Seeing 3D chairs:

Exemplar part-based 2D-3D alignment using a large dataset of CAD models

Mathieu Aubry (INRIA)

Daniel Maturana (CMU)

Alexei Efros (UC Berkeley)

Bryan Russell (Intel)

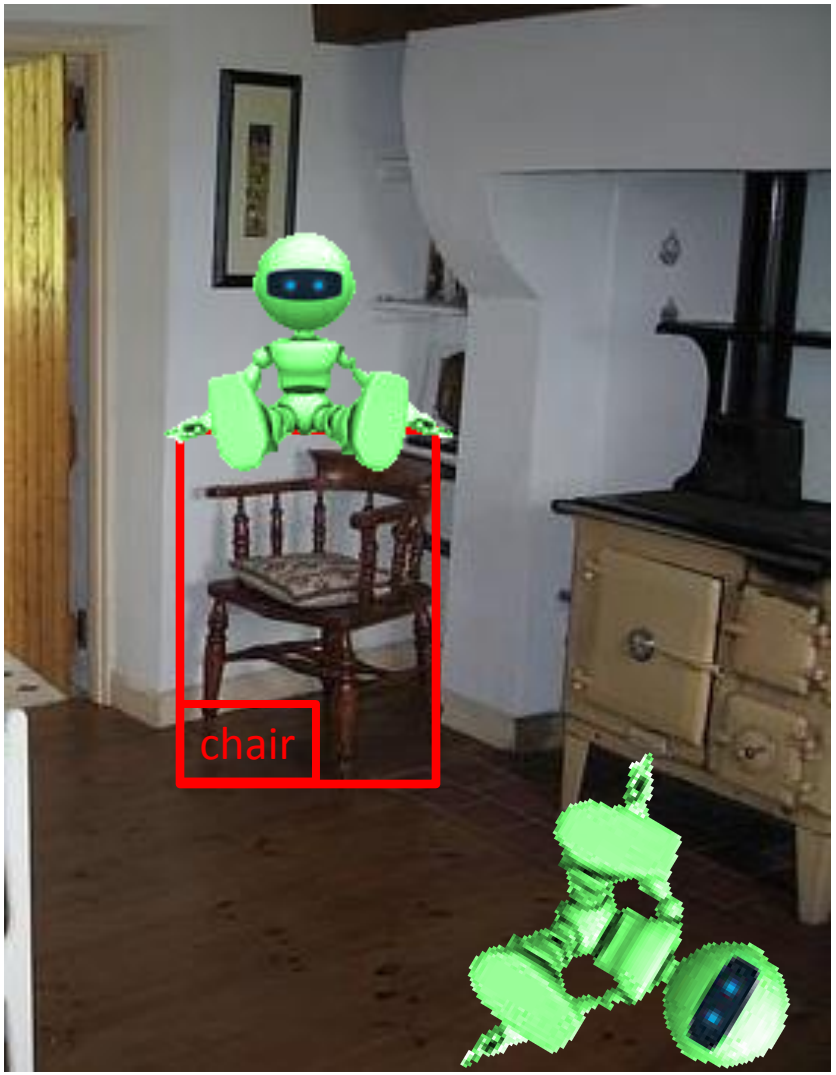
Josef Sivic (INRIA)

Sit on the chair!

Classification

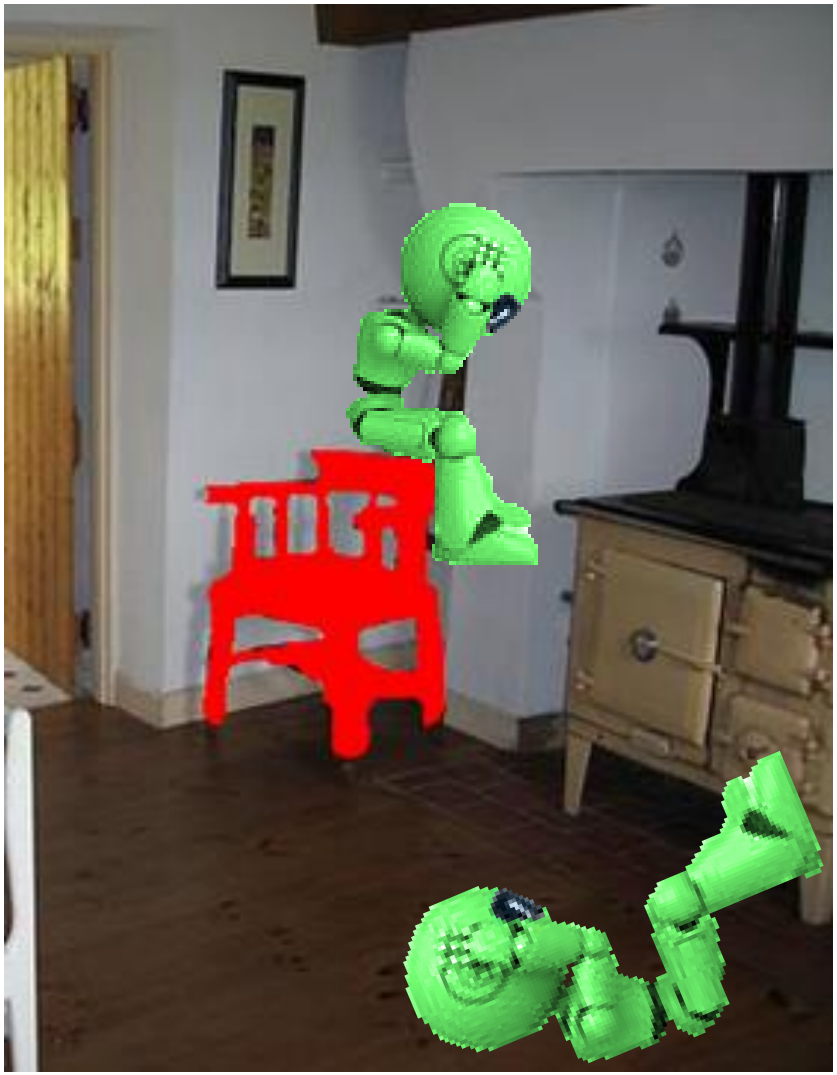
Ex: ImageNet Challenge, Pascal VOC classification.

Detection



Ex: Pascal VOC detection.

Segmentation

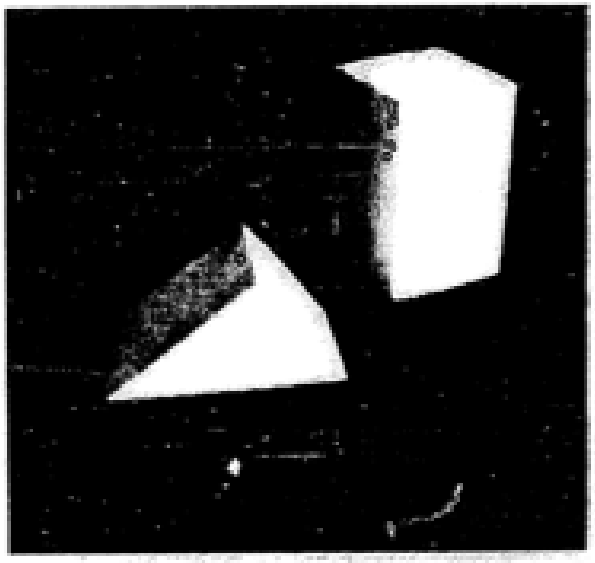


Ex: Pascal VOC segmentation.

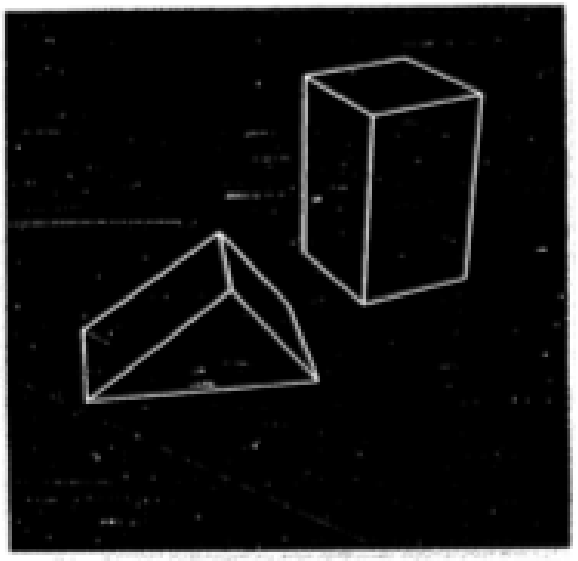
Our goal

From the beginning of computer vision

First PhD in computer vision, MIT 1963
Lawrence G. Roberts
Machine perception of three-dimensional solids

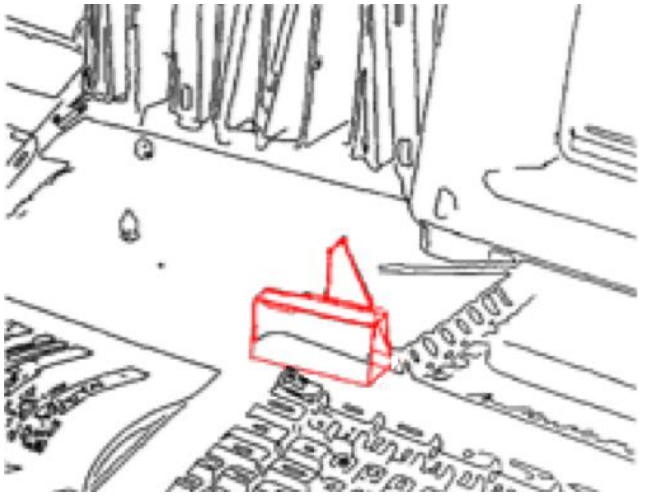


Photograph

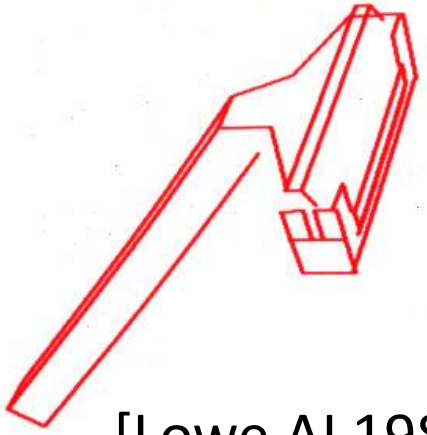


3D model

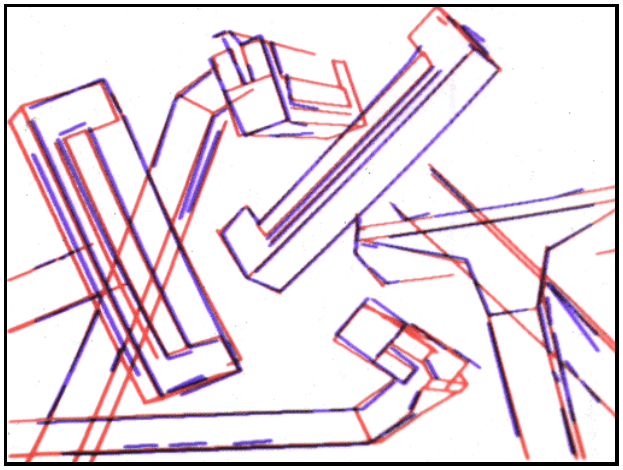
1980s: 2D-3D Alignment

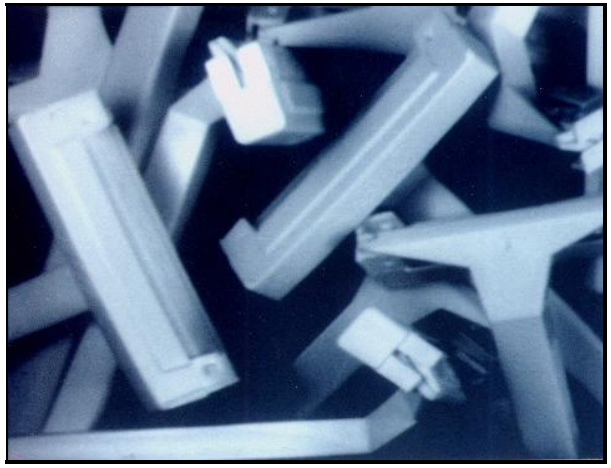


[Huttenlocher and Ullman IJCV 1990]



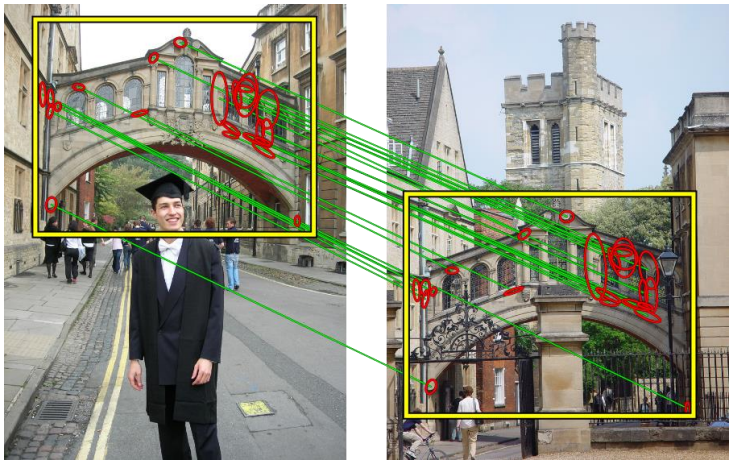
[Lowe AI 1987]



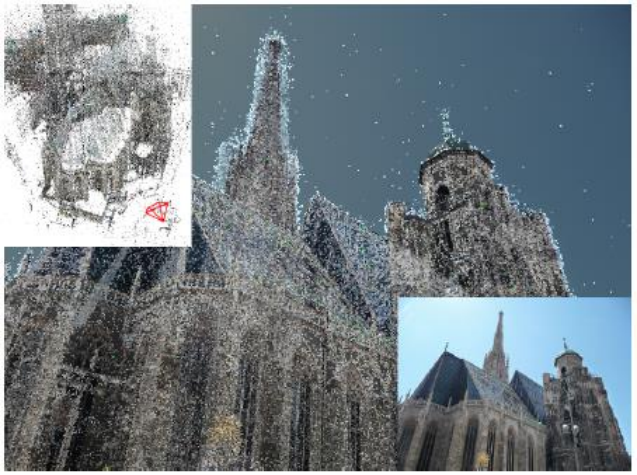


[Faugeras&Hebert'86], [Grimson&Lozano-Perez'86], …

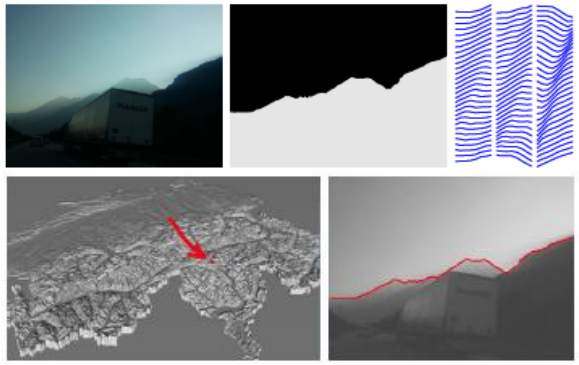
Exact Instance alignment



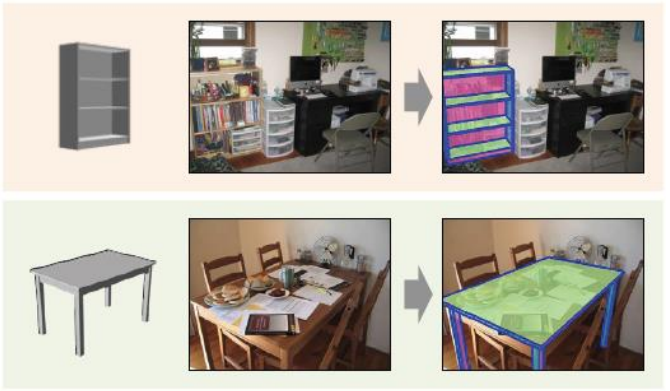
[Philbin et al. CVPR 2007]



[Sattler et al. ICCV 2011]



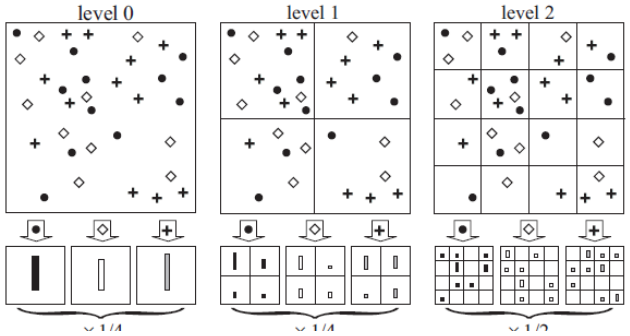
[Baatz et al. ECCV 2012]



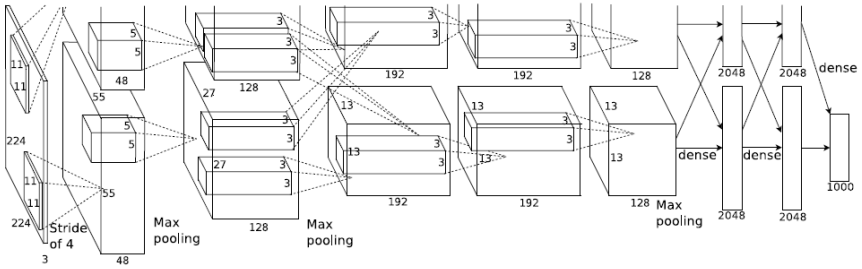
[Lim et al. ICCV 2013]

See also [Rothganger et al. CVPR 2003] ,[Arandjelović and Zisserman ICCV 2011], [Li et al. ECCV 2012], [Snavely et al. SIGGRAPH 2006] …

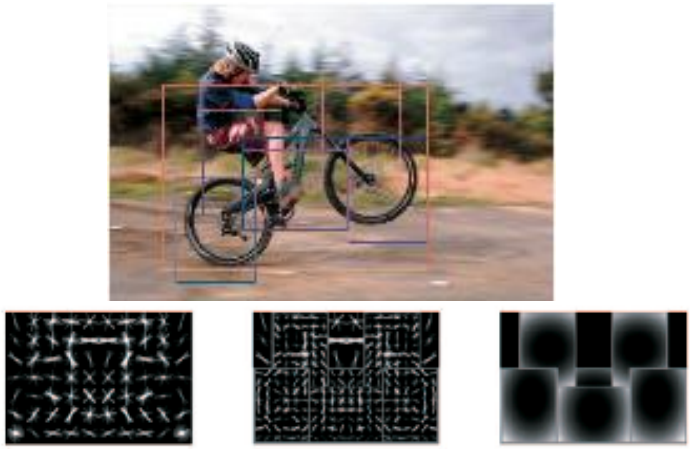
2D category recognition



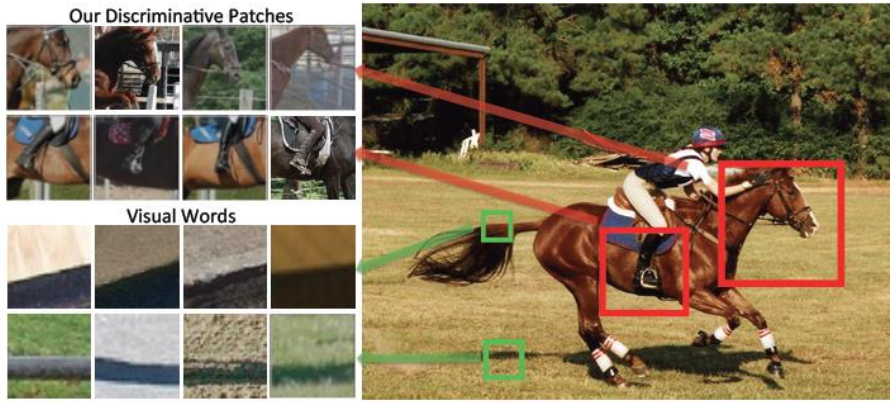
[Lazebnik et al. CVPR 2006]



[Krizhevsky et al. NIPS 2012]



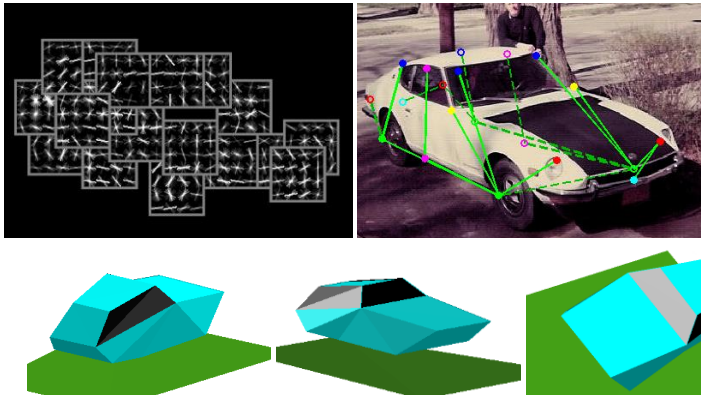
[Felzenszwalb et al.PAMI 2010]



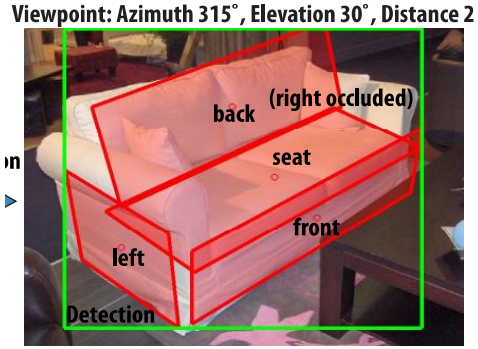
[Singh et al. ECCV 2012]

See also : [Dalal and Triggs CVPR 2005], [Bourdev and Malik ICCV 2009], [Malisiewicz et al. ICCV 2011] ...

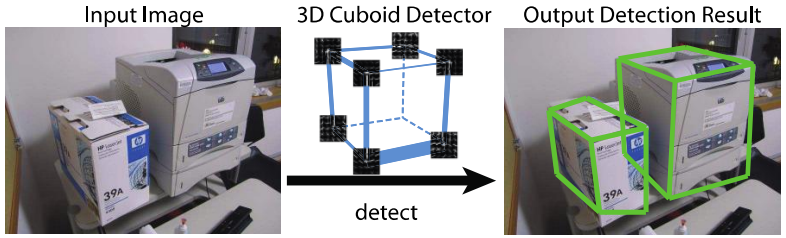
3D category recognition



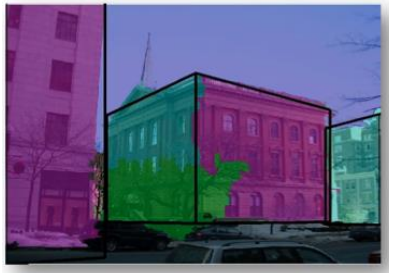
3D DPMs: [Herjati&Ramanan'12], [Pepik et al.12], [Zia et al.'13], …



Simplified part models: [Xiang&Savarese'12], [Del Pero et al.'13]



Cuboids: [Xiao et al.'12] [Fidler et al.'12]



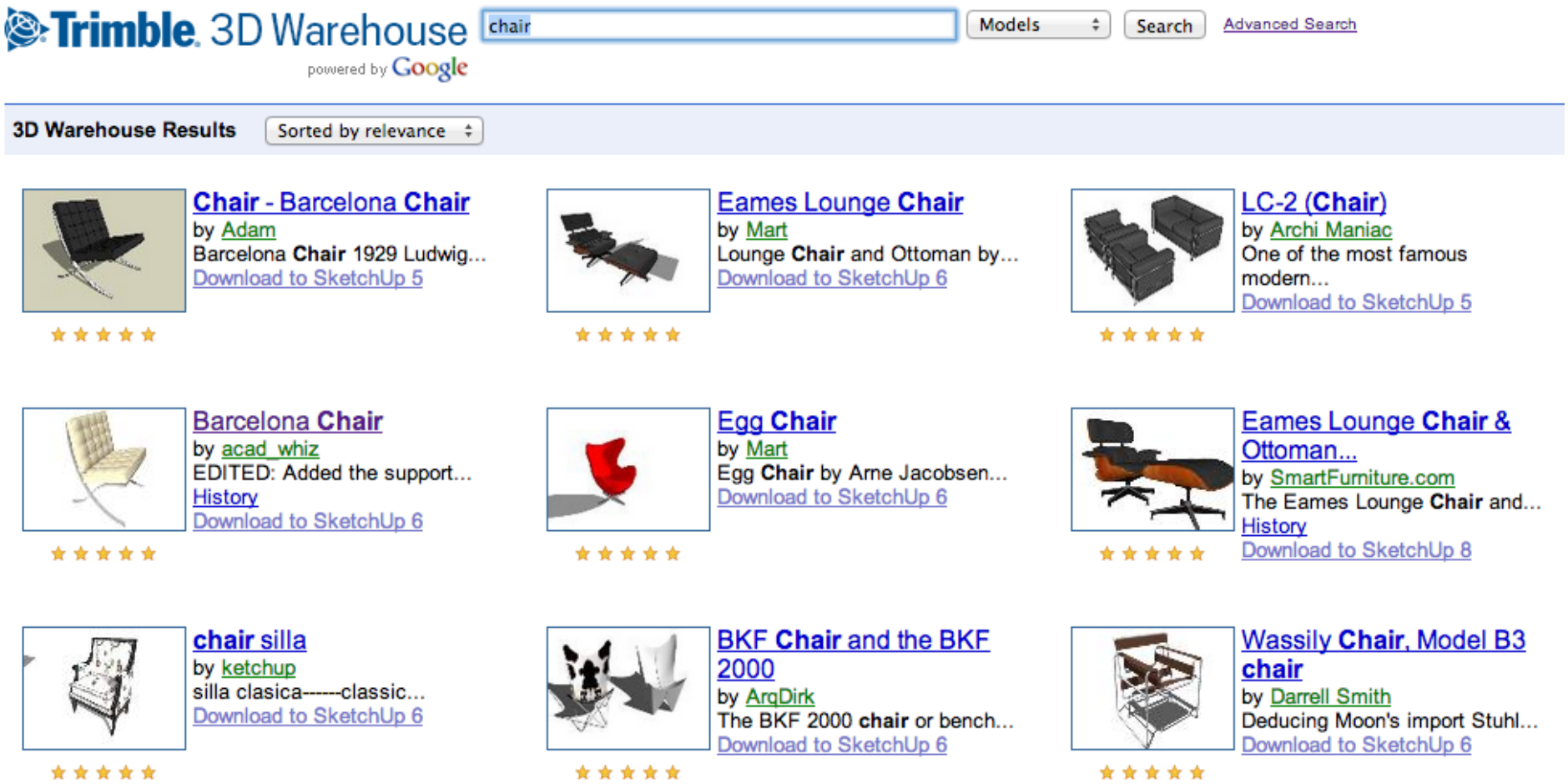
Blocks world revisited: [Gupta et al.'12]

See also: [Glasner et al.'11], [Fouhey et al.'13], [Satkin&Hebert'13], [Choi et al. ' 13], [Hejrati and Ramanan '14], [Savarese and Fei-Fei ' 07]…

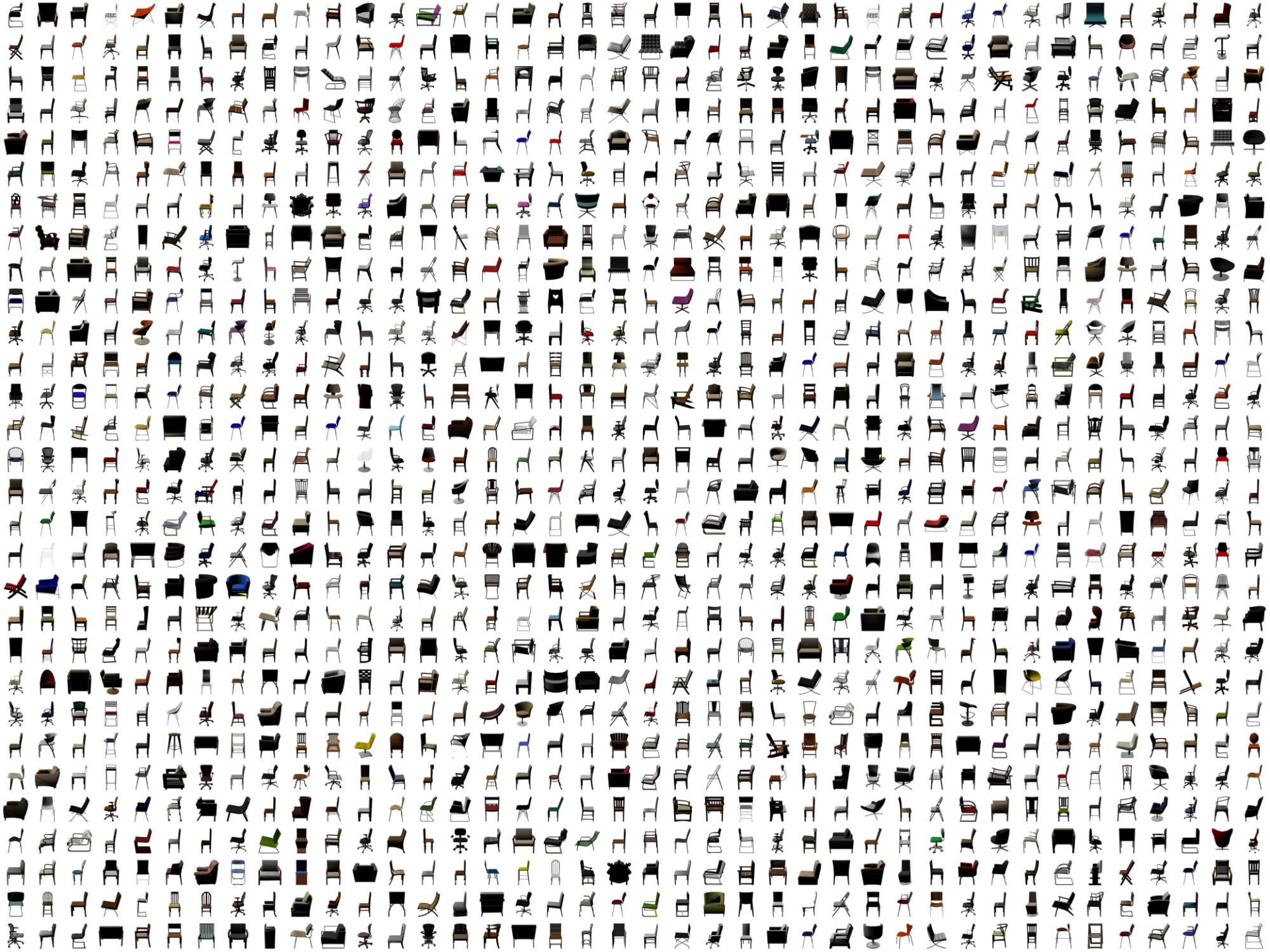
Why chairs?

Difficulty: style

Approach: data-driven

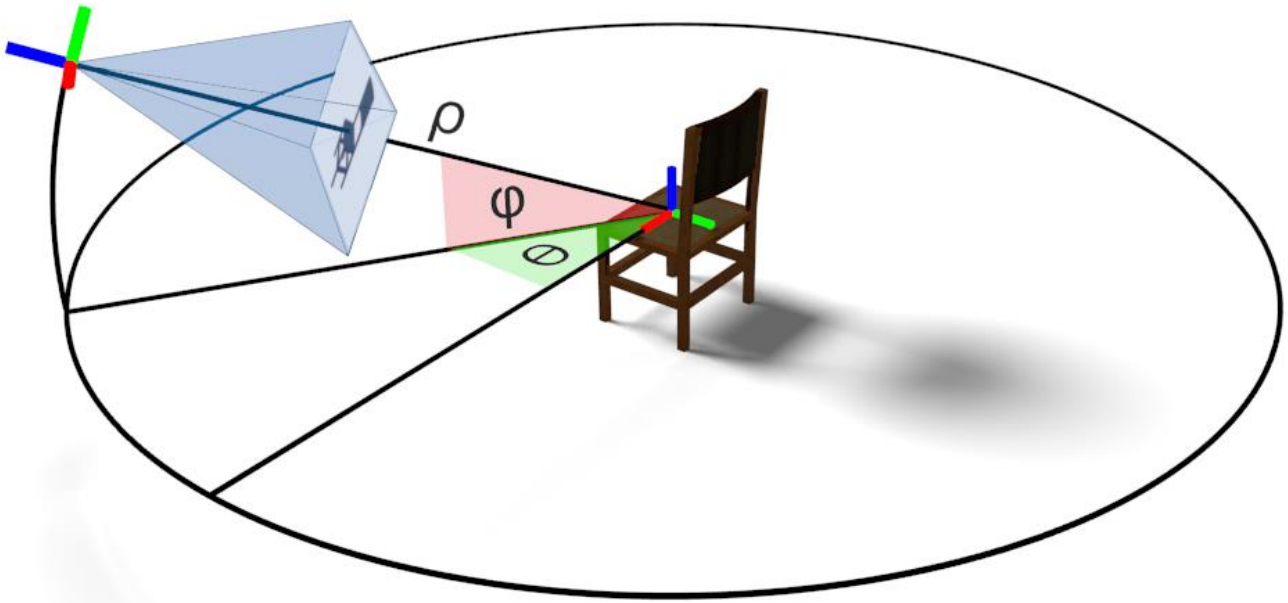


1394 3D models from internet

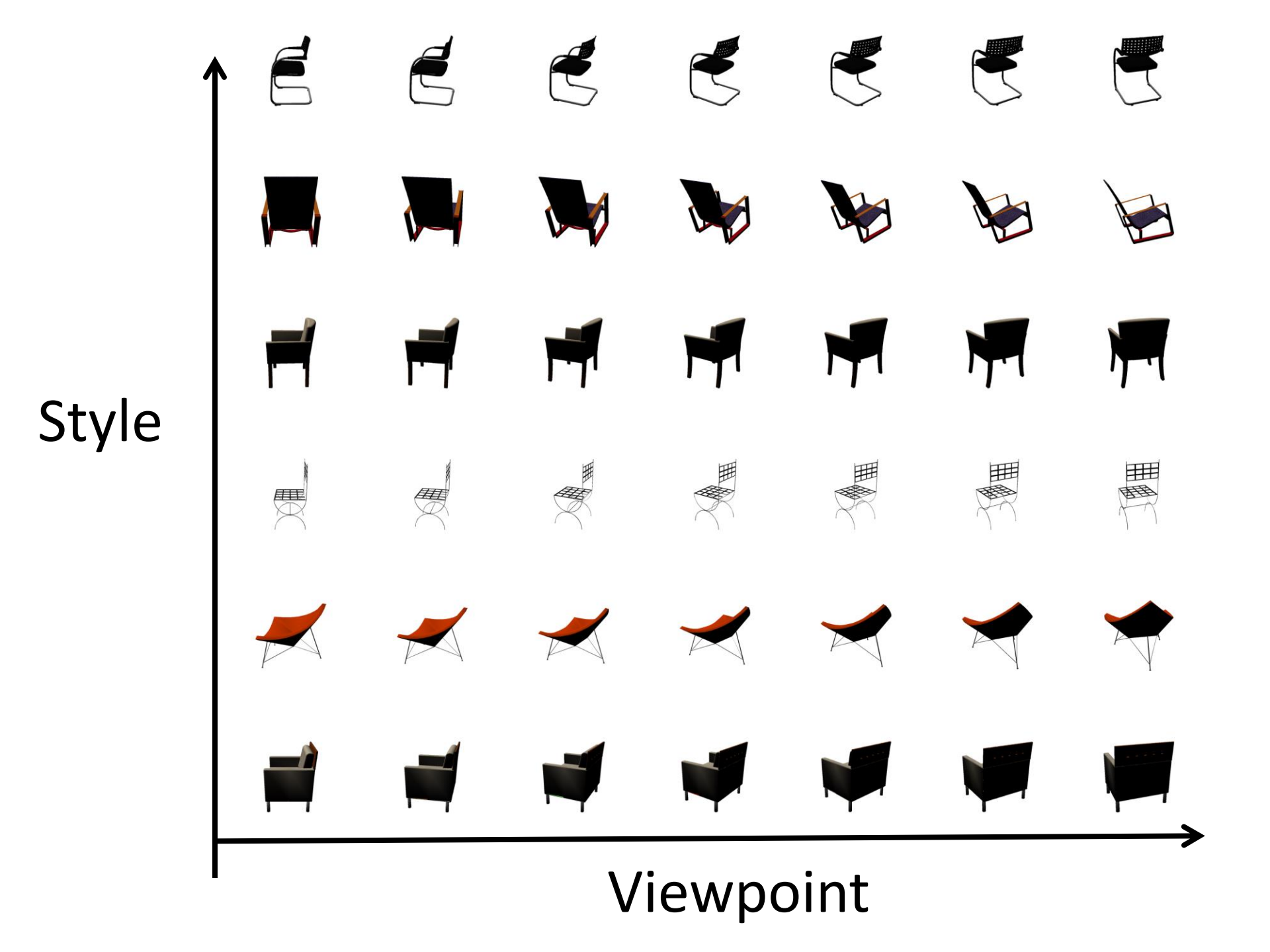


Difficulty: viewpoint

Approach: use 3D models



62 views

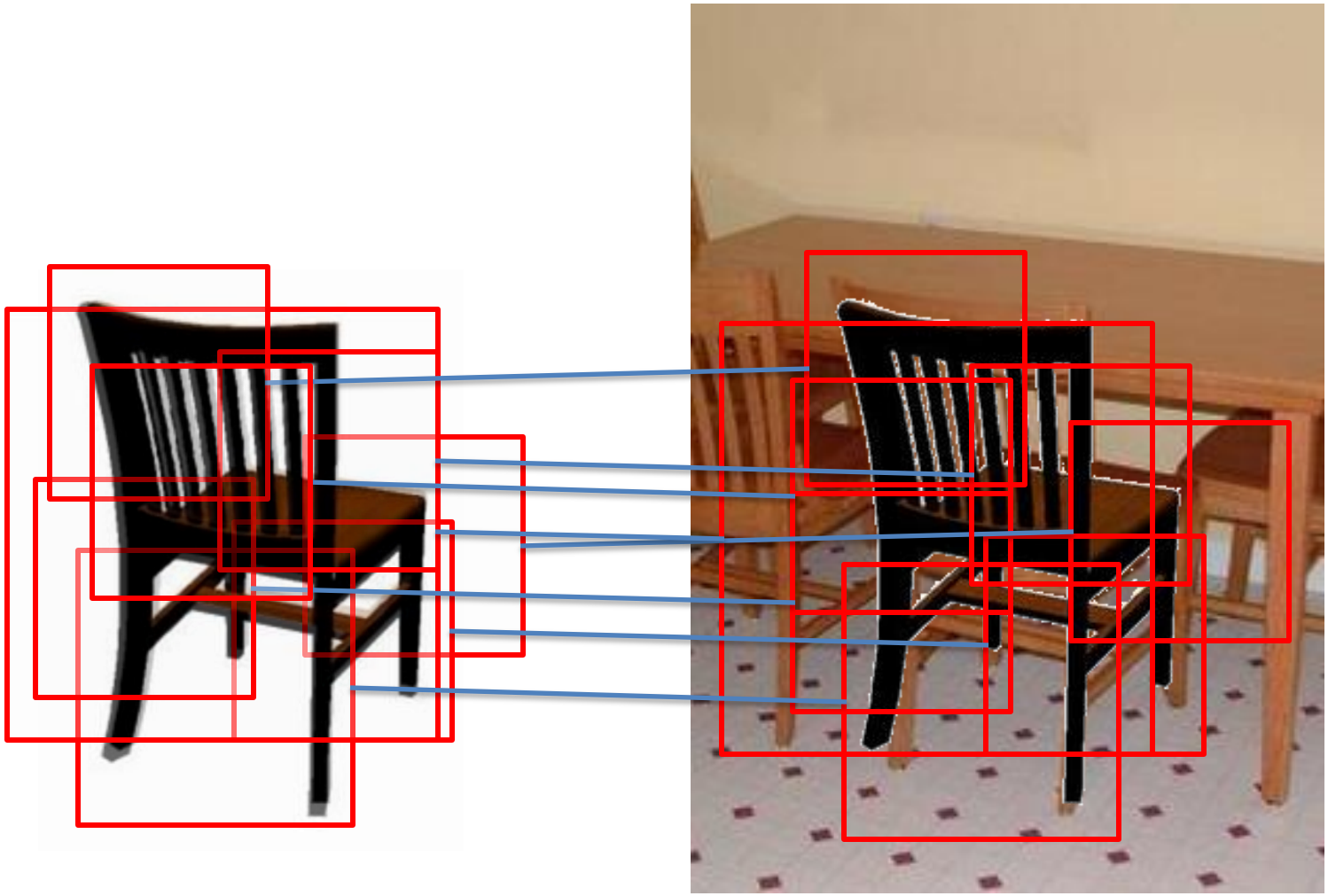

Style
Viewpoint

Difficulty: approximate style

Difficulty: approximate style

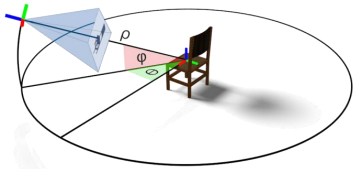
Difficulty: approximate style

Approach: part-based model

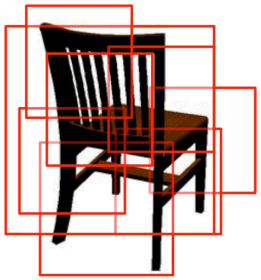


Approach overview

3D collection

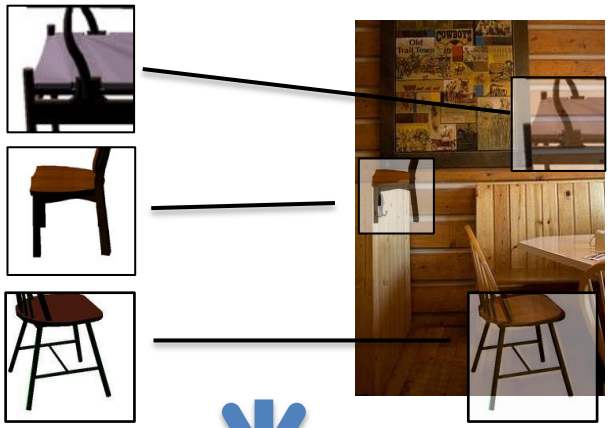


Render views

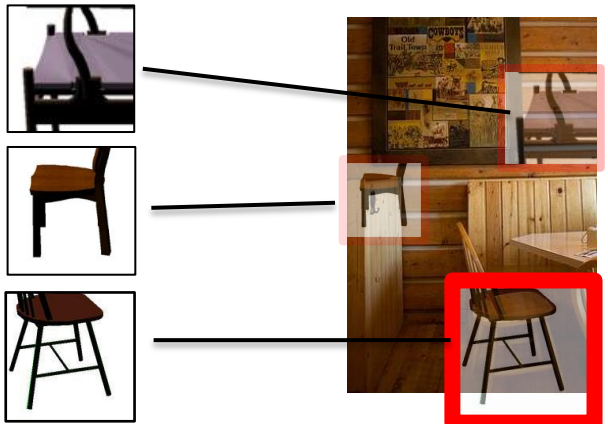


Select parts

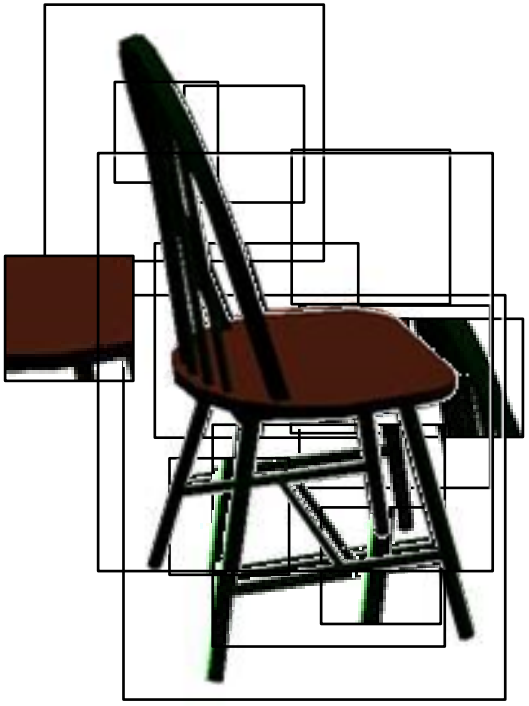
Match CG->real image



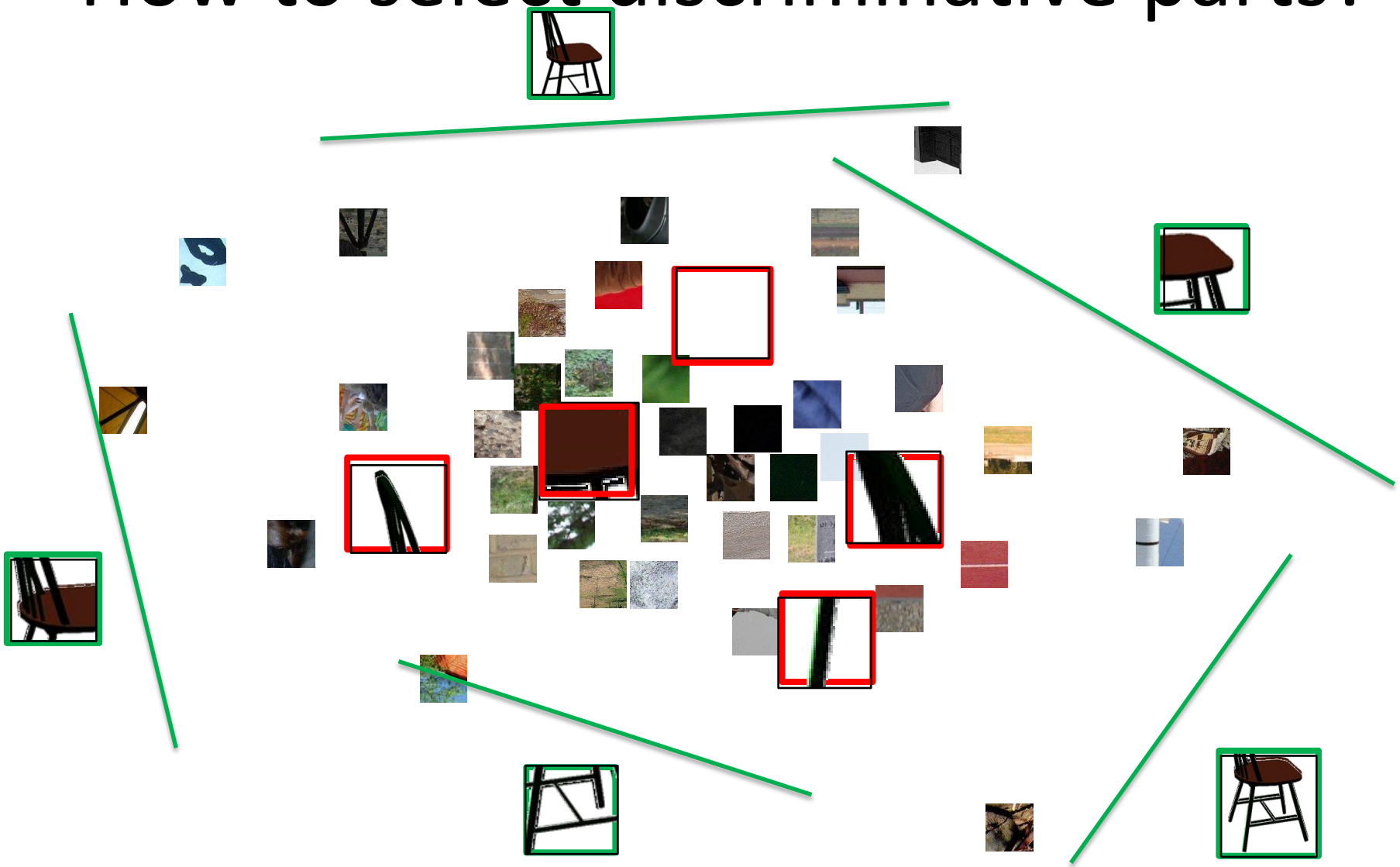
Select the best matches



How to select discriminative parts?



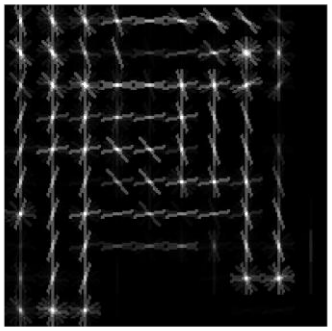
How to select discriminative parts?

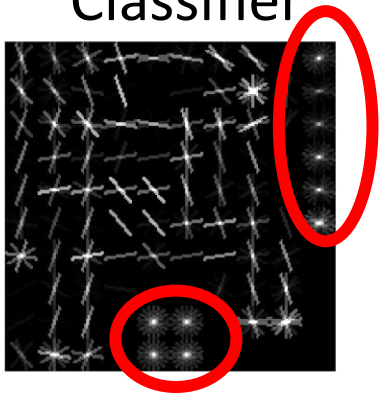


Best exemplar-LDA classifiers

[Hariharan et al. 2012] [Gharbi et al 2012] [Malisiewicz et al 2011]

How to match CG to photograph?





$$w^\top x + b$$

Implementation: exemplar-LDA

See also:
[Shrivastava et al. 2011]

Approach: CG-to-photograph

Implementation: exemplar-LDA

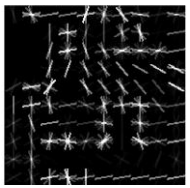
How to compare matches?

Patches

Detectors

(w_1, b_1)

(w_2, b_2)



(w_3, b_3)

Matches

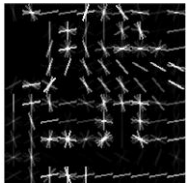
How to compare matches?

Patches

Detectors

(w_1, b_1)

(w_2, b_2)



(w_3, b_3)

Affine Calibration
with negative data

$(a_1 w_1, b'_1)$

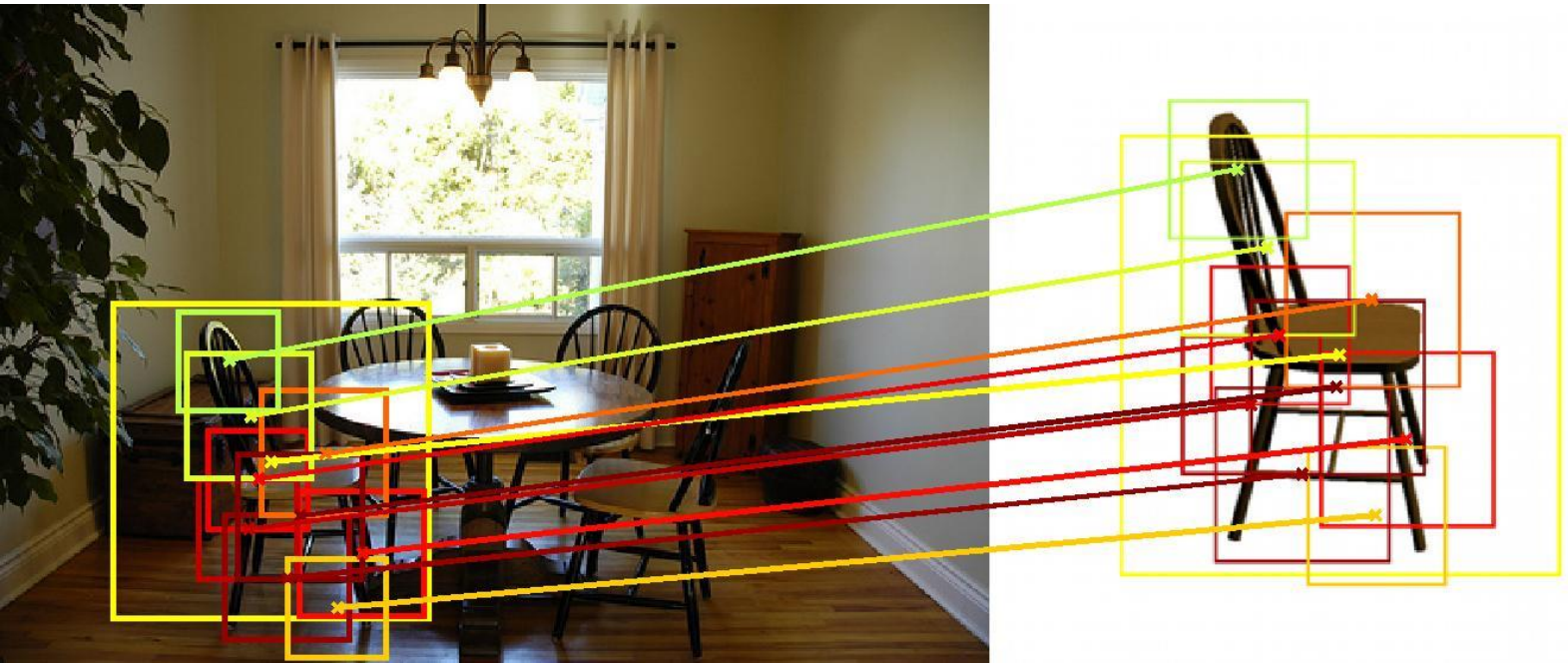
$(a_2 w_2, b'_2)$

$(a_3 w_3, b'_3)$

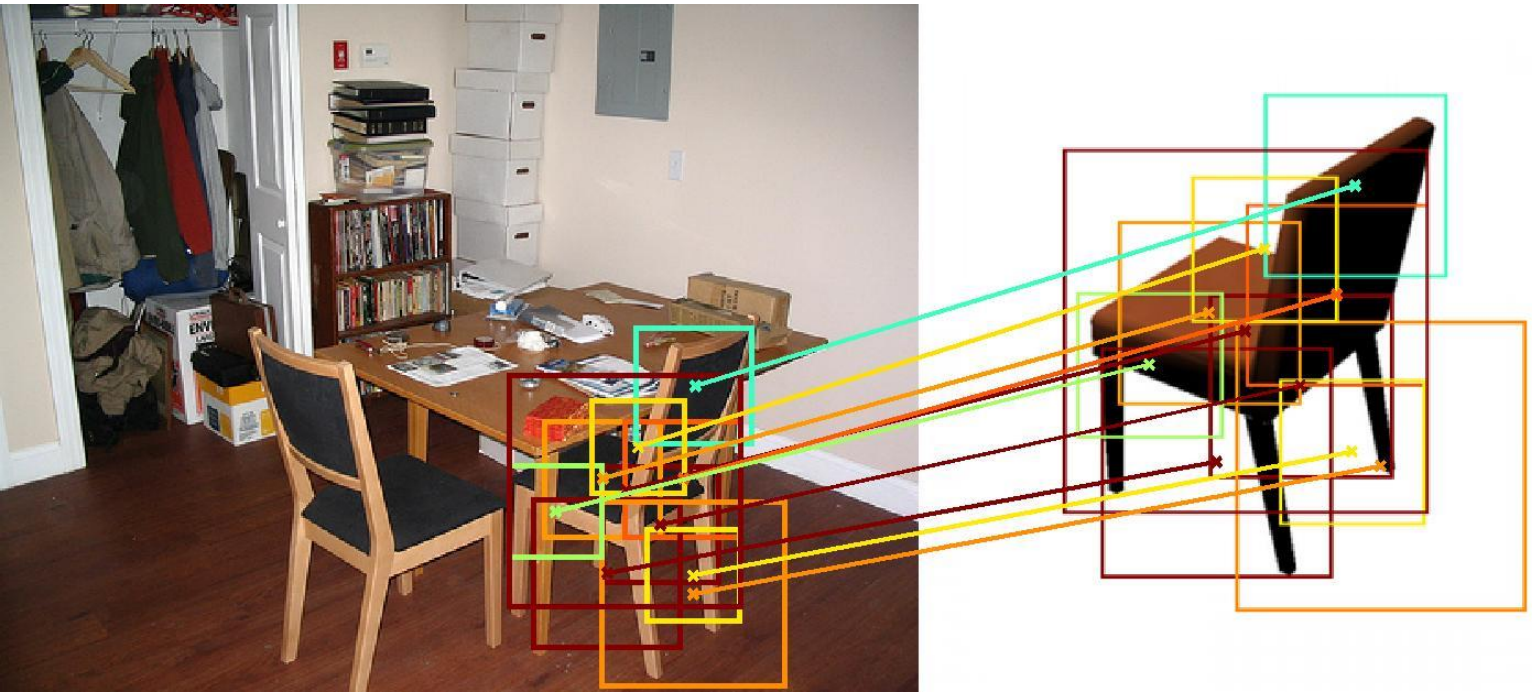
See paper for details

Matches

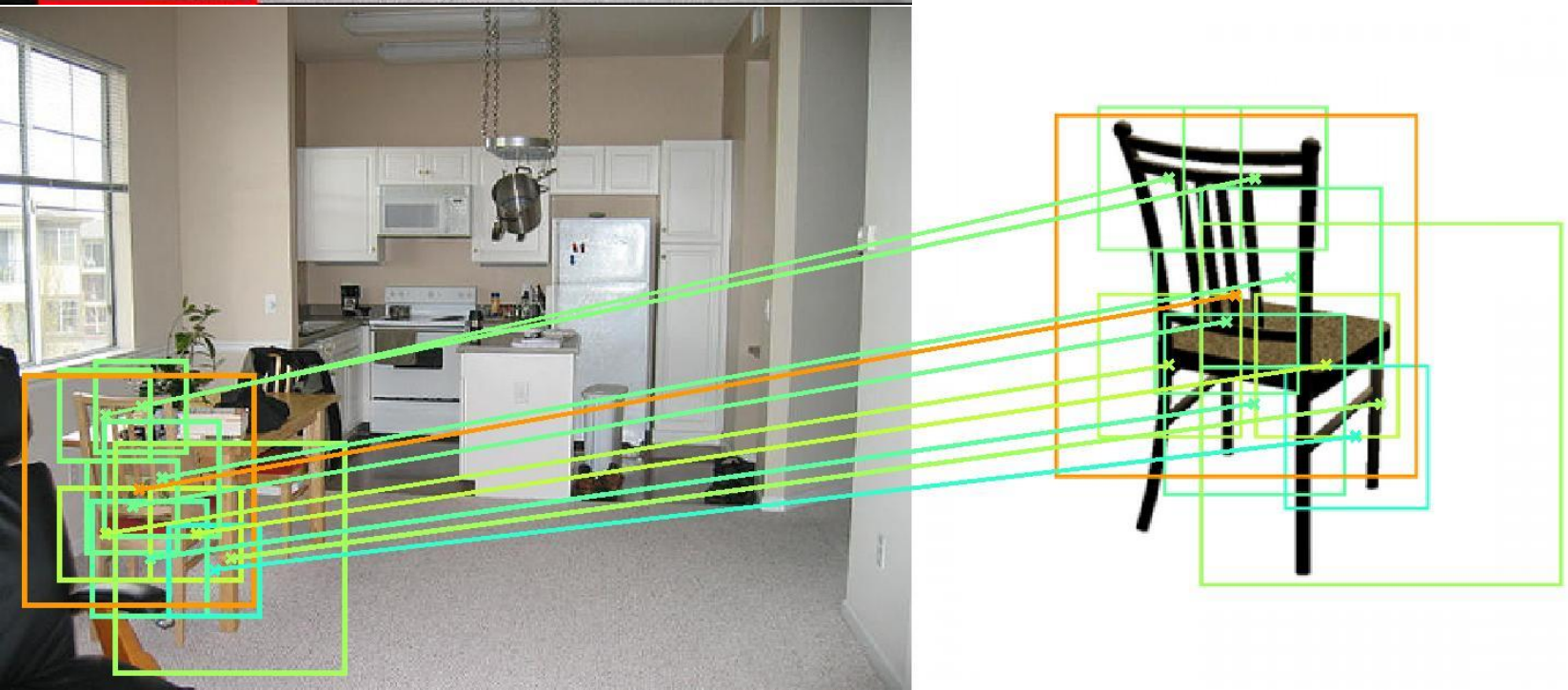
Example I.



Example II.



Example III.



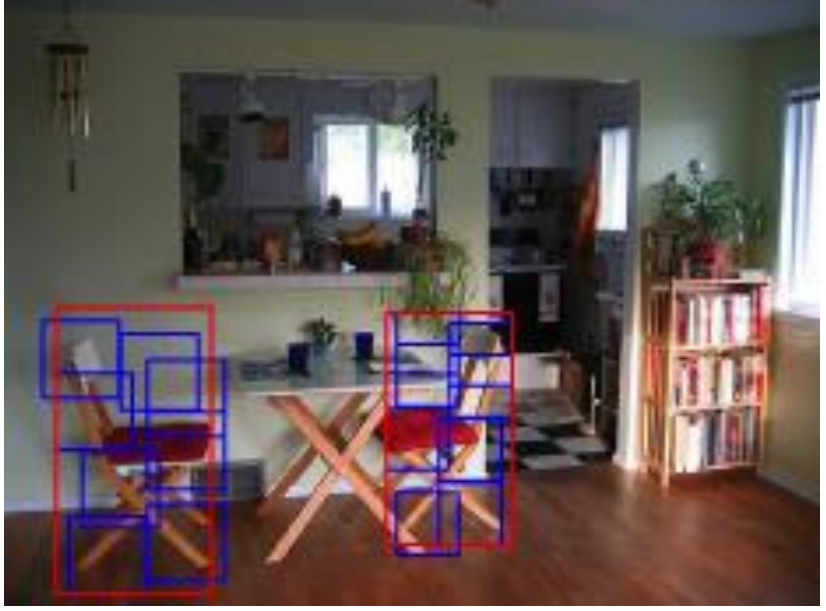
Input image

DPM output

Our output

3D models

Input image



DPM output

Our output

3D models

Results

Test set:

- 179 images from Pascal VOC 2012 (subset of validation data)
- 247 annotated chair bounding boxes

Baselines:

1. Exemplar LDA:

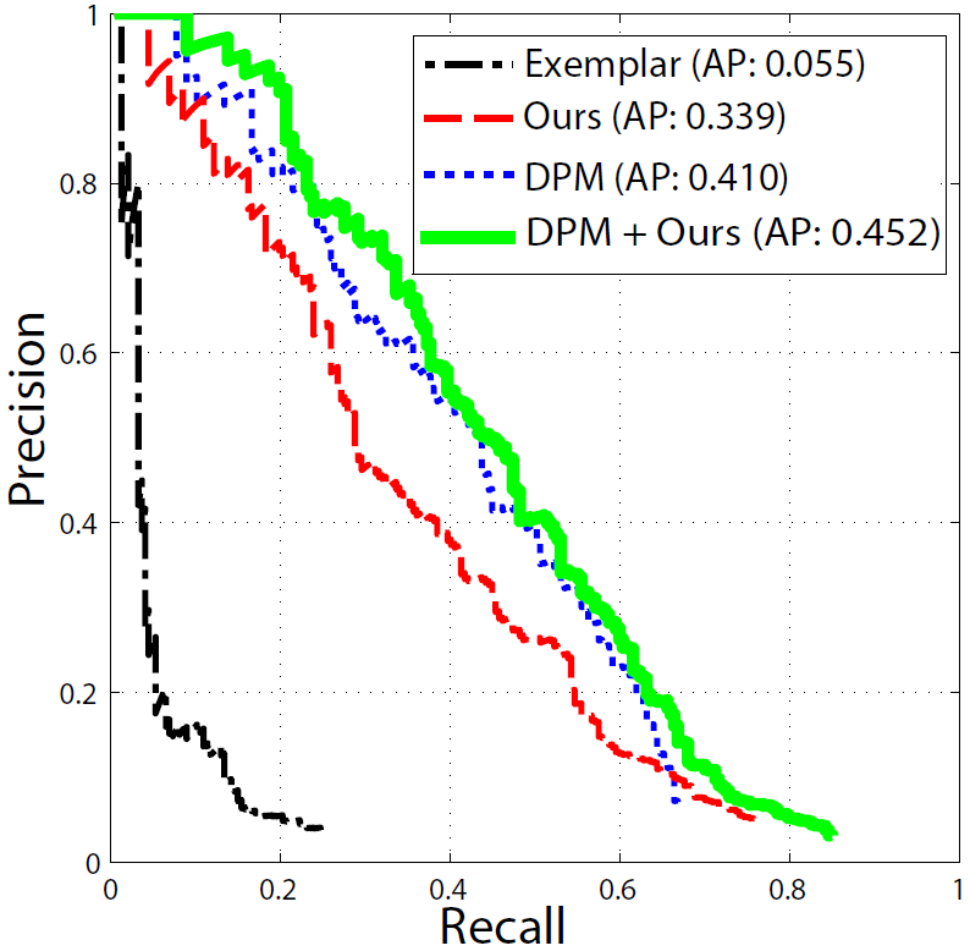
[Hariharan et al. 2012],

[Gharbi et al 2012],

[Malisiewicz et al 2011]

2. DPM:

[Felzenszwalb et al. 2010]



Subjective human evaluation

Orientation quality at 25% recall




	Good	Bad
Exemplar-LDA	52%	48%
Ours	**90%**	**10%**

Subjective human evaluation

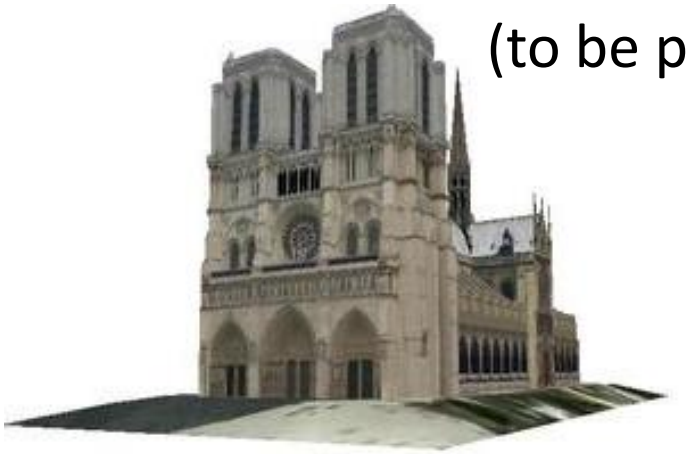
Style consistency at 25% recall



	Exact	Ok	Bad
Exemplar-LDA	3%	31%	66%
Ours	**21%**	**64%**	**15%**

Our related ToG 2014 paper

(to be presented at SIGGRAPH 14)

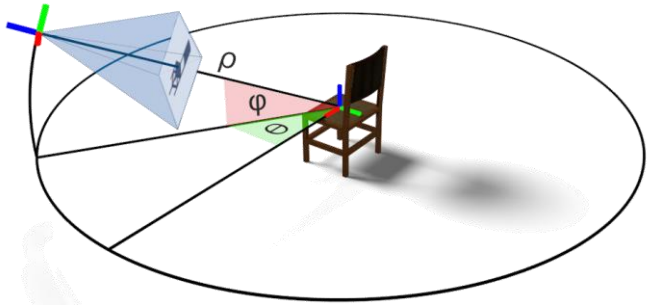


Painting-to-3D Model Alignment Via Discriminative Visual Elements

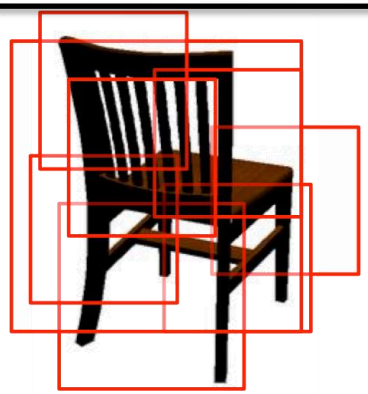
M. Aubry, B. Russell and J. Sivic

Summary

- Large collection of 3D models
  - ✓ Part score calibration



- Render views from 3D
  - ✓CG-real matching



- Part based matching
  - ✓ Finding parts

Data and (soon) code: http://www.di.ens.fr/willow/research/seeing3Dchairs