Local Shape Descriptors

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Why?

- What extra benefit do we get from having a ‘local’ descriptor?

Why?

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- Surface correspondence.
- Feature detection.
- Segmentation.
- ‘Multi-object’ scenes.

How?

- General approach:

  Use same methods used for global descriptors, but centered around each feature (or segment) of the the object separately.

Solutions:

- **2D Shape Contexts.**
- 3D Shape Contexts.
- Spin Images.
- Point Fingerprints.

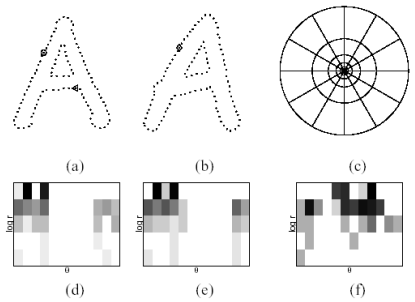
- Local Feature Histograms.
- Local Spherical Harmonics.

Hmmm…

- Choose some random point as center of mass.
- Choose to work with only ‘near’ points?
- How do we decide scale/rotation of the patch?
- How do we find a match among the (much larger) set of ‘shapes’?

2D Solution.

- Shape-Contexts:



- Log-Polar histogram.

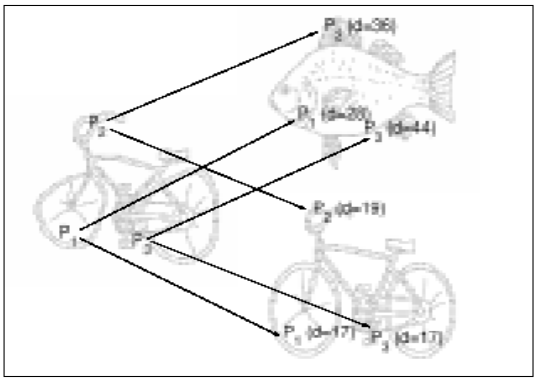
2D Solution.

- Invariant to rotation.
- Scaled by mean distance.
- In order to match shapes, points are matched one-to-one (dummy nodes).

- Can we use this for object retrieval? Why Not?

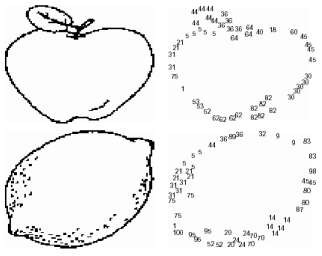
Speed-Up. (Mori et al.)

- Check only a small number of points for robust matching (r=5).



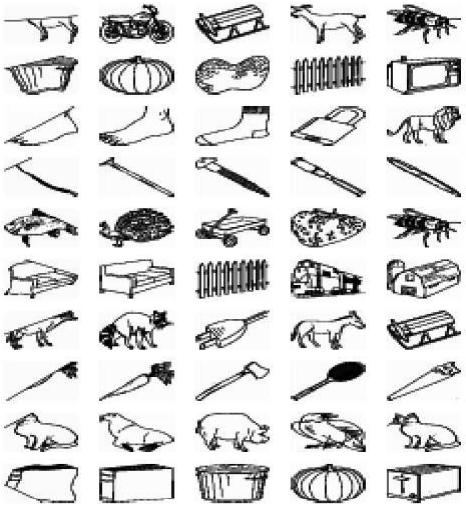
Speed-Up. (Mori et al.)

- Vector Quantization (Shapemes).



- ANN -- O(D*polylog(N))

Results. (Mori et al.)



Solutions:

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- **3D Shape Contexts.**
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3D Solution (Shape-Contexts).

- Use “center of mass”
- Use PCA-HAP for direction.

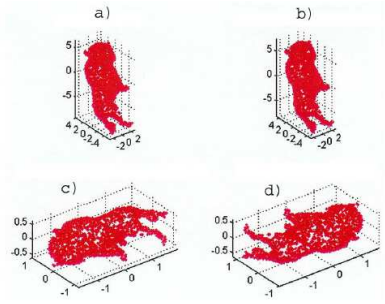
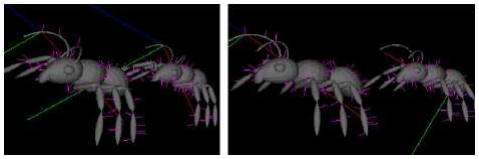


Figure : Normalization stages - a) Original object, b) Object after re-centering, c) Object after rotation and scaling, d) Object after flipping

3D Solution (Shape-Contexts).

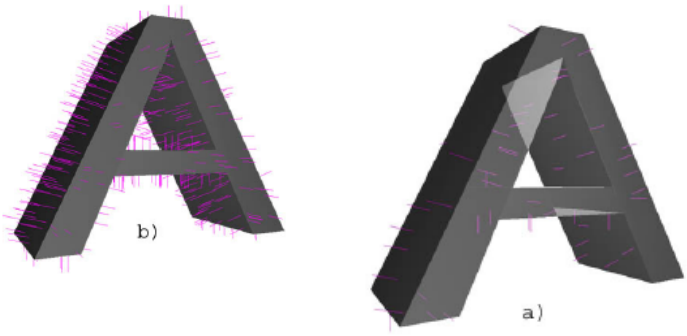
- Problem: What if two points don’t match?



- “Dummy nodes”
- Soft assignment

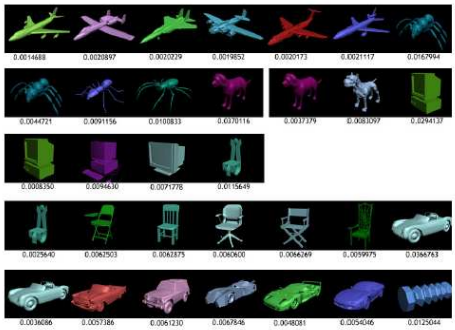
Speed-up possibilities:

- Representative shape contexts.



Speed-up possibilities:

- Shapemes.
- ANN -- (Indyk & Motwani).
- Reduction of Dimensionality (PCA).



Solutions:

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- **Spin Images.**
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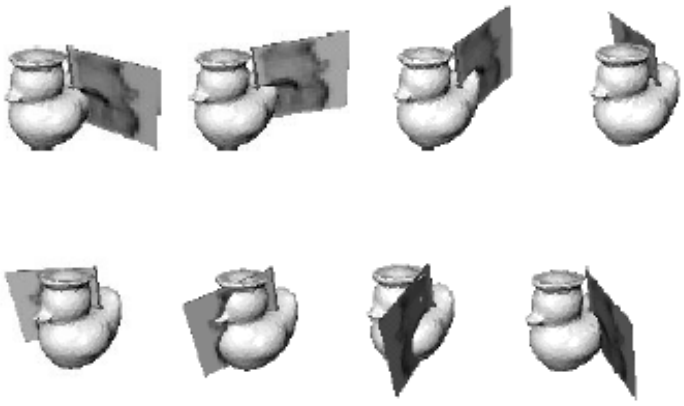
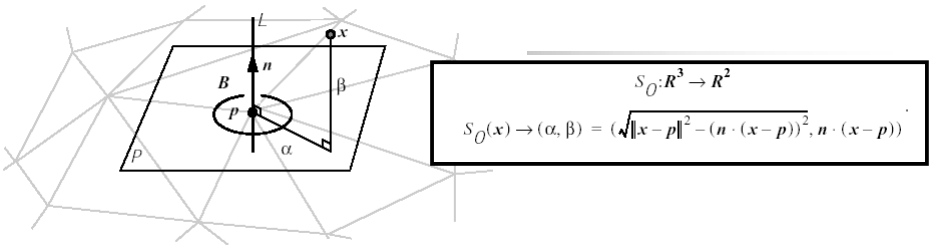
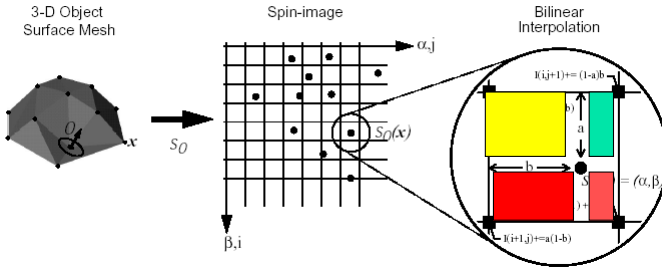
Spin Images

Based on Andrew Johnson's 1997 Thesis



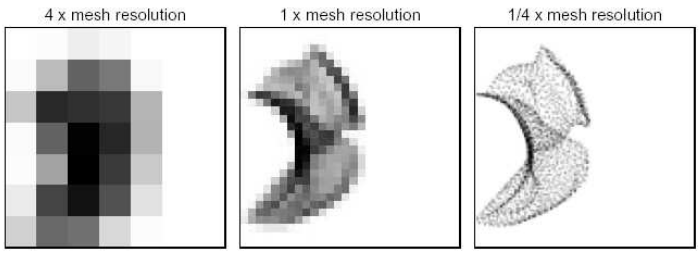
Calculating Bin Distribution





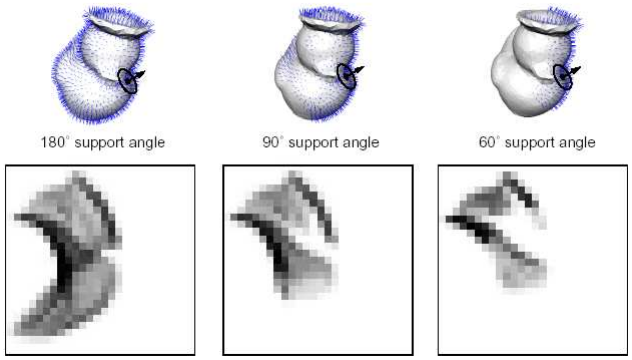
Input Parameters

- Bin Size:
  - More bins give better resolution, but increase comparison computations by a factor of N^2



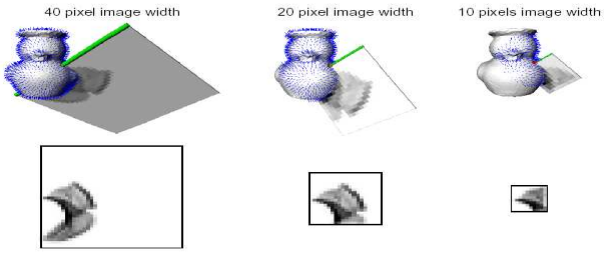
Input Parameters

- Support Angle:



Input Parameters

- Support Distance:
  - Smaller distance finds only local features
  - Larger distance give global features
    - Limited by computation time required for computing large spin images
    - Global spin images require $O(n^2)$ time to create



Computing the Similarities

- N = number of overlapping bins in Spin Images P and Q
- R = Linear Correlation Coefficient

$$R(P,Q) = \frac{N\sum p_i q_i - \sum p_i \sum q_i}{\sqrt{(N\sum p_i^2 - (\sum p_i)^2)(N\sum q_i^2 - (\sum q_i)^2)}}$$

- More precise similarity based on both R (similarity) and N (amount of overlap):

$$C(P,Q) = (\operatorname{atanh}(R(P,Q)))^2 - \lambda\left(\frac{1}{N-3}\right)$$

Speed-Up.

- Eigen-spin-images.
- Assume that the nearest neighbor is within ε (set to the average of the closest s-tuples) and run exhaustive search.

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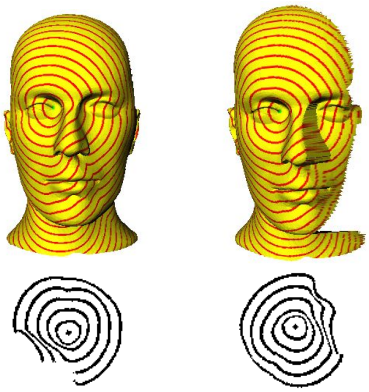
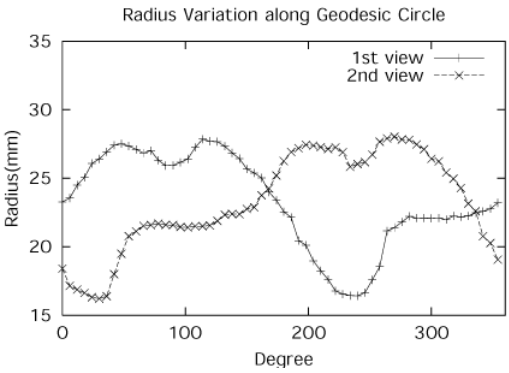
- **Point Fingerprints.**

- Local Feature Histograms.
- Local Spherical Harmonics.

Point Fingerprints.

- Based on C. Chua & R. Jarvis “Point Signatures IJCV ‘97”.





Solutions:

- 2D Shape Contexts.
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- Spin Images.
- Point Fingerprints.

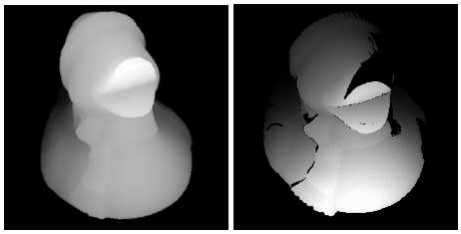
- **Local Feature Histograms.**
- Local Spherical Harmonics.

AI(Alignment Independent) Solutions.

- Local Feature Histograms.

  Pixel place, Surface normals, Curvature.

- Histogram Matching. This works with partially occluded objects.



Solutions:

- 2D Shape Contexts.
- 3D Shape Contexts.
- Spin Images.
- Point Fingerprints.

- Local Feature Histograms.
- **Local Spherical Harmonics.**

AI(Alignment Independent) Solutions.

- "Local" Spherical harmonics.

  Run 'SH' around "feature" point. Gives higher priority to area around feature.
- Speed Up?

Applications: (Discussion)

- Segmentation.
- Registration.
- Creating novel models.

- What else?

The End….