3D Shape Attributes

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Overview

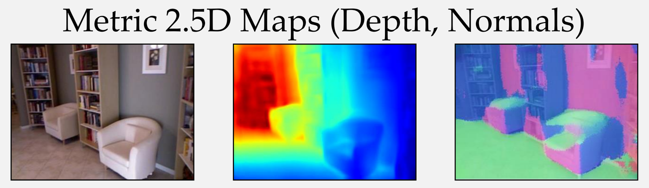
Objective: describe 3D shape of generic objects in terms of qualitative, higher-order properties

Not planar
Smooth surface
1 point of contact
Not point contact
Has hole
Not thin structures
...

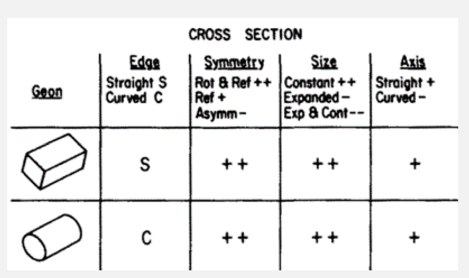
Contrast objective with

Category Specific

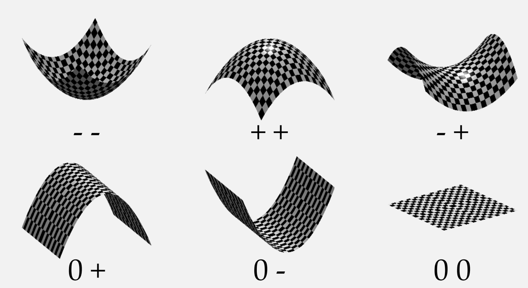
Metric 2.5D Maps (Depth, Normals)



Historical motivation



	CROSS SECTION			
Geon	Edge: Straight S, Curved C	Symmetry: Rot & Ref ++, Ref +, Asymm −	Size: Constant ++, Expanded −, Exp & Cont −−	Axis: Straight +, Curved −
	S	++	++	+
	C	++	++	+



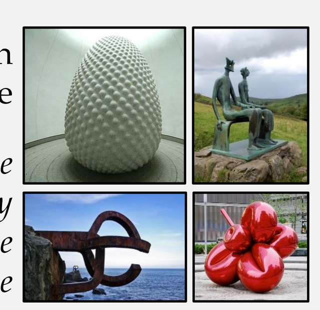
Data source possibilities

Ordinary Objects

Limited shape diversity
Category/shape correlation

Modern Sculpture

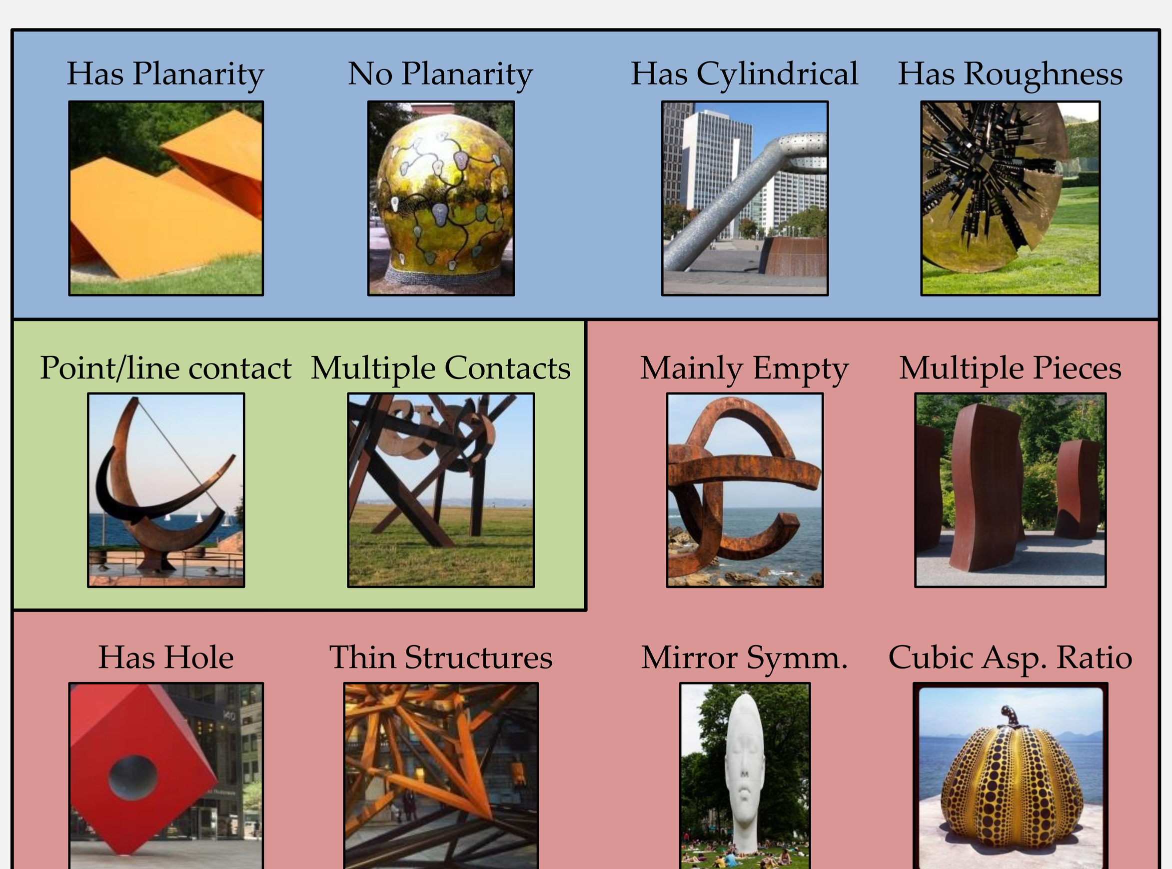
Great shape diversity
Categories we can't describe



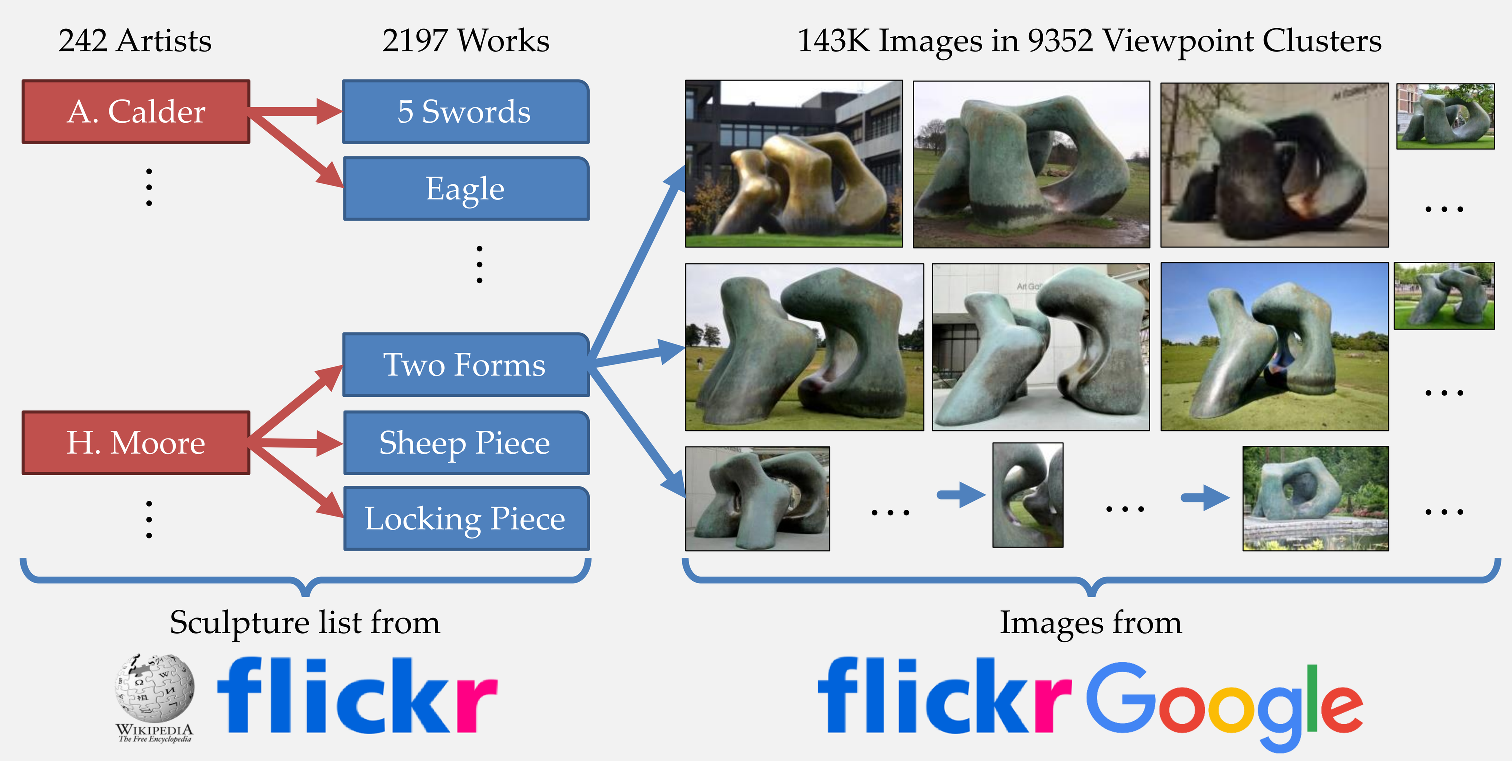
Attributes

We investigate twelve 3D shape attributes inspired by past work in vision

Curvature Properties | Contact Properties | Volumetric Properties



Gathering Data

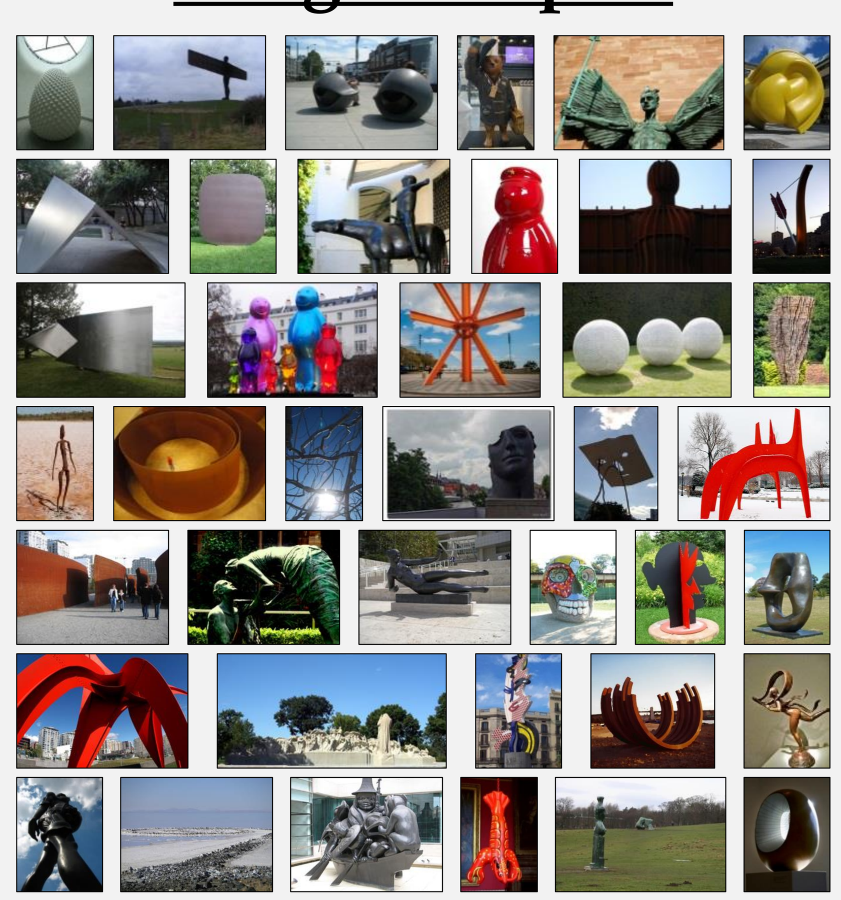


Artist/Shape Correlation

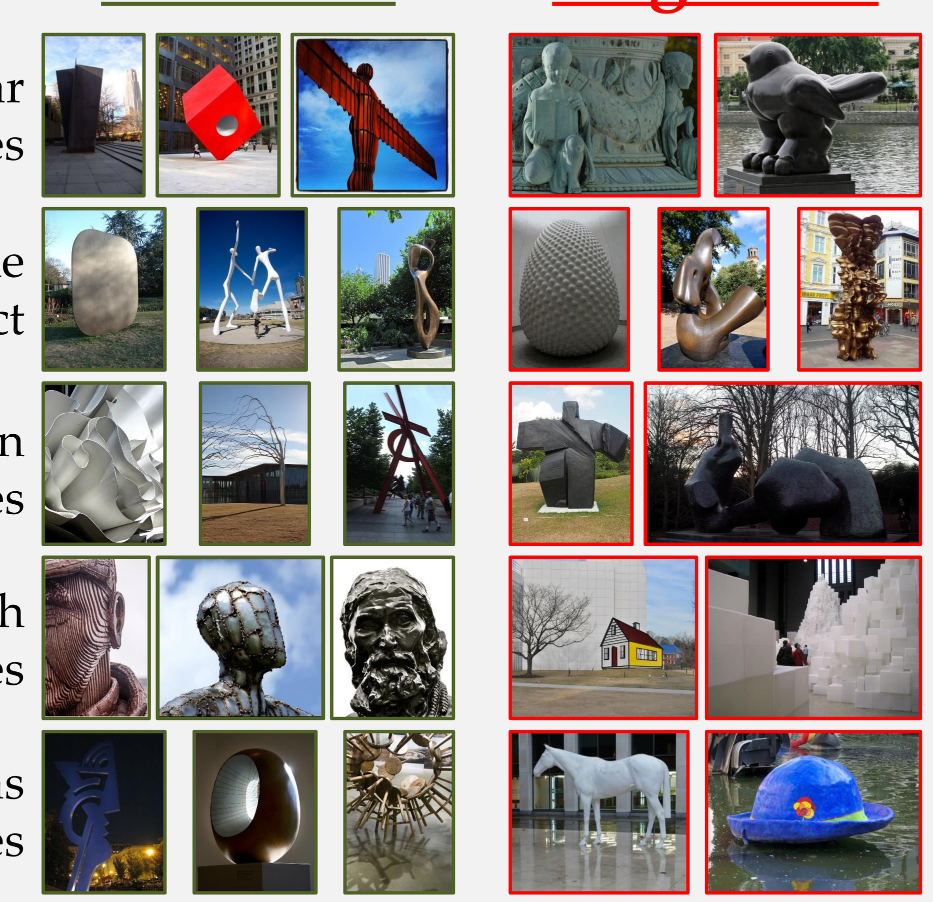
Diverse Materials, Locations

Sculpture Data

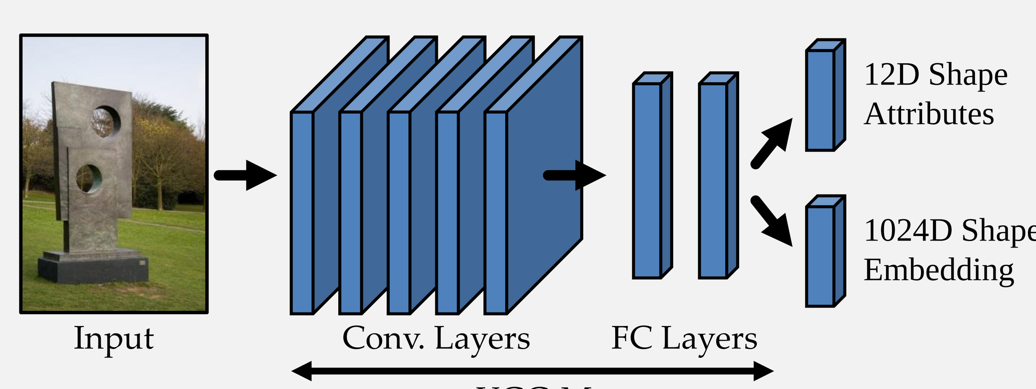
Image Samples



Positives / Negatives



Learning



$$\sum_{i=1}^{N} \sum_{\substack{l=1 \\ Y_{i,l} \neq \emptyset}}^{L} Y_{i,l} \log(P_{i,l}) + (1 - Y_{i,l}) \log(1 - P_{i,l})$$

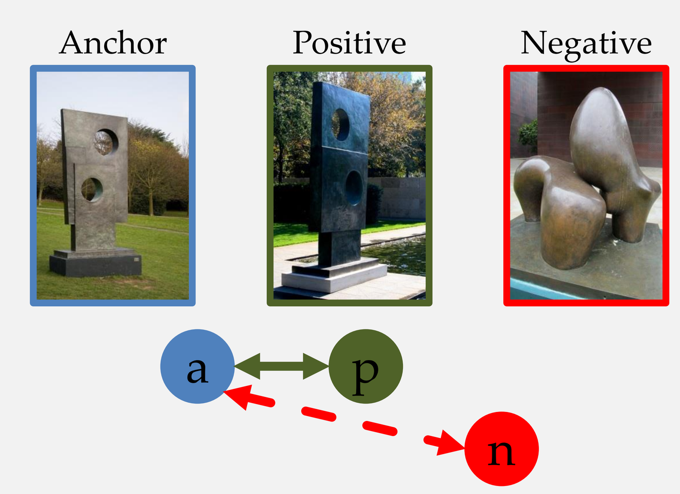
$$+ \sum_{i=1} \max\left(D(x_i^a, x_i^p) - D(x_i^a, x_i^n) + \alpha, 0\right)$$

$Y_{i,l}$ Label: {0, 1, invalid}
$P_{i,l}$ Prediction [0,1]

x_i^a Anchor's feature
x_i^p Positive's feature
x_i^n Negative's feature

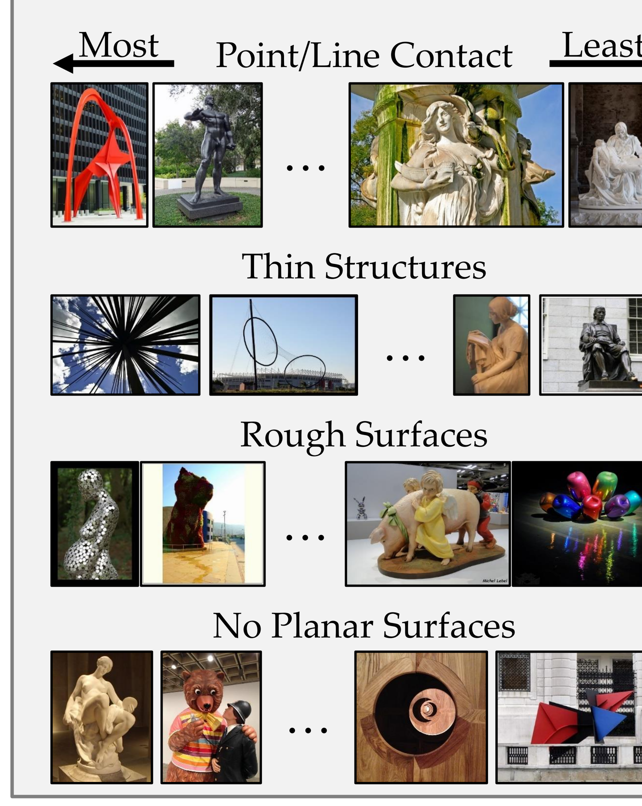
Shape Embedding

Objective: learn features such that two views of same work are closer than two views of different works by a margin



Sculpture Attribute Results

Qualitative



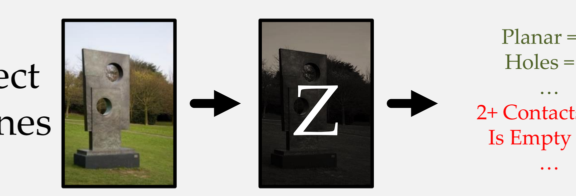
Quantitative (AUROC)

Evaluation done on 35K images by held-out artists

Curvature				Contact	
Planar	!Planar	Cylinder	Rough	Pt/Line	Multiple
82.8	77.2	56.9	76.0	74.4	76.4

Occupancy					
Empty	2+ Pieces	Holes	Is Thin	Mirr. Sym	Cubic Ratio
87.0	60.4	69.3	85.8	60.8	60.3

Indirect Baselines



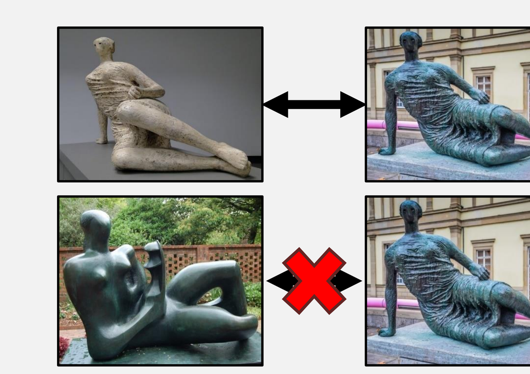
Eigen '14		Barron '15		End-to-end
KDES	HHA	KDES	HHA	
58.5	61.2	59.4	62.5	<u>**72.3**</u>

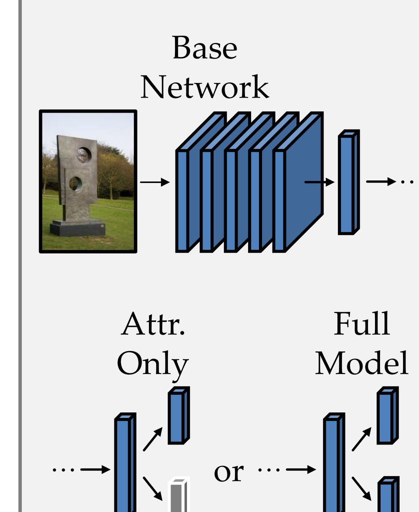
Mental Rotation

Idea: do two images show the same object but rotated?

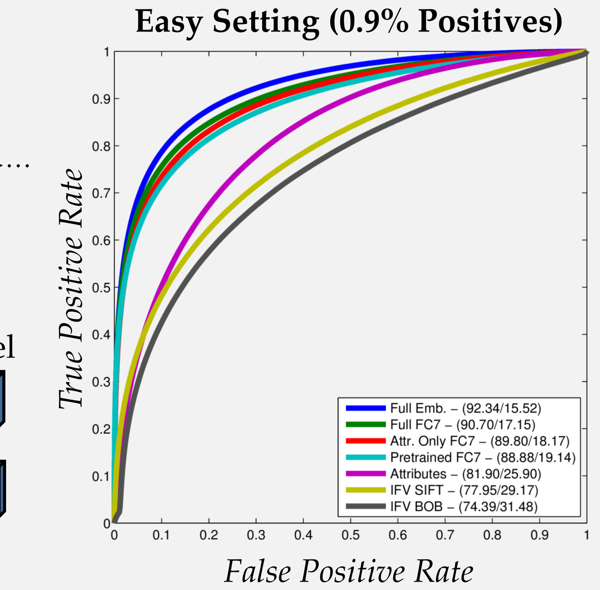
Evaluate as classification over ~100M pairs of images
Cosine similarity = classification prediction for feature
Positive = same work; **Negative** = different work

Easy setting: all pairs (ignore same viewpoint cluster)
Hard setting: remove "easy" positives via BOW+SIFT

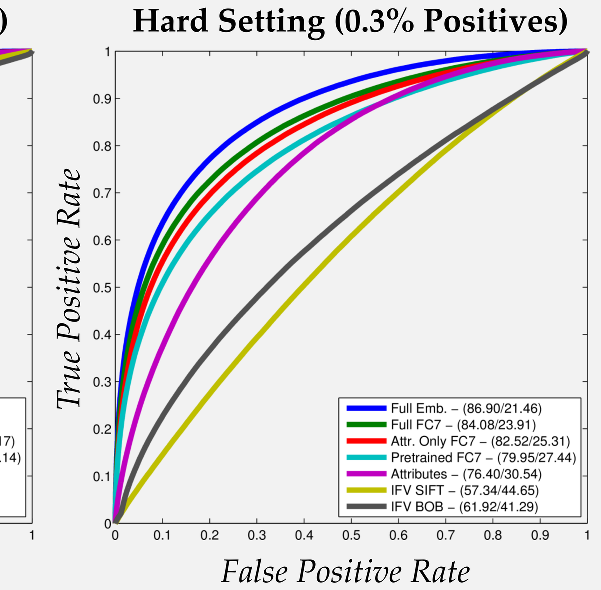




Easy Setting (0.9% Positives)



Hard Setting (0.3% Positives)



PASCAL VOC Results