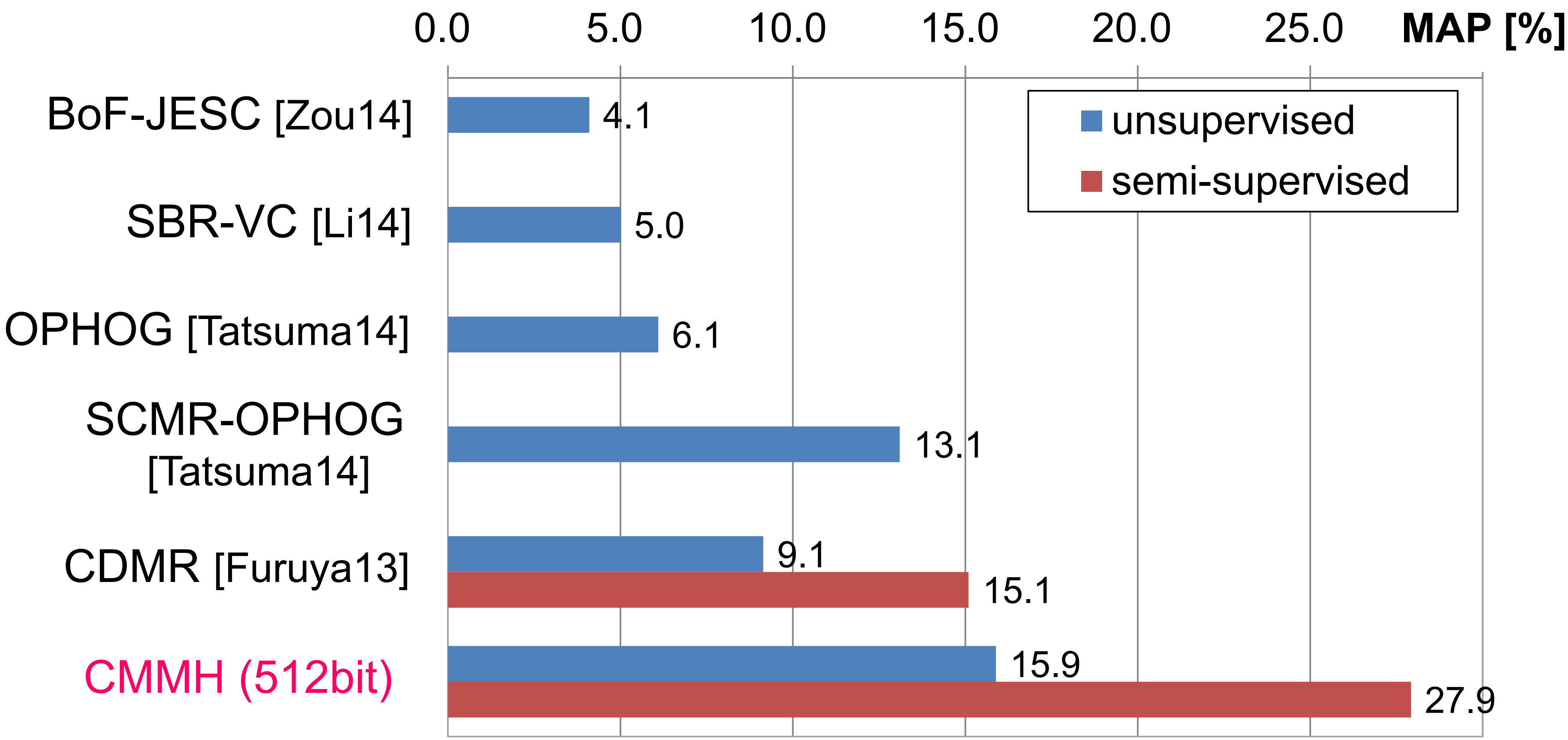
Algorithms	Computation time per query [s]	Memory footprint for retrieval [GBytes]
CDMR		53.66
CMMH (512 bit)	**1.25**	**0.78**

measured by using two Intel Xeon E5-2650 CPUs
256 GB RAM, Nvidia GeForce GTX 770 GPU

Experimental results

Comparison with other retrieval algorithms (SH14)

- More accurate than state-of-the-arts.



Conclusion and Future work

- Conclusion
  - Efficient & accurate sketch-based 3D model retrieval.
    - Cross-Modal Manifold Hashing (CMMH)
      - About 1 second to query 100K-model database.
      - More accurate than state-of-the-arts.
- Future work
  - Further improvement in retrieval accuracy.
  - Evaluation using realistic large-scale database.
    - No “imposters”.

☺ **Poster : 3-29**