CoE 3SK3: Project Part 2

Due: April 2, 2017

The most popular strategy for solving the template matching problem is to compare some statistical features of the template with each patch of the input image and output the patch with the most similar features to the query template. In project part 1, mean pixel value has been used as the feature to do the searching and screening. However, you may find that, mean value is not distinguishable enough to locate the best matched patch in given reference image. In this part, variance and gradient will be introduced as new features for this task, which also can be sped up with different summed area tables. The whole algorithm is like following.

1 Establish summed area tables

With the features mean, variance, and gradient, you need to establish 4 different summed area tables to speed up their computation.

$$L_1(x, y) = \sum_{i=1}^{x} \sum_{j=1}^{y} I(i, j). \tag{1}$$

$$L_2(x, y) = \sum_{i=1}^{x} \sum_{j=1}^{y} I(i, j)^2. \tag{2}$$

$$L_X(x, y) = \sum_{i=1}^{x} \sum_{j=1}^{y} i \cdot I(i, j). \tag{3}$$

$$L_Y(x, y) = \sum_{i=1}^{x} \sum_{j=1}^{y} j \cdot I(i, j). \tag{4}$$

where $I(i, j)$ means the pixel value in i_{th} column and j_{th} row in your reference image.

2 Compute patch features

As you know, feature mean can be computed fast using table L_1. Also, here, feature variance can be computed fast with table L_1 and L_2. You are required

$X:$

-3	-2	-1	0	1	2	3
-3	-2	-1	0	1	2	3
-3	-2	-1	0	1	2	3
-3	-2	-1	0	1	2	3
-3	-2	-1	0	1	2	3
-3	-2	-1	0	1	2	3
-3	-2	-1	0	1	2	3

(a) EP operator in X direction

$Y:$

-3	-3	-3	-3	-3	-3	-3
-2	-2	-2	-2	-2	-2	-2
-1	-1	-1	-1	-1	-1	-1
0	0	0	0	0	0	0
1	1	1	1	1	1	1
2	2	2	2	2	2	2
3	3	3	3	3	3	3

(b) EP operator in Y direction

Figure 1

to figure out how to obtain variance efficiently.

In this task, patch gradient is defined based on Extended Prewitt operator (EP operator), whose expressions in X, Y directions for a $J \times J$ patch are like,

$$EP_X(x, y) = x - \frac{J+1}{2} \tag{5}$$

$$EP_Y(x, y) = y - \frac{J+1}{2} \tag{6}$$

where J is always odd for convenience. For example, for a 7×7 patch $I(D)$, the EP operator should be like Figure 1.

Then, the gradient component in X, Y directions for this patch can be obtained based on,

$$G_X(D) = \sum_{i=1}^{J} \sum_{j=1}^{J} EP_X(i, j) \cdot I(i, j) \tag{7}$$

$$G_Y(D) = \sum_{i=1}^{J} \sum_{j=1}^{J} EP_Y(i, j) \cdot I(i, j) \tag{8}$$

$$\tag{9}$$

In all, the gradient magnitude and direction can be formulated like,

$$G_{mag}(D) = \sqrt{G_X(D)^2 + G_Y(D)^2} \tag{10}$$

$$G_{dir}(D) = \arctan \frac{G_Y(D)}{G_X(D)} \tag{11}$$

Based on these definitions, you are required to figure out how to compute gradient fast using tables L_1, L_X, L_Y.

3 Question

Suppose that the value of each pixel is an integer from 0 to 255. If we store tables L_X and L_Y using unsigned 32-bit integer format, for a 1024×1024 reference image, find the size limitation for your template. Justify your answer in your report.