Review on Mosaicing Techniques in Image Processing

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Abstract- **In image processing, mosaic images are images made by cementing together small tiles. The tiles "tessellate" a source image with the purpose of reproducing the original visual information rendered into a new mosaic-like style. Creation of mosaic images from a sequence of partial views is a powerful means of obtaining a larger view of a scene than available within a single view, and it has been used in wide range of applications. A general framework for retinal and document images is proposed in this paper. This paper also discusses a review on different applications of image mosaicing mainly in the area of retinal image mosaicing and document image mosaicing.**

Keywords – Image mosaicing, Retinal image, Document image, Image processing

I. INTRODUCTION

Over the past decades, the development of novel rendering styles outside the bounds of photorealism, the so called non-photorealistic rendering or NPR [1] has gathered momentum. Photorealism is a genre of painting based on using cameras and photographs to gather visual information and then from this creating a painting that appears to be photographic. Non-photorealistic Rendering (NPR) is a successful area of Computer Graphics and it is nowadays applied to many relevant contexts such as Scientific Visualization, Information Visualization and artistic style emulation [2] [3]. Several NPR techniques have been designed to emulate a broad range of artistic media from pastel to paint [4] and to mimic many artistic techniques such as hatching and shading.

In the digital realm, mosaics are illustrations composed by a collection of small images called 'tiles'. The tiles tessellate a source image with the purpose of reproducing the original visual information rendered into a new mosaic-like style. Computer generated Mosaic image creation [5] is a new research area in recent years. Various mosaics can be created for an image depending on the choice of the tile dataset and the imposed constraints for positioning, deformations, etc. Mosaic images are images made by cementing together small colored tiles. Likely, they are the most ancient examples of discrete primitive based images. A picture (usually a photograph) is divided into (usually equal sized) small sections and each of which is replaced with another photograph that matches the target photo or reconstruct the image by properly painting the tiles.

Mosaic images can be classified into four types, crystallization mosaic [1][6], ancient mosaic[1][6], photo mosaic[1][6], and puzzle image mosaic[1][6]. The first two types of mosaics decompose a source image into tiles (with different color, size and rotation), reconstructing the image by properly painting the tiles. So they can be grouped together under the denomination of tile mosaics [6]. The last two kinds are obtained by fitting images from a database to cover an assigned source image. Hence they may be grouped together under the denomination of multi-picture mosaics [6]. This taxonomy should not be intended as a rigid one. Many mosaic techniques may fit in more than a single class and it is likely that other new types of mosaics will appear in the future.

Automatic mosaic construction has been applied in many fields such as photogrammetry, computer vision, image processing and computer graphics. Building a mosaic image from a sequence of partial views is a powerful means of obtaining a broader view of a scene than from a single view and has been used in a large range of applications [7]. The most traditional application is the construction of large aerial and satellite photographs from collections of images. In the aspect of medical imaging, the large panoramic images can help doctors to conduct comprehensive and visual observation on the focus and the surrounding parts. An application in which mosaics are specifically useful is in the diagnosis and treatment of retinal diseases. Mosaicing is also applied for document image analysis when it is not possible to capture a large document at a reasonable resolution in a single exposure. Another application area is panoramic image mosaics from sequences of images. Here a review on the research works in the field of document image mosaic and retina image mosaic are discussed. The main challenges in image mosaicing are correcting geometric deformations using image data and/or

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camera models, image registration using image data and/or camera models and eliminating seams from image mosaics.
Section 2 discusses a proposed approach for general image mosaicing framework. The relevance of the image mosaicing in retinal images are explained in Section 3. Section 4 focusses on the relevance of image mosaicing techniques the field of document images. Section 4 describes conclusion.

II IMAGE MOSAICING FRAMEWORK

A general framework for retinal image mosaicing and document image mosaicing is proposed in this section. The block diagram for the proposed framework is shown in Fig:1. The algorithm for the framework is given as follows:

1) First we have a images of retina or document
2) Arrange them in correct order and orientation by using the features extracted.
3) Construct the mosaic image.
4) Apply distortion reduction methods to improve the quality of mosaic image.
5) Finally the high resolution mosaic image is obtained.

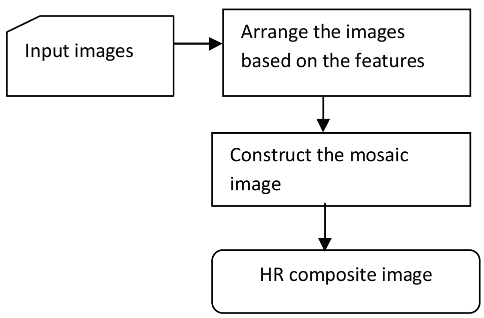

Fig.1: Proposed Framework for Retinal and Document Image Mosaicing

III REVIEW OF IMAGE MOSAICING IN RETINAL IMAGES

In medical imaging, the large panoramic images can help doctors to conduct comprehensive and visual observation on the focus and the surrounding parts, image mosaicing technology has become a research hot spot in the domain of medical image processing. The purpose is to make several images located in different space positions match and mosaic a complete new image.

Retinal images are used to diagnose and monitor the progress of diseases, including diabetic retinopathy which is one of the leading causes of blindness, age-related mascular degeneration, and glaucoma [8]. However, the angle of a retinal photograph is only 30 to 60 degrees. Two or more retinal photographs are needed to capture a general view of entire retina. Building a mosaic image from a sequence of partial views is a powerful means of obtaining a complete, non-redundant view of a scene. Another application in which mosaics are used is ophthalmology[10]. A seamless mosaic formed from multiple fundus camera images aids in diagnosis, provides a means for monitoring the progress of diseases, and may be used as a spatial map during surgical treatment. This section discusses some of the literature present in the retinal image mosaicing.

Can et.al [9] describes a robust hierarchical algorithm for fully-automatic registration of a pair of images of the curved human retina photographed by a fundus microscope. Accurate registration is essential for mosaic synthesis, change detection, and design of computer-aided instrumentation. Central to the algorithm is a 12-parameter interimage transformation derived by modeling the retina as a rigid quadratic surface with unknown parameters, imaged by an uncalibrated weak perspective camera. The parameters of this model are estimated by matching vascular landmarks extracted by an algorithm that recursively traces the blood vessel structure. The parameter estimation technique, which could be generalized to other applications, is a hierarchy of models and methods: an initial match set is pruned based on a zeroth order transformation estimated as the peak of a similarity-weighted histogram; a first order, affine transformation is estimated using the reduced match set and least-median of squares; and the final, second order, 12-parameter transformation is estimated using an M-estimator initialized from the first order estimate. This hierarchy makes the algorithm robust to unmatchable image features and mismatches between features caused by large interframe motions. Before final convergence of the M-estimator, feature positions are refined and the correspondence set is enhanced using normalized sum-of-squared differences matching of regions deformed by the emerging transformation.

Can et.al proposed, an extension of the above algorithm[10] is discussed. Two novel methods are introduced in this paper. The first is a linear, non-iterative method for jointly estimating the transformations of all images onto the mosaic. This employs constraints derived from pairwise matching between the non-mosaic image frames. It allows the transformations to be estimated for images that do not overlap the mosaic anchor frame, and results in mutually consistent transformations for all images. This means the mosaics can cover a much broader area of the retinal surface, even though the transformation model is not closed under composition. This capability is particularly valuable for mosaicing the retinal periphery in the context of diseases such as AIDS/CMV. The second is a method to improve the accuracy of the pairwise matches as well as the joint estimation by refining the feature locations and by adding new features based on the transformation estimates themselves. The physician can now choose any image as the anchor image, and need not worry about identifying a single image that will overlap all others.

A new technique is presented for mosaicing sparsely-overlapping image sets[11], with a target application of assisting the diagnosis and treatment of retinal diseases The primary technical contribution is the use of uncertainty to drive the formation of new matching constraints between unregistered image pairs in the context of multi-image alignment. This is particularly important for low overlap images and images with sparse feature sets such as the blood vessels of retinal images. This technique corrects misalignments in sparsely overlapping image sets without sacrificing overall accuracy.

In [12] a method to construct a mosaic from multiple color and fluorescein retinal images is introduced. A set of images taken from different views at different times is difficult to register sequentially due to variations in color and intensity across images. Introduced a method to register images globally in order to minimize the registration error and to find optimal registration pairs. The reference frame that gives the minimum registration error is found by the Floyd-Warshall's all-pairs shortest path algorithm, and all other images are registered to this reference frame using an affine transformation model.

An automatic retinal image mosaic method is presented in [13], which is based on the principle of blood vessels resemblance. The method depends on the characteristics of the extracted blood vessels that are segmented by combining mathematical morphology with maximum entropy algorithm. Then, the registration objective function is developed by using the maximal overlap degree of the retinal blood vessels information and its optimal parameters are searched by employing a global optimization algorithm, i.e., Genetic Algorithm (GA). Finally, the mosaic process of retinal image is implemented through a fade-by-fade method, which can eliminate the mosaic gaps.

Accurate registration is essential for montage synthesis, change detection, and design of computer-aided instrumentation. [14] describes a robust local feature-based for automatic mosaic of the curved human color retinal images. The kernel of this method is the m space scale invariant feature transforms (mSIFT). The mSIFT algorithm is designed to over-come the SIFT's drawback that detects less features in the flat regions. Using the mSIFT algorithm, second-nearest-neighbor strategy, inlier identification, bilinear warping and multi-blending techniques, pairs of the curved color retinal images can be mosaicked to create panoramic images.

In [15] a new method is presented for retinal image mosaic. Central to the new method is to detect the PCA-SIFT (Principal Components Analysis-Scale Invariant Feature Transform) feature and estimate the quadratic transformation model which is employed to simulate the anatomy of human eyes. The transformations models are estimated by matching PCA-SIFT landmarks. The hierachical notion is used to map the Inter-Image. The random sample consensus (RANSAC) is used to estimate the affine transformation model and remove exterior point. The quadratic is estimated by M-estimator. And the weighted mean is used to Stitch retinal images. The proposed approach can effectively realize the retinal image mosaic.

IV Relevance Of Mosaicing Techniques In Document Images.

Document image analysis requires mosaicing when it is not possible to capture a large document at a reasonable resolution in a single exposure. Such a document is captured in parts and mosaicing stitches them into a single image. This motivates the use of "mosaicing", whereby multiple, overlapping images of the document are stitched together seamlessly to form a high resolution composite image.

In [16] Shiva et.al a new and simple approach to mosaic the two split images of a large document based on matching sum of values of pixels of window in the split images. The method is based on sliding window concept which gives high level features instead pixel level features. The method compares the sum of values of pixels of window in split images to identify Overlapping Region (OLR) in the split images. The OLR, a region in common, helps in mosaicing of two split images of large document. However, a small OLR is assumed to be available at the end of split images of a large document. In addition to this, the OLR in the split images depends on the size of the window. . However, the method works fine for all types of documents but it consumes time and fails if the sequence is missed.

The image mosaicing method for camera-captured documents in [17] is unique in not restricting the camera position, thus allowing greater flexibility than scanner-based or fixed-camera-based approaches. To accommodate for the perspective distortions introduced by varying poses, a two-step image registration process that relies on accurately computing the projectivity between any two document images with an overlapping area as small as 10% is introduced. In the overlapping area, apply a sharpness based selection process to obtain seamless blending across the border and within.

In [18] a novel block-based scheme is employed to ensure t hat corners can be reliably detected over a wide range of images. 2-D discrete cosine transform is computed for image blocks defined around each of t he detected corners and as mall subset of the coefficients is used as a feature vector. A 2-pass feature matching is performed to establish point correspondences from which the homography relating the input images could be computed. The Harris corners have been meticulously selected so that we have the features fairly evenly spread throughout the image.

Hannuksela et.al [19] presented a new user interaction concept for document image scanning with mobile phones. A high resolution mosaic image is constructed in two main stages. Firstly, online camera motion estimation is applied to the phone to assist the user to capture small image patches of the document page. Automatic image stitching process with the help of estimated device motion is carried out to reconstruct the full view of the document. Experiments on document images captured and processed with mosaicing software clearly show the feasibility of the approach.

In [20] a robust method for mosaicing of document images using features derived from connected components is discussed. Each connected component is described using the Angular Radial Transform (ART). To ensure geometric consistency during feature matching, the ART coefficients of a connected component are augmented with those of its two nearest neighbors. The method addresses two critical issues often encountered in correspondence matching: (i)The stability of features and (ii) Robustness against false matches due to the multiple instances of characters in a document image. The use of connected components guarantees a stable localization across images. The augmented features ensure a successful correspondence matching even in the presence of multiple similar regions within the page.

Ligang et.al [21] decomposed the complexity of solving the 8-dof transformation between image pairs into two problems, that is, rectification and registration. This is achievable under a key assumption that sufficient text content forms orthogonal texture flows on the document surface. First, perspective distortion and rotation are removed from images using the texture flow information. Next, the translation and scaling areresolved by a Hough transform-like voting method. In the image composition part, a sharpness based selection process which composes a seamless and blur free mosaic for text content.

In [22] an image mosaicing method for camera-captured document images, and it can be used to stitch multiple overlapping document images into a large high resolution image. First, use the nearest-neighbor(NN) clustering technique in document skew rectification to locate the horizontal vanishing point of the text plane. Secondly, partition the image into multiple overlapping blocks centered with the centroid of each connected component(CC), and introdued a run-length opening Algorithm (RLOA) to compute the local orientation of vertical character stroke(VSB), which is used to locate the document's vertical vanishing point. Thirdly, a three-step hierarchical rectification method is proposed to rectify document images. Finally, it uses local alignment constraints of all the overlapping image pairs to construct global alignment model, thus, to eliminate the error accumulation effectively. This method is unique in not calibrating the internal and external camera parameters in advance and not restricting the camera position, and it can produce a high resolution and accurate full page mosaic from small image patches of a document.

Lijing et.al [23] presented a warped document image mosaicing method based on registration and a composing transformation of Translation, Rotation and Scaling, called TRS transform. This method mosaics two warped images of the same document from different viewpoints through feature extraction, image registration, etc. After mosaicing, the distortions are mostly removed and the OCR results are improved markedly. The above approaches are summarized in Table 1.

Application Area	**Proposed Methods**	**Central Ideas**	**Purpose of Mosaicing**
Retinal Image Mosaicing	Ali Can, Charles V. Stewart, Badrinath Roysam [9]	Based on 12-parameter interimage transformation derived by modeling the retina as a rigid quadratic surface with unknown parameters, imaged by an uncalibrated weak perspective camera	Images of the retina are used to diagnose and monitor the progress of a variety of diseases. Building a mosaic image from a sequence of partial views is a powerful means of obtaining a complete, non-redundant view of a scene.
	A. Can, C.V.Stewart, B.Roysam, H.L. Tanenbaum [10]	Extending above algorithm, a linear, non-iterative method for jointly estimating the transformations of all images onto the mosaic is introduced. To improve the accuracy of the pairwise matches as well as the joint estimation by refining the feature locations and by adding new features is also proposed	
	Gehua Yang, Charles V. Stewart [11]	To generate constraints between image pairs, and use these constraints to estimate a more consistent set of transformations. For each pair, covariance matrices are computed and used to estimate the mapping error covariance matrices for individual features from one image. These features are matched in the second image by minimizing the resulting Mahalanobis distance.	

	Tae Eun Choe, Isaac Cohen, Munwai Lee, Gerard Medioni [12]	Method to register images globally in order to minimize the registration error and to find optimal registration pairs. The reference frame that gives the minimum registration error is found by the Floyd-Warshall's all-pairs shortest path algorithm.		
	Yong Yang, Shuying Huang [13]	Based on the principle of blood vessels resemblance and Genetic Algorithm (GA) .		
	LI Jupeng, CHEN Houjin, YAO Chang, ZHANG Xinyuan [14]	The m space scale invariant feature transform (mSIFT) is used. Using the mSIFT algorithm, second-nearest-neighbor strategy, inlier identification, bilinear warping and multi-blending techniques, pairs of the curved color retinal images can be mosaicked to create panoramic images.		
	LiFang Wei, LinLin Huang, Lin Pan, Lun Yu [15]	Detect the PCA-SIFT (Principal Components Analysis-Scale Invariant Feature Transform) feature and estimate the quadratic transformation model which is employed to simulate the anatomy of human eyes.		
Document Image Mosaicing	G P. Shivakumara, G. Hemantha Kumar, D.S. Guru, P. Nagabhushan [16]	Based on matching sum of values of pixels of window in the split images to identify Overlapping Region(OLR). Also OLR in the split images depends on the size of the window.	Camera-captured document images	It is not possible to capture a large document at a reasonable resolution in a single exposure so multiple, overlapping images of the document are stitched together seamlessly to form a high resolution composite.
	Adrian Philip Whichello, Hong Yan [17]	It is not restricting the camera position, a two-step image registration process is implemented, a sharpness based selection process to ob-tain seamless blending across the border and within.		
	T Kasar, A G Ramakrishnan [18]	Block-based scheme is used. 2-D discrete cosine t ransform and 2-pass f eature matching are performed.		
	T Kasar, A G Ramakrishnan [20]	Based on connected components. Each connected component is described using the AngularRadial Transform (ART)		
	V Jian Liang, Daniel DeMenthon, David Doermann [21]	distortion and rotation are removed from images using the texture flow information, the translation and scaling are resolved by a Hough transform-like voting method. Image composition part, a sharpness based selection process which composes a seamless and blur free mosaic for text content		
	Miao Ligang, Yue Yongjuan [22]	The nearest-neighbor(NN) clustering technique is used in document skew rectification to locate the horizontal vanishing point , a run-length opening algorithm(RLOA) to compute the local orientation of vertical character stroke(VSB), used to locate the document's vertical vanishing point, a three-step hierarchical rectification method is proposed to rectify document images.		

	Tong Lijing, Zhang Yan, Zhao Huiqun [23]	warped document image mosaicing method based on registration and a composing transformation of Translation, Rotation and Scaling, called TRS transform.		
	Jari Hannuksela, Pekka Sangi, Janne Heikkila Xu Liu, David Doermann [19]	Online camera motion estimation is applied to the phone to assist the user to capture small image patches. Automatic image stitching process with the help of estimated device motion is carried out to reconstruct the full view of the document.	Document images scanned with mobile phones	

Table 1: A review on Mosaicing approaches for Retinal images and Document images

V. CONCLUSION

Image mosaicing is a powerful tool for generating larger view of a scene. Various image mosaicing techniques related to retinal and document images are discussed. A general framework for image mosaicing in the retinal and document images is proposed in the paper. A review on retinal image mosaicing and document image in the field of image processing is also discussed. In medical imaging, mosaic images help the doctors to conduct a comprehensive and visual observation on the sourrounding parts.Document mage mosaicing helps to capture a large document at a high resolution in single exposure.

References

[1] S. Battiato, G. Di Blasi, G. M. Farinella and G. Gallo, "A Survey of Digital Mosaic Techniques", Eurographics Italian Chapter Conference ,pp. 129-135,2006.

[2] S Aito T., T Akahashit.: Comprehensible render-ing of 3-d shapes. In Proc SIGGRAPH1990 (1990), 197–206.

[3] C Ollomossej. P.: Higher Level Techniques for the Artistic Rendering of Images and Video. Ph.D Thesis (2004).

[4] Haeberli P, Paint by Numbers: Abstract Image Rappresentation. In Proceedings of SIGGRAPH1990, August 1990.

[5] R.Silverand M.Hawley, Photomosaics. New York: Henry Holt, 1997.

[6] Battiato, G. Di Blasi, G. M. Farinella, and G. Gallo, "Digital mosaic framework: An overview," Eurograph.—Comput. Graph. Forum , vol.26, no. 4, pp. 794–812, Dec. 2007.

[7] Tt A. Can, C.V. Stewart, and B. Roysam, "Robust hierarchical algorithm for constructing a mosaic from images of the curved human retina", Computer Vision and Pattern Recognition. Vol.2, 1999, pp.286-292.

[8] J. B. A. Maintz and M. A. Viergever, "A survey of medical image registration,"Med. Image Anal., vol. 2, no. 1, 1998, pp. 1–36

[9] Ali Can, Charles V. Stewart, Badrinath Roysam, "A Feature-Based, Robust, Hierarchical Algorithm for Registering Pairs of Images of the Curved Human Retina", *IEEE Transactions on Pattern Analysis and Machine Intelligence,* vol.24, No.3, pp.347-364,Maech 2002.

[10] A Can, C.V.Stewart, B.Roysam, H.L. Tanenbaum, "A Feature-Based Technique for Joint, Linear Estimation of High-Order Image-to-Mosaic Transformations: Application to Mosaicing the Curved Human Retina*", IEEE Conference on Computer Vision and Pattern Recognition,* vol. 2, pp: 585 - 591 , 2000.

[11] Gehua Yang, Charles V. Stewart, "Covariance-Driven Mosaic Formation from Sparsely-Overlapping Image Sets with Application to Retinal Image Mosaicing", IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'04), vol. 1, pp: I-804 - I-810, July 2004.

[12] Tae Eun Choe, Isaac Cohen, Munwai Lee, Gerard Medioni, "Optimal Global Mosaic Generation from Retinal Images", IEEE Computer Society International Conference on Pattern Recognition (ICPR'06), vol. 03, pp: 681-684 2006.

[13] Yong Yang, Shuying Huang," Retinal Image Mosaic Base on Genetic Algorithm and Automated Blood Vessel Extracting Approach", World Congress on Intelligent Control and Automation, pp. 7751-7756, June 2008.

[14] LI Jupeng, CHEN Houjin, YAO Chang, ZHANG Xinyuan, "A Robust Feature-Based Method for Mosaic of the Curved Human Color Retinal Images", *IEEE computer society International Conference on BioMedical Engineering and Informatics,* pp 845-849, May 2008

[15] LiFang Wei, LinLin Huang, Lin Pan, Lun Yu, "The Retinal Image Mosaic Based on Invariant Feature and Hierachical Transformation Models", *IEEE 2nd International Congress on Image and Signal Processing,* pp: 1-5, Oct. 2009.

[16] G P. Shivakumara, G. Hemantha Kumar, D.S. Guru, P. Nagabhushan, "Sliding window based approach for document image mosaicing", *Image and Vision Computing,* Vol. 24 Issue 1, pp: 94-100, Jan. 2006.

[17] Jian Liang, Daniel DeMenthon, David Doermann, "Camera-Based Document Image Mosaicing", *IEEE Computer Society International Conference on Pattern Recognition (ICPR'06),* Vol.02, pp:476-479, 2006.

[18] T Kasar, A G Ramakrishnan, "Block-Based Feature Detection and Matching for M osaicing of Camera-Captured Document Images", *TENCON 2007 - 2007 IEEE Region 10 Conference*, pp: 1 - 4, Nov. 2007.

[19] Jari Hannuksela, Pekka Sangi, Janne Heikkila Xu Liu, David Doermann, "Document Image Mosaicing with Mobile Phones", *IEEE International Conference on Image Analysis and Processing*, pp: 575 – 582, Sept. 2007.

[20] T Kasar, A G Ramakrishnan, "CCD: Connected Component Descriptor for Robust Mosaicing of Camera-Captured Document Images", *IEEE Eighth IAPR International Workshop on Document Analysis Systems*, pp: 480 - 486 , Sept.2008

[21] V Jian Liang, Daniel DeMenthon, David Doermann, "Mosaicing of camera-captured document images", Computer Vision and Image Understanding, vol.113 Issue 4, pp:572-579, April 2009.

[22] Miao Ligang, Yue Yongjuan, "Automatic Document Image Mosaicing Algorithm with Hand-held Camera", *IEEE International Conference on Intelligent Control and Information Processing (ICICIP),* vol. 2 pp: 1094 – 1097, July 2011.

[23] Tong Lijing, Zhang Yan, Zha Huiqun "A Warped Document Image Mo saicing Method Based on Registration and TRS Transform", *IEEE/ACIS International Conference on Computer and Information Science*, pp: 179-183, May. 2011.