Finding More Shapes

Hough Transform for Circles

$$(x-x_0)^2+(y-y_0)^2=r^2$$

OR $\begin{matrix} points(x,y)centre(x_0,y_0)radius\,r \\ points(x_0,y_0)centre(x,y)radius\,r \end{matrix}$

```
forall x,y in image                    !all points in the image
   if edge(x,y) >= threshold           !significant points
      forall r in r_min,r_max          !all values of r
         forall %theta in 1,360        !go around the circle
            x_0 = x+rcos(%theta)
            y_0 = y+rsin(%theta)
            accumulator(x_0,y_0) += 1
```

Afterwards you search for the peak/maximum in the accumulator.

Ellipses

$$\frac{(x-x_0)^2}{a^2}+\frac{(y-y_0)^2}{b^2}=1$$

This is a 4D accumulator x_0,y_0, a, b.
If you were to add rotation you would get a 5th dimension

If each parameter has 100 values (10^2) then our 5D accumulator would have 10^{10}.

This will get very slow so it needs some special implementations.

Arbitrary Shapes

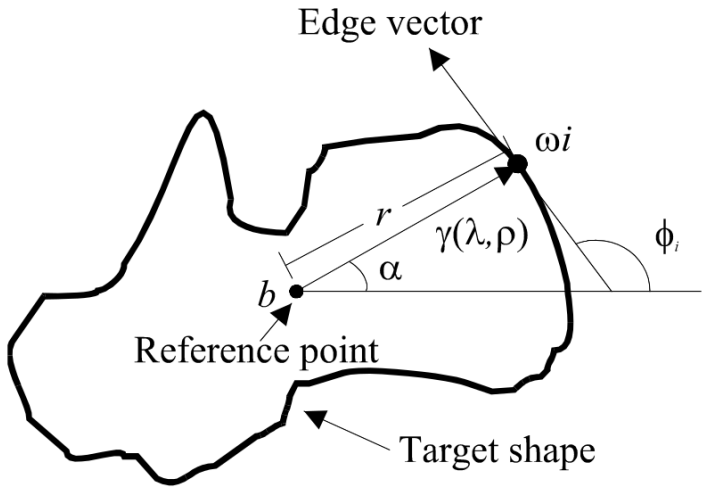
We use a generalised Hough Transform:

1. We form a template
2. Use the template for voting
3. Search for peak

The image below is from the slides and it describes how you define each point in the image based on it's position relative to the centre. We can form a template for this which is then stored in an **R-Table**. This contains the distance and angle to the centre point.
It uses the **edge direction** or Φ(phi) as the index/address in the table.

Multiple points may have the same edge direction and thus be under the same index, this will produce noise but for every noise element you have a correct one so it does not compromise the result.
In order to rotate the image you add a constant to alpha or phi, for scaling, multiply r.

R-table Construction



$\hat{\varphi}_i'$	$\gamma = (r,\alpha)$
0	$(r_0,\alpha_0),(r_1,\alpha_1),(r_2,\alpha_2)$
$\Delta\phi$	⋮
$2\Delta\phi$	⋮
...	...