

## Edge Detection and Hough Transforms

Recognition Strategy: Determine a measure of change in the pixel's neighbourhood. The first derivative in 2D space is the image gradient.

$\psi$  = Direct of the maximum growth of a function

$|\nabla f(x, y)|$  = Magnitude of growth

$\phi$  = Perpendicular to edge detection

$$|\nabla f(x, y)| = \sqrt{\left(\frac{\delta f}{\delta x}\right)^2 + \left(\frac{\delta f}{\delta y}\right)^2}$$

$$\psi = \arctan\left(\frac{\delta f / \delta x}{\delta f / \delta y}\right) \quad \phi = \psi - \pi/2$$

$$h_x = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix} \quad h_y = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

If the image is very noisy we can use a larger neighborhood in our kernels. These masks are very sensitive to noise so instead we could use the Prewitt operator or the Sobel operator.

Prewitt:

$$h_{hor} = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}, h_{dia} = \begin{bmatrix} 0 & 1 & 1 \\ -1 & 0 & 1 \\ -1 & -1 & 0 \end{bmatrix}, \dots$$

Figure 1: Untitled

Sobel (Gaussian):

### Hough Transform:

The image space is transformed into a parameter space a voting procedure is carried out in the parameter space and object candidates are obtained as local maxima.

$$h_{hor} = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}, h_{ver} = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

Figure 2: Untitled

straight line:  $f(x, y, \rho, \theta) = x \cos \theta + y \sin \theta - \rho = 0$

$\rho$  = Distance between origin and the line



Figure 3: Untitled

Each point in the Hough space is a line defined by its coordinates.

A point(x,y) in the image space is transformed into a sinusoidal curve in the parameter space. Each orientation of lines passing through p(x,y) represents a sinusoidal curve in the Hough transform.

**Line Detection:**

$H(\rho, \theta) = 2D$  Array for parameter space. 1. Find the gradient image:  $G(x, y) = |G(x, y)| \angle G(x, y)$  2. For any pixel

We can define a delta theta range which will allow room for error in the angle of the gradient space.

**Circle Detection:**

1. For any pixel satisfying  $|G(x, y)| > T_s$  increment all elements to satisfy the following simultaneous equations