



# Autotagging to Improve Text Search for 3D Models

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- Motivation: **Keyword search** for 3D models
  - ◆ Unlike images, 3D models are not usually embedded in text content
  - ◆ How can we search unlabeled geometry?
- Challenges
  - ◆ Lack of reliable datasets
  - ◆ Distances are metric but semantics are not
  - ◆ Representations of geometry are nonunique



# Autotags

- Solution: **automatic annotation**
  - ◆ Given an unlabeled model, assign descriptive tags
  - ◆ Probabilistically propagate tags and confidences between similar models
  - ◆ Perform keyword search on autotags
- We use **Google 3D Warehouse** as a corpus
  - ◆ **192,343** user contributed 3D models
  - ◆ Tags are only moderately reliable
  - ◆ Too many tags to train explicit models



# Autotagging Algorithm

- **Geometric Similarity**

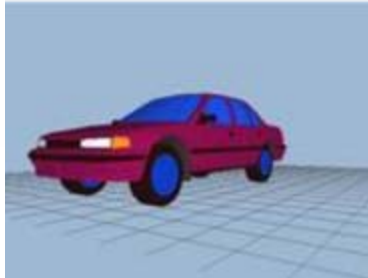
- ◆ Given unlabeled model  $\omega$  and corpus model  $\omega_x$ , define  $P(\omega \approx \omega_x) = (1 - D(\omega_x, \omega_y))^2$  as their similarity, where  $D$  is  $L^2$  on Zernike descriptors

- **Tag Propagation Rule**

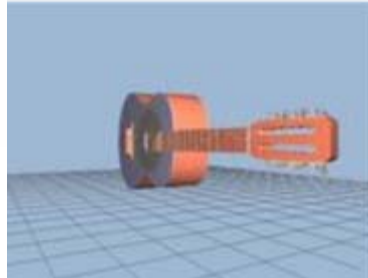
- ◆ Given the  $N$  nearest neighbors of  $\omega$ , and a tag  $\lambda^i$

$$P(\lambda^i, \omega) = \bigcup_{n=1}^{|N|} P(\omega \approx \omega_n) \wedge P(\lambda^i, \omega_n)$$

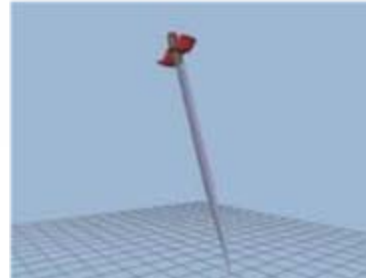
# Results on Benchmark Models



car, vehicle,  
sedan, dodge,  
charger



steel string, guitar,  
string, seagull,  
acoustic guitar



sword, blade,  
*sign, architecture,*  
*landscape*



*house,* instrument,  
musical instrument,  
musical, piano



airplane, *house,*  
aircraft, plane, jet



mug, drink,  
beverages, coffee,  
*interior*



chair, wood, furniture,  
wooden, simple chair



animal, human,  
biped, man, *aircraft*

Images from the Princeton Shape Benchmark

# Demo

- Columbia Shape Search

Columbia Shape Search
Vg+

Columbia Robotics Lab | Columbia Vision and Graphics Center | Google 3DWarehouse | Corey Goldfeder

<input style="width: 90%;" type="text"/> <input type="button" value="Search"/> <input type="button" value="Random Model"/>	<b>Search By</b> <input checked="" type="radio"/> Name <input type="radio"/> Original Tags	<b>Search Method</b> <input type="radio"/> Precomputed <input type="radio"/> Raw Zernikes <input checked="" type="radio"/> 3DWarehouse PCA	<b>use for</b> <input type="checkbox"/> 3DWarehouse June 07 Snapshot <input checked="" type="checkbox"/> Princeton Shape Benchmark Train <input checked="" type="checkbox"/> Princeton Shape Benchmark Test	<b>ResultsAutotag</b> <input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>
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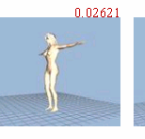








**human\_arms\_out**  
*Princeton Shape Benchmark Test (see voxels)*

Page 1 >>

**Description:**  
**Original Tags:** human arms out, human, biped, animal

50 neighbors found. Autotagged based on 69 neighbors.

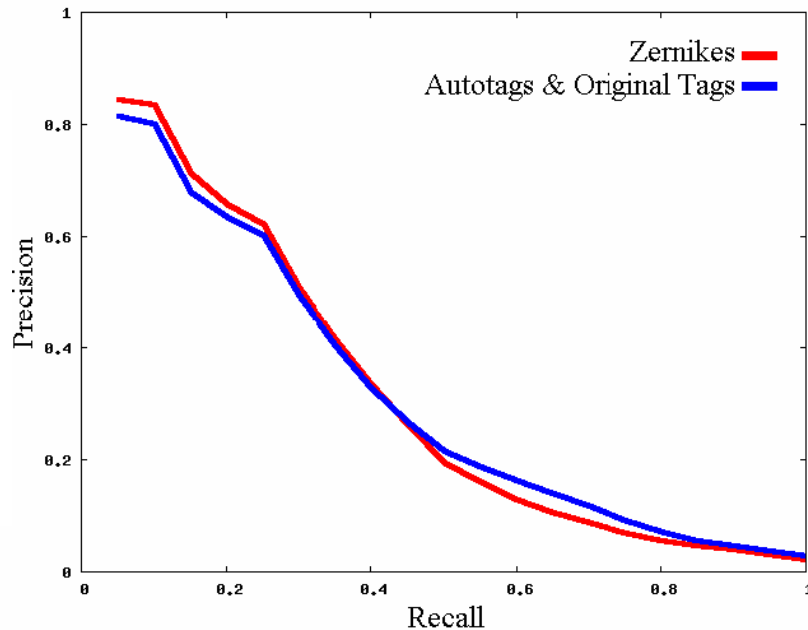
**Computed Tags:** animal, human, biped, humanarmsout, human\_arms\_out, arms

 0.01052	 0.01478	 0.02003	 0.02193	 0.02521	 0.02621	 0.02777
 0.02871	 0.02880	 0.02893	 0.02907	 0.02953	 0.03019	 0.03043

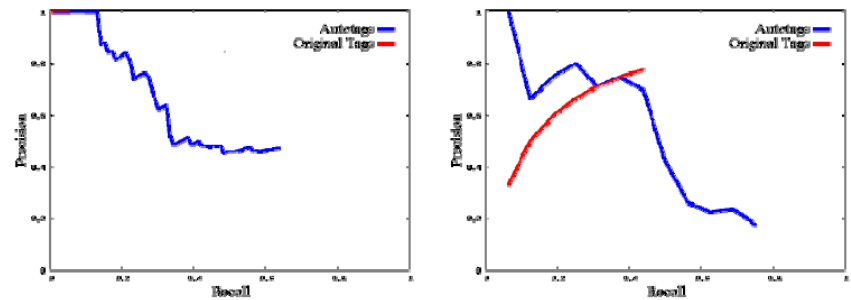
- Try it yourself at [shape.shorturl.com](http://shape.shorturl.com)

# Experimental Results

## Discriminative Power

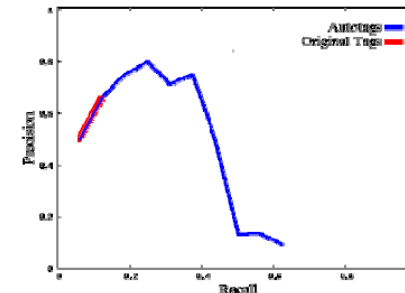


## Tag Quality



(a) Search for "airplane"

(b) Search for "sword"



(c) Search for "head"



# Conclusions and Future Work

- Conclusions
  - ◆ Autotags **transfer** most of the discriminative power of Zernike descriptors into text search
  - ◆ Along with anchor text, etc. we can **roughly replicate** the performance of Zernikes using text
- Future Work
  - ◆ Different shape descriptors
  - ◆ Finer-grained priors for reliability of corpus tags
  - ◆ Local clustering to reduce sample bias in corpus



- See also our poster in SMI '08 and our winning entry in SHREC '08 (classification track)
- Thanks to Google for providing the dataset
- Questions?