## 0.1 Gradient

$$\nabla I(u,v) = \begin{pmatrix} I_x(u,v) \\ I_y(u,v) \end{pmatrix}$$

## 0.2 linear filters

$$I_x = \begin{bmatrix} -0.5 & 0 & 0.5 \end{bmatrix}$$

$$I_y = \begin{bmatrix} -0.5 \\ 0 \\ 0.5 \end{bmatrix}$$

## 0.3 3x3 Filters

$$\frac{1}{4} \cdot \begin{bmatrix} 0 & -1 & 0 \\ -1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

**Prewitt**

$$H_y^P = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

$$H_x^P = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

$$\nabla I^P(u,v) \approx \frac{1}{6} \cdot \begin{pmatrix} (I * H_x^P)(u,v) \\ (I * H_y^P)(u,v) \end{pmatrix}$$

**Sobel**

$$H_y^S = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

$$H_x^S = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

$$\nabla I^S(u,v) \approx \frac{1}{8} \cdot \begin{pmatrix} (I * H_x^S)(u,v) \\ (I * H_y^S)(u,v) \end{pmatrix}$$

**Direction**

$$E(u,v) = \sqrt{I_x^2(u,v) + I_y^2(u,v)}$$

$$\Phi(u,v) = \tan^{-1}\left(\frac{I_y(u,v)}{I_x(u,v)}\right) = \arctan(I_x(u,v), I_y(u,v))$$