IMAGE MOSAICING USING HARRIS CORNER DETECTION FOR MEDICAL APPLICATIONS

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Abstract— In today's era where digital image processing is being widely used in several areas like data hiding, aerial imaging, video processing & medical field, etc. Image mosaicing is a field which is also emerging at a fast pace. It is the process of merging fragmented images that are obtained by scanning different parts of a single large image with certain part of overlapping region to produce a single and complete image. It is nothing but joining of two or more images and making a new and wide area image. In this paper, the process of feature detection will be discussed using Harris Corner Detection algorithm, which is our method of choice because of its advantages like consistency of detection, localization, stability, and low complexity. Application of Image Mosaicing is used here for medical images.

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. A highly precise integrated image can be obtained by drawing this relation precisely [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 remote sensing, 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.

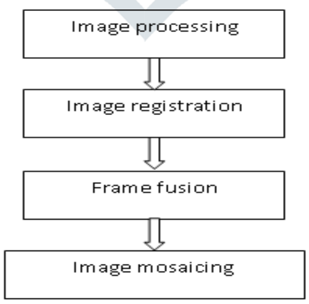

Figure 1: Flowchart depicting segmentation of image mosaicking

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.

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]:

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

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

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

Where M is a 2x2 autocorrelation matrix computed from image derivatives:
Measure of corner response:

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

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:

$$\begin{aligned} R &= \det M - k(\mathit{trace}\, M)^2 \\ \det M &= \lambda_1 \lambda_2 \\ \mathit{trace}\, M &= \lambda_1 + \lambda_2 \end{aligned} \qquad \textbf{(4)}$$

III. COMPUTING HOMOGRAPHY

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. The algorithm was first published by Fischler and Bolles. 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}.

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 you think belongs to the structure being fit and how many structures you have in the image. If there are multiple structures, then 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
Pfail = (Probability that a given trial is a failure) L
Pfail = (1 - Probability that a given trial is a success) L
Pfail = (1 - (Probability that a random data item fits the model)N)L

$$P_{fail} = (1 - (P_g)^N)^L \qquad \textbf{(5)}$$

$$L = \frac{\log(P_{fail})}{\log(1-(P_g)^N)} \quad (6)$$

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:

$$q \equiv Hp \quad (7)$$

(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

$$q \times Hp = 0 \quad (8)$$

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:

$$h = (h11; h12; h13; h21; h22; h23; h31; h32; h33)^T \quad (9)$$

N point correspondences give 2N linear constraints, using (8). This results in a system of the form Bh = 0.

The following problem must then be solved:

$$\min_h \|Bh\|^2 \ subject \ \ to \|h\| = 1 \quad (10)$$

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. (10).

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. Finally x-offset and y-offset values specifying the offset of the reference image origin relative to the output panorama needs to be calculated.
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 we will use the alpha values as follows to compute the color at a pixel in there, suppose there are two images, $I1$, $I2$, overlapping in the output image; each pixel (x, y) in image Ii is represented as $Ii(x, y) = (\alpha i_R, \alpha i_G, \alpha i_B, \alpha j)$ where (R, G, B) is the color values at the pixel. We will compute the pixel value of (x, y) in the stitched output image as $[(\alpha 1_R, \alpha 1_G, \alpha 1_B, \alpha 1) + (\alpha 2_R, \alpha 2_G, \alpha 2_B, \alpha 2)] / (\alpha 1+\alpha 2)$.

V. RESULTS

The algorithm discussed in the paper has been implemented in MATLAB 7.12. Figure 2 and 3, x-ray images of chest and hand [8] shows the result of image mosaic of the experiment using medical images. 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.

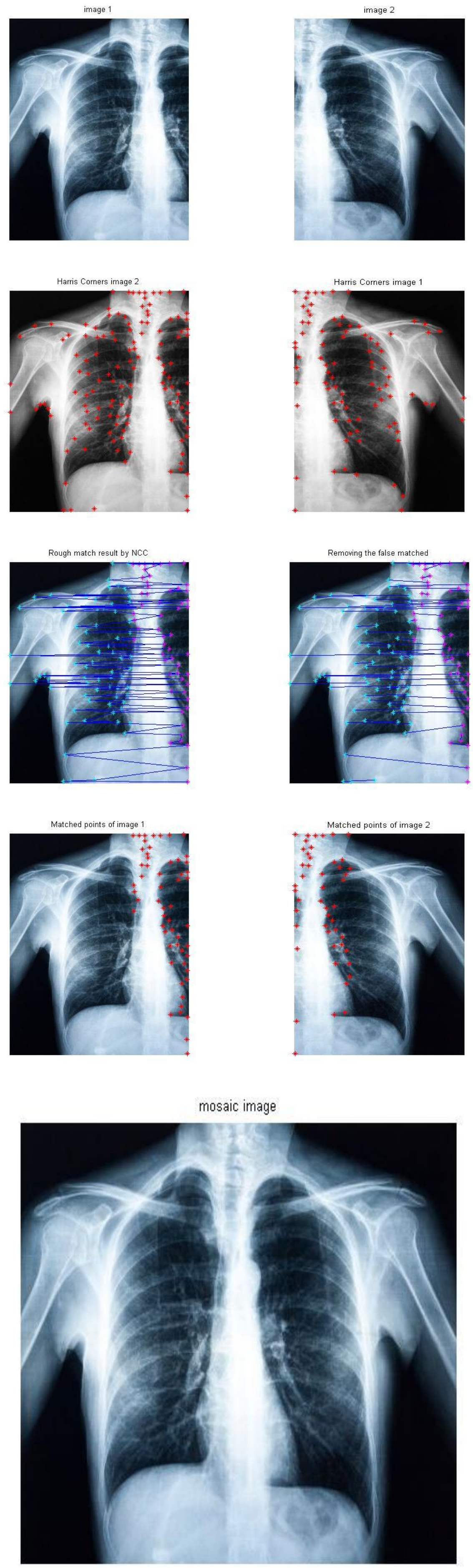

Figure 2: Results of Image Mosaic for x-ray of chest

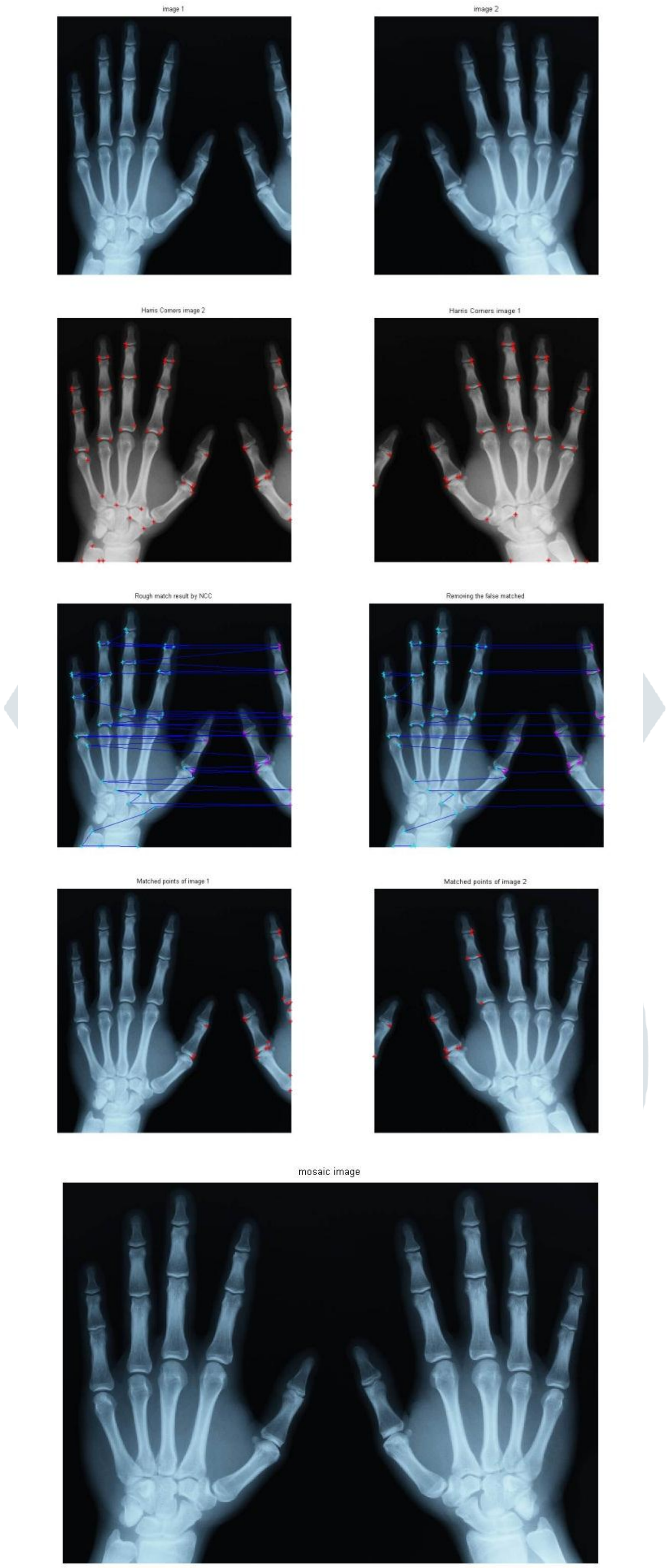

Figure 3: Results of Image Mosaic for x-ray of hands

VI. CONCLUSION

Image Mosaicing techniques have a long history and evaluation methodologies. In this paper it was observed that to mosaic two different images there are four basic steps which are essential i.e. feature detection; feature matching, transformation and image fusion. 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.

REFERENCES

[1] Chao Sui, Ngai Ming Kwok, Tianran Ren, “Image Mosaic Construction Using Feature Matching and Weighted Fusion”, School of Mechanical and Manufacturing Engineering The University of New South Wales Sydney, Australia, Vol. 6, pp. 2782 - 2786, 2010.

[2] Lisa G. Brown. A survey of image registration techniques. ACM Computing Surveys, 24(4):325–376, December 1992.

[3] D. I. Barnea and H. F. Silverman, "A class of algorithms for fast digital registration," IEEE Trans. Comput, vol. C-21, pp. 179- 186, 1972.

[4] C. D. Kuglin and D. C. Hines, "The phase correlation image alignment method," in Proc. IEEE 1975 Int. Conf.Cybernet. Society, New York, pp. 163-165.

[5] Raman Maini & Dr. Himanshu Aggarwal, “Image Processing Study and Comparison of Various Image Edge Detection Techniques”, International Journal of Image Processing (IJIP), Vol. 3, Issue 1.

[6] I-Jen Lai and Wen-Hsiang Tsai, “Secret-Fragment-Visible Mosaic Image - A New Computer Art and Its Application to Information Hiding”, Vol. 6, Issue 3, pp. 936-945, Sept. 2011.

[7] S. Battiato, Di Blasi, G.M. Farinella, G. Gallo, “A Survey of Digital Mosaic Techniques”, Eurographics Italian Chapter Conference, 6 – 95125 Catania (Italy), 2006.

[8] Abhinav Kumar *et* Al, “Automatic Image Alignment and Stitching of Medical Images with Seam Blending”, World Academy of Science, Engineering and Technology, International Journal of Medical, Health, Biomedical, Bioengineering and Pharmaceutical Engineering. 2010