EE5175: Image Signal Processing - Lab 2 report

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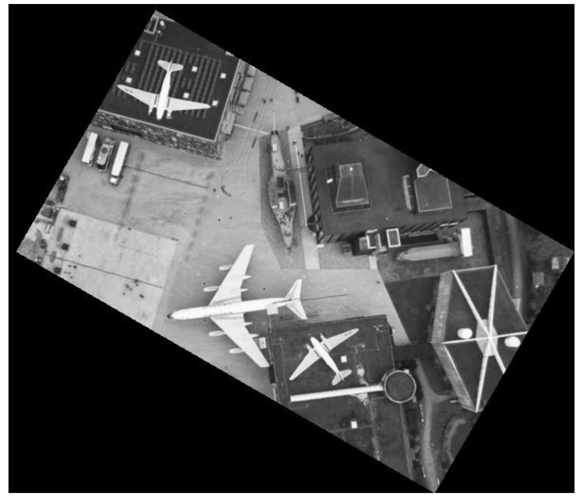
Contents

1 Occlusion detection

Aim: Given two images which are known to be related by an in-plane rotation and translation, find the rotation angle and the translation offsets. Also, find the differences between the two images.

(a) First image



(b) Second image

2 Homogeneous co-ordinates and the Similarity transform:

Let the co-ordinates of a particular point of the image be (x, y). Then homogeneous co-ordinates are defined as the 3x1 vector given below:

$$\begin{bmatrix} \alpha x \\ \alpha y \\ \alpha \end{bmatrix}$$

for some $\alpha \in \mathbb{R}$. With this notation of co-ordinates, geometric transformations can be written as a simple matrix equation.

As we have seen in lab 1, we have three in-plane geometric transformations: **Translation, Rotation and Scaling**. A similarity transform is a combination of these three transformations. Let us assume that the source image co-ordinates are (x_s, y_s) and the target image co-ordinates are (x_t, y_t). In homogeneous co-ordinates representation, the similarity transform equation can be written as:

$$\begin{bmatrix} x_t \\ y_t \\ 1 \end{bmatrix} = \begin{bmatrix} s_x cos(\theta) & s_x sin(\theta) & t_x \\ -s_y sin(\theta) & s_y cos(\theta) & t_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_s \\ y_s \\ 1 \end{bmatrix} \tag{1}$$

(θ is the rotation angle in clockwise direction). In the given problem, it is mentioned that the two images differ only by an in-plane rotation and translation. Hence, $s_x = s_y = 1$.

We have three variables: θ, t_x, t_y which we need to solve for. Each point-to-point correspondence would give two equations. Hence, we need two point-to-point correspondences to solve for the three variables. Let us assume the point correspondences we have are $(x_{s1}, y_{s1}) \rightarrow (x_{t1}, y_{t1})$ and $(x_{s2}, y_{s2}) \rightarrow (x_{t2}, y_{t2})$. With this data and the similarity transform equation, we can form a matrix equation involving the three variables.

The matrix equation is given below:

$$\begin{bmatrix} x_{t1} \\ y_{t1} \\ x_{t2} \\ y_{t2} \end{bmatrix} = \begin{bmatrix} x_{s1} & y_{s1} & 1 & 0 \\ y_{s1} & -x_{s1} & 0 & 1 \\ x_{s2} & y_{s2} & 1 & 0 \\ y_{s2} & -x_{s2} & 0 & 1 \end{bmatrix} \begin{bmatrix} cos(\theta) \\ sin(\theta) \\ t_x \\ t_y \end{bmatrix} \tag{2}$$

By simply inverting the matrix, we can find the parameters.

3 Correction of second image:

We can see that the second image is rotated and translated version of the first image. To construct the original image from it, we need the parameters which we have found in the previous section. Once these parameters are known, the reconstruction process is a simple target-to-source mapping followed by bilinear interpolation. The reconstructed image is shown below:

(a) Original first image

(b) Reconstructed second image

Clearly, the reconstructed image looks almost like the first image - the inverse rotation and translation are convincing. However, the image suffers from the issue of lower sharpness due to bilinear interpolation.

Now that we have the corrected version of the second image, we can find the differences between the first and second image by finding the absolute intensity difference. Spots where the image looks dark indicate that no significant changes have occurred in those places. However, spots which are bright indicate places where significant changes have occurred. The change-capturing image is given below:

Change capturing image

Clearly, we can see that two airplanes are present on the second image which are not there in the first image and this has been captured by the change-capturing image too. If closely seen, we can find that some boundaries are also captured. This is because at the boundaries, the intensities will get mixed due to bilinear interpolation. Hence, when its subtracted from the sharp image intensities, the differences would be significant which show up as a white boundary line in the change-capturing image.

4 Observations and Conclusions

1. For a similarity transform, there are five parameters in general $(t_x, t_y, \theta, s_x, s_y)$ and hence, at least three point-to-point correspondences are required to determine them. In the given problem, only two were enough since s_x and s_y were known.

2. Even though the inverse similarity transform looks convincing, the sharpness is lower than that of the original image because of bilinear interpolation.

3. To detect changes between two images, we have to first make sure that they have captured the same scene and both the images are aligned with each other.

4. This method could also be used to detect boundary lines present in an image. All we need to do is average out the intensities using some interpolation algorithm (Eg. Bilinear interpolation) and then plot the change-capturing image.