Image-Based Rendering using Image Warping

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ABSTRACT

Image Mosaicing is a method of assembling multiple overlapping images of the same scene into a larger image. The output of the image mosaic will be the union of two input images. Image-mosaicing algorithms are used for obtaining a mosaiced image. This is practised a developing field. Recent years have seen quite a lot of advancement in the field.

Our work is based on feature based approach of image mosaicing. The steps in image mosaic consist of feature point detection, feature point descriptor extraction and feature point matching. Feature extraction is an Image mosaicing technique which is done by using various corner detection algorithm. RANSAC algorithm is applied to eliminate variety of mismatches and acquire transformation matrix between the images. The input image is transformed with the right mapping model for image stitching.

Therefore, this paper proposes an algorithm for mosaicing two images efficiently using RANSAC feature matching method and then image transformation, warping and by blending methods. Importance of Image mosaicing can be seen in the field of medical imaging, computer vision, data from satellites, military automatic target recognition.

Keywords: image mosaicing, image Warping, Homography, RANSAC, feature detection.

I. INTRODUCTION

The automatic construction of large high resolution image mosaics is an active area of research in the field of computer vision, image processing and computer graphics. Image mosaicing is commonly used to increase the visual field of view by pasting together many video frames. Image Mosaicing stitches multiple correlated images to obtain an image of greater field of view (FOV). The camera's field of view is always smaller than the human field of view. Further large objects often cannot be captured in a single picture as is the case in aerial photography. Using a lens having a wider field of view (fish eye lens) can be a partial solution, but the images obtained with such a lens have substantial distortion, further, capturing the entire scene with a limited resolution of video camera compromises image quality. Cameras, which have low FOV can't generate images with higher FOV while mosaicing can help us achieve it. It is a special case of scene reconstruction through which images are related by planar homography. Two or more images can be stitched with each other uniquely without loss of information in any images with a greater FOV.

Numerous mosaicing algorithms have been proposed. Applications of the algorithms proposed is based on the quality of the results we obtain. It depends upon human perception as well as machine perception.

This paper proposes a unique algorithm for mosaicing two images. Input images are taken and features are detected. RANSAC is applied to find feature correspondences between images. Images are then projected in a plane and blended together. Mosaicing could be regarded as a special case of scene reconstruction where the images are related to planar homography only. An Image Mosaic is a synthetic composition generated from a sequence of images and it can be obtained by understanding geometric relationships between images. The geometric relations are the coordinate systems that relate the different image coordinate systems. The appropriate transformations are applied via of a warping operation than by merging the overlapping regions of warped images. In image mosaicing two input images are taken and these images are fused to form a single large image. This merged single image is the output mosaiced image. 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 different sets of data may consist of two digital images taken of a single scene from different sensors at different time or from different viewpoints. In image registration the geometric correspondence between the images is established so that they may be transformed, compared and analyzed in a common reference frame. This is of practical importance in many fields, including remote sensing, computer vision, medical imaging. The quality of the mosaiced image and the time efficiency of the algorithm used are given most importance in image mosaicing. 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. The whole method is implemented using MATLAB software.

II. **METHODOLOGY**

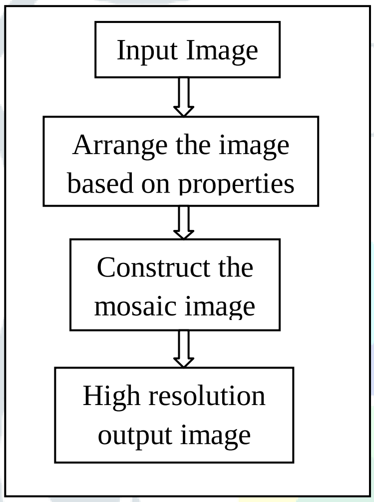


Fig: - Existing Framework for image mosaicing

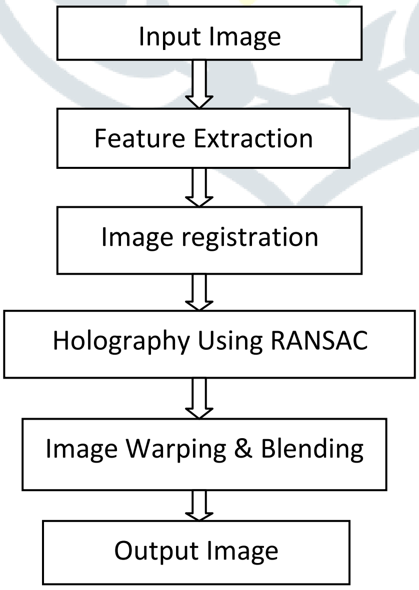


Fig: - Framework for Image mosaicing

Feature Detection and Matching Feature Detection and Matching

Feature Detection and feature correspondence between images is one of the basic steps in Mosaicing of Images. As we have to align and blend the images, we need to have feature correspondence between the images to blend them properly.

The first step in the image mosaic process is feature detection. The efficiency of extracted feature points in the two images is ascertained by the invariance and accuracy of the feature detector in the overlapping region. Therefore we introduce Harris detector in our mosaic framework. Harris corner detecting was point feature extracting algorithm by C. Harris and M.J. Stephens in 1988. Its main idea is to design a local detecting window in image. When the window moves in each direction the average grey variation of window is more than threshold, then the centre point of the window is extracted as corner point[6], [7] & [8].When we just shift one pixel in an image that can create a significant change in the corner.

Considering gray intensity of pixel (u, v) be I (x, y), the variation of gray pixel (x,y) with a shift of (u, v) can be denoted as

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

On applying Taylor series expansion we have

$$\mathrm{E(u,v)} = [\mathrm{I_x u + I_y v +\ O\,(u^2,v^2)}]^2$$

For a small shift of (u,v) we have

$$\mathrm{E(u,v)} = [\mathrm{u,v}]\ \mathrm{M}\begin{bmatrix}\mathrm{u}\\ \mathrm{v}\end{bmatrix}$$

Where M is a matrix of 2X2 which has been calculated from the image derivatives:

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

If λ1, λ2 are the Eigen values of matrix M, then corner, edge, and flat area of the image can be computed from the Eigen values as follows:

- Flat area: both λ1, λ2 are very small.
- Edge: one of λ1, λ2 is smaller and the other is bigger.
- Corner: both λ1, λ2 are bigger and are nearly equal.

For extracting the corner, Harris gives a formula

$$\text{R= det M} - (\text{trace M})^{2}$$

Where,

o det M = λ1 λ2

o trace M = λ1+ λ2

- **Algorithm Steps**

Input: Gray scale image, Gaussian variance, k Value, Threshold T

Output: Map indicating position of each detected corner.

1 for each pixel (x, y) in image calculate the Autocorrelation matrix M:

$$M = \sum_{x,y}\begin{bmatrix} I_x^2 & IxIy \\ IxIy & I_y^2 \end{bmatrix}$$

Where,

2 for each pixel of image has Gaussian filtering, get new matrix M, and discrete two dimensional zero-mean Gaussian function as follows:

$$\text{Gauss} = \exp\left[-\frac{(\mathrm{u}^2-\mathrm{v}^2)}{2\delta^2}\right]$$

3 Calculating the cornerness measure for each pixel (x, y), get R:

$$R = [I_x^2 x I_y^2 - (I_x I_y)^2 - K[I_x^2 I_y^2]^2]^2$$

4 Choose the local maximum point, Harris method consider that the feature points are the pixel value which corresponding with the local maximum interest point.

5 Set the threshold T, detect corner points.

III. IMPROVED ALGORITHM FOR CORNER

In this novel we adopt neighbouring point eliminate method to avoid setting threshold T, ensure the corner will homogeneous distribution and avoid corner clustering. We can select one stencil (e.g. 3X3) to process for image. If there is not only one corner point under this stencil, we retain the corner which has the largest value of R. Experimental shows that the method inhibition the clustering phenomenon better.

Firstly detect all corner points C (i, j) in the image, and calculate R save them into matrix Mat [Sum], Sum is the number of the corners. Then sort new sequence by the value of R, and save them into the matrix Mat1 [Sum], choose the large value of R in the matrix Mat1 [Sum] for the final detection corner. At last we have the neighbour point eliminate processing for image. If there are more than one corner point, retain the corner point which has the large value of R.

IV. HOMOGRAPHY COMPUTATION

- **Homography**

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

The steps for homography detection algorithm using RANdom Sample Consensus (RANSAC) scheme is

1. Firstly, 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.
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) < €
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 step 4.

- **RANSAC Algorithm**

RANSAC, is a method to calculate the parameters of a mathematical model from a set of observed data.. Input of RANSAC algorithm is a set of observed data, a parameterized model which can explain or fit to the observations, along with some confidence parameters. RANSAC achieves its goal by iterative selection of a random subset of the original data.

Given a fitting problem with parameter x, it estimates the parameters considering the following assumption:

1. Parameter 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 Pg
4. The probability that the algorithm exit without finding a good fit if one exists is Pf

Then the algorithm is:

1. N data items at random are selected.
2. Parameter x is estimated.
3. Number of data items which fit the model with parameter vector x are found out within a user defined tolerance. Let it be K. 4. If K is large enough, it is accepted and exit with success.
5. The process is repeated 1.4 L times
6. The process is failure if it again enters the loop.

Value of L is found by the following formulae:

P_{fail} = Probability of L consecutive failures

= Probability that a given trial is a failure) L

= (1 - (Probability that a random data item fits the model) N) L

$$P_{fail} = [1-(P_g)^{N}] L$$

$$L = \frac{\log(p_{fail})}{\log(1-(p_g)^N)}$$

- **Advantages: -** Even if a substantial number of outliers exist in the data set, RANSAC is able to perform a strong assessment of the model parameters very accurately. Robustness is a major property of this algorithm.

V. IMAGE WARPING & BLENDING

- **Image warping**

Image warping is the process of digitally employing an image such that any shapes represented in the image have been significantly distorted. Warping can also be used for correcting image distortion as well as for inventive purposes. Basically we can simply warp all the input images to a plane defined by one of them known as reference image. The two images that will form the mosaic are warped, by using the geometric transformation. While an image can be reconstituted in various ways, pure warping means that points are mapped to points without changing the colours. It can be mathematically based on any function from the plane to the plane. If the function is injective then the original can be reconstructed.

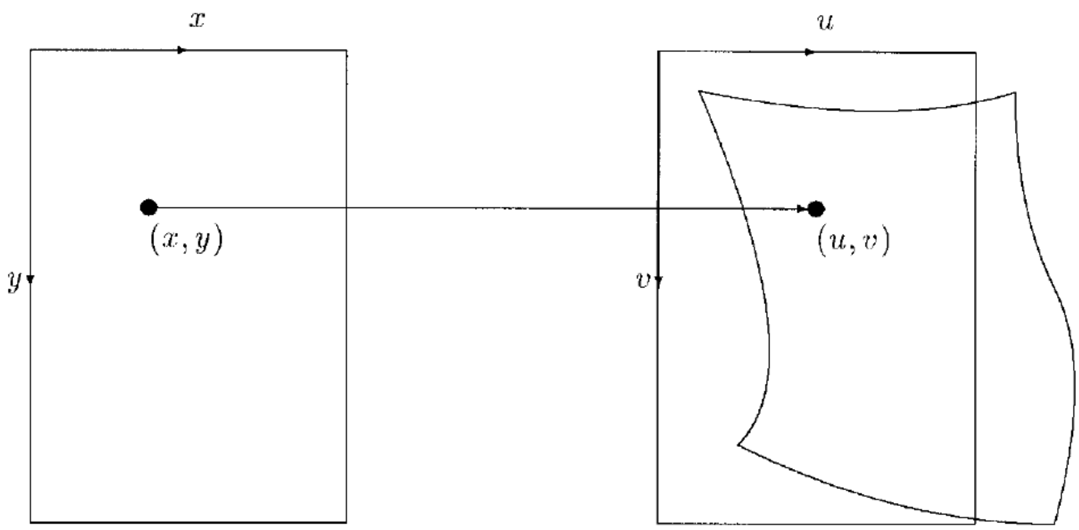


FIG- Notation for image warping.

A warping is a pair of two-dimensional functions, $u(x, y)$ and $v(x, y)$, which map a position (x, y) in one image, where x denotes column number and y denotes row number, to position (u, v) in another image (see Fig). There have been many approaches to finding an appropriate warp, but a common theme is the compromise between insisting the distortion is smooth and achieving a good match.

Basically we can simply warp all the input images to a plane defined by one them known as composite panorama.

- 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. Finally x-offset and y-offset values specifying the offset of the reference image origin relative to the output panorama needs to be calculated.
- 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.

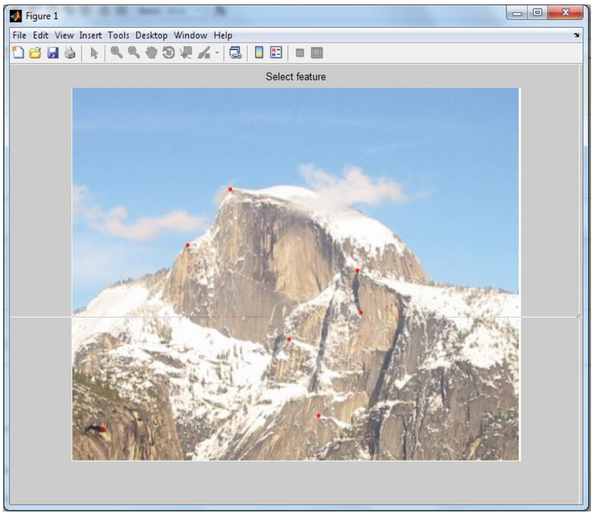
➢ **Image Blending**

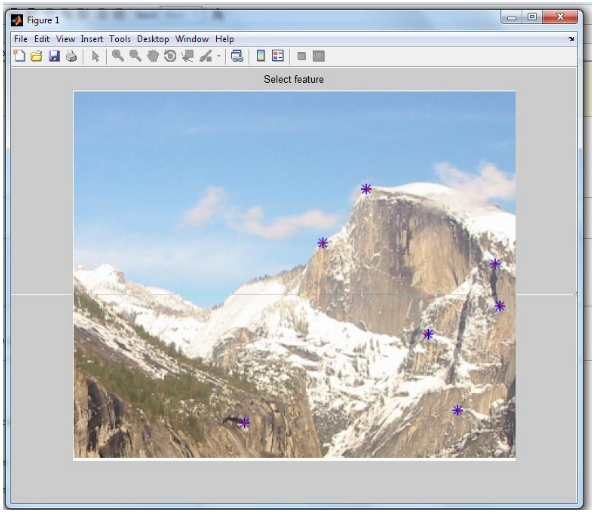
The final step is to blend the pixel colours in the overlapped region to avoid the seams. Simplest available form is to use feathering, which uses weighted averaging color values to blend the overlapping pixels. We generally use alpha factor often called alpha channel having the value 1 at the centre pixel and becomes 0 after decreasing linearly to the border pixels. Where at least two image overlap occurs in an output mosaic we will use the alpha values as follows to compute the color at a pixel in there, suppose there are 2 images, $I1$, $I2$, overlapping in the output image; each pixel (x, y) in image Ii is represented as $Ii(x, y) = (\alpha iR, \alpha iG, \alpha iB, \alpha j)$ where (R, G, B) are the colour values at the pixel. We will compute the pixel value of (x, y) in the stitched output image as $[(\alpha 1R, \alpha 1G, \alpha 1B, \alpha 1) + (\alpha 2R, \alpha 2G, \alpha 2B, \alpha 2)] / (\alpha 1+\alpha 2)$.

VI. Results and Discussions

Figure: (a) First input image for mosaic. (b) Second input image for mosaic.

Figure: Image mosaic produced by mosaic.





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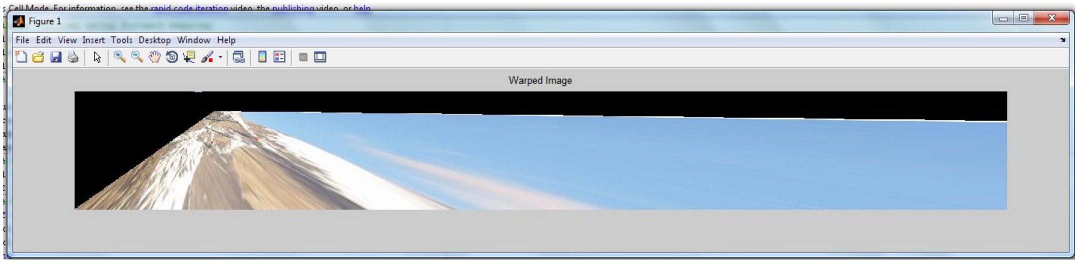

Figure: Image mosaic produced by mosaic.

- **EXPERIMENT**

The algorithm proposed here has been implemented in Matlab R2010a and has been executed in system. Fig 3 is the original input images and it provides the corners by using Harris corner detector. Fig 4 show the result of corner by using improved Harris corner Detector. Fig 5 shows the rough match result by normalized cross correlation method. Fig 6 removing the false matched corner. Fig 7 and 8 shows the matched corner points in both the input images by using RANSAC algorithm after the output image mosaic is obtained.

Table 1 represents a qualitative analysis of an existing algorithm and the proposed algorithm for image blending. PSNR and entropy is increasing which shows the better quality of mosaic image. However, the value of blur metric is decreasing that shows the smoothing of the image.

Table 1: Qualitative Assessment

Blending Algorithms	Quality assessment parameters		
	PSNR(dB)	Entropy	Blur Metric
Existing Algorithm	28.6012	2.9972	0.1972
Proposed Algorithm	28.6857	7.9913	0.1434

VI. CONCLUSION

Image Mosaicing techniques have a long history and evaluation methodologies. In this paper, some of the popular algorithms have been vividly studied. The proposed method applies the corner detector technique to extract feature points from a partially overlapping image pair. By defining a similarity measure metric, the two sets of feature points can be compared, and the correspondences between the feature points can be established. Corner Detection were implemented properly on various input images and tested. Variation of threshold provides the required outputs and it can be further manipulated to get good corner points. The images obtained through Corner detection algorithms are further processed through RANSAC algorithm to obtain greater correlation between images; these were warped and blended properly. The outputs obtained for various input images were quite satisfactory.

VII. Future Works and Developments

Future works can be done on removing the aliasing (Image feathering) that were introduced as noise. For removal of noise, Poisson or Laplacian distribution method can be used. Images with non-overlapping regions can be taken into consideration for mosaicing purposes. RANSAC algorithm can be further developed. Image mosaicing for document mosaicing should be taken into account. Some images are not quite well blended, which needs further modifications in programming. The main reason being that a lot of feature points have been detected because of which RANSAC algorithm fails. So we need to work upon other techniques which can map these points or we should find some another way to reduce these feature points.

Appendix:Basic Imaging Geometry and Geometric Transformation

- **Basic Imaging Geometry**

A commonly used camera model is:

$$\lambda_p = A\,[R|T]P_w$$

This relates the coordinates of a 3-D point in the world coordinate system P_w =[X Y Z 1]^T to its corresponding image point [x y 1]^T. λ is a projective constant. Here R denotes a rotation matrix and T , a translation vector. A represents the matrix of internal camera parameters. The internal parameter matrix is of the form :

$$\begin{bmatrix} f_x & s & u_0 \\ 0 & f_y & v_0 \\ 0 & 0 & 1 \end{bmatrix}$$

Here f_x and f_y are the camera focal lengths in the x- and y- directions respectively; u_0 and v_0 represent the position of the principal point, and is the skew factor between the two image coordinate system axes.

- **Geometric Transformations**

We classify geometirc transformations, in increasing order of generality, as follows: (for simplicity, we consider 2-D to 2-D transformations alone)

1. Euclidean or Rigid Body transformation:

p' = R_p + t

where

$$R = \begin{bmatrix} \cos\theta & -sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$$

is a rotation matrix and t = [t_x t_y] ^{T} translation vector. p' and p are the transofrmed and original 2-D points, respectively, represented in non-homogeneous coordinates [x' y'] ^{T} and [xy] ^{T} , respectively. Euclidean invariants are lengths (distances between two points),

and angles.

2. Similarity transformation:

p' = cRp+t

where c is scaling factor. Similarity invariants are angles, ratios of lengths, and ratios of areas.

3. Affine transformation:

$$p' = \begin{bmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{bmatrix} p + \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$

Affine invariants are parallel lines, ratio of lengths of parallel lines, ratio of areas.

4. Projective transformation: This is the most general gemoetric transformation. Here, the two 2-D points p' and p (represented in homogenous coordinates), are related by a 3*3 non-singular transformation matrix (a homography)

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{31} \\ r_{31} & r_{32} & r_{33} \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

Projective invariants include the cross ratio of four collinear points, or four concurrent lines

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