CNS/EE-148
Homework 1

1 A few words about normalization (homework 1)

In the first homework you were asked to normalize patches and images. Normalization is required in order to have comparable quantities in all images.

One idea is to map linearly the greyvalues in the image to $[0, 1]$: the minimum greyvalue is mapped to 0, the maximum is mapped to 1. This is a good idea, but doesn't take into account the artifacts. The minimum and maximum may be reached due to a defect in the camera CCD. For instance, you could reach the value 0 and 255 at single pixels, and have values between 150 and 200 everywhere else. In order to avoid this problem, you can filter the image with a low-pass filter (i.e. smooth the image).

A better idea is to subtract the average brightness in the image and divide by the contrast. The average brightness in the image is measured by the mean greylevel, and the contrast can be measured by the standard deviation. With this method, you end up with a signal that has zero mean and unit standard deviation. If you want to restrict yourself to a fixed range of values $[-I_{max}, I_{max}]$, you can then 'truncate' the signal: if the gray level is below $-I_{max}$ you reassign $-I_{max}$ to it, and if it is above I_{max} you reassign I_{max} to it. Mean and standard deviation of images can be computed easily in matlab via commands $mean(I(:))$ and $std(I(:))$.

2 Normalization and correlation

In the case of template matching, each patch extracted from the new image should be normalized separately. This is due to the fact that brightness and contrast are local properties, and not necessarily uniform over the image. Of course, the template should be normalized as well, but this needs to be done only once.

In these conditions, this sounds like the convenient matlab function $conv2$ cannot be used anymore: you have to extract from the image a patch that has the same size as the template, normalize this patch, and compute the correlation value R between this patch and the normalized template. This correlation value can be computed by considering both normalized patch and normalized template as vectors (through the use of matlab's function $reshape$). R is just the dot-product of those two vectors.

Another option if you want to keep the computing efficiency of *conv*2 is to convolve the non-normalized-image with the normalized template, search for the local extrema, then to normalize the image patch. This method assumes that brightness and contrast vary slowly over the image, so that normalizing before or after computing the correlation will have the same effect. This method should lead to reasonable results whenever the assumption of smoothness is verified.