Department of Computer Science
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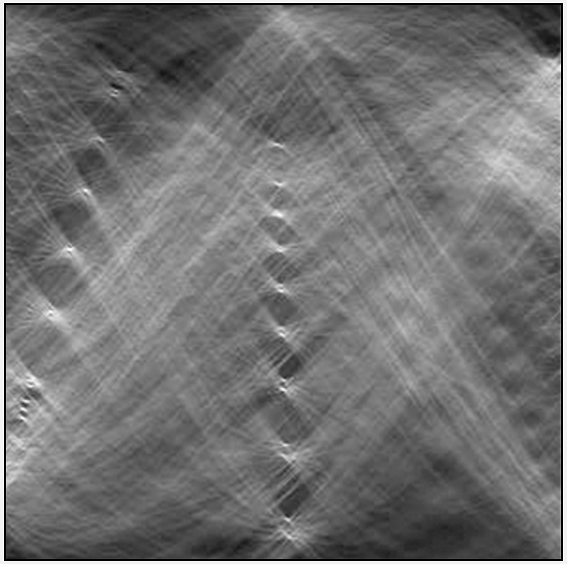
COMS30030
Image Processing and Computer Vision



Problem Discussion - Week 03

Key Points, Feedback and Comments

Comments for Seminar on Hough Transforms

1. Most lines in an image can be detected by using a slope vs. intercept Hough space.

2. A line given by $y = mx + c$ is defined by the point (m, c) in the Hough space.

3. An edge point (x_0, y_0) in an image (e.g. with gradient magnitude above a threshold) 'supports' an infinite number of lines with different slopes and intercepts. In Hough space, each such line corresponds to a point, and all such points lie along the line $c = y_0 - mx_0$, i.e. in a slope-intercept Hough space, we can consider that an edge point gives rise to a line and vice versa.)

4. A set of N edge points lying on a line $y = m_0 x + c_0$ in the image give rise to a set of N lines in Hough space which all intersect at the point (m_0, c_0).

5. If an image contains only one line, then we can detect its presence by analytically determining the intersection of all the lines in Hough space 'generated' by each of the edge points along the line (including using least squares for example if there is error in the position of the edge points).

6. However, in practice, we will have multiple lines in an image and so we can't easily find all the intersections using an analytical method.

Comments for Seminar on Hough Transforms

7. Instead, we quantise the Hough space into a finite number of 'cells' or 'bins', each corresponding to a discrete slope and intercept. Each edge point in our image then 'votes' for all the cells which it supports (which will lie along a line in this case) and the cells which end up with a sufficiently large number of votes (a threshold is required here as the minimum support required for confirming a line detection) then determines the lines in the image.

8. Thus, applying this algorithm to Task 1, the cell corresponding to a slope of 1 and intercept -1 ends up having a vote from each of the four edge points in the image, enabling us to detect the presence of the line.

9. **BUT** - our slope-intercept Hough space has a major problem - it is not able to represent vertical lines, which have a slope of inf and will have problems with any near vertical lines. Hence we need to use an alternative representation for our Hough space.

10. The (ρ, θ) representation enables all lines to be represented in Hough space. A line in an image is defined by all the x and y which satisfy $\rho = x \cos\theta + y \sin\theta$, where ρ is the perpendicular offset of the line from the origin and θ is the angle of its normal.

Comments for Seminar on Hough Transforms

11. In (ρ, θ) Hough space, a line in an image maps to a point and all lines supported by an image point lie on a sinusoid in the Hough space. A set of edge points on a line will give rise to multiple sinusoids and where they intersect defines the lines in the image.

12. As above, when multiple lines are present in an image, we use a quantised version of the space and count up votes given to cells by each edge point in the image.

13. In Task 2, we can observe the number of maxima in the Hough transform images to determine which is the corresponding image. For example, the triangle and pentagon have 3 and 5 line features respectively and thus correspond to to the 3rd and 2nd from the left Hough transform images, respectively. I.e. there are 3 peaks in the 3rd image and they clearly correspond to where the sinusoids intersect.

14. Similarly, the 4th from the left Hough image corresponds to the flag image (there are multiple peaks corresponding to multiple lines) whilst the far left Hough image has a single, albeit spread out peak, corresponding to the near vertical lines in the building image. That leaves the flame image, which has little if any linear structures and results in a spread of sinusiods in Hough space without any discernable common intersection.