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Exercise Sheet 9
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Exercises in Tracking & Detection

The objective of this Exercise Sheet is to implement the Mean Shift tracking algorithm (without the adaptive window size) described in Bradski et al. in *Computer Vision Face Tracking For Use in a Perceptual User Interface.*

Exercise 1 Color Histogram and Color Probability Distribution

a) In the first image, manually define a rectangular region.

b) *Color Histogram.* Write a function `colorHist` that takes a region of the colored image as input and generates a histogram with 256 bins using the Hue channel in the HSV space (you may use the function `rgb2hsv` from Matlab). Use the region defined in (a) as input and plot the histogram.

c) *Color Probability Distribution.* Write a function `probMap` that takes a region of the colored image and a color histogram from (b) as input, and generates the probability distribution of this region. The input histogram serves as a lookup table such that the hue channel of each pixel in the colored image is looked up in its corresponding bin and is converted to the frequency (number of elements) of the same bin. To normalize, the maximum value of the probability distribution must be 255.

Show the probability distribution in the region, defined in (a), of the succeeding images in the sequence.

Exercise 2 Mean Shift Tracking

a) In the first image, define a rectangular region $\{(x_{min}, y_{min}), (x_{max}, y_{max})\}$ that tightly encloses the red car. Find the color histogram of this region as shown in Exercise 1.

b) For the succeeding frames, we track the red car by iteratively updating the location of the region using mean shift. The Mean Shift algorithm is implemented by moving the center (x_c, y_c) of the region such that for each iteration, the center updates as:

$$x_c = \frac{\sum_x \sum_y x P_I(x,y)}{\sum_x \sum_y P_I(x,y)} \quad (1)$$

$$y_c = \frac{\sum_x \sum_y y P_I(x,y)}{\sum_x \sum_y P_I(x,y)} \quad (2)$$

for $x = x_{min}, \ldots, x_{max}$ and $y = y_{min}, \ldots, y_{max}$, where $P_I(x,y)$ is the Color Probability Distribution as discussed in Exercise 1.

The iteration stops when the center moves for less than 2 pixels or when the maximum iteration (20) is reached .