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CMSC426 Exam 1 Notes

Convolution and Filters

- Deconvolution process
  - Find individual values in the kernel based on where the convolution has only 1 nonzero input
- Some Kernel Examples

$$\text{Gaussian Kernel} \implies \frac{1}{16}\begin{bmatrix}1 & 2 & 1\\2 & 4 & 2\\1 & 2 & 1\end{bmatrix}$$

$$\text{Sobel Kernel} \implies G_x = \begin{bmatrix}1 & 0 & -1\\2 & 0 & -2\\1 & 0 & -1\end{bmatrix}, G_y = \begin{bmatrix}1 & 2 & 1\\0 & 0 & 0\\-1 & -2 & -1\end{bmatrix}$$

$$Sharpen \implies \begin{bmatrix}0 & -1 & 0\\-1 & 5 & -1\\0 & 5 & 0\end{bmatrix}$$

- Padding Options
  - Zero padding → Pad edges of matrix with all 0's

$$\begin{bmatrix}\begin{vmatrix}0 & 0\end{vmatrix} a & b & \dots\end{bmatrix}$$

  - Reflection padding → Reflect end of matrix

$$\begin{bmatrix}\begin{vmatrix}b & a\end{vmatrix} a & b & \dots\end{bmatrix}$$

  - Repeated Cyclic

$$\begin{bmatrix}\begin{vmatrix}y & z\end{vmatrix} a & b & \dots & y & z\end{bmatrix}$$

  - Edge Values

$$\left[\left|a \quad a\right|a \quad b \quad \dots \quad y \quad z\left|z \quad z\right|\right]$$

Camera Projections

- **Pinhole Model**
  - Projection from 3D onto 2D plane
  - Lines viewed with a pinhole camera will have their vanishing point at infinity if the line is in a plane parallel to the image plane
  - Focal length f $\rightarrow$ Distance from camera pinhole to plane
  - (X, Y, Z) is the point in 3D space, (x, y) is the point in 2D

$$y = \frac{fY}{Z}$$

$$x = \frac{fX}{Z}$$

- Orthographic Projection of 2 parallel lines must be parallel in the image

Geometric Transformations

- **Types of Transformations**

$$\text{Projective/Homography (8DoF/4pts)} \implies \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix}$$

$$\textbf{Invariants -}\text{ Colinearity, Cross Ratios}$$

$$\text{Affine (6DoF/3pts)} \implies \begin{bmatrix} a_{11} & a_{12} & t_x \\ a_{21} & a_{22} & t_y \\ 0 & 0 & 1 \end{bmatrix}$$

$$\textbf{Invariants -}\text{ Parallelism, Area Ratios, Length Ratios}$$

$$\text{Similarity (4DoF/2pts)} \implies \begin{bmatrix} sr_{11} & sr_{12} & t_x \\ sr_{21} & sr_{22} & t_y \\ 0 & 0 & 1 \end{bmatrix}$$

$$\textbf{Invariants -}\text{ Angles, Length Ratios}$$

$$\text{Euclidean/Translation (3DoF/2pts)} \implies \begin{bmatrix} r_{11} & r_{12} & t_x \\ r_{21} & r_{22} & t_y \\ 0 & 0 & 1 \end{bmatrix}$$

Invariants - Angles, Length Ratios

- `Given 4 points solve for their transformations`

$$\begin{bmatrix} \prime x_1 \\ \prime y_1 \end{bmatrix} = \begin{bmatrix} m_1 & m_2 \\ m_3 & m_4 \end{bmatrix} + \begin{bmatrix} t_1 \\ t_2 \end{bmatrix}$$