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Automatic Image Mosaicing Using Sift, Ransac and Homography

Stafford michahial, Latha M, Akshatha S, Juslin F, Ms Manasa B, Shivani U
Asst. Prof, Dept of TE, GSSSIETW, Mysore, Students of TE, GSSSIETW, Mysore

***Abstract* — The aim of computer vision is to understand and interpret the information represented in the images. Information from many images can be combined into one image to aid for better understanding of what they represent. The amount of data which can be collected by the camera is small compared to the human eye. Though there exist complex lens to increase the eld of view, it would be good if we could use the normal cameras to comprehend more information. Image mosaicing is a technique which enables to combine together many small images into a one large image, from which more information can be collected easily. Image-mosaicing algorithms are used for obtaining a mosaiced image. There are five steps used in image mosaicing which includes; Image acquisition, SIFT, image registration, Homography using RANSAC, Image warping and blending.**

***Index Terms*—Image Registration, Homography, RANSAC, SIFT, Warping.**

I. INTRODUCTION

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 coordinate transformations that relate the different image coordinate systems. By applying the appropriate transformations via a warping operation and merging the overlapping regions of warped images, it is possible to construct a single image indistinguishable from a single large image of the same object, covering the entire visible area of the scene. This merged single image is the motivation for the term mosaic. 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. Various steps in mosaicing are acquisition, applying SIFT algorithm, registration, Homography using RANSAC, Image warping and blending. 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 remote sensing, medical imaging, and computer vision [1].Registration methods can be loosely divided into the following classes: algorithms that use image pixel values directly, e.g., correlation methods [2]; algorithms that use the frequency domain, e.g., fast Fourier transform based (FFT-based) methods [3]; algorithms that use low-level features such as edges and corners, e.g., feature based methods [1]; and algorithms that use high-level features such as identified (parts of) objects, or relations between features, e.g., graph-theoretic methods [1]. Homography is mapping between two spaces which is often used to represent the correspondence between two images of the same scene. 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. 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. 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. Blend modes are used to blend two layers into each other.

II. PROPOSED METHODOLOGY

The image mosaicing procedure generally includes following steps. Firstly, we input the images. Secondly, using SIFT algorithm which detects features in an image, we can identify the similar objects in other images. By estimating the Homography, which relates pixels in one frame to their corresponding pixels in another frame, followed by warping and blending of input frames according to the estimated homographies is done so that their overlapping regions align. Fig1 shows the flow chart of the proposed methodology.

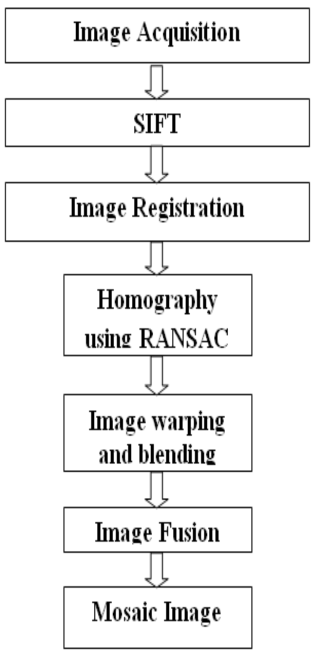

Fig-1: Flow chart of proposed methodology

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A. *IMAGE ACQUISITION*

Image acquisition in image processing can be broadly defined as the action of retrieving an image from some source, usually a hardware-based source, so it can be passed through whatever processes need to occur afterward. Performing image acquisition in image processing is always the first step in the workflow sequence because, without an image, no processing is possible. The image that is acquired is completely unprocessed and is the result of whatever hardware was used to generate it, which can be very important in some fields to have a consistent baseline from which to work. One of the ultimate goals of this process is to have a source of input that operates within such controlled and measured guidelines that the same image can, if necessary, be nearly perfectly reproduced under the same conditions so anomalous factors are easier to locate and eliminate. Fig 2and Fig 3 are the input images taken in normal camera at different angles.

Fig-2: Input image 1

Fig-3: Input image 2

B. *SIFT ALGORITHM*

SIFT stands for 'Scale Invariant Feature Transform'. Lowe proposed a scale invariant feature transform algorithm [9] in the year 1999. It has some unique features, such as rotation, affine transformation, scale invariance and noise immunity. SIFT is a corner detection algorithm which detects features in an image which can be used to identify similar objects in other images. SIFT produces key-point descriptors. Key-point descriptors are given as input to the Nearest Neighbour Search (NNS) and produce closely matching key-point descriptors.

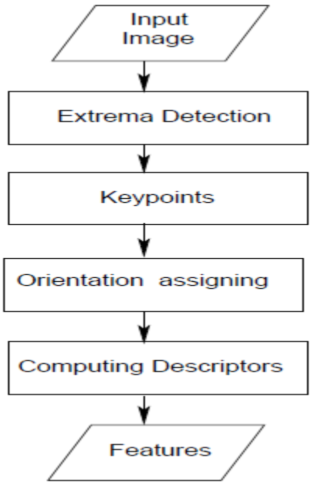

Fig-4: Major phases of SIFT algorithm

SIFT has four computational phases as shown in the Fig4 which includes: Scale-space construction, Scale-space extrema detection, key-point localization, orientation assignment and defining key-point descriptors. Brief function of each phase is given below,

1. Scale space detection [11], preliminary confirm the key points, location and the scale. The middle point is compared with its neighbourhood points to detect utmost points.
2. Using Taylor expansion, the extreme points and location are carefully determined using the following equation:

$$D(x) = D + \frac{\partial D^T}{\partial x} x + \frac{1}{2} x^T \frac{\partial^2 D}{\partial x^2} x \qquad (1)$$

3. By the help of key point neighbourhoods, the gradient m (x, y) and the direction are estimated for an image L(x, y). The gradient and direction can be formulated as:

$$m(x,y) = \sqrt{(L(x+1,y) - L(x-1,y))^2 + (L(x,y+1) - L(x,y-1))^2} \qquad (2)$$

$$\theta(x,y) = \arctan\left(\frac{L(x,y+1) - L(x,y-1)}{L(x+1,y) - L(x-1,y)}\right) \qquad (3)$$

Taking the gradient value and characteristics into consideration, each sample points is added to the histogram. The direction for the feature points are estimated from the maximum peak values from the histogram.

4. Feature vectors [12] are generated. The arrow in each cell stands for gradient direction along with the amplitude of pixels. The seed point can be formed by aligning the unidirectional gradients followed by the Normalization. Fig5 shows the result of SIFT Algorithm.

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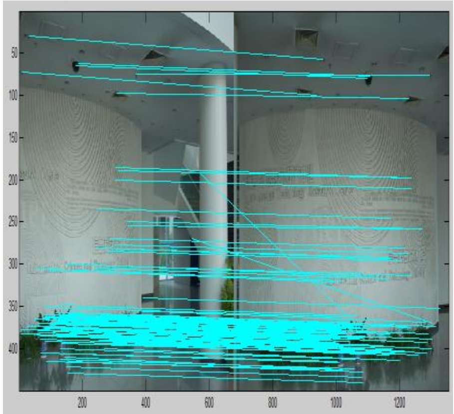

Fig-5: Output of SIFT algorithm

C. IMAGE REGISTRATION

Image registration is the task of matching two or more images. It has been a central issue for a variety of problems in image processing [12] such as object recognition, monitoring satellite images, matching stereo images for reconstructing depth, matching biomedical images for diagnosis, etc. Registration is also the central task of image mosaicing procedures. Carefully calibrated and rerecorded camera parameters may be used to eliminate the need for an automatic registration. User interaction also is a reliable source for manually registering images (e.g. by choosing corresponding points and employing necessary transformations on screen with visual feedback). Automated methods for image registration used in image mosaicing literature can be categorized as follows: Feature based [7] methods rely on accurate detection of image features. Correspondences between features lead to computation of the camera motion which can be tested for alignment. In the absence of distinctive features, this kind of approach is likely to fail. Exhaustively searching for a best match for all possible motion parameters can be computationally extremely expensive. Using hierarchical processing (i.e. coarse-to-fine [5]) results significantly speed-ups. We also use this approach taking advantage of parallel processing for additional performance improvement. Frequency domain approaches for finding displacement and rotation/scale are computationally efficient but can be sensitive to noise. These methods also require the overlap extent to occupy a significant portion of the images (e.g. at least 50%). Iteratively adjusting camera-motion parameters leads to local minimums unless a reliable initial estimate is provided. Initial estimates can be obtained using a coarse global search or an efficiently implemented frequency domain approach.

D. COMPUTING HOMOGRAPHY

A 2D point (x; y) in an image can be represented as a 3D vector x =(x1; x2; x3) where x = X1/X3 and y = X2/X3.This is called the homogeneous representation of a point and it lies on the projective plane P^2. A homography is an invertible mapping of points and lines on the projective plane P^2.Other terms for this transformation includes collineation, projectivity, and planar projective transformation. Hartley and Zisserman [6] provide the specific definition that a homography is an invertible mapping from P^2 to itself such that three points lie on the same line if and only if their mapped points are also collinear. They also give an algebraic definition by proving the following theorem: A mapping from P2 → P2 is a projectivity if and only if there exists a non-singular 3*3-matrix H such that for any point in P^2 represented by vector x it is true that its mapped point equals Hx. This tells us that in order to calculate the homography that maps each xi to its corresponding x_i'. It is sufficient to calculate the 3*3 homography matrix, H. All of the homography estimation algorithms that are discussed require a set of correspondences as input. So far these algorithms are only robust with respect to noise if the source of this noise is in the measurement of the correspondence feature positions. There will be other situations where the input will be corrupted with completely false correspondences, meaning that the two features in the images don't correspond to the same real world feature at all. There is a need to discuss ways to distinguish inlier and outlier correspondences so that the homography can be estimated robustly using only inlier matches.

A. RANSAC algorithm

RANSAC (Random Sample Consensus) is the most commonly used robust estimation method for homographies according to [8]. The idea of the algorithm is pretty simple; for a number of iterations, a random sample of 4 correspondences is selected and a homography H is computed from those four correspondences. Each other correspondence is then classified as an inlier or outlier depending on its concurrence with H. After all of the iterations are done, the iteration that contained the largest number of inliers is selected. H can then be recomputed from all of the correspondences that were considered as inliers in that iteration. One important issue when applying the RANSAC algorithm described above is to decide how to classify correspondences as inliers or outliers. Statistically speaking, the goal is to assign a distance threshold, t, (betweenx0 and H_X for example), such that with a probability α point is an inlier. Hartley and Zisserman [6] provide a derivation of how to calculate t. Another issue is to decide how much iteration to run the algorithm for. It will likely be infeasible to try every combination of 4 correspondences, and thus the goal becomes to determine the number of iterations, N, that ensures with a probability p that at least one of the random samples will be free from outliers. Then, the algorithm:

1. Selects N data items at random.
2. Estimates parameter x.
3. Finds how many data items (of M) fit the model with parameter vector x within a user given tolerance. Call this K.
4. If K is big enough, accept fit and exit with success.
5. Repeat 1.4 L times.
6. Fail if you get here.

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How big K has to be depends on what percentage of the data we think belongs to the structure being fit and how many structures we have in the image. If there are multiple structures than, after a successful fit, remove the fit data and redo RANSAC.

We can find L by the following formulae:

P_{fail} = Probability of L consecutive failures.

P_{fail} = (Probability that a given trial is a failure) L.

P_{fail} = (1 - Probability that a given trial is a success)L.

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

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

$L = log(P_{fail}) / log(1-(P_g)^N)$

E. IMAGE WARPING AND BLENDING

A. Image Warping

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 [14]. This can be based mathematically on any function from part of the plane to the plane. If the function is injective the original can be reconstructed. If the function is a bijection any image can be inversely transformed. The last step is to warp and blend all the input images to an output composite mosaic. 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.

B. Image Blending

The final step is to blend the pixels colours in the overlapped region to avoid the seams. Simplest available form is to use feathering, which uses weighted averaging colour 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 atleast two images overlap occurs in an output mosaic we will use the alpha values to compute the colour at a pixel in there.

F. IMAGE FUSION

Image fusion is the process of combining of two images into a single image that has the maximum information content without producing details that are non-existent in the given images. Image fusion is the process that combines information from multiple images of the same scene. These images may be captured from different sensors, acquired at different times, or having different spatial and spectral characteristics. The object of the image fusion is to retain the most desirable characteristics of each image. With the availability of multisensor data in many fields, image fusion has been receiving increasing attention in the researches for wide spectrums of applications. There are various methods that have been developed to perform image fusion. In this paper we have used Intensity-hue-saturation (IHS) transform based fusion, Principle component analysis (PCA) based fusion Multi scale transform based fusion.

G. IMAGE MOSAIC

Image mosaic is a process of merging two images in order to obtain a larger one. Two phases are considered in the mosaic process namely image registration and image blending. Taking into account that the images are already well registered, this work presents a blending process based on a multi-resolution decomposition for seamless mosaicing of satellite images [10]. The generation of a cut line, which considers texture information, can be used to look for the best splicing curve in the overlapping area. Fig6 shows the final output of the mosaiced image.

Fig-6: Final mosaiced image

III. LIMITATIONS

One of the major limitations of the implementation is mosaicing of only two images at a time is possible. Mosaicing of multiple images cannot be achieved. Then repeatedly warping new images to one reference image makes the image alignment doesn't look good anymore.

IV. CONCLUSION

Image mosaicing is useful for a variety of tasks in vision and computer graphics. Due to the wide range of applications, image mosaicing is one of the important research areas in the field of image processing. Here we have presented some of the very fundamental and basic techniques and improved algorithms used in image mosaicing. This paper presents a complete process for image mosaicing.

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AUTHOR'S BIOGRAPHY

Mr Stafford Michahial did his M.Tech in 2012 and pursuing Ph.D. in the area of Medical Image processing from VTU. At present, he is working as Asst .Professor in the department of Telecommunication Engineering of GSSS Institute of Engineering and Technology for Women, Mysore. He has published several papers in international conferences and journals. His areas of interest include signal and image Processing and AI Robotics.

Mrs Latha M completed her M. tech in 2013. At present, she is working as Asst. Professor in the department of Telecommunication Engineering, GSSS institute of engineering and technology for women, Mysore.

I, Akshatha S completing my Telecommunication engineering from GSSS institute of engineering and technology for women, Mysore.

I, Juslin F completing my Telecommunication engineering from GSSS institute of engineering and technology for women, Mysore.

I, Manasa B completing my Telecommunication engineering from GSSS institute of engineering and technology for women, Mysore.

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