CHAPTER 7
APPLICATIONS OF SHD DETECTOR

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7. APPLICATIONS OF SHD DETECTOR

7.1 INTRODUCTION

Corner points are interesting points and they are used in many real-time applications, such as computer vision, image processing applications, stereo matching, image registration, stitching of panoramic photographs, object detection/recognition, motion tracking, shape analysis, camera calibration, and 3-D reconstruction.

The corner detection techniques described in the previous chapters are very useful for the above application. Since SHD exhibits the best performance, it is used in several examples to demonstrate mosaicing of images.

In this chapter, corner detection is used in image matching, registration and mosaicing applications. Examples are provided for the images captured from camera and satellite for roads, building, outdoor scene and cell towers.

7.2 IMAGE MATCHING

In this section corner detection algorithm is used for image matching between two images or among multiple images by certain matching algorithm. Initially, the image matching experiment is conducted by detecting the corner, using SHD method to extract key points of images. For the images shown in figure 7.1(a) left image and 7.1(b) right image, 169 features and 95 features are detected, respectively.
Feature point descriptor plays a major role to judge about the matching of points. To do this, the designer requires identification of feature points. To give that identity to those points, we use feature descriptors. In this process, we need to extract the feature descriptor for each feature point. Descriptors are simple 21x21 gray scale pixel patches extracted from an image blurred by a Gaussian (sigma=3 pixels). The blurring is done to obtain some tolerance to feature localization errors. A feature point descriptor of size 21x21 pixels is used in this thesis. By using or getting the information from neighborhood pixels and their features, we can generally obtain the identity criteria.

By comparing the input image with the reference image, matching information is obtained. This is based on the feature point information. The candidate who matches the maximum features with the original input image was declared as the best candidate. This candidate has the set of features of the neighbourhood data set also. The data set which has minimum Euclidean distance with respect to the input image was considered as nearest neighbourhood data set[43]. Such data is considered as a pair of matching points. Figure 7.1(c) shows numbers of matched feature are 9.
Fig. 7.1: Matching results using proposed SHD method (a) Left image (b) Right image and (c) Image matching.

We detected corner features for another flower image pairs as shown in figure 7.2. The number of detected features is 384 and 386 as shown in figure 7.2(a) and 7.2(b) respectively and its corresponding number of matching are 335 as shown in figure 7.2(c).

Fig. 7.2: Matching result using SHD method (a) Left image (b) Right image and (c) Image matching.

7.3 IMAGE REGISTRATION

Accurate point-to-point correspondence between the reference and input images[42,43] is essential to work an image registration.
The basic problem in image registration is correspondence detection. If the images contain rich in image features, it is preferred to use feature based methods that uses a sparse set of corresponding image features (e.g. points and lines) which estimates the image-to-image mapping. The first step in the registration is to detect key point features. These image features can be detected using corner detectors.

The two MITS (Madnapalle Institute of Technology & Science) campus surrounding the satellite images pair with a size of 512x512 pixels collected from Google earth. These images shown in figures 7.3(a) and 7.3(b) and with different view angles used for image registration. The location of feature points detected by SHD method is shown in figures 7.3(c) and 7.3(d). The number of detected features is 3056 and 3005, which are indicated in red and green colours, respectively.

The corresponding number of initial matching points using Euclidean distance is found 39 as shown in figure 7.3(e). Finding correct matching points using RANSAC as shown in figure 7.3(f) and the number of matches is 22. Figure 7.3(g) shows the image registration result[42,43].
Fig. 7.3: Google earth satellite images  (a) reference image (b) sensed image, (c) and (d) detected features (e) initial matches (f) RANSAC matches (g) registered image result.

Fig. 7.4: Google earth JNTU Anantapur campus satellite images  (a) reference image  (b) sensed image  (c) registered image result.
Figure 7.4(a)–(b) shows JNTU Anantapur campus satellite images with size 512x512 pixels and with different orientations. The number of features is detected in figure 7.4(a) and 7.4(b) is 3745 and 3629 respectively. The registration parameters are computed and shown in Table 7.1. Initial numbers of matches found are 1136. The number of correct matches found is 1118 after RANSAC. Finally, figure 7.4(c) shows the image registration result.

![Figure 7.4](image)

Fig. 7.5: Anantapur town satellite images (a) reference image (b) sensed image (c) registered image result.

A pair of Anantapur town satellite images is shown in figures 7.5(a) and 7.5(b). These images with different view angles are used for image registration. The number of features detected in figure 7.5(a) and 7.5(b) are 3388 and 3443 respectively. The registration parameters are computed and are indicated in Table 7.1. Initial number of matches found is 84. The number of correct matches found is 49 after RANSAC. Finally figure 7.5(c) shows the image registration result.
Table 7.1 shows the estimation for three satellite image pairs and their image registration parameters [42] $\Delta x, \Delta y$, RMSE, $S$, and $\theta$ of the affine transform model between reference and sensed images.

Table 7.1  Image registration results

<table>
<thead>
<tr>
<th>Images</th>
<th>Image size</th>
<th>$S$ Scale</th>
<th>$\theta$ rotation</th>
<th>$\Delta x$ pixels</th>
<th>$\Delta y$ pixels</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fig7.3(a)</td>
<td>512x512</td>
<td>0.489</td>
<td>10.454$^0$</td>
<td>80.741</td>
<td>189.198</td>
<td>0.172</td>
</tr>
<tr>
<td>Fig7.3(b)</td>
<td>512x512</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fig7.4(a)</td>
<td>512x512</td>
<td>0.962</td>
<td>8.230$^0$</td>
<td>-93.50</td>
<td>27.206</td>
<td>0.215</td>
</tr>
<tr>
<td>Fig7.4(b)</td>
<td>512x512</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fig7.5(a)</td>
<td>512x512</td>
<td>0.518</td>
<td>18.648$^0$</td>
<td>78.897</td>
<td>225.497</td>
<td>0.240</td>
</tr>
<tr>
<td>Fig7.5(b)</td>
<td>512x512</td>
<td></td>
<td></td>
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</tbody>
</table>

In this thesis, proposed method used steerable filters. These filters are used due to its invariant properties of rotation and scaling. These two properties are playing a major role in image registration. After detecting features in the both images, we use Euclidean distance approach to match the feature points. In the last step, RANSAC method is applied to eliminate the mismatch feature points and hold the correct matched pairs. The table 7.1 shows the experimental results for translation, rotation and scaling parameters and achieved low RMSE value.

7.4 IMAGE MOSAICING

The corner features are basically used as a reference points in the feature based mosaic system [20,21,22,44]. The primary objective of mosaic image is to enhance the FOV and image resolution. In
general, the human vision has the 200 degrees and the camera vision has 50X35 degrees. With this comparison, it is clear that with a single shot, the camera can’t capture a scene as seen by human eye. Hence, we are using image mosaicing. Blurring and ghosting generally occurs while capturing images. These may occur while the camera and object move in the same direction. The advanced cameras are also facing certain limitations. If the speed of camera is less than the recommended speed, the camera will not be able to take the complete picture. Mosaic system has three steps; feature detection, mapping features and construction of wide angle single image. Proposed SHD method is running on an i3 cpu 2.20GHz and memory 2GB PC. An arbitrary set of images of Madnapalle Institute of Technology & Science, Madnapalle,(MITS) campus were collected, using a panoramic set up. Images are taken from different planes. A hand held camera with 8 mega pixel is used to capture the images. The camera was operated in manual mode.

The mosaic experiments which are carried out and tested on three MITS west block building images are shown in figure 7.6. The number of feature points detected 531 are indicated with red colour, 455 with blue colour and 413 with green colour as shown in figure 7.6(a), (b) and (c) respectively. The number of possible correspondence is 112, between figure 7.6(a) and (b) as shown in figure 7.6(d), which included false matches. The numbers of correct matches are 49 after applying a RANSAC as in figure 7.6(e). Figure 7.6(f) and (g) shows the
number of initial matches 156 and correct matches are 80 between 7.6(b) and (c). Finally mosaic image shown in 7.6(h).

Fig. 7.6(a)-(h): MITS west block building image mosaic results using feature points.
Figure 7.7 shows another image mosaic process of two MITS central library building images. The number of detected features in both images is 1465 and 1825 as shown in figure 7.7(a) and (b) respectively used for stitching. The numbers of initial matches are found 271 and 199 correct matches using proposed method. Finally figure 7.7(c) shows mosaic image.
The two MITS East block building images used for mosaic are shown in figure 7.8(a) and (b). First we detect the number of corners using our method are 2422 and 2558. The number of tentative matches is 114 and correct matches are 13. The mosaic image result is shown in figure 7.8(c).
Fig. 7.9(a)-(b): Ellora caves images   (c) Mosaic image.

The two Ellora cave images used for mosaic are shown in figure 7.9(a) and (b). The detected number of corners using SHD method is 3120 and 3031 for 7.9(a) and 7.9(b), respectively. The number of corresponding matches is 206 and correct matches are 180. The figure 7.9(c) shows mosaic image result.

The input images of the MITS Campus are shown in below figures 7.10(a) to (d). Figure 7.10(e) mosaic image of the MITS campus.
7.5 SUMMARY

This chapter explains corner detector applications such as image registration, matching the images that represent the same scene and mosaic images. The three satellite image pairs are used for...
registration applications. Registration parameters are computed using proposed SHD method and achieved low RMSE value. Proposed SHD method will also use in mosaic applications. The five mosaic images were shown with little distortion from its original. This thesis is concluded in next chapter.