

## Survey on Machine Learning Approaches for Image Stitching for Panoramic View and Monitoring Global Land Usage using Satellite Images

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**Abstract:** Image stitching (Mosaicing) is considered as a dynamic research area in computer graphics and computer vision. Image stitching is concerned with concatenating two or more images of the same scene into one high resolution image which is called panoramic image. Image stitching techniques can be categorized into two general approaches: direct and feature based techniques. Direct techniques compare all the pixel intensities of the images with each other, whereas feature based techniques aim to determine a relationship between the images through distinct features extracted from the processed images. The last approach has the advantage of being more robust against scene movement, faster, and has the ability to automatically discover the overlapping relationships among an unordered set of images. The purpose of this paper is to present a survey about the feature based image stitching. The main components of image stitching will be described. A framework of a complete image stitching system based on feature based approaches will be introduced.

**Keywords:** Image Stitching, Mosaicing, Panoramic View, Feature Based Detection, Image Blending.

### I. INTRODUCTION

This paper deals with the literature survey of numerous machine learning approaches for image stitching. Image/photo stitching is process of joining multiple photographic images with overlapping fields of view to get a segmented panorama or high-resolution image. It is also known as image mosaicking. Most common methodologies of image stitching needs exact overlaps between images and identical exposures to produce seamless results. In addition of using image stitching in computer vision and computer graphics applications, there are some digital cameras can stitch their photos internally.

On other hand, the human visual system has a field of view of around 135 x 200 degrees, but a typical camera has a field of view of only 35 x 50 degrees. Therefore, panoramic image stitching works by taking lots of pictures from an ordinary camera and stitching them together to form a composite image with a much larger field of view. The quality of image stitching is measured by the similarity of the stitched image to each of the input images. It also can be measured by the visibility of the seam between the stitched images.

The use of image stitching in real time applications is considered as a challenging field for image processing experts. It has wide applications in the field of video conferencing, video matting, video stabilization, 3D image reconstruction, video summarization, video

compression, satellite imaging, and several medical applications. An interesting application of image stitching is the ability to summarize and compress videos taken with a panning camera.



Fig. 1. Block Diagram of Image Stitching

The proposed block diagram of the proposed work is depicted in fig.1. The design of this video coding standard aims to get higher efficiency. The designed image stitching model includes various stages like, image acquisition, pre-processing, image registration, image blending and post processing. Pre-processing in the sense image calibration that aims to minimize the difference between ideal lens model and the camera lens combination. Image registration is the core of image stitching its purpose it to create geometrical correspondence between the images, in other words it is a processing of aligning of two images. Image blending is processed to make the transition from one image to another image smoother. So, the joint between two images can be removed. Post processing will be done to get final enhanced panoramic images.

### II. LITERATURE SURVEY

This section describes the literature survey of the proposed work based on research carried out by many researches related to various machine learning approaches for image stitching.

#### 1. Wavelet-Based Seamless Image Stitching Under L1 and L2 Norm, 2014, IEEE Conference:

The author has proposed a novel wavelet based seamless image stitching algorithm, where the dissimilarity is defined in the gradient and curvature domain. In order to reduce the artefacts in image stitching due to the misalignment of image registration, they design a new energy function combining different norm function for different frequency sub-bands of wavelet transform according to the priors of multi resolution image representation. The good stitched image will optimize the energy function by efficient convex optimization algorithm. The experimental results show that this method can produce visually pleasant results when trivial misalignment exists. However some of the results clearly show that the

PSNR does not provided the visual quality of the images.

In this study, a novel image registration method based on image block is proposed to make a rough match for the blocked image and fine match in the most similar blocks by taking advantage of the FAST (features from accelerated segment test) algorithm which runs faster. The algorithm combining the optimal seam and multi-resolution fusion is adopted to fuse the stitched image and realise seamless stitch of multiple images in order to achieve a seamless image of high resolution. The advantage is straightening of multiple images. The built model works well for the camera images not high resolution satellite images.

2. *“Image Stitching of Textures for Augmented Reality Medical Training”*, 2014 International Conference on Computer Assisted System in Health:

The author has presented a 3D model reconstruction using well known SIFT (scale invariant feature transform and SURF (speeded up robust feature). In order to obtain this realistic texture, the images of the real object should be captured in high definition, and from different angles. As different angles produces different illumination, the lighting condition of the images is to be corrected and synchronized before it can be mapped onto the 3D model. However results clearly shown that algorithms failed to work when it is implemented on medical data, due to lack of variation of colour intensities.

3. *“Tiling of Satellite Images to Capture an Island Object”*, 2014 Springer:

The method proposed in this paper is based on domain specific knowledge of geometrical transformation and image content. The proposed model focuses on the individual image pieces alignment. They used the co-ordination of the reference system, their conversion to screen pixel addresses. Thus they have achieved significant performance. However the described model lacks of enhancement scalability of the overall system.

4. *“A Fast Image Stitching Algorithm Based On Improved SURF”*, 2014 10th International Conference on Computational Intelligence and Security:

The author uses a fast image stitching algorithm based on improved speeded up robust feature (SURF) is proposed to overcome the real-time performance and robustness of the original SURF based stitching algorithms. The method is adopted to build a binary classifier which identify the key feature points and removes non key feature points from the SURF descriptor. In addition they used RELIEF-F algorithm for dimension reduction and simplification of the improved SURF descriptor to achieve image registration. The threshold-based weighted fusion algorithm is used to achieve seamless image stitching. The proposed algorithm is good in terms of real time

performance and robustness. However, the multi model takes longer time than the original SURF for feature detection.

5. *“Efficient Image Stitching of an Image Sequence by Selecting Dominate Frames”*, 2015 IEEE Conference:

This paper presents an image stitching technique using ORB (Oriented FAST and rotated BRIEF). The homography between the stitching candidate and the region of the stitching interest is then estimated by the correspondence of feature points. The proposed has been verified in the online experiment to present efficiency of the system. However, the proposed scheme only takes several numbers of frames instead of all the frames in the video.

6. *“A Novel Approach for Automatic Image Stitching of Spinal Cord MRI Images using SIFT”*, 2015 IEEE International Conference on Pervasive Computing:

The author proposed an automatic image stitching of spinal cord MRI images by exploring the effectiveness of the scale invariant feature transform (SIFT) for feature matching. After initial set of feature correspondences has been computed from SIFT features, Random Sample Consensus (RANSAC) is used to reject the outliers and robustly estimate the best fitting homography to produce high accuracy alignment despite of noisy correspondence between image pair. However, because of the illumination difference between the images generated output is not perfectly seamless.

7. *“Seamless Fundus Image Stitching using WLD to Improve Field of View”*, 2015 Fifth IEEE International Conference:

The author presents a new technique for stitching multiple fundus images of a single patient. The proposed method uses weber local descriptor for features extraction and presents a novel technique to achieve seamless blending. After feature extraction and feature matching RANSAC is used for calculating inliers and to remove outliers.

Homography is used to align the images. The results achieved the seamless mosaic image. However, if there are more images to be stitched the processing time will be more.

8. *“A New Image Stitching Approach for Resolution Enhancement in Camera Arrays”*, 2015 Ninth IEEE International Conference:

The author proposed a new feature extraction based image stitching algorithm to the camera arrays. One of the advantages of the proposed algorithm, the new high resolution single image is formed by using low resolution image sensors. In the study, camera arrays are formed in 2x4 size by utilizing a different number of image sensors having the same features. The images obtained from the camera arrays is combined with a

new image stitching algorithm based on the feature extraction and matching using Harris detector and RANSAC. However, the approach is less accurate due to lack of enhancement approaches.

9. *“Underwater Image Stitching based on SIFT and Wavelet Fusion”*, 2015 IEEE:

The author presents one underwater image stitching model combined with the Scale Invariant Feature Transform (SIFT) and the wavelet fusion. Poor visibility in the sea and the variations in the illumination, view points, etc. have been comprehensively taken into consideration for image matching. Wavelet fusion is then made full use of to undertake the underwater image mosaic. It is shown in the simulation experiment that good behaviours in the vision effects and matching precision for the underwater images. However, the proposed model does not hold good for limited range and non-uniform lighting etc.

10. *“Natural Color Satellite Image Mosaicking Using Quadratic Programming in De-correlated Color Space”*, 2015 IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing:

The author presents a simple and robust method to perform the global colorimetric harmonization of multiple overlapping remote sensing images in natural colours (RGB) by using linear colour correlation model. This parameter-free method deals simultaneously with any number of images, with any spatial layout, and without any single reference image. It is based on the resolution of a quadratic programming optimization problem. It can be well suitable to produce high resolution mosaic images but doesn't work well for overlapping parts for any number of input images.

11. *“Cylindrical Panoramic Image Stitching Method Based On Multi-cameras”*, 2015 IEEE Conference on Cyber Technology in Automation and Control System:

The author describes a cylindrical panoramic generation method based on multi-cameras. Primarily, they use a backward-division model that can rapidly solve distortion of fish eye lens. Second, in order to maintain consistency of stitching, use the cylindrical projection. Third, they apply SIFT feature detection method to image mosaic process. To ensure the accuracy of matching, they use the RANSAC algorithm to purify the detected feature points. In addition, we use an image fusion method based on Laplace pyramid. The proposed panorama algorithm is simple, reliable and capable of making panorama image easily. However, the limitation is it only uses panoramic collection device such as camera.

12. *“Efficient Image Stitching of Continuous Image Sequence With Image and Seam Selections”*, 2015 IEEE Sensors Journal:

The author describes a model about image stitching technique with better quality and less processing time for online stitching of continuous image sequences. They select only dominant frames with significant visual quality. They use particle sampling to categorize the stitching label and homography matrix for the estimation. And also they have designed a seam planning algorithm to eliminate unclear ghost effect. The proposed technique maximally preserve the visual content while eliminating inconsistencies. But the built model works well only for the frames acquired by the single camera.

13. *“Seamless Image Stitching Using Structure Deformation with HoG Matching”*, 2015 IEEE Conference in Information and Communication Technology:

The author uses a structure deformation for image stitching. They use image stitching based on common stitching algorithms such as speeded up robust features (SURF) feature detection, approximated nearest neighbour (ANN) matching and random sample consensus (RANSAC) parameter estimation. And they use homography similarity to identify if input images have enough correlation. To reduce structure misalignment, they use double-seam selection. Through local maximum in gradient domain, they find 1-D feature points along with each seam. To find matching points, they used histogram of oriented gradients (HoG) which find matching points robustly. In addition, we use multi-band blending algorithm to remove intensity difference efficiently. However, proposed stitching method was tested only on 2 images.

14. *“Image Stitching of Dissimilar Images”*, 2015 IEEE Conference in Information and Nano Technology:

The author presents a method for stitching for dissimilar objects. They observe that images with significant dissimilarity often cannot be stitched well without producing unnecessary artefacts. They used an existing key point detector, namely SIFT. They then used a descriptor in order to find information about the key points. Instead of using 8-bin histogram, they just used 4 bins in order to improve the performance of the algorithm for lighting varying images. After creating description of key points, other processes, such as matching, local homography, warping, seam blending and colour adjusting, followed. But the drawback is, the built model focuses only on the object stitching, they lack with the processing time.

15. *“A Fast UAV Image Stitching Method on GeoSOT”*, 2015 IEEE Conference in Geoscience and Remote Sensing:

This paper proposed an innovative fast method based on global subdivision GeoSOT grid frame by



employing SURF detector and RANSAC. And this method can apply to the high-speed image stitching of a certain area at different times on the UAV. It facilitates the local UAV image data extraction. However, the multi-model algorithm fails if no consistency is found among the image sequences.

16. *“Feature-Based Panoramic Image Stitching”, 2016 IEEE Conference in Control, Automation and Robotics:*

This paper presents a feature based panoramic image stitching model. This is achieved by first detecting the overlapping area of the acquired images, and then aligning and blending the seams of the images automatically to create a seamless panoramic image. The process of image acquisition, image registration, image blending and composing are discussed. Although the algorithm can successfully stitch images together, it is restricted to an image set that has no exposure differences and no very high lens distortion.

17. *“Stitching 3D Ultrasound Head Images of Neonates to Monitor Changes in Ventricular Volume”, 2016 IEEE EMBS Conference on Biomedical Engineering and Sciences:*

The author has proposed a method to stitch two 3D US images of neonatal brain to monitor changes in the ventricular volume. They have used mutual information as the image similarity metric and the images were normalized using a discrete Gaussian to suppress the noise effects of the image before calculating mutual information. The optimal parameter values for step length, number of histogram bins and translation scale were estimated through testing. However, the built model has not compared with the existing models.

18. *“Multimodal Image Stitching Algorithm for Weed Control Applications in Organic Farming”, 2016 IEEE Computing Conference:*

This author puts main emphasis on the SURF algorithm for agricultural image applications in organic farming. The algorithm is used for a multimodal image stitching algorithm for biological weed control in the agricultural sector. Based on the algorithm a ground truth agricultural crop map is produced to allow a proper detection of weed. The proposed model holds good for multispectral camera images with harsh environment. However, the results using multiple cameras have to be examined.

19. *“Fast Image Stitching for Continuous Casting Steel Billet Images”, 2016 IEEE International Conference on Consumer Electronics-Asia:*

In this paper, the author considers the problem of stitching continuous casting steel billet images captured from billet production line. It has been shown that integrated individually captured continuous billet

images would be beneficial to vision-based surface inspection. They presents a fast image stitching framework for continuous billet images relying on homography estimation. But the built model is reasonably slow in detection of matching points.

20. *“Optimal Seam line Detection for Multiple Image Mosaicking via Graph Cuts”, 2016 Elsevier ISPRS Journal of Photogrammetry and Remote Sensing:*

The author proposed to efficiently detect globally optimal seam lines for mosaicking a set of geometrically aligned street-view panoramic or aerial images. The integrated energy complexity term is calculated based on the histogram oriented gradients (HOG) vector of small image region. And they also proposes a multiform joint optimization via multi label graph cuts to deal with multi overlapped images. The proposed model is best suited for street panoramic view which is more reasonable and effective but needs a higher computational cost and larger memory.

21. *“Colour Correction in Image Stitching Using Histogram Specification and Global Mapping”, 2016 IEEE Conference in Image Processing:*

The author describes about the colour correlation method is an important issue in image processing. There will be colour inconsistencies between the images to be stitched. The proposed model used the histogram specification and global mapping. The main contribution is using original pixels and the corresponding pixels after histogram specification to compute a global mapping function with an iteration method, which can effectively minimize color differences between a reference image and a test image.

The color mapping function can spread well the color style from the overlapping region to the whole image. The drawback of the built model is the mapping function is computed for each color channel. This simple processing does not consider the relation of the three color channels, and this may produce some color artifacts.

22. *“Image Stitching with Single-Hidden Layer Feedforward Neural Networks”, 2016 IEEE Joint Conference:*

The author intends to get the higher precision for parametric estimation. They uses scale invariant feature transform (SIFT) and single hidden layer feed forward neural network (SLFN). In this method, features are extracted from the image sets by the SIFT descriptor and form into the input vector of the SLFN. The output of the SLFN is those translation, rotation and scaling parameters with respect to reference and registered image sets. They also apply a fast learning scheme, called pseudo inverse learning, to train SLFN to get higher training efficiency. The built model is more accurate and faster as compared to RANSAC.

Although perspective transformation parameters being obtained by training the SLFN can accurately registrant the overlap areas of two images, there is salient at the edge of the stitching result. This cause of this phenomenon is over-fitting.

23. *“Optimal Local Warp Model for Image Stitching”*, 2016 9th International Congress on Image and Signal Processing:

The author has told about the geometrical warp model alignment is the key problem in image stitching. The model mainly focuses on the alignment error and stitching quality. The algorithm named homography based local warp model has been adopted for this work. Using this they achieved more accurate alignment and better stitching quality. But they find that this model is in general not optimal mainly due to the involved parameters is same for all positions in the stitched images.

24. *“Multi-Viewpoint Panorama Construction with Wide-Baseline Images”*, 2016 IEEE Transactions on Image Processing:

The author intends to produce visually plausible panoramic image with input taken from different viewpoints. This approach allows wide baselines between images and non-planar scene structures. Instead of 3D reconstruction, they design a mesh based framework to optimize alignment and regularity in 2D. They adopted solving a global objective function consisting of alignment and a set of prior constraints, they construct panoramic images, which are locally as perspective as possible and yet nearly orthogonal in the global view. They improve composition and achieved good performance on misaligned area. But proposed model has some limitation, if a straight line spans across multiple image, this method can only preserve local straightness in each image.

25. *“A Parallel Method for Arial Image Stitching using ORB Feature Points”*, 2017 IEEE Conference:

The author has proposed an ORB feature point technique that has binary vector for feature descriptor. It speeds up processing time and feature matching. In order to calculate homography matrix between stitching sequence robustly, they have adopted RANSAC estimation. A position-weighted image fusion algorithm which takes the location information of image pixels into consideration is also presented here. So that the image can be stitched and problem of artefacts can be solved using this model. And also computing speed is improved. But the drawback of the proposed model is works only for arial images.

26. *“Efficient Brightness Adaptive Deep-Sea Image Stitching using Biorthogonal Multi-Wavelet Transform and Harris Algorithm”*, 2017 International Conference on Intelligent Computing and Control:

The author has mainly focuses on overlapping pictures assembling so as to represent one bird's eye image view. The proposed model has 4 steps. First, the Harris Algorithm is employed to extract the feature points within the reference and detected pictures. Second, feature matching is applied for treating the geometer difference of the signature vectors are achieved by Biorthogonal multi wavelet Transformation. Third, transformation factors are achieved by treating the least-square rule supported by general wavelet transformation. Finally, the Picture resampling and transformation are executed for the treatment of additive interpolation which induces the image registration and image stitching. The results show the efficient stitching of deep-sea images with varying brightness and color parameters with better PSNR values. But the proposed model only evaluated for lesser number of inputs and has not compared with previous algorithms.

27. *“A Content-aware Metric for Stitched Panoramic Image Quality Assessment”*, 2017 IEEE International Conference on Computer Vision Workshops:

The author presents an adaptively fusible perspective geometrical error metric and structure guided metric that is specifically designed for image stitching. They first analysis the different types of errors typically encountered in image stitching including common visual distortions and ghosting, structure inconsistency. They compute local variance for optical field energy between distorted and reference image in order to remove ghosting effect. The model can well eliminate the distortion types. However, the built model only concentrates on distortions, they haven't centred on accuracy and speed of the algorithm.

28. *“Image Mosaicing Using Bidirectional Algorithm”*, 2017 IEEE International Conference on Innovations, Embedded and Communication System:

The author describes about mosaicing of two input images which have some overlapping region and produces high resolution mosaic image as output. In order to do the mosaicing .of two input images it uses Bidirectional algorithm which is a direct intensity based method of image mosaicing, thus by comparing the intensity values between the two input images it finds the overlapping region between them. The Bidirectional algorithm works well for mosaicing of two input images if they are horizontally or vertically aligned. However, the system does not handle the misaligned images.

29. *“Evaluation of Feature Based Image Stitching Algorithm using OpenCV”*, 2017 IEEE International Conference:

This paper describes the basic algorithms necessary for feature based image stitching and shows the result of algorithm through experiment 1. The results show that

blending and bundle adjustment are needed to stitch multiple images seamlessly. In experiment 2, we stitched 15 images using openCV and Hugin under different conditions. Through the results, we could know the benefits of stitching several times in groups instead of stitching all at once. However, since the experiment in this paper is only stitching 15 images, which is a rather small amount, it is insufficient to suggest a general method of time-efficient image stitching.

30. *“360-Degree Video Stitching for Dual-Fisheye Lens Cameras Based on Rigid Moving Least Squares”, 2017 Normal Journal:*

The author introduces a novel method to align images using interpolation grids based on rigid moving least squares. Furthermore, jitter is the critical issue arising when one applies the image-based stitching algorithms to video. It stems from the unconstrained movement of stitching boundary from one frame to another. Therefore, they also propose a new algorithm online and adaptively to maintain the temporal coherence of stitching boundary to provide jitter-free 360-degree videos. The proposed technique well suitable for smooth transition and minimizes the jitter. However, the built model only concentrated on the minimization of jitters, accuracy factor and processing is not mentioned.

31. *“Stitching Images of Dual-Cameras On-board Satellite”, 2017 Elsevier:*

The author introduces a relative geometrical calibration model in order to recover geometrical relation of dual cameras on board one satellite. Seamless mosaic images can be acquired based on the mapping relation between geometric models of virtual camera and dual-cameras. Here they have concentrated on angle errors and charge coupled distortions (CCD). The proposed model can achieve seamless mosaic image without internal accuracy lost. Despite of this, stitching accuracy may be effected by high frequency errors.

32. *“Image Security using Image Encryption and Image Stitching”, 2017 IEEE International Conference:*

The author has been proposed regarding image security mainly concentrating on image stitching. It involves set of decrypted images will be processed by the feature extraction, feature matching, homography estimation, RANSAC and blending. The results proves that the image stitching using feature based technique is more beneficial to use for performing image stitching on multiple decrypted image. However, it lacks with input images in non-sequential order.

33. *“Adaptive Alpha-Trimmed Correlation Based Underwater Image Stitching”, 2017 IEEE International Conference:*

The author has been proposed a method which is based on a novel stitching technique called Alpha-Trimmed Correlation. The system is designed to adapt to the difficulties encountered in underwater image stitching. The system comprises of three major sections: image enhancement, image registration, and image stitching. The image enhancement section eliminates the clouding effect and restores color to a certain extent. Feature detection and matching is implemented using SIFT. The advantage of using SIFT features is its invariance to rotation and scaling. These feature were further used to estimate the homography. The proposed Alpha-Trimmed Correlation helped generate seamless panoramic images. The advantage is the proposed technique works well for lesser number of inputs, however it fails to create database for the underwater images.

34. *“Parallelization of Algorithms for Image Stitching Using Distributed Memory Architecture”, 2017 International Conference on Nascent Technologies in the Engineering Field:*

The author presents a system to parallelize algorithms required in the automated stitching of satellite images by using distributed memory architecture. The use of invariant features and random sampling will make this system more robust, while maintaining its accuracy. The multi-level blending approach will preserve detail in the images while providing a smoother transition between them. The proposed improves the performance of the image stitching process. The main drawback is built model has not compared with any of the previous models.

35. *“Analysis of Moving DLT, Image and Seam Selections Algorithms with MS ICE, Autostitch, and OpenCV Stitcher for Image Stitching Applications”, 2017 CEECCOT:*

The image stitching algorithms based on Moving DLT and efficient image and seam selections were analysed here. The Moving DLT method estimated the as projective- as-possible warps for proper alignment of images that violated usual imaging assumptions. Here, the method of bundle adjustment was used to align multiple images together to form bigger panoramas. The method aims to deal with enhancing the efficiency and reduction of computational cost. However, there applied no post-processing technique for removal of ghosting effects.

36. *“Wide-Angle Image Stitching Using Multi-Homography Warping”, 2017 International Conference:*

This paper proposes a multi-homography warping to stitch wide-angle images with unknown lens distortion, which integrates multiple local homographies with a global homography for accurate alignment and shape preservation. And they have used SURF in order to



detect feature point. This method improves the performance of inlier selection on wide-angle image pairs, and can achieve both accurate alignment in the overlapping region and shape preservation in the non-overlapping region. The drawback is the built model works well for camera images and not sure about the high resolution satellite images.

37. "A Multi-Image Stitching Method and Quality Evaluation", 2017 4th International Conference on Information Science and Control Engineering:

This paper proposes a two-couple feature point matching method for urban scenery image stitching problems. According to perceptual characteristics of the Human Vision System (HVS), the image stitching quality evaluation criteria is set to verify the validity of the stitching method. It removes the repetitive, redundant information to reduce the data amount in the image sequence and present the real world objectively and accurately. However the proposed model is well suitable for only limited number of images.

38. "Acceleration of Image Stitching Using Embedded Graphics Processing Unit", 2018 IEEE International Conference on Information Technology:

The author proposes an image stitching model based on parallel implementation of invariant feature point based image warping and stitching using GPU embedded platform. The RANSAC is used for the inlier and outlier detection. The image processing on GPU is expected to give high performance enhancement. And also well know image registration is implemented and tested on GPU platform. The proposed approach is comparatively faster. However, this lacks with the misaligned images.

39. "A Novel Automatic Image Stitching Algorithm for Ceramic Microscopic Images", 2018 IEEE International Conference on Image Processing:

The author mainly aims to get full size, information rich image. In order to solve this problem this paper proposes a novel automatic image stitching algorithm for ceramic microscopic images. Firstly, an algorithm for sorting out-ordered ceramic images into ordered sequences was proposed, which is based on local matching relationship and specific threshold. Next, an image stitching algorithm based on Principal Component Analysis (PCA) and Speeded up Robust Feature (SURF) was proposed to get the complete image. The RANSAC technique is adopted to calculate projective transformation matrix between the images. The results shows that it is more feasible than effective than traditional SIFT. However, it works well for ceramic microscopic images not sure about satellite high resolution images.

40. "Colour Correction Based on Histogram Matching and Polynomial Regression for Image Stitching", 2018

3rd IEEE International Conference on Image, Vision and Computing:

The author analysis that there are often colour differences between neighbouring views due to different exposure levels and view angles. They mainly concentrating on multi-view image and video stitching, especially when occlusion or parallax exists. They used histogram matching and polynomial regression. The results show that the method has good effects on the colour difference no matter whether parallax exists or not. However, it can noted that proposed model has not been compared with any of the previous techniques.

41. "Seamless Stitching of Panoramic Image Based on Multiple Homography Matrix", 2018 IMCEC:

The author presents, the matching feature points were calculated through A-KAZE feature point detection algorithm. Then, the projection model was determined on the basis of Direct Linear Transformation (DLT) algorithm, and the target images were divided into 25×25 blocks, which were projected with APAP algorithm. The global projection transformation model was estimated according to each multiple homography matrix. In order to achieve seamless stitching and image fusion the Min-Cut/Max-Flow of edge detection operator and Laplacian multi-resolution fusion algorithm are added in this paper. The advantage is it can remove fractures in these stitching results. However, the built model has not concentrated on any of the post processing procedure.

42. "Multi-plane Image Stitching Base on Image Semantic under Large Viewpoint Changes", 2018 Conference Paper:

The author presented, a robust multi plane image stitching based image semantic model. They assume that the regions with the same semantic label are in the same plane, the image can be divided into multiple planes with transition borderline by semantic segmentation (dense CRF and Morphological Operations). Finally, image stitching is completed by mixing multiple image planes with gaussian weights along the borderline, and warping image with perspective and similarity transformation. RANSAC is used to remove wrong matching pair. The advantage is the quality of image stitching. However, the segmentation accuracy is poor that needs to optimize.

43. "Multi-perspective image stitching and regularization via hybrid structure warping", 2018 Conference Paper Computing in Science and Engineering:

The author proposes an optimized local warping method based on projection transformation to reduce the distortions in overlapping region. Moreover, a multi-constraint hybrid structure warping model is proposed to maintain the shape of non-overlapping region. Finally, an improved content preserving image

regularization method is obtained to repair irregular boundaries of panorama. The SIFT algorithm was used to extract features and matching was performed using RANSAC. The advantage is it remove ghosting effect and lowered distortion, result is visually plausible. However, the drawback regarding distortion is not fully overcome.

44. *“Image Seamless Stitching and Straightening Based on The Image Block”, 2018 Conference Paper Computing in Science and Engineering:*

In this study, a novel image registration method based on image block is proposed to make a rough match for the blocked image and fine match in the most similar blocks by taking advantage of the FAST (features from accelerated segment test) algorithm which runs faster. The algorithm combining the optimal seam and multi-resolution fusion is adopted to fuse the stitched image and realise seamless stitch of multiple images in order to achieve a seamless image of high resolution. The advantage is straightening of multiple images. The built model works well for the camera images not high resolution satellite images.

45. *“Aerial Image Stitching Algorithm Based on Improved GMS”, 8th International Conference on Information Science and Technology:*

The author employed a grid based motion statistics (GMS) which is a fast and ultra-robust image feature matching technique. Firstly, they apply the ORB algorithm to extract and describe the feature points of the image. Then, GMS based bidirectional matching is used to acquire the initial matching points. After that, false matches are rejected by constructing epipolar constraint. Finally, they use Random Sample Consensus Algorithm (RANSAC) to calculate the transformation model and fuse the aligning images by weighted average fusion algorithm. The advantage is lesser time. However, the accuracy is lacking compared to SIFT.

Table 1. Survey of Image Stitching Techniques

Title	Year	Algorithm	Advantage	Disadvantages
Wavelet-Based Seamless Image Stitching Under L1 And L2 Norm [01]	2014	Wavelet Based	It produces visually pleasant results when trivial misalignment exists.	PSNR does not provided the visual quality of the images
Image Stitching of Textures for Augmented	2014	SIFT and SURF	Achieves good accuracy	algorithms failed to work when it is

Reality Medical Training [02]			result.	implemented on medical data, due to lack of variation of colour intensities
Tiling of Satellite Images to Capture an Island Object [03]	2014	Geometrical Transformation	Significant Performance	model lacks of enhancement scalability of the overall system
A Fast Image Stitching Algorithm Based On Improved SURF [04]	2014	SURF and RELIEF-F	good in terms of real time performance and robustness	The multi model takes longer time than the original SURF for feature detection.
Efficient Image Stitching of an Image Sequence by Selecting Dominate Frames [05]	2015	ORB	efficiency of the system	only takes several number of frames instead of all the frames in the video
A Novel Approach for Automatic Image Stitching of Spinal Cord MRI Images using SIFT [06]	2015	SIFT and RANSAC	high accuracy	generated output is not perfectly seamless
Seamless Fundus Image Stitching using WLD to Improve Field of View [07]	2015	RANSAC	seamless mosaic image	processing time will be more
A New Image Stitching Approach for Resolution Enhancement in Camera Arrays	2015	RANSAC and HARRIS	Good accuracy	No enhancement Approaches



[08]				
Underwater Image Stitching based on SIFT and Wavelet Fusion [09]	2015	SIFT and Wavelet	Good vision effect	does not holds good for limited range and non-uniform lighting
Natural Color Satellite Image Mosaicking Using Quadratic Programming in De-correlated Color Space [10]	2015	Quadratic Programming	produce high resolution mosaic images	Doesn't works well for overlapping parts for any number of input images.
Cylindrical Panoramic Image Stitching Method Based On Multi-cameras [11]	2015	SIFT and RANSAC	simple, reliable and capable of making panorama image	limitation is it only uses panoramic collection device such as camera
Efficient Image Stitching of Continuous Image Sequence With Image and Seam Selections [12]	2015	Homography	maximally preserve the visual content while elimination inconsistencies	But the built model works well only for the frames acquired by the single camera.
Seamless Image Stitching Using Structure Deformation with HoG Matching [13]	2015	ANN, SURF and RANSAC	remove intensity difference efficiently	Proposed stitching method was tested only on 2 images.
Image Stitching of Dissimilar Images [14]	2015	SIFT	Accurate object stitching	More processing time.
A Fast UAV Image Stitching Method on	2015	SURF and RANSAC	Quality data extraction.	Fails if no consistency is found among the image

GeoSOT [15]				sequences.
Feature-Based Panoramic Image Stitching [16]	2016	Feature based	Can successfully stitch images together.	very high lens distortion
Stitching 3D Ultrasound Head Images of Neonates to Monitor Changes in Ventricular Volume [17]	2016	Discrete Guassian	Good accuracy	has not compared with the existing models
Multimodal Image Stitching Algorithm for Weed Control Applications in Organic Farming [18]	2016	SURF	holds good for multispectral camera images with harsh environment	However, the results using multiple camera has to be examined.
Fast Image Stitching for Continuous Casting Steel Billet Images [19]	2016	Homography	fast image stitching framework	Reasonably slow in detection of matching points.
Optimal Seam line Detection for Multiple Image Mosaicking via Graph Cuts [20]	2016	HOG	more reasonable and effective	Needs a higher computational cost and larger memory.
Colour Correction in Image Stitching Using Histogram Specification and Global Mapping [21]	2016	Histogram and Global mapping	Works well for the overlapping images.	Produce some colour artefacts.
Image Stitching with Single-Hidden	2016	SIFT and SLFN	can accurately registrant the overlap areas	Causes over-fitting

Layer Feedforward Neural Networks [22]			of two images	
Optimal Local Warp Model for Image Stitching [23]	2016	Homography	better stitching quality	model is in general not optimal mainly due to the involved parameters is same for all positions in the stitched images
Multi-Viewpoint Panorama Construction with Wide-Baseline Images [24]	2016	Global Objective Function	They improve composition and achieved good performance on misaligned area	if a straight line spans across multiple image, this method can only preserve local straightness in each image.
A Parallel Method for Aerial Image Stitching using ORB Feature Points [25]	2017	ORB	problem of artefacts can be solved using this model	drawback of the proposed model is works only for aerial images
Efficient Brightness Adaptive Deep-Sea Image Stitching using Biorthogonal Multi-Wavelet Transform and Harris Algorithm [26]	2017	Wavelet Transform and Harris	efficient stitching of deep-sea images with varying brightness and colour parameters	Only evaluated for lesser number of inputs and has not compared with previous algorithms.
A Content-aware Metric for Stitched Panoramic Image Quality Assessment [27]	2017	Geometrical Error Metric	The model can well eliminate the distortion types	they haven't concentrated on accuracy and speed of the algorithm
Image Mosaicing Using Bidirectional	2017	Bidirectional	works well for mosaicking	system does not handle the

Algorithm [28]		Algorithm	of two input images if they are horizontally or vertically aligned	misaligned images
Evaluation of Feature Based Image Stitching Algorithm using OpenCV [29]	2017	Feature based	Good accuracy	More time consuming
360-Degree Video Stitching for Dual-Fisheye Lens Cameras Based on Rigid Moving Least Squares [30]	2017	Rigid Moving Least squares	well suitable for smooth transition and minimizes the jitter	accuracy factor and processing is not mentioned
Stitching Images of Dual-Cameras On-board Satellite [31]	2017	Geometrical calibration Model	Can achieve seamless mosaic image without internal accuracy lost	Stitching accuracy may be effected by high frequency errors.
Image Security using Image Encryption and Image Stitching [32]	2017	RANSAC	more beneficial to use for performing image stitching on multiple decrypted image	It lacks with input images in non-sequential order.
Adaptive Alpha-Trimmed Correlation Based Underwater Image Stitching [33]	2017	Alpha Trimmed Correlation	The proposed technique works well for lesser number of inputs	It fails to create database for the underwater images.
Parallelization of Algorithms for Image Stitching Using Distributed Memory	2017	Parallelization Algorithm	Improves the performance of the image stitching	Main drawback is built model has not compared with any of the previous models.

Architecture [34]				
Analysis of Moving DLT, Image and Seam Selections Algorithms with MS ICE, Autostitch, and OpenCV Stitcher for Image Stitching Applications [35]	2017	Moving DLT	Enhancing the efficiency and reduction of computational cost	There applied no post-processing technique for removal of ghosting effects.
Wide-Angle Image Stitching Using Multi-Homography Warping [36]	2017	Multi-Homography	Can achieve both accurate alignment in the overlapping region and shape preservation in the non-overlapping region.	Built model works well for camera images and not sure about the high resolution satellite images.
A Multi-Image Stitching Method and Quality Evaluation [37]	2017	Two Couple Feature Point	It removes the repetitive, redundant information to reduce the data.	Well suitable for only limited number of images.
Acceleration of Image Stitching Using Embedded Graphics Processing Unit [38]	2018	GPU and RANSAC	comparatively faster	However, this lacks with the misaligned images.
A Novel Automatic Image Stitching Algorithm for Ceramic Microscopic Images [39]	2018	PCA and RANSAC	works well for ceramic microscopic images	Doesn't hold good for high resolution satellite images.
Colour Correction Based on Histogram Matching	2018	Polynomial Regression	method has good effects on the colour difference	has not been compared with any of the previous techniques

and Polynomial Regression for Image Stitching [40]				
Seamless Stitching of Panoramic Image Based on Multiple Homography Matrix [41]	2018	DLT	It can remove fractures in this stitching results.	Model has not concentrated on any of the post processing procedure.
Multi-plane Image Stitching Base on Image Semantic under Large Viewpoint Changes [42]	2018	CRF	quality of image stitching	Segmentation accuracy is poor
Multi-perspective image stitching and regularization via hybrid structure warping [43]	2018	SIFT and RANSAC	it remove ghosting effect and lowered distortion	Drawback regarding distortion is not fully overcome.
Image Seamless Stitching and Straightening Based on The Image Block [44]	2018	FAST	straightening of multiple image	Model works well for the camera images not high resolution satellite images.
Aerial Image Stitching Algorithm Based on Improved GMS [45]	2018	GMS	The advantage is lesser time	However, the accuracy is lacking compared to SIFT.

### III. CONCLUSIONS

Image stitching is considered as an active research area in the fields of computer vision and computer graphics. It has a large amount of different algorithms for features detection and description. Many algorithms like SIFT, SURF, RANSAC, PCA, DLT, GMS, CRF and Embedded GPU etc. has been discussed in this



paper. However, those algorithms have one or the other major drawbacks like SIFT algorithm fails for working with more number of images [33], PCA and SURF is miserably fails in working with very high resolution satellite images [39], DLT is not used any post processing techniques [41], CRF and RANSAC technique achieved less segmentation accuracy and distortion [42], Embedded GPU is not suitable for misaligned images [38], etc. Hence, further work includes the designing of a novel model that image stitching technique for panoramic view using satellite images which overcomes the above drawbacks.

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