Photo Album

by Ahmed Ibrahim

The Hough Transform

- **The Hough Transform** is a technique which is used to isolate curves of a given shape in an image.
- Any curve defined in **parametric form** may be found using the Hough Transform.
- Curves such as lines, circles and ellipses are very easy to find.
- In industry most manufactured parts have such boundaries, so these curves may serve the purpose.
- This transform technique is relatively unaffected by noise.

The Hough Transform

Line Detection

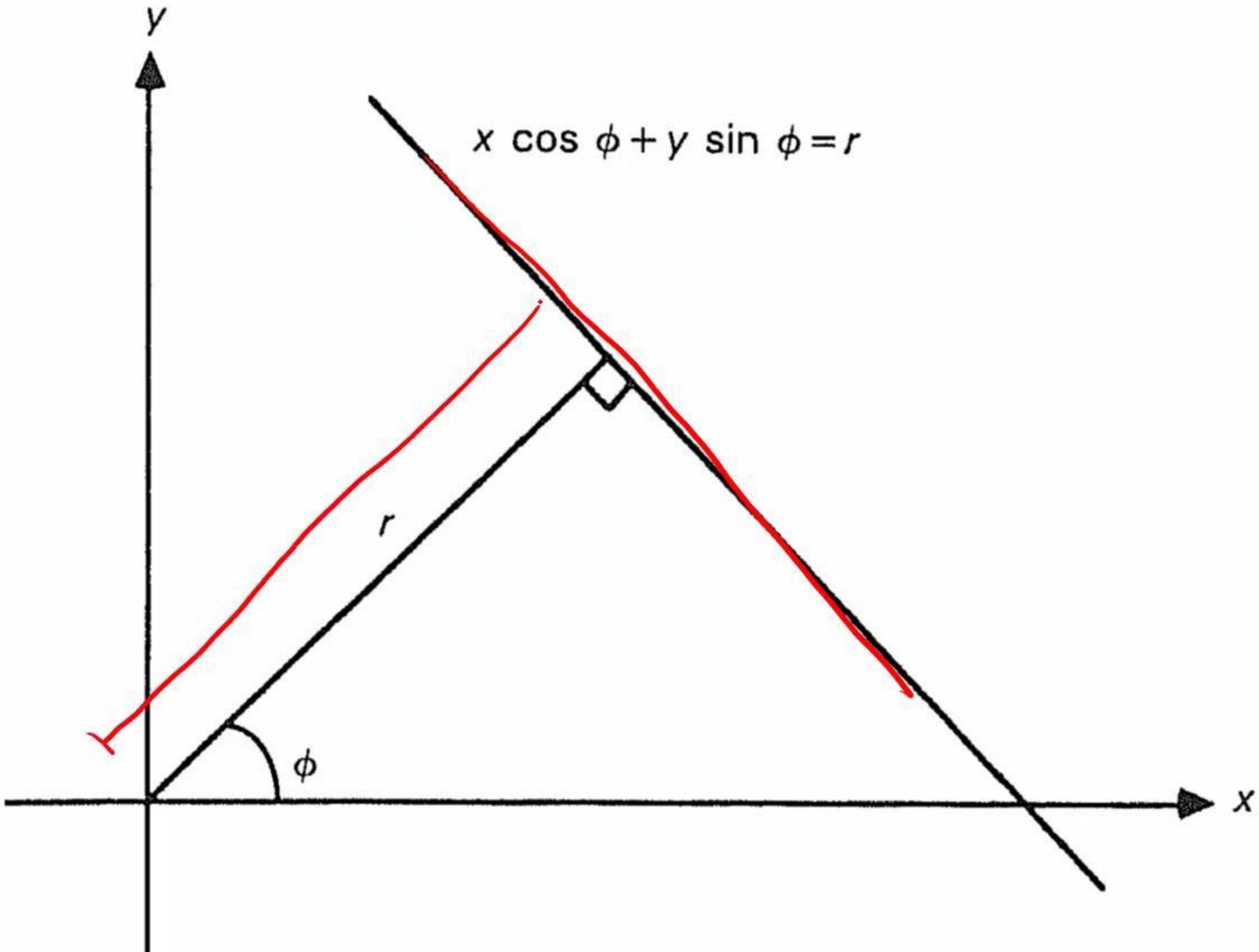
- Equation of straight line given in parametric form is:

$$x \cos \phi + y \sin \underline{\phi} = \underline{r}$$

- Where **'r'** is the length of a normal to the line from the origin and **'ϕ'** is the angle this normal makes with the X-axis

The Hough Transform

Line Detection



The Hough Transform

Line Detection

- If we have a point (x_i,y_i) on this line, then:

$$x_i \cos \phi + y_i \sin \phi = r$$

- A line will have some constant value of **'r'** and **'ϕ'**.
- Suppose, however, that we do not know which line we are considering, but we do know the coordinates of the point(s) on the line.
- Now we can consider **'r'** and **'ϕ'** as variables and point (x_i,y_i) as constants.

The Hough Transform

Line Detection

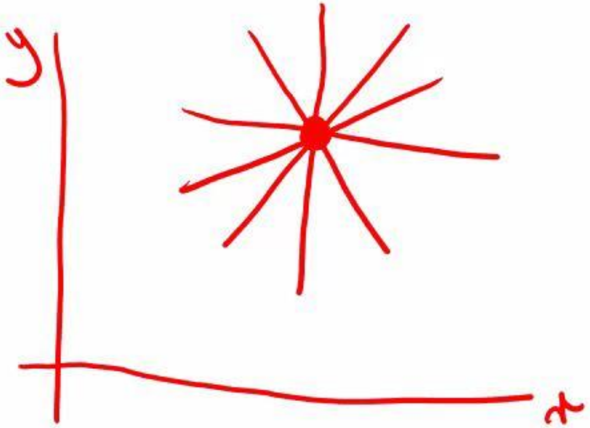
- In this case the equation

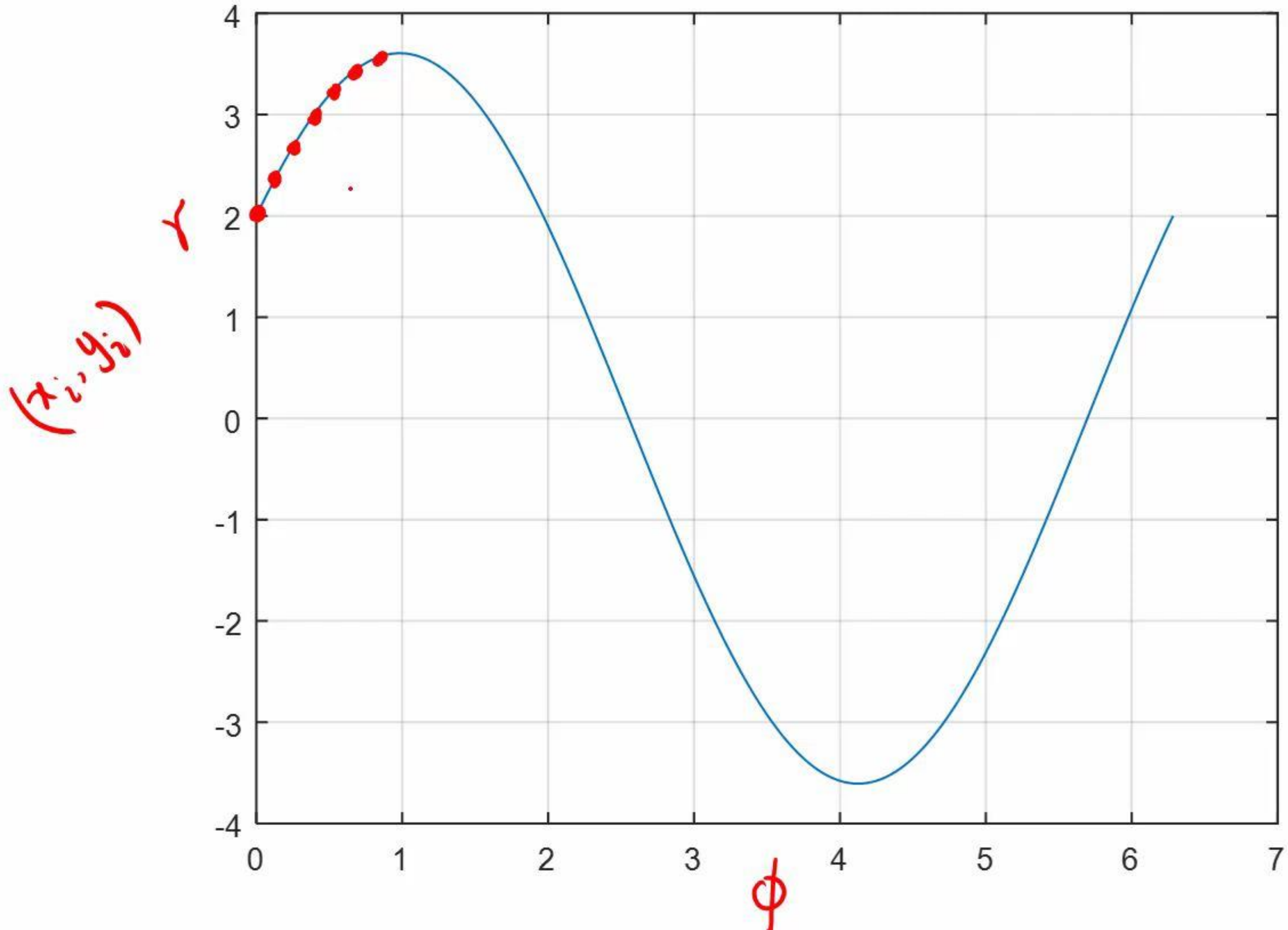
$$x_i \cos \phi + y_i \sin \phi = r$$

- Defines the values of **‘r’** and **‘ϕ’** such that the line passes through the point (x_i, y_i).
- If we plot the values of **‘r’** and **‘ϕ’** for this given point then we will get a sinusoidal curve in **(r-ϕ) space**.

The Hough Transform

Line Detection

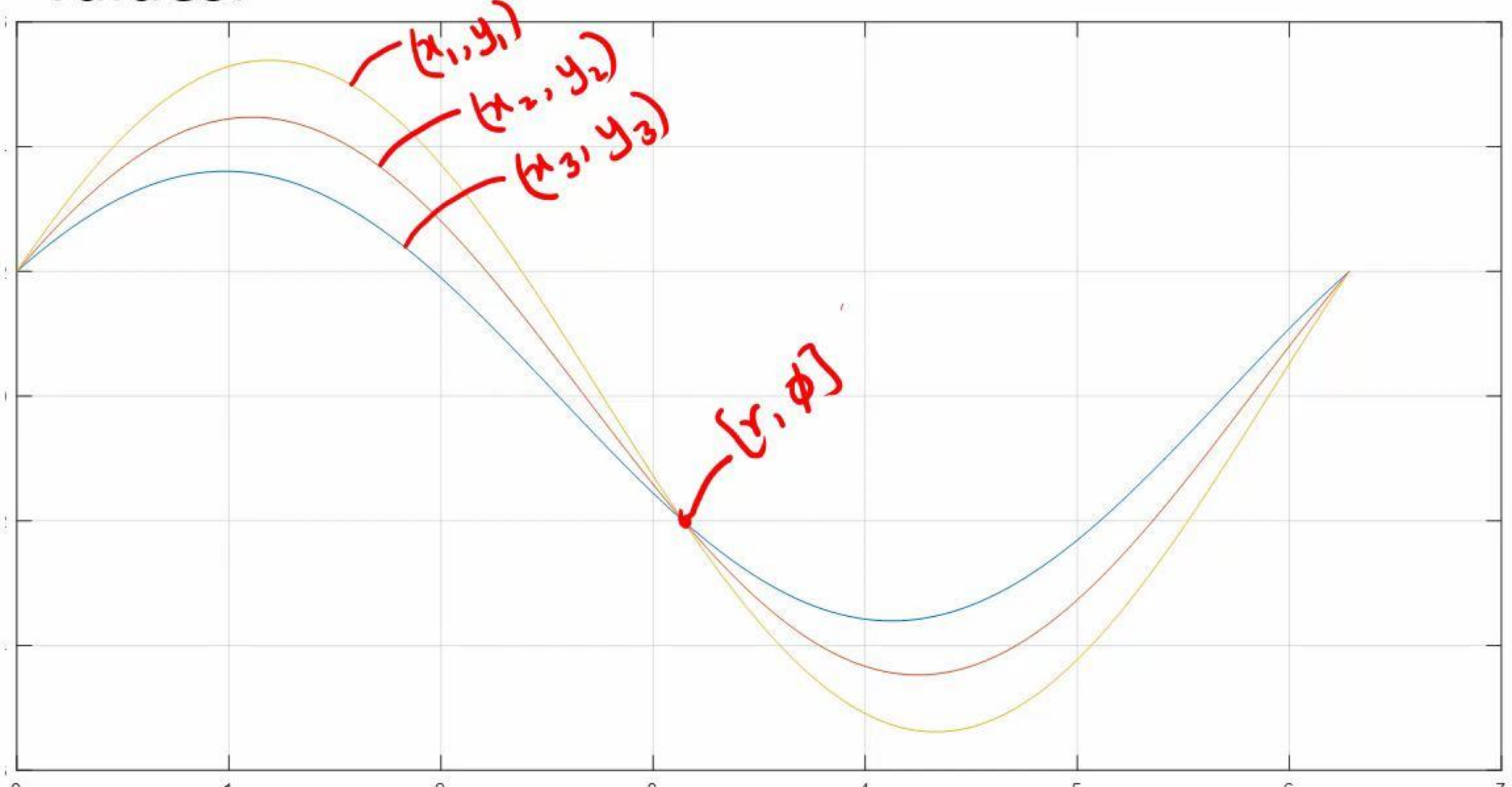




The Hough Transform

Line Detection

- All points which are collinear to this point will correspond to one common pair of **‘r’** and **‘ϕ’** values.



The Hough Transform

Line Detection

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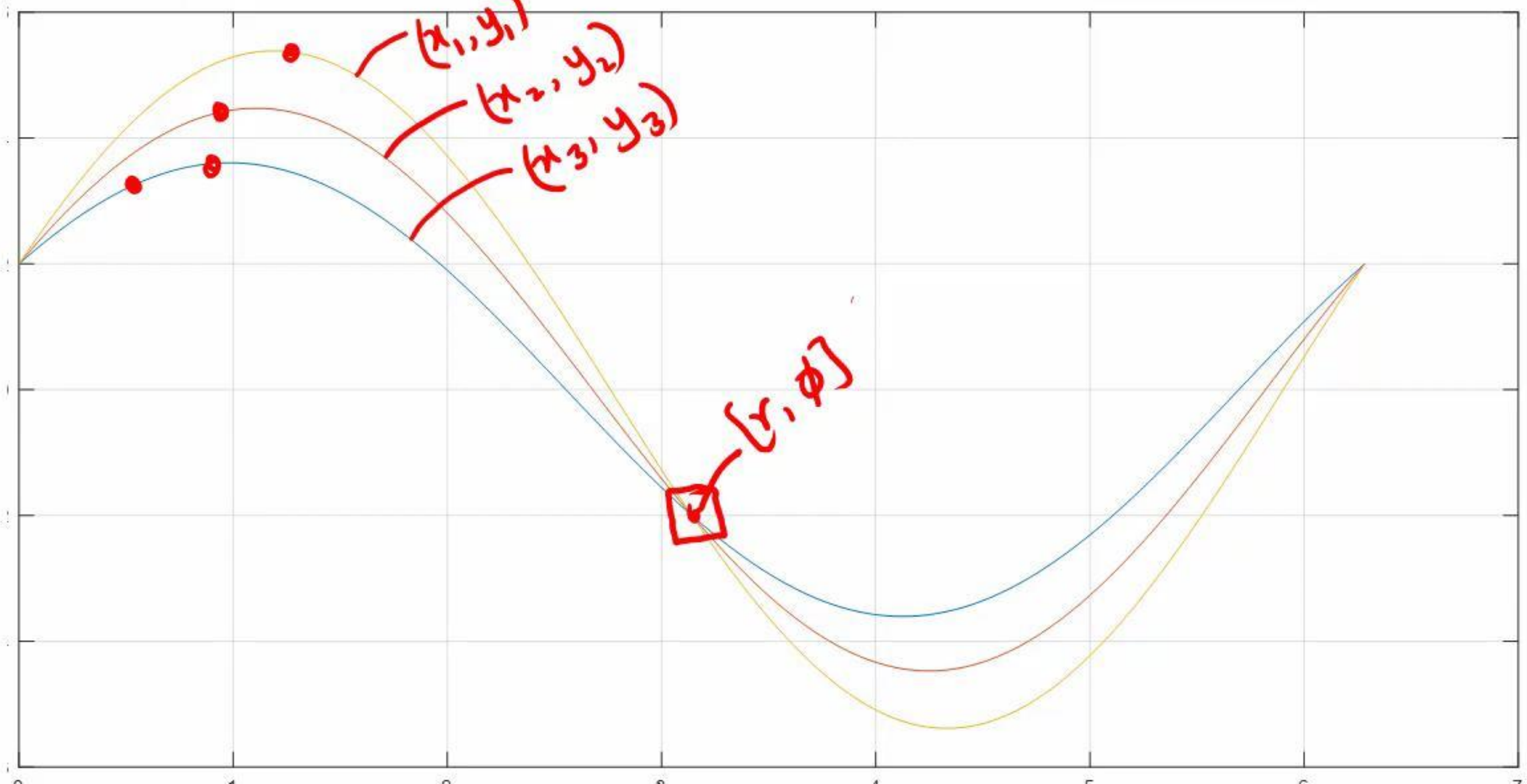
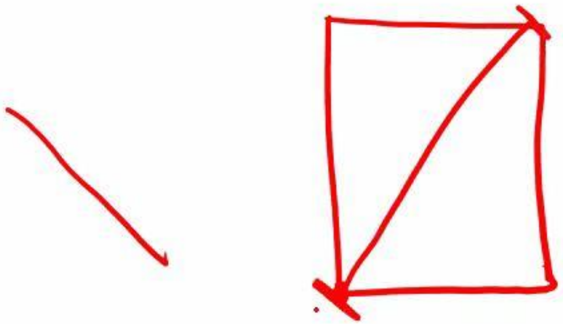


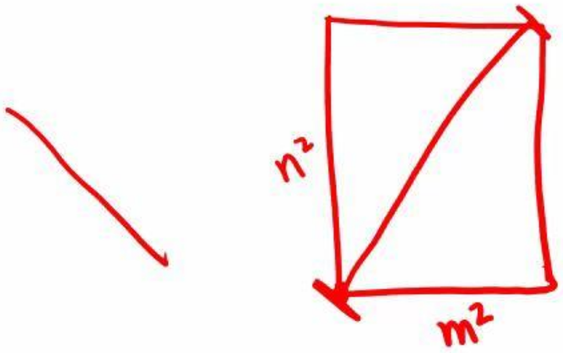
The Hough Transform



<u>Line Detection</u>

- Since now we have two variables **'r'** and **'ϕ'** we need to discretize them.
- Φ is ranging from '0' to '180' and if we use a resolution of 1 deg. then we will have 180 discrete values of ϕ.
- For **'r'** maximum distance from the origin may be a limit, which effectively will be the pixel location that is farthest from the origin, i.e. **sqrt(m^2+n^2).**

The Hough Transform



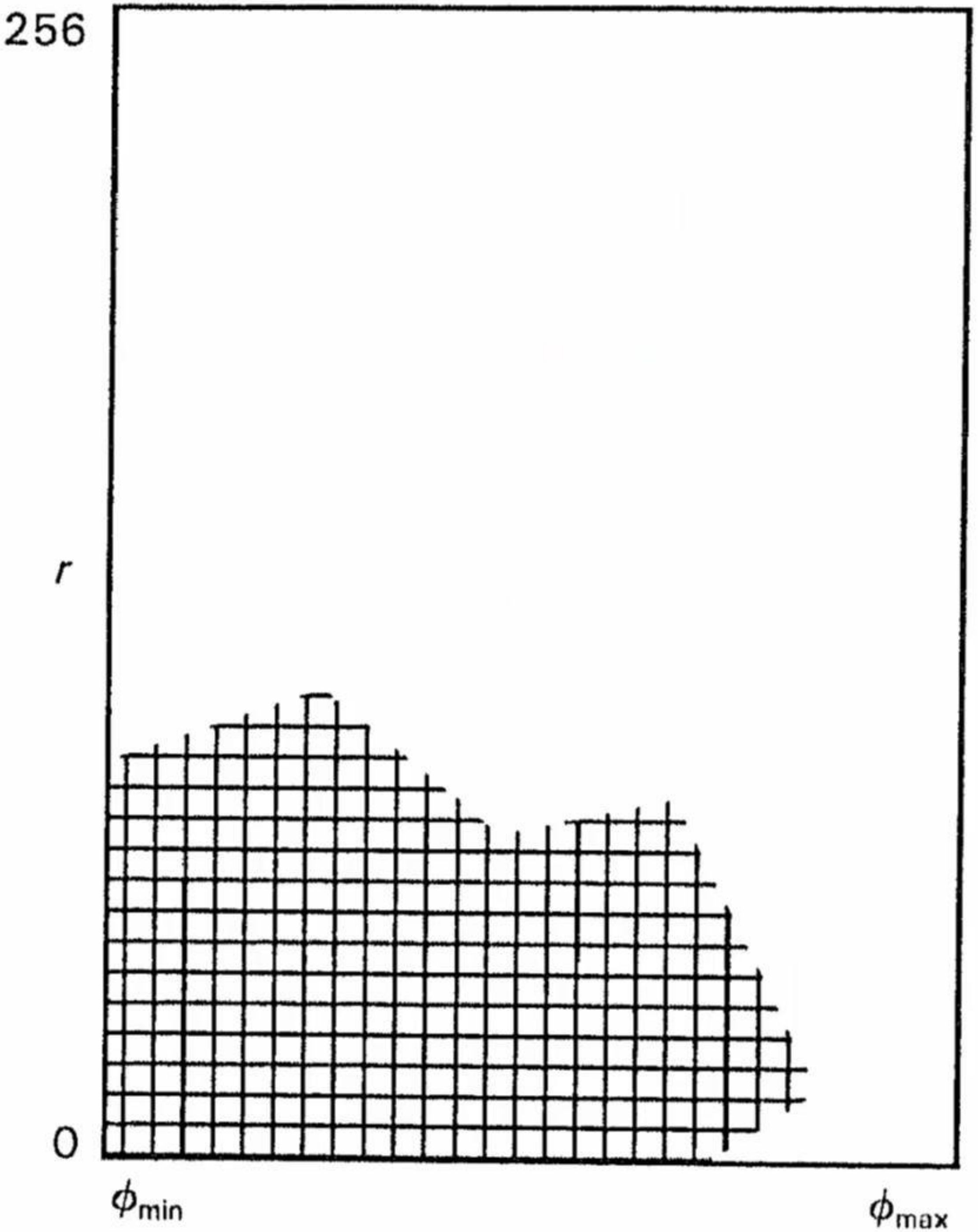
Line Detection

- Since now we have two variables **‘r’** and **‘ϕ’** we need to discretize them.
- **Φ** is ranging from ‘0’ to ‘180’ and if we use a resolution of 1 deg. then we will have 180 discrete values of ϕ.
- For **‘r’** maximum distance from the origin may be a limit, which effectively will be the pixel location that is farthest from the origin, i.e. **sqrt(m^2+n^2).**
- Our representation of **(r-ϕ) space** is now simply a 2-dimensional array of size, let 300x180, each element corresponding to a pair of **‘r’** and **‘ϕ’**.

The Hough Transform

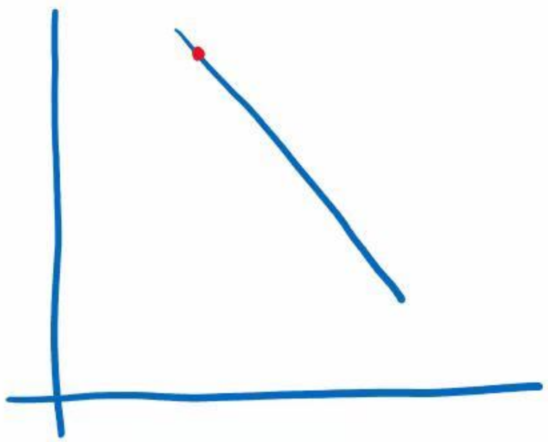
Line Detection

- This is called an **accumulator** since we are going to accumulate evidence of curves given by particular boundary points (x,y) in the image plane.



Microsoft Whiteboard

Hough Transform



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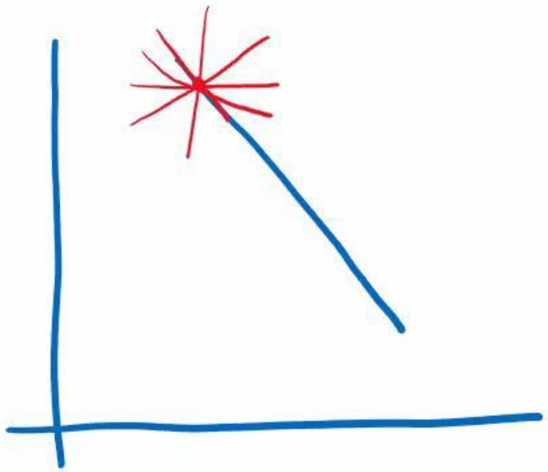
Hough Transform



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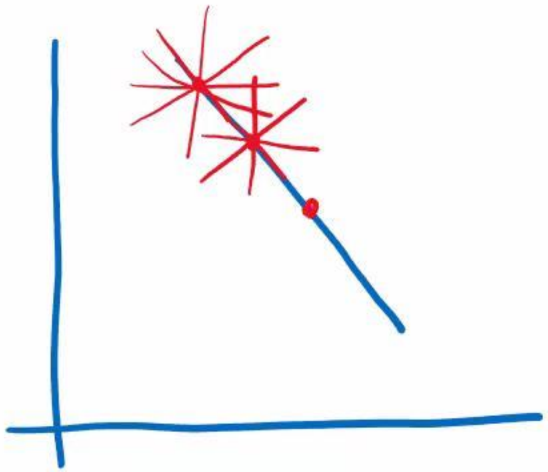
Hough Transform



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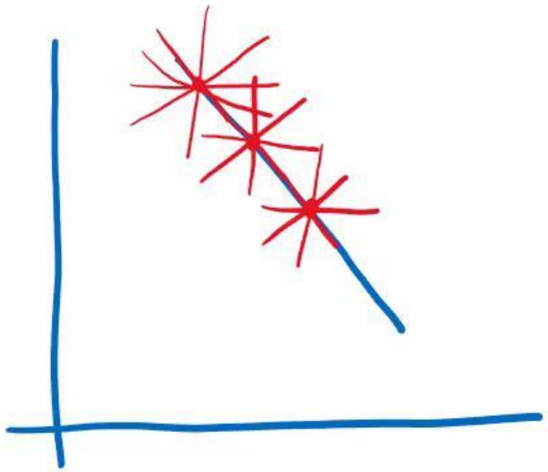
Hough Transform



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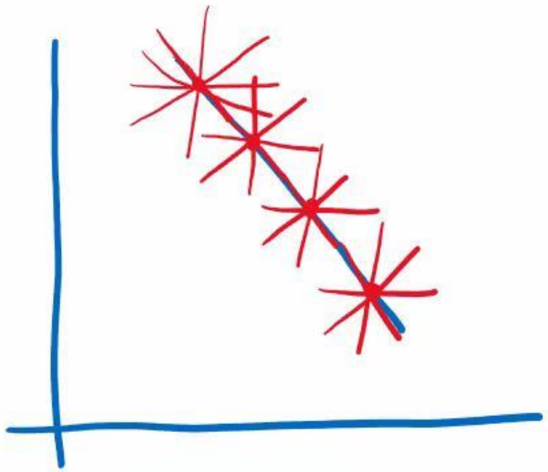
Hough Transform



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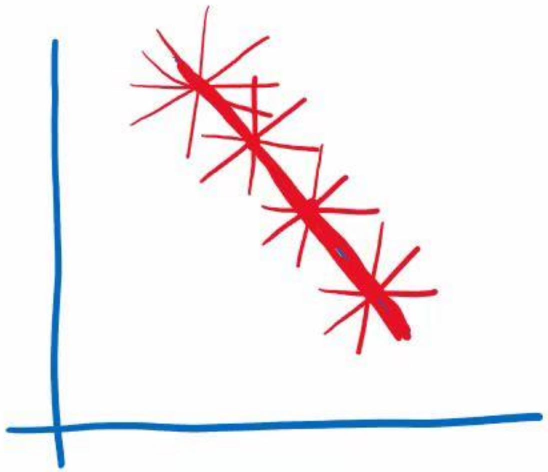
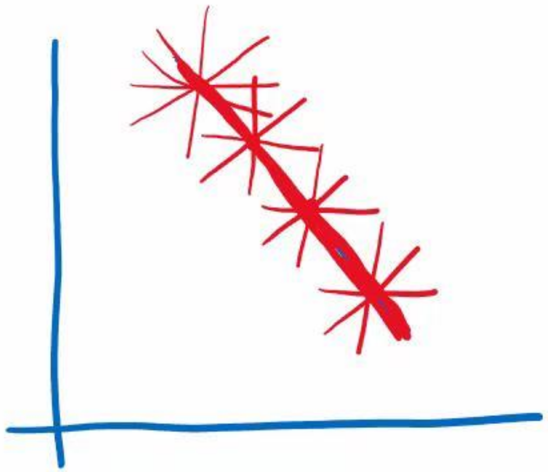
Hough Transform



Hough Transform



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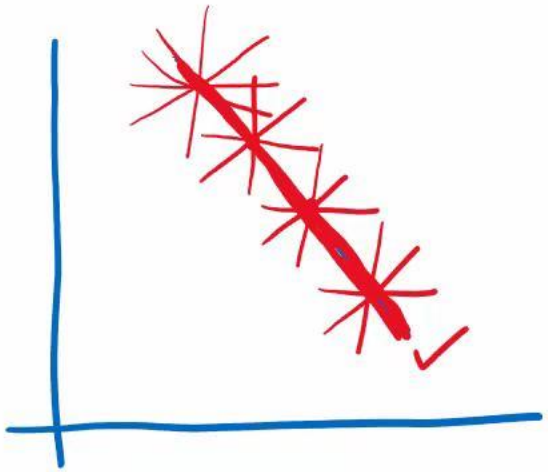
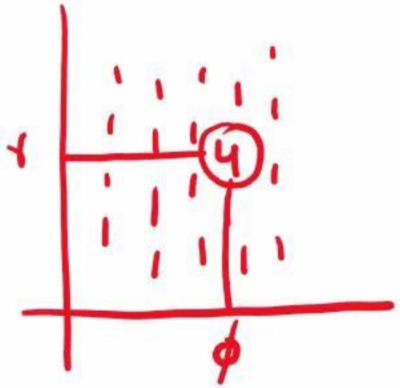
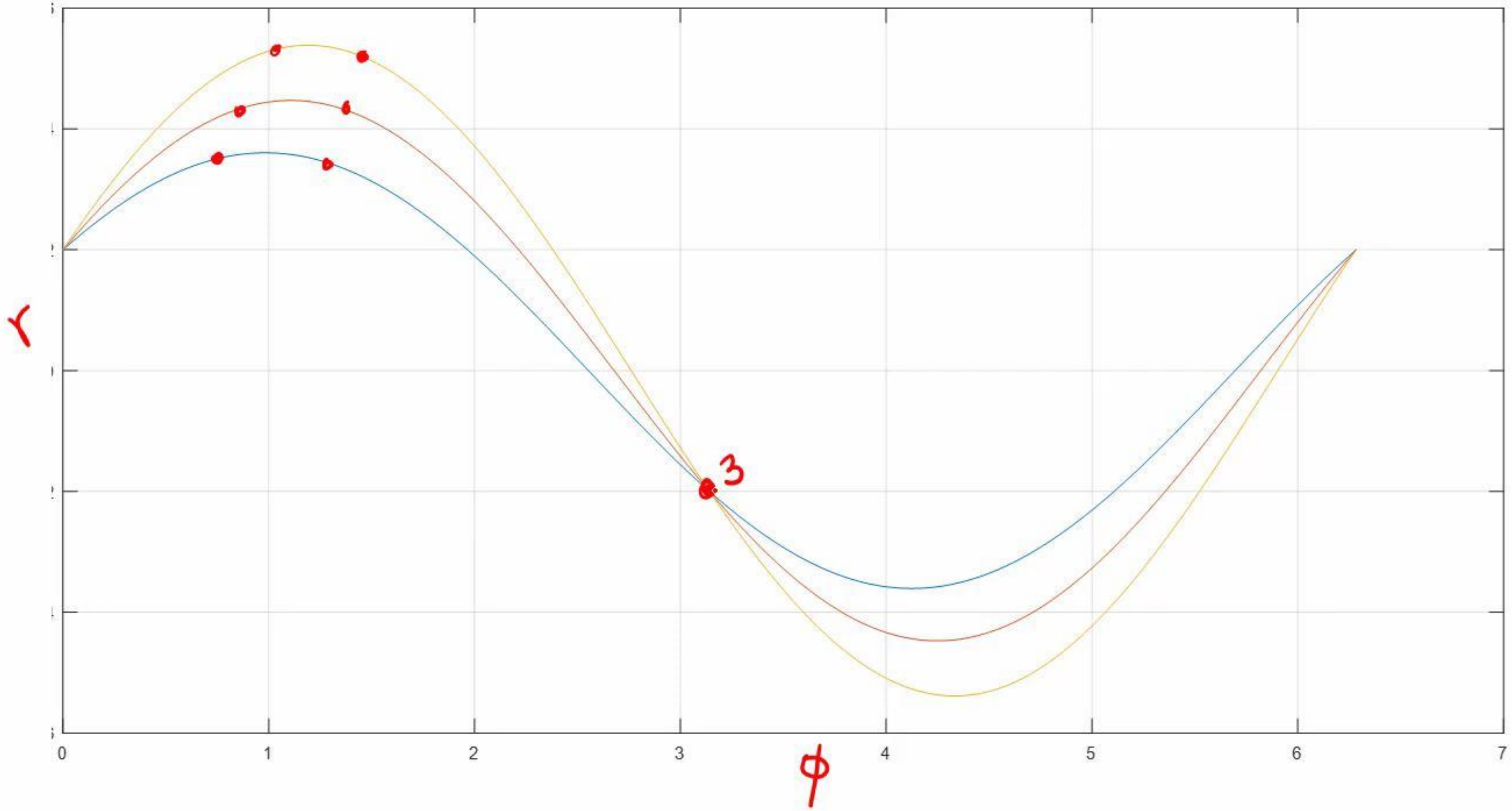




The Hough Transform

Line Detection



The Hough Transform

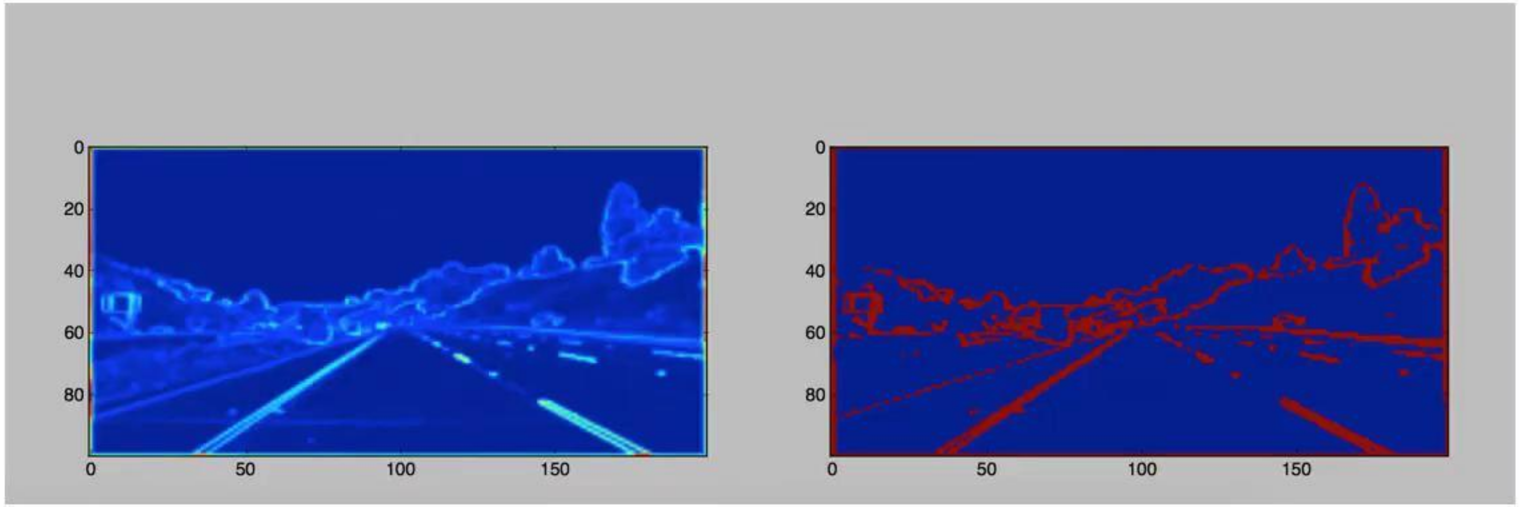
Circle Detection

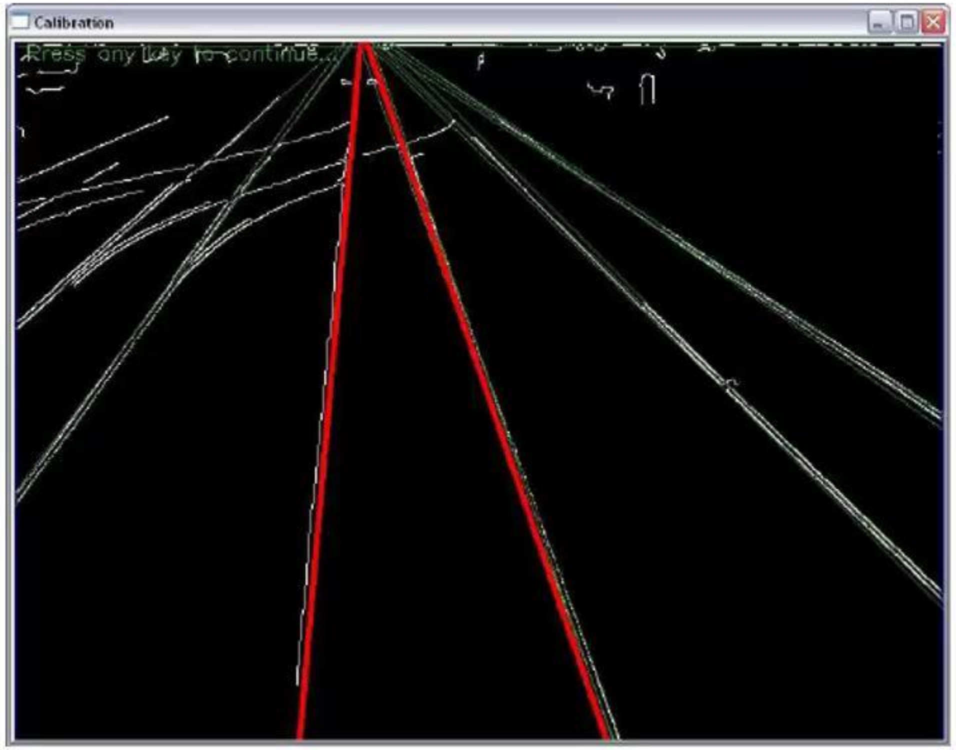
- Parametric equation of a circle is given as

$$(x-a)^2 + (y-b)^2 = r^2$$

The Hough Transform

Line Detection





The Hough Transform

Circle Detection