Implementation of Image Mosaicing By Harris Corner Detection Technique

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Abstract- *This paper represents a novel design and control architecture of the continuous stirred tank reactor (CSTR) based on its mathematical equivalent modeling of the physical system. The plant is formed analytically for the normal operating condition of CSTR. Then the transfer function model is obtained from the process. The analysis is made for the given process for the design of controller with Convectional PID (trial and error method), Ziegler Nichols method, Fuzzy logic method and Model Reference Adaptive method. The simulation is done using MATLAB software and the output of above four different methods was compared so that the Model Reference Adaptive Controller has given better result. This thesis also compares the various time domain specifications of different controllers.*

Keywords- Image Mosaicing; Image Registration; Image Fusion; Feature Extraction.

I. INTRODUCTION

Image mosaicing is the process of merging split images that are obtained by scanning different parts of a single large document image with some sort of overlapping region to produce a single and complete image of the document. It is connecting two or more images and making a new and wide area image. In any case a part of the needed scene can be taken at once for restriction of the resolution of a camera, a photography angle, etc., by taking the scene many times so that a part of image should be overlapped, and mosaicing the images, the scene can be obtained. Thereby, even a 360-degree panorama picture can be created. At this time, in mosaicing, the biggest is problem how the position relation between two or more images is drawn [1].

The word mosaic dates back to the 4th century B.C., and is generally associated with the Greeks. In fact, the word mosaic is of Greek origin, meaning “patient work of art, worthy of the muses”. The Greeks, and later the Romans, embraced the mosaic in many areas of architecture as a decorative element.

Various steps in mosaicing are feature extraction and registration, stitching and blending. The first step in Image Mosaicing is feature extraction. In feature extraction, features are detected in both input images. Image registration refers to the geometric alignment of a set of images. The set may consist of two or more digital images taken of a single scene at different times, from different sensors, or from different viewpoints. The goal of registration is to establish geometric correspondence between the images so that they may be transformed, compared, and analyzed in a common reference frame. This is of practical importance in many fields, including Aerial Imaging, medical imaging, and computer vision [2]. Registration methods can be loosely divided into the following classes: algorithms that use image pixel values directly, e.g., correlation methods [3]; algorithms that use the frequency domain, e.g., fast Fourier transform based (FFT-based) methods [4]; algorithms that use low-level features such as edges and corners, e.g., feature based methods [3]; and algorithms that use high-level features such as identified (parts of) objects, or relations between features, e.g., graph-theoretic methods [2].

The next step, following registration, is image warping which includes correcting distorted images and it can also be used for creative purposes. The images are placed appropriately on the bigger canvas using registration transformations to get the output mosaiced image. Blending is the technique which modifies the image gray levels in the vicinity of a boundary to obtain a smooth transition between images by removing these seams and creating a blended image by determining how pixels in an overlapping area should be presented. Blend modes are used to blend two layers into each other. The term image spline refers to digital techniques for making these adjustments. A good image spline makes the seam perfectly smooth, yet preserves as much as the original information as possible.

A. Design Prototype for mosaicing:

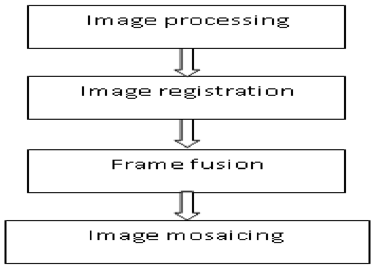


Figure 1: Flowchart depicting segmentation of image mosaicking

II. FEATURE EXTRACTION

In an image, a Feature is used to denote a piece of information which is relevant for solving the computational task related to a certain application. The types of features are edges, corner/interest point, blobs and ridges. Edges are points where there is a boundary (or an edge) between two image regions. In general, an edge can be of almost arbitrary shape, and may include junctions. Edges are the one dimensional structure while corners have a local two dimensional structure. They referred as point-like features in an image. There are various edge detection techniques, which uses Roberts operator, Sobel operator, Laplace operator and the Prewitt operator [5].

They are several features which we mentioned above, that may be used for detection and matching, and certain criteria are used to justify the type of feature chosen. These criteria are that the features should be unique, able to be detected without difficulty, and have a good spatial distribution over the images. It has been found that corners form their own class of feature as the property of being a corner is hard to define mathematically. Therefore we introduce Harris Corner detector in our mosaic framework.

A. Harris Corner Detector

The Harris Corner Detector was given in 1988. Harris and Stephens improved upon Moravec's corner detector by considering the differential of the corner score with respect to direction directly, instead of using shifted patches. The Harris corner detector is a popular interest point detector due to its strong invariance to: rotation, scale, illumination variation and image noise. The Harris Corner Detection Technique works on Eigen Values Concept and the use of auto correlation function is also seen. The Harris corner detector is based on the local auto-correlation function of a signal; where the local auto-correlation function measures the local changes of the signal with patches shifted by a small amount in different directions. The Harris corner detector gives a mathematical approach for determining whether the region is flat, edge or corner. Harris corner technique detects more features. For the change of intensity for the shift [u, v]:

$$E(u,v) = \sum_{xy} w(x,y)[I(x+u, y+v) - I(x,y)]^2 \quad \textbf{(1)}$$

Where w(x, y) is a window function, I(x + u, y + v) is the shifted intensity and I(x, y) is the intensity of the individual pixel of the image.

For small shifts [u,v] we have the following approximation

$$E(u,v) \cong [u,v]\, M \begin{bmatrix} u \\ v \end{bmatrix} \quad \textbf{(2)}$$

Where M is a 2x2 autocorrelation matrix computed from image derivatives:

Measure of corner response:

$$M = \sum_{xy} w(x,y) \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} \quad \textbf{(3)}$$

Let λ_1, λ_2 be the Eigen values of matrix M. The Eigen values form a rotationally invariant description. There are three cases to be considered:

1. If both λ_1, λ_2 are small, so that the local auto-correlation function is **flat**, the windowed image region is of approximately constant intensity.
2. If one Eigen value is high and the other low, so the local auto-correlation function is ridge shaped, then only local shifts in one direction (along the ridge) cause little change in M and significant change in the orthogonal direction; this indicates an **edge**.
3. If both Eigen values are high, so the local auto-correlation function is sharply peaked, then shifts in any direction will result in a significant increase; this indicates a **corner**.

To extract the corner, Harris constructed the expression as:

$$R = \det M - k(\mathit{trace}\, M)^2$$

$$\det M = \lambda_1 \lambda_2$$

$$\mathit{trace}\, M = \lambda_1 + \lambda_2 \quad \textbf{(4)}$$

III. COMPUTING HOMOGRAPHY

A. RANSAC Algorithm:

Homography is the third step of Image mosaicing. In homography undesired corners which do not belong to the overlapping area are removed. RANSAC algorithm is used to perform homography. RANSAC is an abbreviation for "RANdom Sample Consensus." It is an iterative method to estimate parameters of a mathematical model from a set of observed data which contains outliers. It is a non deterministic algorithm in the sense that it produces a reasonable result only with a certain probability, with this probability increasing as more iteration are allowed. RANSAC algorithm is used for fitting models in the presence of many available data outlined in a robust manner. Given a fitting problem with parameters, it estimates the parameters considering the following assumptions:

1. Parameters can be estimated from N data items.
2. Available data items are totally M.
3. The probability of a randomly selected data item being part of a good model is P_g.
4. The probability that the algorithm will exit without finding a good fit if one exists is P_{fail}.

B. Homography

It is a mapping between two spaces which often used to represent the correspondence between two images of the same scene. It's widely useful for this project where multiple images are taken from a rotating camera having a fixed camera center ultimately warped together to produce a panoramic view.

Let's take a situation of the projection transformation of planes in images. We have two cameras C1 and C2 looking at a plane π in the world. Consider a point P on the plane π and its projections.

$p = (u1, v1, 1)^T$ and $q = (u2, v2, 1)^T$. There exists a unique (up to scale) 3 × 3 matrix H such that, for any point P :

$$q \equiv Hp \quad \textbf{(5)}$$

(Here ≡ implies the left and right hand sides are proportional and those homogeneous coordinates are trivially equal)

As mentioned earlier H only depends on the plane and the projection matrices of the two cameras and being a projective transformation matrix can be only defined up to a scale.

Lastly to say, as q and Hp are only proportional to each other so equivalently we have

$$q \times Hp = 0 \quad \textbf{(6)}$$

This H is a projective transformation of the plane, also referred to as a homography.

Since the matrix H has 8 DOF, 4 point correspondences determine H.

Thus, H is estimated with a minimization scheme using:

$$h = (h11; h12; h13; h21; h22; h23; h31; h32; h33)^T \quad \textbf{(7)}$$

N point correspondences give 2N linear constraints, using (6). This results in a system of the form Bh = 0.

The following problem must then be solved:

$$\min_h \|Bh\|^2 \ subject\ \ to \|h\| = 1 \quad \textbf{(8)}$$

The Homography Detection Algorithm using RANSAC scheme:

1. First corners are detected in both images.
2. Variance normalized correlation is applied between corners, and pairs with a sufficiently high correlation score are collected to form a set of candidate matches.
3. Four points are selected from the set of candidate matches, and a homography is computed using eq. (8).
4. Pairs agreeing with the homography are selected. A pair (p, q), is considered to agree with a homography H, if for some threshold
   Dist (Hp, q) < ε
5. Steps 3 and 4 are repeated until a sufficient number of pairs are consistent with the computed homography.
6. Using all consistent correspondences, the homography is recomputed by solving eq. (8).

IV. WARPING AND BLENDING

A. Image Warping

The last step is to warp and blend all the input images to an output composite mosaic. Image Warping is the process of digitally manipulating an image such that any shapes portrayed in the image have been significantly distorted. Warping may be used for correcting image distortion as well as for creative purposes (e.g., morphing).While an image can be transformed in various ways, pure warping means that points are mapped to points without changing the colors. Basically we can simply warp all the input images to a plane defined by one of them known as reference images. The output in this case is known as composite panorama.

1. First we need to make out the output mosaic size by computing the range of warped image coordinates for each input image, as described earlier we can easily do this by mapping four corners of each source image forward and computing the minimum x, minimum y, maximum x and maximum y coordinates to determine the size of the output image.
2. The next step is to use the inverse warping as described above for mapping the pixels from each input image to the plane defined by the reference image, is there to perform the forward and inverse warping of points, respectively.

B. Image Blending

The final step is to blend the pixels colors in the overlapped region to avoid the seams. Simplest available form is to use feathering, which uses weighted averaging color values to blend the overlapping pixels. We generally use alpha factor often called alpha channel having the value 1 at the center pixel and becomes 0 after decreasing linearly to the border pixels. Where at least two images overlap occurs in an output mosaic.

V. RESULTS

The algorithm discussed in the paper has been implemented in MATLAB 14.1a. Figure 2 and 3 shows Aerial images of Oakland Island and Desert Image [8]. Image (a) and image (b) is an input image. Figure (c) and Figure (d) is the corner detecting result of image (a) and image (b) by using Harris corner detecting algorithm. Figure (g) and figure (h) are the images that showing matched points of input images. Finally the figure (i) is the mosaic image without any seam.

Figure 2(a)

Figure 2(a)

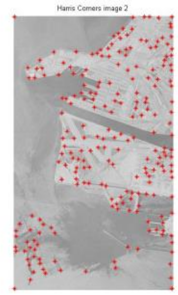


Figure 2(c)

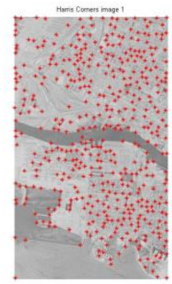


Figure 2(d)

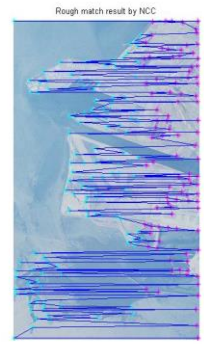


Figure 2(e)

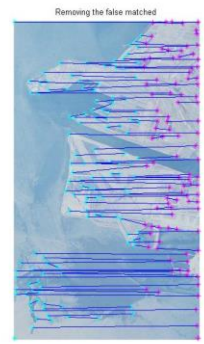


Figure 2(f)

Figure 2(g)

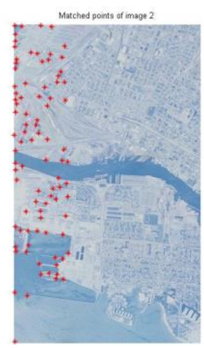
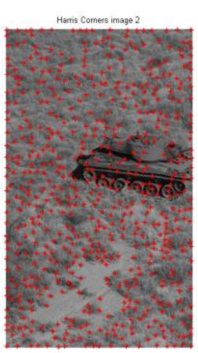


Figure 2(h)

Figure 2(i)

Figure 2: Results of Image Mosaic for aerial image of Oakland Island

Figure 3(a) Figure 3(a)



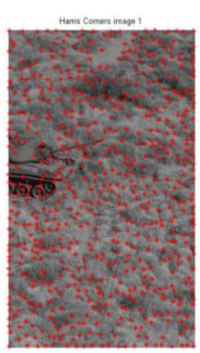
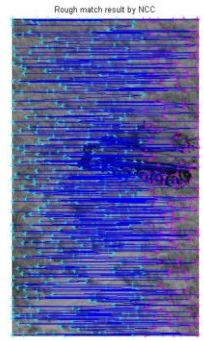


Figure 3(c) Figure 3(d)



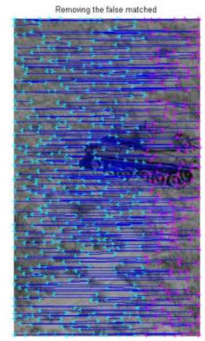


Figure 3(e) Figure 3(f)

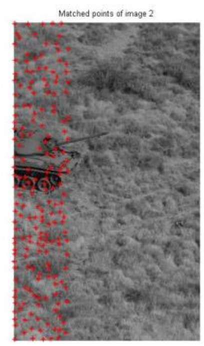


Figure 3(g) Figure 3(h)

Figure 3 (i)

Figure 3: Results of Image Mosaic for aerial image of Desert

Table 1: Comparative analysis of performance parameter

S.No	Image [8]	MSE	NAE	RMSE	PSNR
1	Oakland	21.69	2.56	4.56	40.82
2	Desert (Tank)	27.10	3.02	5.20	39.85
3	San Francisco	28.86	3.11	5.37	39.58
4	San Diego	39.75	3.95	6.30	38.19
5	San Diego North Island	23.19	2.72	4.81	40.53

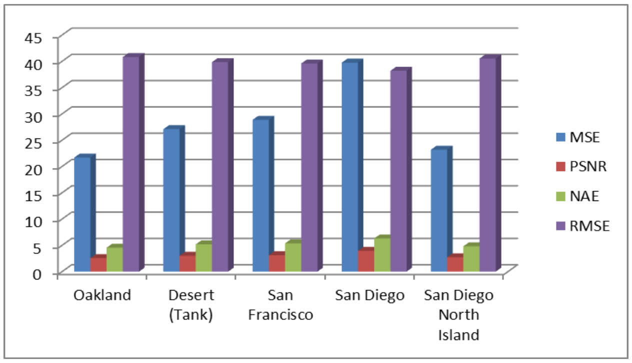


Figure 4: Graph showing performance parameter

It is clearly shown from above table and graph that peak signal to noise ratio (PSNR) obtained from the simulation is virtuous ample for any images. Also results obtained are example of seamless image mosaicing.

VI. CONCLUSION

After studying various feature detecting techniques, Harris Corner Detector was chosen as our tool for feature detection as it is invariant to rotation, scale, illumination variance and image noise. Mathematical analysis was done in detail of the Harris Corner Detector. Auto-correlation and Eigen value concept were the primary tools used in Harris Corner Detection and was studied in detail to extract features from an image. After feature detection, feature matching was studied thoroughly. We adopted a correlation coefficient measure that gave us satisfied results. Finally both feature detection and feature matching were implemented successfully for Aerial images and then fusion of the two matched images were done using least square method and a seamed mosaic was obtained.

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