

## EE 451 – LAB 8

### Image Registration

In this laboratory you will learn how to use the C6713 DSK environment to do off-line image registration. Image registration can be carried out in the pixel domain using correlation techniques.

#### Introduction

Image registration is the process of overlaying two or more images of the same scene taken at different times, different wavelengths, from different views, or by different sensors. The process aligns a reference image with a target image. Common examples are photographs, still video images, radar and sonar images. Image registration is required in remote sensing tasks such as scene classification, environmental monitoring, and medicine applications such as monitoring tumor growth, treatment verification.

There are two major types of image registration: area based methods and feature based methods. For area based image registration methods, the method looks at the structure of the image via correlations in the pixel or the Fourier domain. Alternatively, feature based methods look at particular features within the image such as lines, curves, line intersections, and boundaries and search for these common features in the reference and the target images.

Classical area-based registration methods like cross-correlation are used to directly match image intensities, without any structural analysis. Consequently, they are sensitive to the intensity changes introduced by noise, varying illumination, differences in the optical filters (in multi-wavelength applications), or different sensor characteristics. A representative of the area-based registration methods is the Normalized Cross-Correlation (NCC). The NCC has the following form

$$NCC(x', y') = \frac{\sum (I_r(x + x', y + y') - \bar{I}_r)(I_t(x, y) - \bar{I}_t)}{\sqrt{\sum (I_r(x + x', y + y') - \bar{I}_r)^2} \sqrt{\sum (I_t(x, y) - \bar{I}_t)^2}}$$

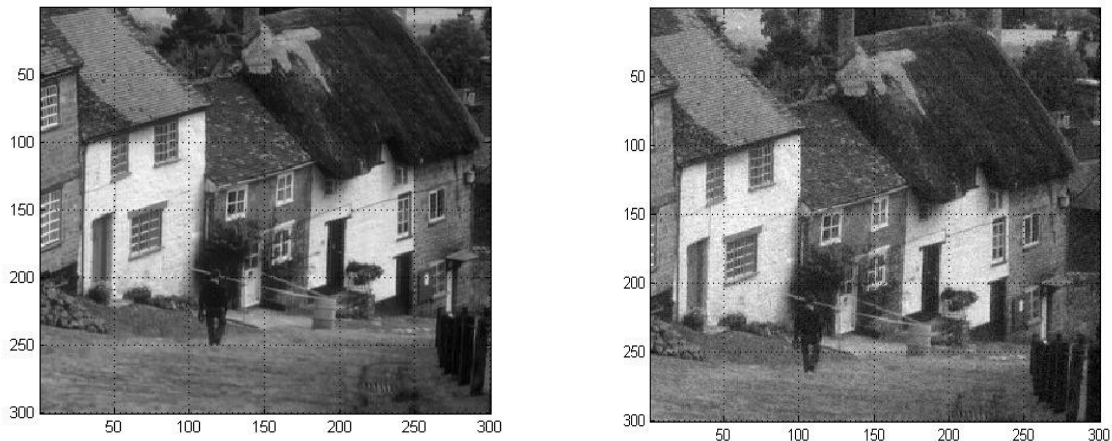
Where  $I_r(x,y)$  is the  $(x,y)$  intensity value of reference image, and  $\bar{I}_r$  is the mean value of the image, and  $I_t(x,y)$  and  $\bar{I}_t$  are the intensity and the mean values of the target image, respectively. The registration process consists on computing the NCC function and finding its maximum which will yield the registration error.

#### The Prelab

For this lab you need to implement a normalized cross-correlation method on the C6713.

1. Write a MATLAB code to read and display pixel values of a reference and target images. The target image has a different overall illumination level and is noise-corrupted by an additive uniformly distributed random noise. Pixel values are stored in header files

in the EE 451L web site as 2-D arrays of size  $100 \times 100$  pixels. These correspond to the center areas of the images shown in Figure 1.



**Figure 1.** Reference and target images to be registered.

### The Lab

1. Write a program that implements the NCC method you implemented in the prelab. The program should be able to find registration errors of less than 30 pixels in both x and y directions. Start CCS and begin a new project. We will use the polling method to (i) read the header files (ii) compute the maximum value for the NCC function, and (iv) output the registration error.
2. You may use `printf()` or `LOG_printf()` to print the results of the NCC (the registration error in the x and y directions). The `printf()` will not overload the DSP as this will be done once at the end of the registration process.
3. What are the lags in the x and y directions? How long does it take to compute the correlation function?
4. Several schemes can be used to optimize and drastically reduce the execution time of a program. Some of these include implementation of instructions in parallel, elimination of NOPs or delay slots, unroll of loops, or software pipelining. A solution readily available from CCS is to switch on the optimizer from the compiler options. Select Build Options  $\rightarrow$  Compiler  $\rightarrow$  Basic and set Opt Level to either to Function(-o2) or File(-o3). The options -o2 and -o3 attempt to do software optimization.
5. How long does it take to compute the correlation function when -o2 or -o3 options are used?