

# **Edge and Boundary Interpretation using Huffman and Clowes catalogue**

*Presented By:*

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# Project Goals

- Implement edge and boundary detection algorithm using Huffman and Clowes catalogue of possible trihedral vertices types
- Given a picture with some object on it resolve all possible interpretations of boundaries of the object

# Course of action

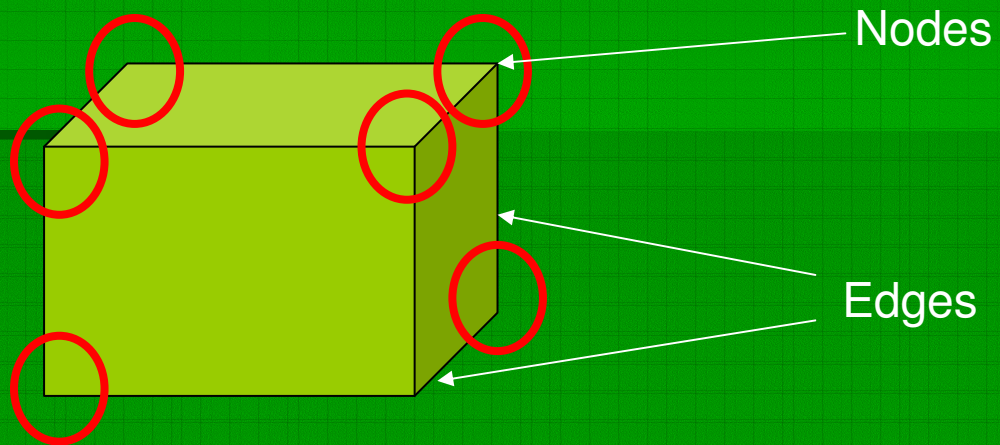
## Consistent line drawing labeling via relaxation labeling

1. Initial the label set for each line drawing label to  $\{+, -, \langle, \rangle\}$
2. Repeat at all edges concurrently until no label set decreases in size
  - If label  $L$  at edge  $e$  cannot form a consistent junction using available labels at edges intersecting  $e$  in a common vertex, filter  $L$  from  $e$ 's label set

# Course of action

- Relaxation labeling:

- Nodes → Vertices → Corners
- Edges → Boundaries



# Course of action

- Resolve the corners of the object
- Determine the types of the resolved corners according to trihedral model of Huffman and Clowes
- Apply the algorithm of Consistent line drawing labeling via relaxation labeling on the vertexes from step 2
- Display the obtained interpretations

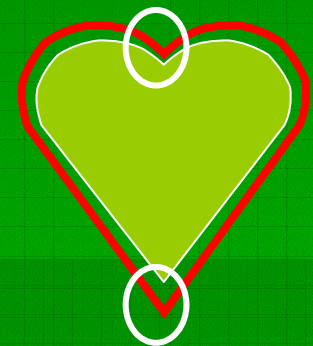
# Resolve the corners of the object

## ■ CSS – The curvature scale space technique

The process of CSS image corner detection is as follows:

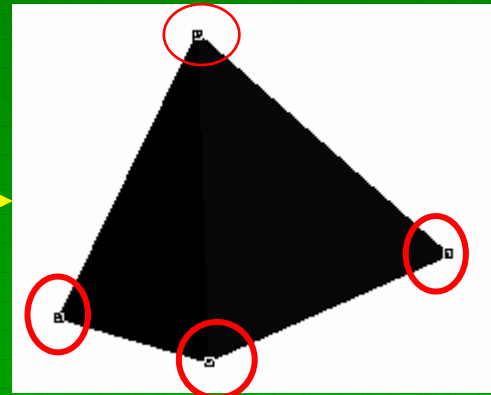
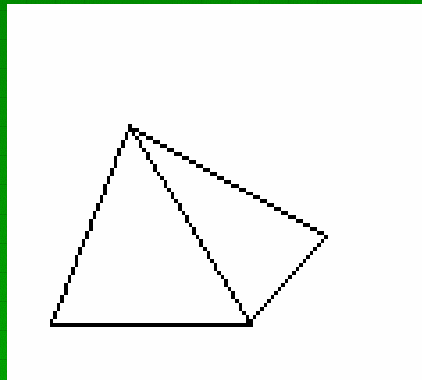
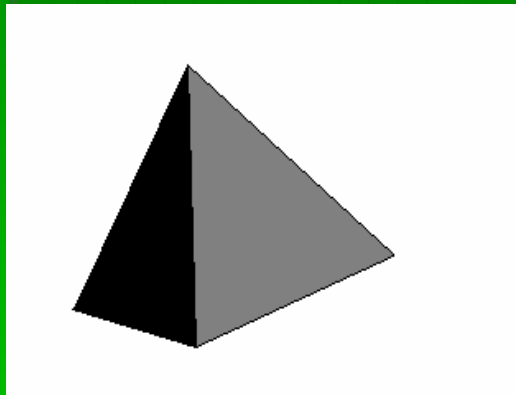
- Utilize the Canny edge detector to extract edges from the original image.
- Extract the edge contours from the edge image:
  - Fill the gaps in the edge contours.
  - Find the T-junctions and mark them as T-corners.
- Compute the curvature at highest scale  $\sigma_{high}$  and determine the corner candidates by comparing the maxima of curvature to the threshold  $t$  and the neighboring minima.
- Track the corners to the lowest scale to improve localization.
- Compare the T-corners to the corners found using the curvature procedure and remove corners which are very close.

The following is an explanation of each stage of the CSS corner detector.



# Resolve the corners of the object

- CSS



# Determine the types of the resolved corners

- For each corner detect the line segments that are connected to it
- For each detected vertex determine the type of the corner and order the lines in clockwise order

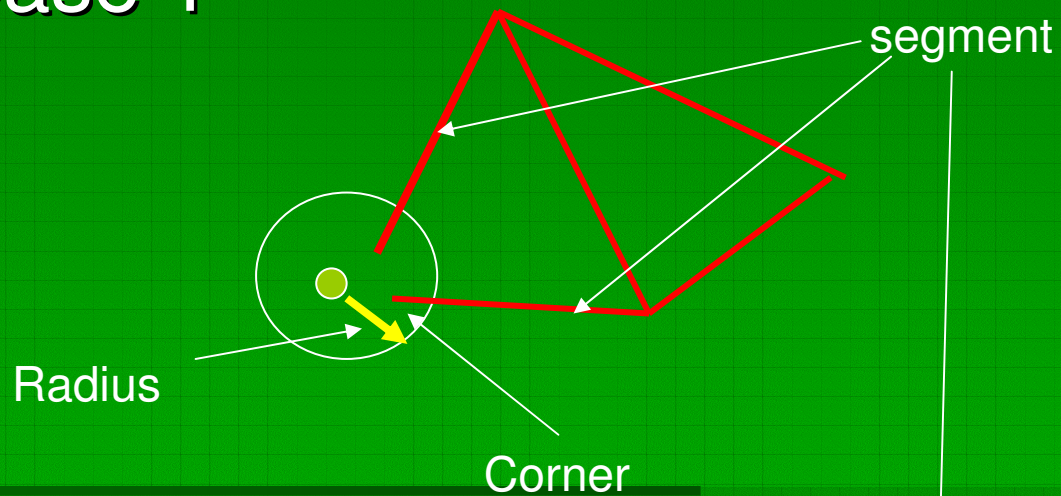


# Determine corner segments

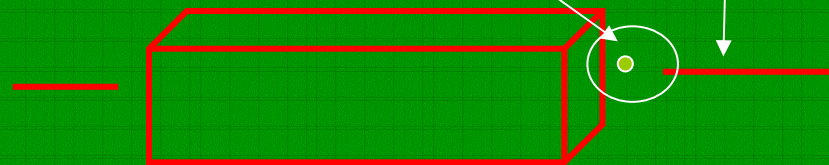
- Canny edge detector
- On the resulting binary image we apply Hough transform for lines detection (Matlab implementation was used)
- For each corner we scan the neighborhood in radius of some predefined threshold to detect the edge points of segments that are connected to this corner

# Determine corner segments

- Case 1

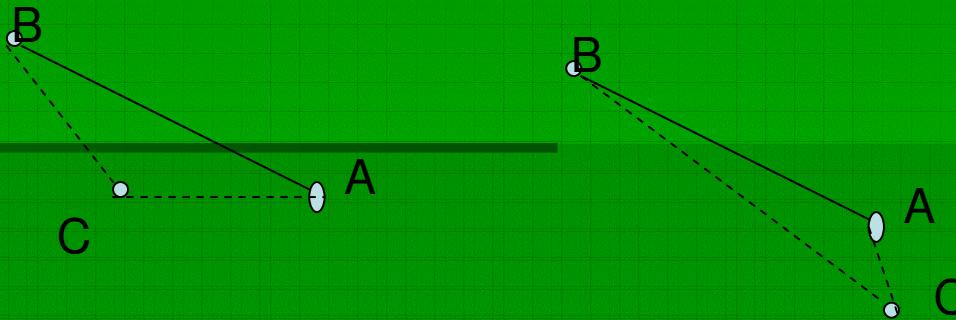


- Case 2



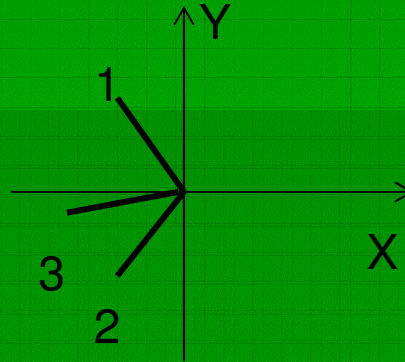
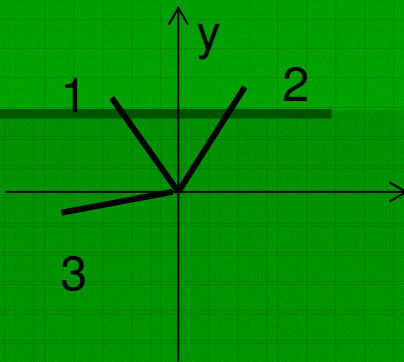
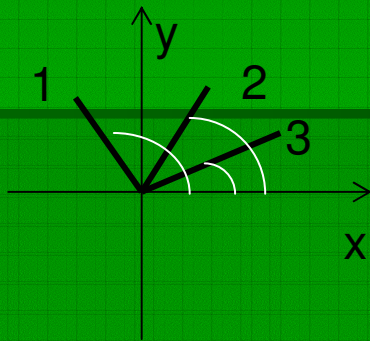
# Determine corner segments

- Cosine test:
  - Left C is on the interior of line AB
  - Right C is not on the interior of line AB

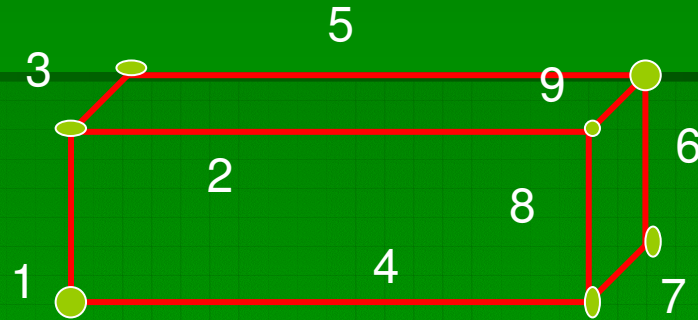


# Determine the type of the corner

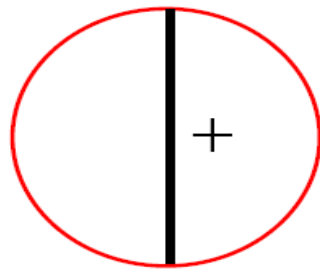
- Sort segments  $\text{atan}(d(x), d(y))$
- T- junction resolved according to the previous step
- V- junction two segments in the vertex
- W-junction and Y-junction
  - $(1) - (3) > 180$  and  $(1) - (2) < 180$
  - $(1) - (3) > 180$  and  $(2) - (3) < 180$



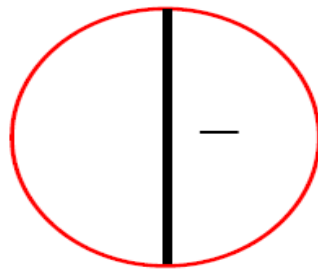
# Consistent line drawing labeling via relaxation labeling



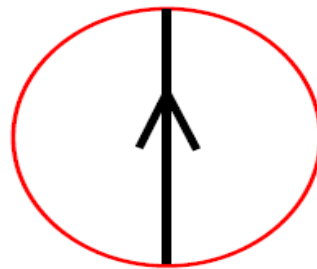
- Assign for each line segment all possible labels



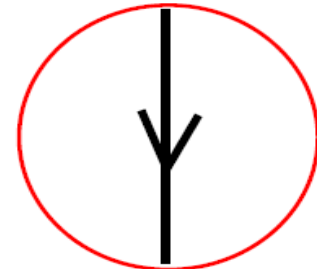
Convex  
orientation edge



Concave  
orientation edge



Depth edge

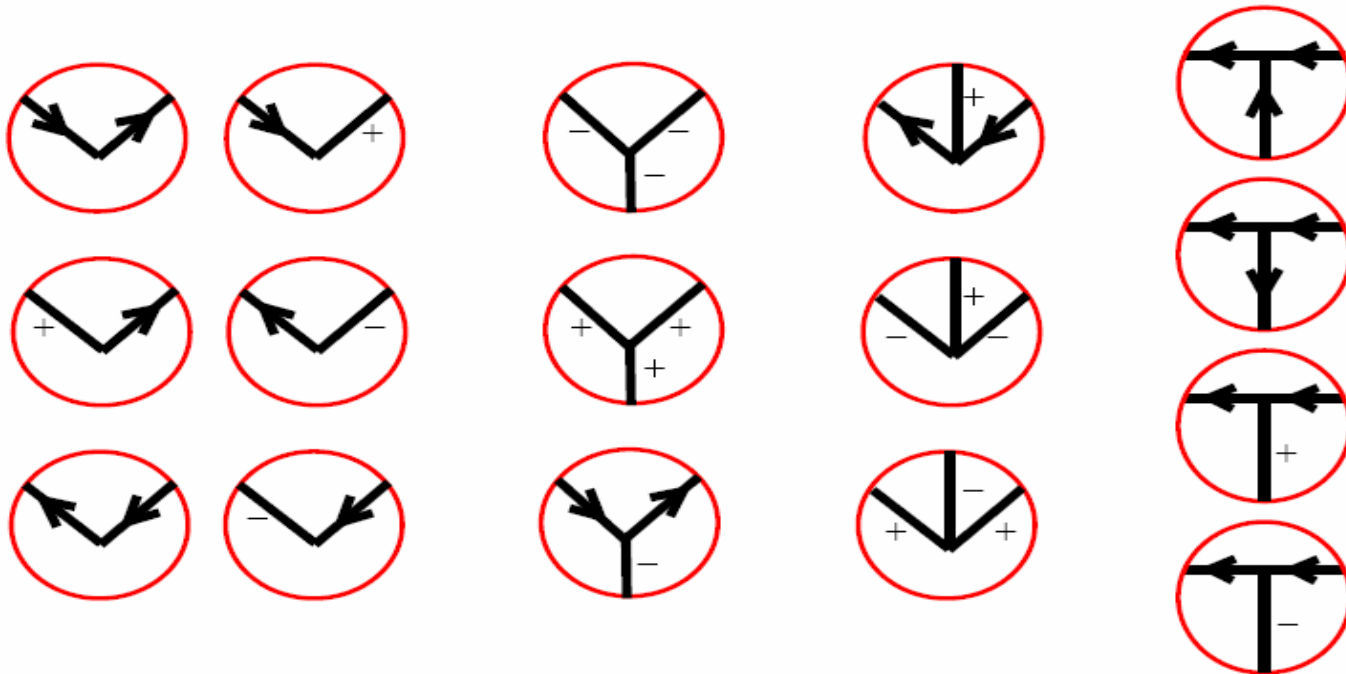


Depth edge

# Consistent line drawing labeling via relaxation labeling

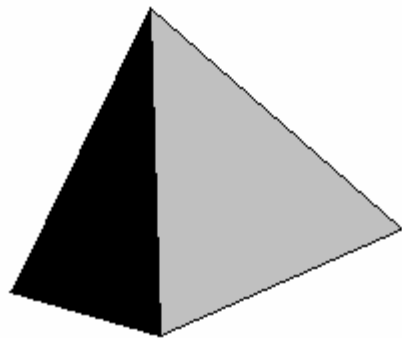
- For each vertex perform:  
For each line that is connected to the vertex remove the labels from line that are not valid according to Huffman and Clowes catalogue

Huffman and Clowes complete catalog (1971)



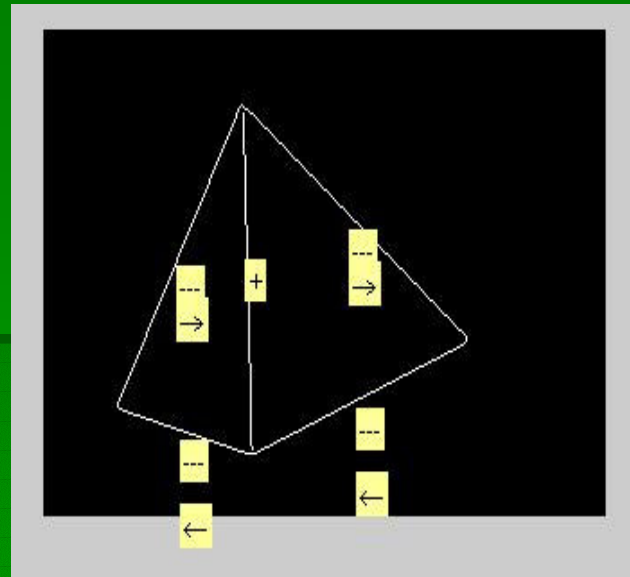
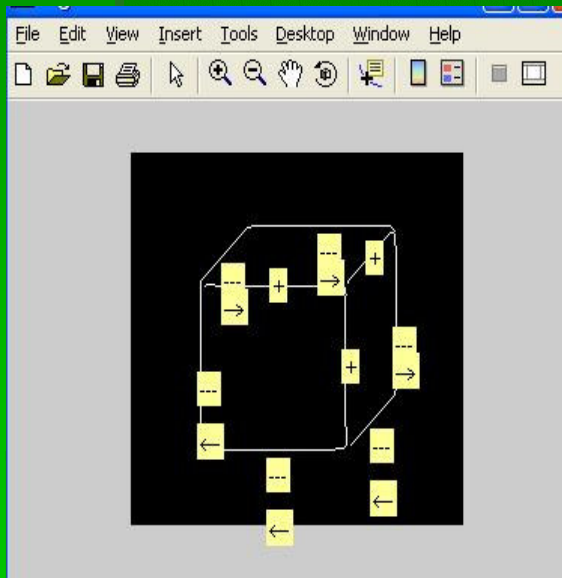
# Results

- Input image:
  - Only vertexes from catalogue
  - Ribs are not colored
  - Sharp contrast between the object faces
  - Problematic input leads to illegal output



# Results

- Outputs:





# References

- IEEE Transactions on Pattern Analysis and Machine Intelligence, Farzin Mokhtarian and Riku Suomela, Vol. 20, NO. 12, December 1998
- Application of the generalized Hough transform to corner detection, E.R Davies, MA, DPhill, CPhys, FInstP
- A local edge detector used for finding corners, Fet Shen, Han Wang, School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore
- Site of introduction to computational and biological vision, University Ben Gurion of the Negev.  
[www.cs.bgu.ac.il/~icbv061](http://www.cs.bgu.ac.il/~icbv061)

**Thank You 😊**