Harris Corner Detection for Image Mosaic

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Abstract *— Image Mosaicing is a process of assembling the multiple overlapping images of the identical 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 gaining a mosaiced image. Mosaicing is blending together of several arbitrarily shaped images to form one large radiometrically balanced image so that the boundaries between the original images are not seen. In this paper, we have described the methods used to create panorama image. Here objective is to offer different methods and algorithms used to produce panoramic image and also to present a new image mosaicing algorithm based on RANSAC and corner detection algorithms. Harris algorithm detects more features and is only rotationally invariant.*

Keywords— Image Mosaicing, Extraction, Warping, Corner, Homography, Blending

I. INTRODUCTION

Image Mosaicing technology is becoming more and more popular in the fields of image processing, computer graphics, computer vision and multimedia. Image mosaicing is the stitching of multiple correlated images to generate a larger wide-angle image of a scene. 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 relates the different image coordinate systems. The appropriate transformations is applied via of a warping operation than by merging the overlapping regions of warped images. In image mosaicing two input images are taken and this images are fused to form a single large image. This merged single image is the output mosaiced image.

Different steps required for doing image mosaicing are feature extraction, registration, stitching (merging images) and blending. Image registration is the process of aligning two or more images taken from one point or same thing is captured from different point. Main purpose of doing image registration is to create geometric correspondence between images so that we can compare images and apply other steps appropriately. After registration next is stitching, in stitching or image merging, all images are transformed according to registration parameter on single big canvas and final step is to do image blending which make the transition from one image to another image smoother so that joint between two images can be removed.

In Harris corner detection algorithm the differential of the corner score with respect to direction. The Harris/ Plessey operator has the best detection rate of the three operators and has been shown to have a good repeatability rate. For many applications, localization is not critical. For these reasons the Harris/Plessey operator is widely used in practice.

In homography undesired corners which do not belong to the overlapping area are removed. To remove the undesired corners which do not belong to the overlapped area, Random Sample Consensus (RANSAC) algorithm is used. It removes the false matches in the image pairs. Reprojection of frames is done by defining its size, length, width. Stitching is done finally to obtain a final output mosaic image.

II. LITERATURE REVIEW

Registration and mosaicing of images have been in practice since long before the age of digital computers. Shortly after the photographic process was developed in 1839, the use of photographs was demonstrated on topographical mapping. Images acquired from hill-tops or balloons were manually pieced together. After the development of airplane technology (1903) aero photography became an exciting new field. The limited flying heights of the early airplanes and the need for large photo-maps, forced imaging experts to construct mosaic images from overlapping photographs. This was initially done by manually mosaicing images which were acquired by calibrated equipment. The need for mosaicing continued to increase later in history as satellites started sending pictures back to earth.

Several image registration survey methods were proposed by many authors [1,2,3,4]. L.G. Brown published survey of image registration methods and he classified into four main methods based on type of problem, image acquisition, and applications. In the multimodal registration, images are acquired by different sensors of same scene. This method is used in medical image analysis and remote sensed data processing applications. Template registration finds a match for reference pattern in the sensed image. This registration method is used in object detection and recognition, character recognition and signature analysis.

In Feature Extraction and Matching It can be started with corner detection algorithms where we have described Harris, SUSAN, Forstner and SIFT algorithms.

In Harris Corner Detector Instead of using shifted patches, Harris and Stephens improved Moravec's corner detector by considering the differential of the corner score with respect to direction.

The corners or interest points may be interchanged and refers to point features in an image. The detected corner points correspond to the points in the two dimensional image with high curvature. Corners are declared at the junctions (meeting point) of two or more edges. Number of approaches for detecting corners such as Harris, SUSAN, KLT and FAST, etc.

Automated methods for image registration used in image mosaicing literature can be categorized as follows:

Feature based 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 [13]) results in significant speed-ups. We also use this approach also 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.

III. ALGORITHM OF HARRIS CORNER DETECTION

This Algorithm was developed by Chris Harris and Mike Stephens in 1988 as a low level processing step to aid researchers trying to build interpretations of a robot's environment based on image sequences. Specifically, Harris and Stephens were interested in using motion analysis techniques to interpret the environment based on images from a single mobile camera. Like Moravec, they needed a method to match corresponding points in consecutive image frames, but were interested in tracking both corners and edges between frames. Harris and Stephens developed this combined corner and edge detector by addressing the limitations of the Moravec operator. The result was far more desirable detector in terms of detection and repeatability rate at the cost of requiring significantly more computation time. A local detecting window in image is designed. The average variation in intensity that results by shifting the window by a small amount in different direction is determined. At this point the center point of the window is extracted as corner point. We can easily get the point by looking at intensity values within a small window. Shifting the window in any direction gives a large change in appearance. Harris corner detector is used for corner detection. On shifting the window if it’s a flat region than it will show no change of intensity in all direction. If an edge region is found than there will be no change of intensity along the edge direction. But if any corner is found than there will be a significant change of intensity in all direction. Harris corner detector gives a mathematical approach for determining whether the region is flat, or if there is an edge or corner. Harris corner technique is very much helpful in detecting more features and that technique is rotational invariant and scale variant. For image mosaicing we adopted a morphological approach for corner detection proposed in. The corresponding corner detector is based in an operation named asymmetrical close.

Fig. 1: Circles indicate selected corner

A morphological close of an image first dilates it using a structuring element, followed by an erosion by the same element. In the asymmetrical close different structuring elements are used in the dilation and erosion. This operation is performed twice thereby using four different structuring elements and generating two intermediate images.

IV. RANSAC ALGORITHM

Calculating 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 iterations are allowed. The algorithm was first published by Fischler and Bolles. RANSAC algorithm is used for fitting of models in presence of many available data outliners in a robust manner. Given a fitting problem with 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 Pg.
4) The probability that the algorithm will exit without finding a good fit if one exists is Pfail.

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.

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.

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

$$L = log(Pfail)/ log(1-(Pg)N)$$

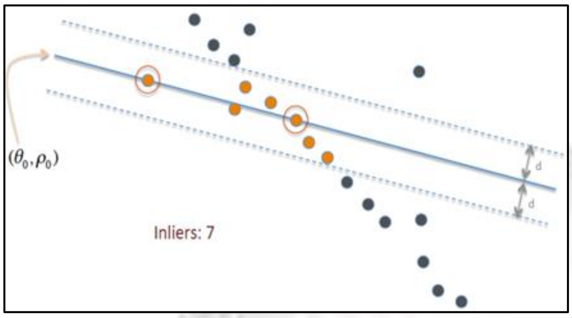


Fig. 2: RANSAC: Inliers and Outliers.

V. IMAGE MOSAICING PROCESS

The image mosaicing procedure generally includes three steps. First, we register input images by estimating the homography, which relates pixels in one frame to their corresponding pixels in another frame. Second, we warp input frames according to the estimated homographies so that their overlapping regions align. Finally, we paste the warped images and blend them on a common mosaicing surface to build the panorama result.

1) Image Registration: given a set of N images I1,I2,…In} with a partial overlap between at least two images, compute an image-to-image transformation that will map each image *I2,…In*, into coordinate system of.
2) Image Warping: warp each image *I2,…In*, using the computed transformation.
3) Image Interpolation: resample the warped image.
4) Image Compositing: blend images together to create a single image on the reference coordinate system

In the forward mapping the source image is scanned pixel by pixel, and copies them to the appropriate location in the destination image. The reverse mapping goes through the destination image, pixel by pixel, and samples the corresponding pixel from the source image. The main advantage of the reverse mapping is that every pixel in the destination image will have assigned an intensity value. In the forward mapping case, some of the pixels in the destination images may not be coloured, and would have to be interpolated.

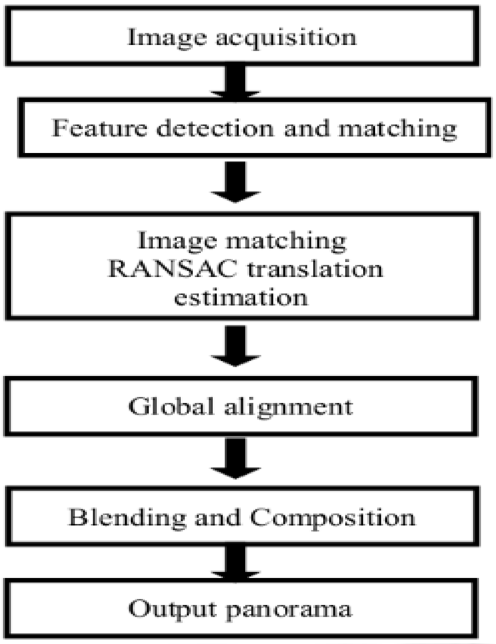


Fig. 3: Image Mosaicing Model

VI. 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 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 prerecorded 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).

VII. IMAGE WARPING AND BLENDING

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 trans formed in various ways, pure warping means that points are mapped to points without changing the colors. 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 bisection any image can be inversely transformed. The last step is to warp and blend all the input images to an output composite mosaic. Basically we can simply warp all the input images to a plane defined by one them known as composite panorama.

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 we will use the alpha values

VIII. EXPERIMENTAL RESULTS

Now that all the steps and relevant details of the mosaicing operation have been carefully described, some of the mosaics created will be presented.

The algorithm proposed here has been implemented in Matlab R2014a and has been executed in system with configuration i5 processor, 4 GB RAM, 2 GB cache memory and 2.8GHz processor.

Fig. 4: The input images.

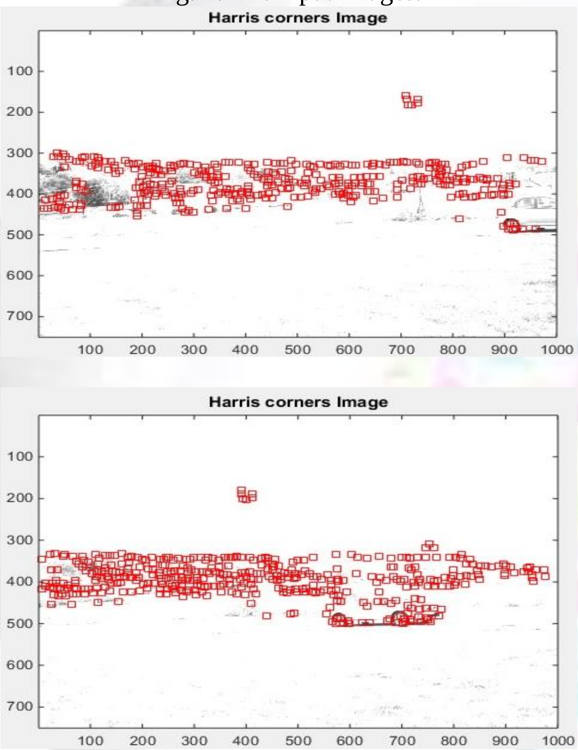
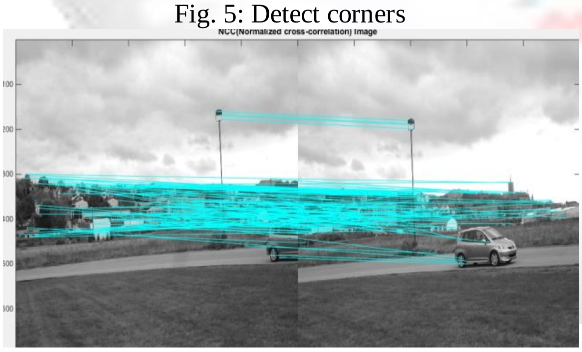


Fig. 5: Detect corners



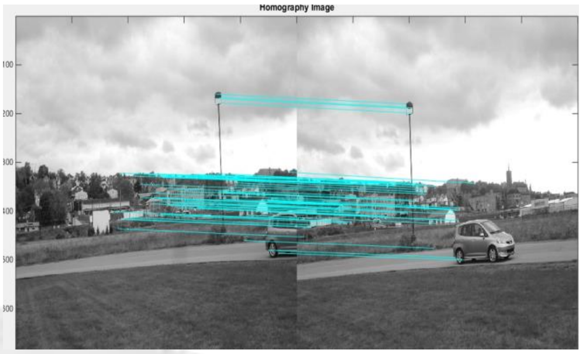


Fig. 6: Rough match result by NCC

Fig. 7: Result of image mosaic

IX. CONCLUSION

Image Mosaicing methods are generally used in producing panoramic or stretching of images. In this paper, some of the popular algorithms have been explores. Harris corner detection method is robust as well as rotationally invariant. However, it is scale variant. Mosaicing process we have managed to significantly improve the resulting mosaics. The first of these details consists of using a corner detector to locate only a few well defined features on each picture. Another important tip is to select corners that don't define a straight line and that are as spread as possible in the overlapping area. Thus, we accomplished both a high speed and a good quality feature point detection algorithm here.

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