CNS/EE-148
Homework 4

Handed out: 05/03/04
Due: 05/11/04 before class in Moore 109

1 Constellation Model - 8 points

1.1

Suppose that we have image patches I_i^j for each detected feature at location x_i^j (i indicates the feature type and j the number of the detected feature). Suppose that we have conditional probability density functions $p(I|\text{good feature})$ and $p(I|\text{background clutter})$. Extend the 1-object 1-part model to take this information into account. Derive an expression for the likelihood ratio. In this formulation the appearance I and position x of the patches is assumed to be independent; give examples of situations where it is reasonable to assume this independence, and situations where x and I are clearly correlated.

1.2

Extend the multi-part object model to the case where all the parts look alike, i.e. we have a single detector which operates for all the F parts. In this case we obtain a single list of detected features rather than F separate lists.

2 Harris and Lucas-Tomasi-Kanade detectors. - 12 points

2.1 Lucas-Tomasi-Kanade detector

In class Pr.Perona described the Lucas-Tomasi-Kanade feature detector. This feature detector computes the matrix

$$H = \nabla I \cdot \nabla I^t = \begin{bmatrix} I_x^2 & I_x \cdot I_y \\ I_x \cdot I_y & I_y^2 \end{bmatrix} \tag{1}$$

and averages it over a small window:

$$\overline{H}(x, y) = \int_{window} H(x, y) \cdot dx \cdot dy \tag{2}$$

The locations of the local maxima of the smallest eigenvalue are selected as good features, provided they exceed an arbitrary threshold.

Compute the equation that gives the smallest eigenvalue λ_2 as a function of the trace and the determinant of $\overline{H}$, then implement it with Matlab. In order to calculate derivatives I_x and I_y, you can convolve with the filter $[-1\ 0\ 1]$ and its transpose $[-1\ 0\ 1]'$. Convolution is done with matlab's function conv2. Typically, the integral that gives $\overline{H}$ as a function of H is computed by a convolution by a gaussian filter, and gaussian filters in the x direction or in the y direction can be approximated by $1/4 * [1\ 2\ 1]$ and $1/4 * [1\ 2\ 1]'$. Don't forget to integrate over both x and y !

You also have to choose a threshold under which local maxima of λ_2 will be rejected - this threshold is arbitrary.

How does this detector perform, what kind of features does it typically pick ?

Note: in order to avoid problems due to aliasing, you may want to smooth the image a bit as a preprocessing step. This is done by a convolution of the same gaussian $1/4 * [1\ 2\ 1]$ in the x and y directions.

2.2 Harris detector

In file harrisDetector88.pdf.gz you will find the original paper describing the Harris detector. Notice that it uses the same matrix H (this matrix is called 'second-order moment matrix'), but not the same 'recipe' to detect features.

Implement the Harris detector and compare it to the Lucas-Tomasi-Kanade one. The parameter k at the bottom of page 150 is usually taken as 0.04, but you can vary this value. Notice that the corresponding coefficient in the expression of λ_2 (Lucas-Tomasi-Kanade detector) is 0.25. Which one performs better ?

As always, illustrate those features detectors by a few examples. Don't submits books of results, the TA won't be happy.