CAP5415 Computer Vision
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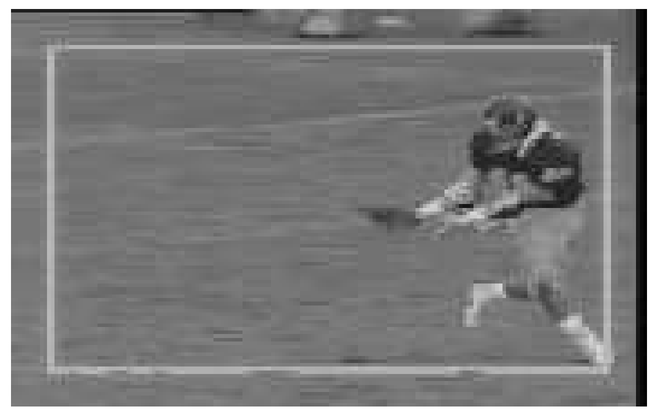
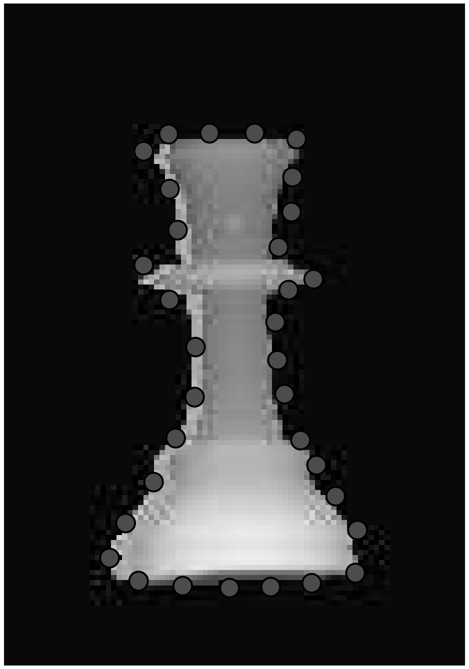
Deformable Contours



Deformable Contours



Deformable Contours

- Minimize the Energy Functional

$$E = \int \left[\alpha(s) E_{cont} + \beta(s) E_{curv} + \gamma(s) E_{image} \right] ds$$

- Where the integral is taken along the contour **c** and each of the energy terms in the functional is a function of **c** or the derivatives of **c** with respect to *s*. The parameters α, β, and γ control the relative influence of the corresponding energy term, and can vary along **c**.

Deformable Contours

- Continuity

$$E_{cont} = \left\| \frac{d\mathbf{c}}{ds} \right\|^2$$

$$E_{cont} = \left\| p_i - p_{i-1} \right\|^2$$ Discrete Approximation

$$E_{cont} = \left(\bar{d} - \left\| p_i - p_{i-1} \right\| \right)^2$$ A better form

Deformable Contours

- Curvature (Smoothness)

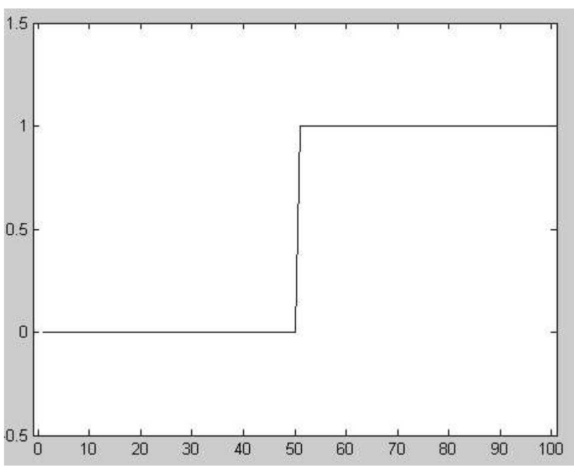
$$E_{curv} = \left\| \frac{d^2\mathbf{c}}{ds^2} \right\|^2$$

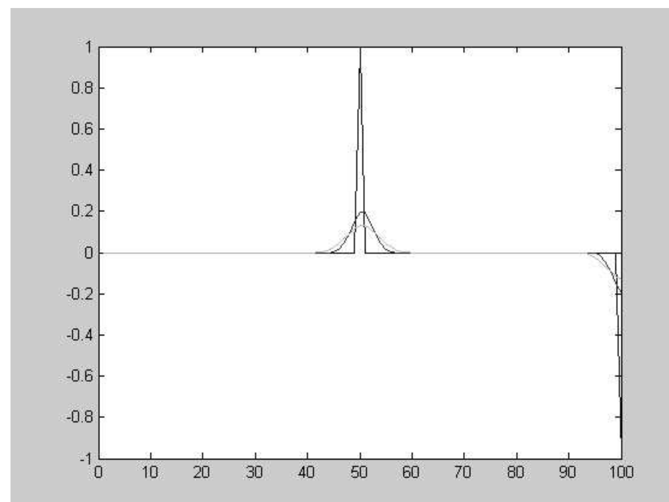
$$E_{cont} = \left\| p_{i-1} - 2p_i + p_{i+1} \right\|^2$$ Discrete Approximation

Deformable Contours

- Image (Edge Attraction)

$$E_{curv} = -\|\Delta I\|$$





Greedy Algorithm (Williams & Shah)

Let *I* be the intensity image and $p_1, \ldots p_k$ be the initial positions of the snake points.

While a fraction greater than *f* of the snake points move in an iteration:

1. For each *i*, find the location of $N(p_i)$ for which the functional is minimum and move the snake point p_i to that location.
2. For each *i*, estimate the curvature *k* of the snake and look for local maxima. Set $\beta(j)=0$ for all p_j at which the curvature has a local maximum and is above certain threshold and at which the image gradient is above certain threshold.
3. Update the value of the average distance

Suggested Reading

- Chapter 5, Emanuele Trucco, Alessandro Verri, "Introductory Techniques for 3-D Computer Vision“
- Donna Williams, and Mubarak Shah. “A Fast Algorithm for Active Contours and Curvature Estimation,” Computer Vision, Graphics and Image Processing, Vol 55, No.1, January 1992, pp 14-26.

Programming Assignment #2

$$\frac{\partial}{\partial x} G_\sigma = -\frac{x}{2\pi\sigma^4} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Y

X

0.0001	0.0005	0.0011	0	-0.0011	-0.0005	-0.0001
0.0007	0.0058	0.0131	0	-0.0131	-0.0058	-0.0007
0.0032	0.0261	0.0585	0	-0.0585	-0.0261	-0.0032
0.0053	0.0431	0.0965	0	-0.0965	-0.0431	-0.0053
0.0032	0.0261	0.0585	0	-0.0585	-0.0261	-0.0032
0.0007	0.0058	0.0131	0	-0.0131	-0.0058	-0.0007
0.0001	0.0005	0.0011	0	-0.0011	-0.0005	-0.0001

Programming Assignment #2

$$\frac{\partial}{\partial y}G_\sigma = -\frac{y}{2\pi\sigma^4}e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Y

0.0001	0.0007	0.0032		0.0053	0.0032	0.0007	0.0001
0.0005	0.0058	0.0261		0.0431	0.0261	0.0058	0.0005
0.0011	0.0131	0.0585		0.0965	0.0585	0.0131	0.0011
0	0	0		0	0	0	0
-0.0011	-0.0131	-0.0585		-0.0965	-0.0585	-0.0131	-0.0011
-0.0005	-0.0058	-0.0261		-0.0431	-0.0261	-0.0058	-0.0005
-0.0001	-0.0007	-0.0032		-0.0053	-0.0032	-0.0007	-0.0001

X

Programming Assignment #2

$$S_x = \left(\frac{\partial}{\partial x} G_\sigma \right) * I$$

$$S_y = \left(\frac{\partial}{\partial y} G_\sigma \right) * I$$

$$|\Delta| = \sqrt{S_x^2 + S_y^2}$$

Programming Assignment #2

Least Square Fitting

Let the line be: $y = ax + b$

$$\text{Solve} \begin{bmatrix} \sum_i x_i y_i \\ \sum_i y_i \end{bmatrix} = \begin{bmatrix} \sum_i x_i^2 & \sum_i x_i \\ \sum_i x_i & n \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix}$$

Programming Assignment #2

Maximum Likelihood Fitting

Let the line be : $ax + by + c = 0$

Find the Eigen Vectors $\begin{bmatrix} a \\ b \end{bmatrix}$ of the matrix

$$\begin{bmatrix} \sum_i x_i^2 - \frac{\left(\sum_i x_i\right)^2}{n} & \sum_i x_i y_i - \frac{\left(\sum_i x_i\right)\left(\sum_i y_i\right)}{n} \\ \sum_i x_i y_i - \frac{\left(\sum_i x_i\right)\left(\sum_i y_i\right)}{n} & \sum_i y_i^2 - \frac{\left(\sum_i y_i\right)^2}{n} \end{bmatrix}$$

Compute $c = -a \frac{\sum_i x_i}{n} - b \frac{\sum_i y_i}{n}$