Articulated Hand Posture Recognition System using IDSC Features

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CS676: Computer Vision and Image Processing
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April 12, 2011

Outline

Problem Statement

To capture and recognize various articulated hand postures using inner-distance shape context(IDSC) descriptor.

Hand Postures

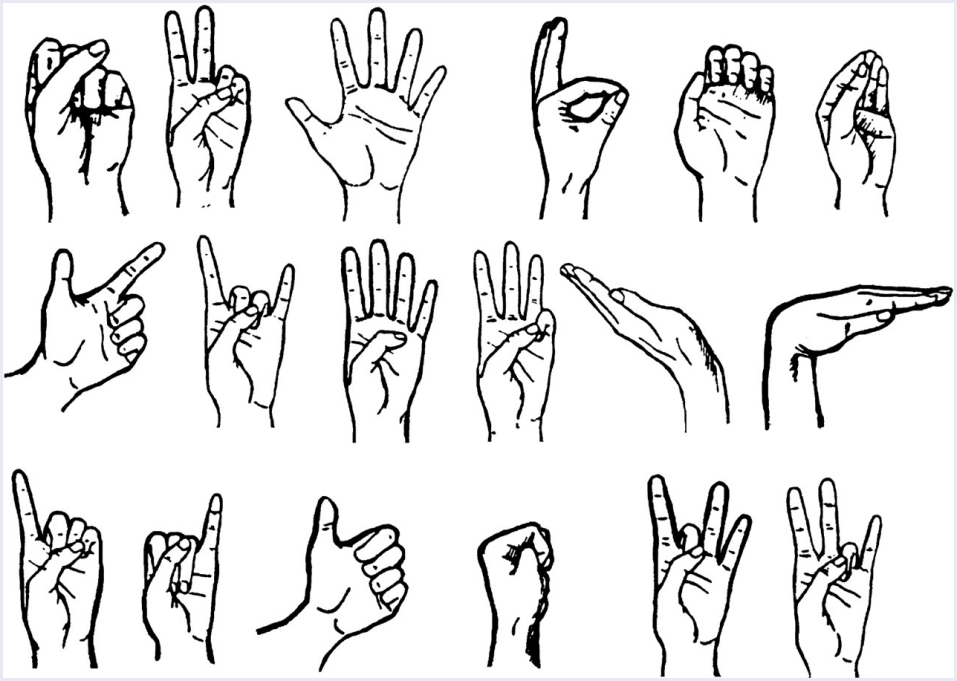

Figure: Various hand postures: Hand states(open/closed), Sign Languages , Grasp Patterns

Two problems

(a) Two State Classification(open/closed)

(b) Sign Language Classification

Challenging Problem

- Complexity of Hand Articulations: 27 DOFs.
- The occlutions of fingers.

Two problems

(c) Two State Classification(open/closed)

(d) Sign Language Classification

Challenging Problem

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Shape Context

- The shape context is a descriptor used to measure similarity and point correspondences between shapes.
- It describes each point along the objects' contour wrt to other points in the contour.
- The descriptor of a point p_i is a coarse histogram h_i of the relative coordinates of remaining $n-1$ points.

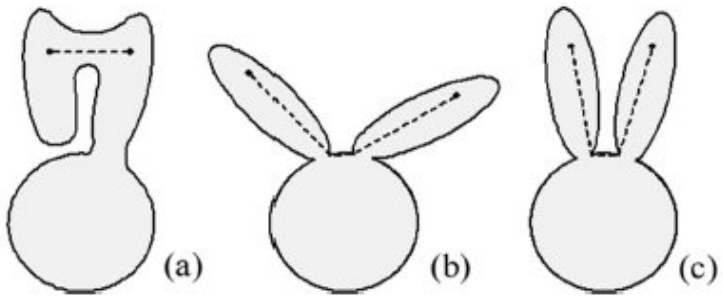
$$h_i(k) = \#\{q \neq p_i : (q - p_i) \in bin(k)\}$$

- The computation of histogram is based on both relative distance and angle.
- The Shape Context descriptor is a robust, compact and highly discriminative description of objects as it captures the distribution of each point relative to all other points.

Inner Distance Shape Context

- The inner distance is proposed by Haibin Ling.
- Proved to be very useful for articulated objects.
- Normal Shape context uses L2 distance measure. Whereas, the IDSC descriptor uses the inner distance calculated as the length of the shortest path within the shape boundary.
- Invariant to shape articulations.

Figure: inner distance using points on shape boundary



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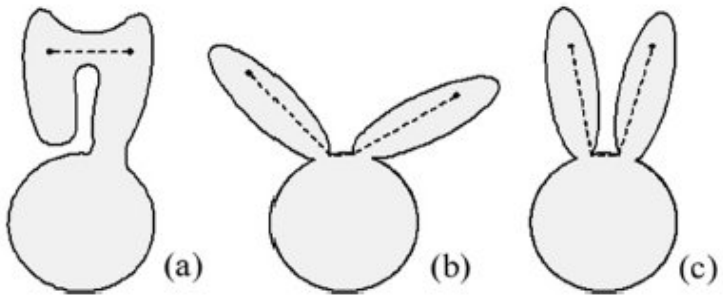

Methodology

- The palm regions are extracted from hand images using thresholding and mean smoothing.
- The longest contour of the image is extracted from the image boundary.
- 200 points are taken uniformly from the contour and represented as a graph.
- IDSC descriptor is calculated using these 200 points. This returns a histogram description of each point along the objects' contour to describe other points in the contour wrt to distance and angle..
- These signatures are used as feature representation for input in SVM to address the classification problem.

Computation of IDSC Descriptor

Inner-distance computation

- The idea is to find out the length of the shortest path between two points on the shape.
- A graph is built using sampled points.For each pair of sample points p_1 and p_2 , if the line segment connecting p_1 and p_2 falls entirely within the object, an edge between p_1 and p_2 is added to the graph with its weight equal to the Euclidean distance $||p_1 - p_2||$.
- All pair shortest distance matrix is computed using Bellman-Ford's all pair shortest path algorithm.
- Relative distance between points is described by inner distance.

Inner-angle computation

- Relative orientation between points p and q is calculated as the angle between contour tangent at p and the direction of path (p,q). This is called inner-angle.
- The inner angle is calculated along calculation of shortest distance between all points.

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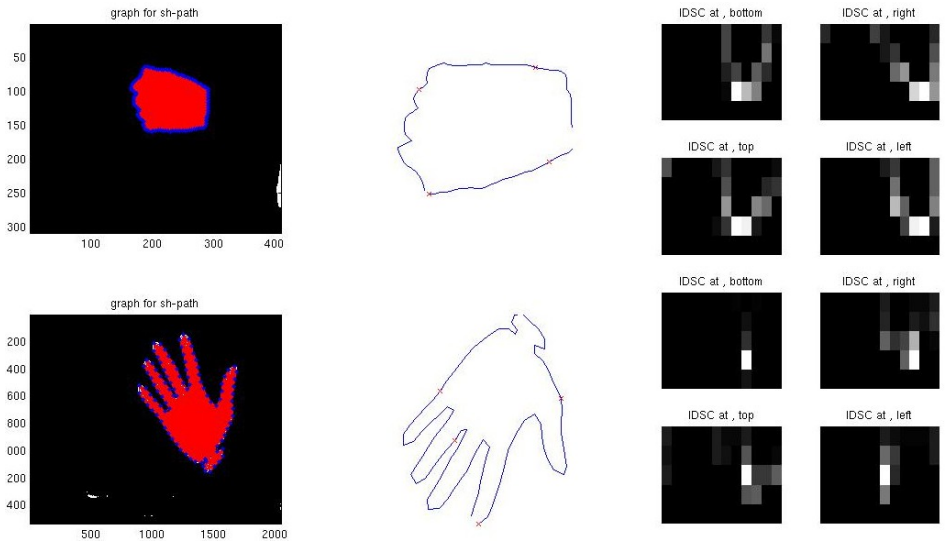
IDSC

IDSC Computation

- The histogram is computed based on both inner-distance and inner-angle for each point on the contour.
- This descriptor is used as a feature representation for a particular hand posture image.

Figure: inner distance using points on shape boundary



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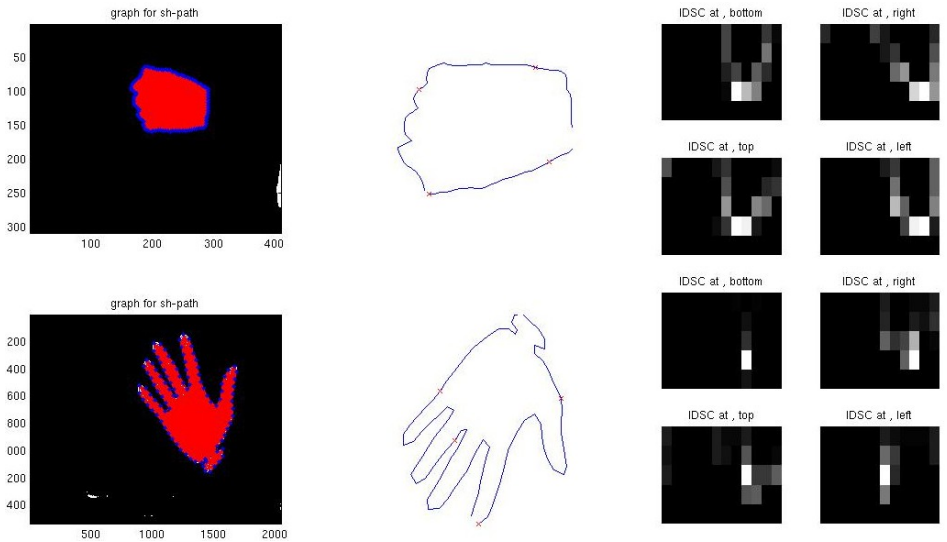

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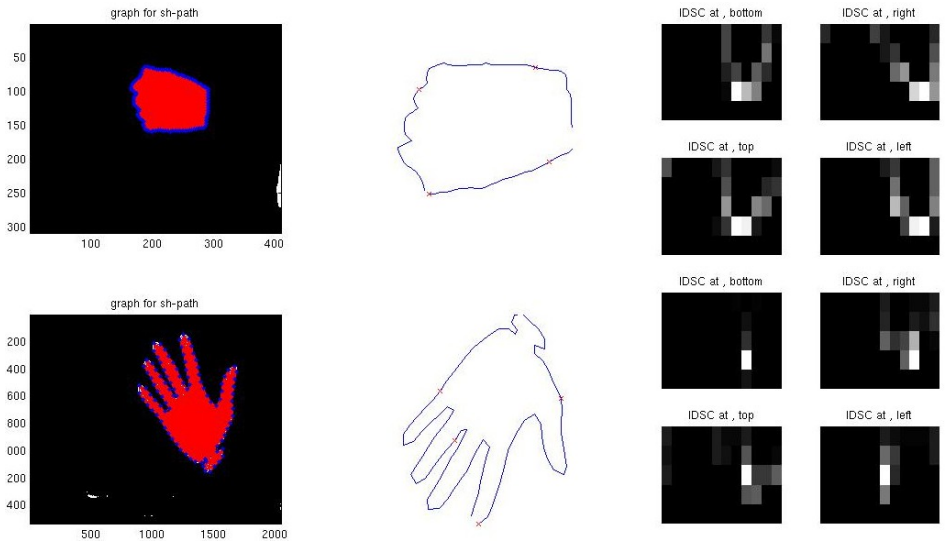
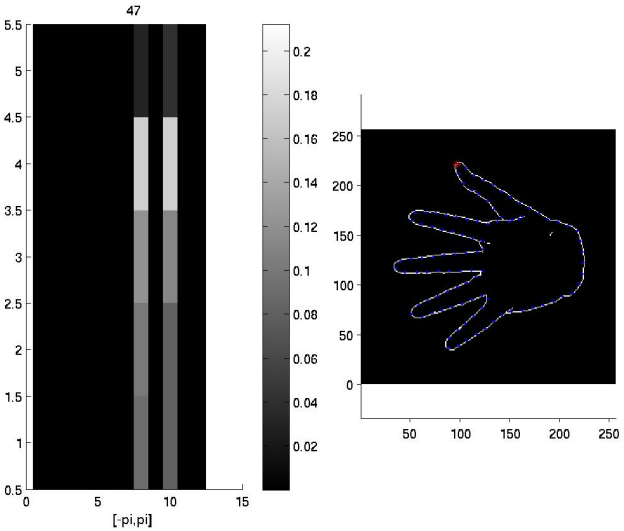
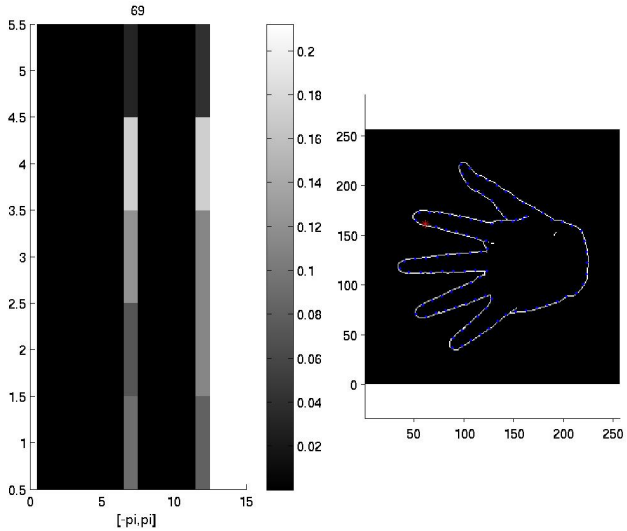
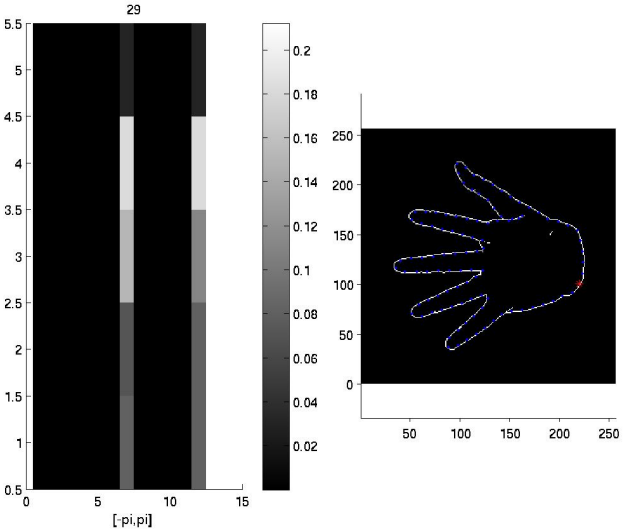
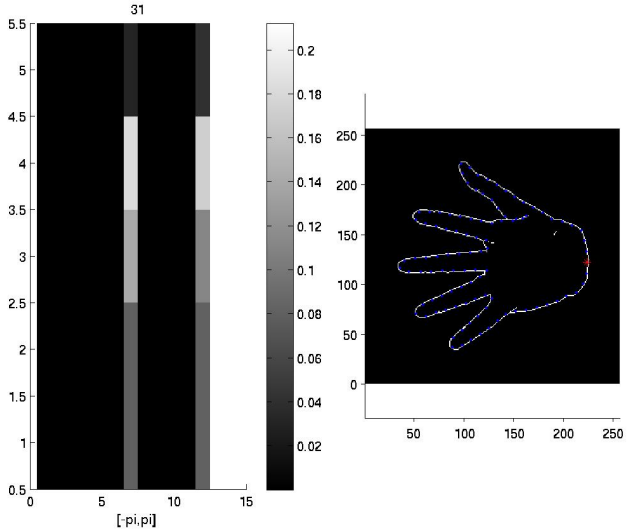


Visualizing IDSC









Experiments

Hand State Recognition

- The SVM is trained using the IDSC descriptions of open/closed hand contour images, 100 examples per state.
- The hand postures contained very high in−plane rotations(upto $+/-180$) and substantial out−of−plane rotations(upto $+/-45$).
- The training set is built such that it has images from all the rotations.
- The algorithm is tested on 100 images each of closed and open states.

Results

- 64% recognition with normal SC descriptors.
- 74% recognition with IDSC descriptors.
- These results were improved after including a pre−processing step.

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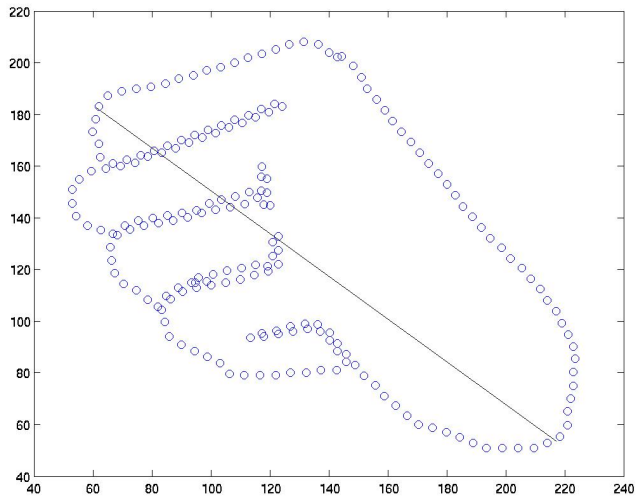
Pre−Processing

- The training and test images are grouped into 10 different bins uniformly based on their primary orientation direction.
- The orientation direction is estimated by computing the scatter direction of the images through principal component analysis (PCA).



- The SVM is trained with the hand state instances of the corresponding orientation.
- To test, the primary direction of the test image is computed and is projected on the appropriate SVM for classification.
- The results improved upto 81% recognition.

Sign Language Recognition

- Not yet done.
- Planning to work on 5 different sign language and use leave-one-out cross-validation technique to classify.

Datasets

- Hand Image Dataset from Image and Video computing group, Boston University. The link to the database is here.
- Own database of hand posture images of 2−3 different persons for testing purposes.

References

- Gopalan, Raghuraman and Dariush, Behzad, Toward a vision based hand gesture interface for robotic grasping, IEEE/RSJ international conference on Intelligent robots and systems, pages 1452–1459, 2009.
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