Template matching

In order to detect a template λ in a picture f we can compute the cross correlation of λ with f. The values of the result can be taken as a first approximation to a match measure, where large values correspond to a probable match, and small values correspond to a probable mismatch.

A better match measure should be invariant to scaling. We can achieve that as follows. Let w be a window in the picture of the same dimensions as λ. In vector notation, the cross-correlation match measure at the location of w is $\lambda \bullet w$, the dot product between λ and w. A better match measure that is invariant to scaling can be obtained by computing the cosine of the angle between λ and w. It is given by $\frac{\lambda \bullet w}{|\lambda| \ |w|}$. Since $|\lambda|$ is constant, it is enough to compute the following values:

$$\frac{\lambda \bullet w}{|w|}$$

This is the normalized cross correlations measure.

The algorithm for computing the non-normalized template matching values can be written as follows. For each pixel (i, j) in f compute the match measure $Q(i, j)$ by:

$$Q(i,j) = \sum_{\text{coordinates } \alpha,\beta \text{ in } \lambda} \lambda(\alpha, \beta) \ f(i+\alpha, j+\beta)$$

The algorithm for computing the normalized template matching values can be written as follows. For each pixel (i, j) in f compute the match measure $Q(i, j)$ by:

$$Q(i,j) = \frac{\sum_{\text{coordinates } \alpha,\beta \text{ in } \lambda} \lambda(\alpha, \beta) \ f(i+\alpha, j+\beta)}{\sqrt{\sum_{\text{coordinates } \alpha,\beta \text{ in } \lambda} f^2(i+\alpha, j+\beta)}}$$

In both cases large values of Q correspond to likely matches.

The normalized template matching algorithm can be implemented in terms of cross correlations by the following steps:

1. Compute the non normalized correlations:

$$C = \lambda \otimes f$$

2. Compute f_2 by squaring each vlaue of f:

$$f_2(i,j) = f^2(i,j)$$

3. Compute λ_1 by replacing each value of λ with 1:

$$\lambda_1(\alpha, \beta) = 1$$

4. Compute the squares of the normalization factors:

$$N_2 = \lambda_1 \otimes f_2$$

5. Compute the match measures Q:

$$Q(i,j) = \frac{C(i,j)}{\sqrt{N_2(i,j)}}$$

Example:

The template is given as: $\lambda =$

0	2
1	2

and the picture as: $f =$

1	0	2	2	10
1	0	2	2	10
1	0	1	2	10

Compute cross correlation: $C =$

Square picture values: $f_2 =$

Replace all values in template with 1: $\lambda_1 =$

1	1
1	1

Compute the cross correlation of λ_1 with f_2: $N_2 =$

Normalize the cross correlation values: $Q =$
