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Performance Evaluation of Various Image Features Detectors and Descriptors Used in the Development of Panorama from Real Time Video Files

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Abstract: ***Image mosaicing is a method where two or more pictures of the same image can be combined into a big picture and a high resolution panorama created. It is helpful for constructing a bigger picture with numerous overlapping pictures of the same scene. The image mosaic development is the union of two pictures. The significance of image mosaicing in the sector of computer vision, medical imaging, satellite data, army automatic target recognition can be seen. Picture stitching can be performed from a broad angle video taken from left to right to develop a wide-scale panorama to obtain a high-resolution picture. This research paper includes valuable content which will be very helpful for creating significant choices in vision-based apps and is intended primarily to establish a benchmark for scientists, regardless of their specific fields.***

In this paper it has been seen that distinct algorithms perform differently in terms of time complexity and image quality. We have looked at a variety of feature detectors and descriptors such as SIFT-SIFT, SURF-SURF, STAR-BRIEF and ORB-ORB for the development of video file panoramic images. We have noted that SIFT provides excellent outcomes, giving the image the largest amount of key points identified at the cost of computational time and SURF, ORB, has fewer key points obtained, where it has been seen that ORB is the simplest of the above algorithms, but produces no good performance quality image outcomes. A good compromise can be achieved with SURF. Depending on the application, the metric for image feature extraction would change. In addition, the speed of each algorithm is also recorded. This systemic analysis suggests many characteristics of the stitching of images.

Keywords: SIFT, SURF, ORB, Panorama.

I. INTRODUCTION

Image mosaicing is a method in which several images are collected after the geometric association between these pictures has been established. The geometric associations are coordinate transformations that generally relate to the different system of coordinates. The Image Mosaic [1,2,3] is a synthetic structure created from an image set and attainable by knowing the geometrical associations of images. The geometric relationships are the coordinate systems related to the various image coordinate systems. The linear relationship between the images so that it is compared, transformed, and analysed in a specific reference framework is created for image registering.

A warping process uses the correct transitions rather than splitting the overlapping areas of distorted pictures. Image Blending is the method that modifies the grey image concentrations close to the border to ensure that images are transformed smoothly by removing these seams and obtaining a blended image. Blending methods are used to combine two parts.

In the past, the n distinct cameras in multiple locations and at distinct perspectives were a prerequisite for a panorama approach. However, a perfect panorama could not be obtained owing to the absence of consistency between camera shots leading to a time delay. Uncoordinated time slots and angle setups were the necessary factors behind it. Wireless sensor networks have been implemented to resolve this issue by using a series of detectors to capture various angles and views. The current image stitching process still doesn't produce a very good outcome and a lot can be achieved. This aspect of image processing also involves initiatives and many innovative algorithms can still be implemented. Image stitching is used in numerous apps such as creating 3D views from various nodes, video conferencing, nodes, astronomy, comics, architectural tours.

OpenCV 3.1 was used for this paper and Python was selected for programming due to its relatively easy information processing. Most code includes calls from the original OpenCV library to applications, so that use of Python does not cost significantly. This article addresses a panoramic stitching algorithm that can be executed in real time and presents measurements in terms of resolution and performance.

For example, the examined algorithm will allow a mobile camera unit to be used as a conventional scanner simply by moving the camera thru the scanned image. The algorithm implements an independent, true world perception technique, an overall concept that is very important in any sector in which cameras, robots and AI, machine view, etc. are used for scanning or monitoring the actual world.

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Previous research into fully automated panorama stitching [1,3] and the calculation of an ego-motion of the camera from the photos it registers serve as the basis of the study.

The issue here is if it can be produced scalable and executable in real time if the resulting performance is adequate for any practical apps. In favor of focusing our attempts further on developing an algorithm, we used OPEN-CV for implementation using the Python environment.

This paper is structured accordingly. In Section II, we outlined some latest methods in picture mosaicing, in Section III, we outlined distinct techniques of image feature registration and implementation. The experiment method followed by outcomes in Section V is presented in Section IV. Finally, Section VI includes conclusion and potential research.

II. LITERATURE SURVEY

As described in the paper "Dominant plane homography for parallax processing of picture stitching" [2], to achieve a valid seam, the standard seam removal technique is adapted. Compared to the local distortion, global distortion of the image is recognized. But this is not possible if there is no longer parallax in the picture and there is a lot of outstanding characteristics. Images should involve at least non-salient in order to function properly with this technique.

This technique overcame the issue of illumination modifications caused by distinct exposures, as described by writer: Takeyup Song; Changwon Jeon; Hanseok Ko et al. in the proposed paper "Image stitching using caos-inspired dissimilarity metric."[4] In this process, the key feature points are obtained by sift and the closest function points are replaced by k-d search tree algorithm and k afterwards with the use of a new option i.e. matching algorithm. The outliers are removed.

The image stitching algorithm is described in [5] based on feature retrieval. The pixels of images on the basis of the Canny edge detection algorithm were obtained here and then the pixels for the image with the border feature pixels of the images were combined. This algorithm offers a fresh alternative for calculating pixels for the border function in the image mosaic algorithm.

The paper named "perspective preserving distortion in the image stitching"[6] combines the local projection transformation with corresponding structural method of non-overlapping areas in no overlapping areas. The precision of the alignments and less distortion with regards to multi-perspective image projection and maintenance. But more modifications like reflection, rotation and spin on the local geometries have not been taken into account in this Algorithm. This is the area where this algorithm is to be developed.

The multiple detector algorithms were compared in [7]. In this paper you will also find the widely used "Oxford" test image data-set and the overlapping error concept. The paper also describes an assessment of the concept of repetitiveness that the detector uses.

The descriptor techniques are analyzed in detail in [8]. Descriptors based on metrics recognized as reaffirmation and precision were assessed. This paper strongly corresponds with the method undertaken by this proposal. Like [5], the "Oxford" dataset is used in this experiment.

The speed of detection and description of image features is primarily involved in [9]. This is the framework for this paper's speed testing. However, it records independently the outcomes from the overall delay needed for the identification of key points as well as for the removal of descriptors, both as in this paper.

The assessment of detectors and descriptors is described in detail in [10]. The subject of this paper was the tracking of objects from a video stream, so the experiment information was used in a video image collection. This paper also defines the precision, repeatability and descriptor performance measuring model.

III. PANORAMIC IMAGE STITCHING PROCESS

3.1: Image stitching fundamentals

Panorama recognition is based on the feature matching the images, image extractor, image stitching, bundle adjustment, and multi-band mixture. Panoramic image stitching. The focus is especially on the work of M. Brown and D.-Brown and D. Lowe [11]. G. Lowe [2002]. They implemented method that is fully automatic in nature for panorama making. Their automated system needs recognition that belongs to the panorama. Prior to the proposal of the algorithm, the panorama development was limited to the image number and their sequence. The algorithm was designed as follows in five stages: image feature matching phase extract as well as match the SIFT (Scale Invariant Feature Transformation) between images. To extract and match the features, k-d trees were used to locate them approximates by applying the k-close neighbour algorithm. This algorithm's time complexity is n*log(n)'s Big-O.

This step gives an overview of the aligned set of images by combining and overlaying. RANSAC-Random Consensus is popular to select a homographically compatible set of inliers from the images [12]. There are no compatible images.

For all pairs of images that potentially match, RANSAC Inliers are the set of geometrically consistent features. RANSAC Outliers for each pair of potentially matching images are defined as a set of inconsistent features within the overlapping areas. This is purely probabilistic phase. The idea of this model is to compare the probabilities that are generated by a false edge detection between the outliers and the inliers. A pair match between images is formed which then leads as attaching images to the panoramic sequence. The benefit of this model is that the mosaic can be seen with several different images as well as the image noise not corresponding to any of the images in the set is very helpful.

Each step selects the best matching image and is added one at a time to the bundle. The image mosaic algorithm is performed with the same rotation and focal length as the image that it fits into, while the image is being added to the bundle. Each feature is expected into the entire image it matches. In this model, camera parameters play a major role.

Image Blending: In overlapping N-point correspondences, the final step is to blend pixel colours, using region to prevent seams. 2N linear constraints. Use (2) is the easiest form available. Feathering that uses average weighted colour values.

3.2: Image detection and extraction methods:

Two major methods of image detection are available; 1. Direct, 2. Feature-based. Direct strategies compare the intensity of each pixel of an image with that of the other, while feature-based technologies extract and correlate distinct feature characteristics from the images processed. This approach is better because it is faster, more robust against scene rotation and has the ability to determine the overlap between un-ordered images automatically. Pixel to pixel variation in direct technique is reduced to form image-stitching process. During the processing of feature based systems, a feature set is pulled off and the matching is done. In the direct or pixel based technique, the intensity of each image in pixels is related to the other [12]. The main advantage of direct technology is that; it diminishes the sum of absolute pixel differences. Every pixel is compared to each other in this technique, so it is a very complicated strategy. They vary with the scale and rotation of the image. The image alignment data obtained from direct method is optimally utilized. The role of every image element in the image is measured. This technique is restricted by a small range of convergence. Direct Method uses pixel-specific information. Homographic approximations [13,14] are always updated to keep the cost function to a minimum. A phase-correlation is used for some parameters of the homography. Image stitching and image alignment are essential for the determination of similar pixels in the overlapping area of the images. Some change occurs, which requires the replacement of pixels from one image to the next, when two consecutive photos with a slight shift take the same camera during the capture of the second image. Factors can be grouped into the matrix of homography. The complexity of the matrix corresponds to the different transformation classes.

3.3 **Projective layouts**

Different maps projections can be used to arrange images stitched from the same point in the space for image segments.

Rectilinear: When the whole panosphere converges in one point, a two dimensional plane view of an image with stitches is possible. Despite the image directions, straight lines are shown as straight. When viewed around 120 ° or other, a severe distortion is seen near the image boundary. In panoramic vision, a major purpose of rectilinear projection is found in the exercise of cubic faces with cubic mapping [15].

Cylindrical: images Stitched as a horizontal 360 ° field of view with a limited vertical field of view is displayed in cylindrical projection. Panoramas are projected cylindrically as though the image is drawn into a cylindrical panel and seen from the interior. Horizontal lines are shown on a double-dimensional plane as curved lines and vertical lines as straight lines. Vertical distortion increases rapidly as the top of the panosphere approaches [24].

Spherical: A cylindrical projection derivative is spherical projection or equally rectangular projection. The stitched image is displayed as a vertical field of view 360 ° horizontal with a 180° view leading to a complete sphere in this projection. Sphere-projected panoramas are seen as if the image is enveloped in an inner sphere. Horizontal lines are seen on a two-dimensional level as curved lines, and vertical lines are displayed as vertical lines themselves [24].

Stereographic: The virtual cameras are fixed straight down to set the field to show the entire ground and areas above it. Stereographic projection or fisheye projection is used to create a small panorama on the globe. By pointing the virtual camera up, a tunnelled effect is created. Due to the conformity of the stereographic projection, visually pleasing results are produced.

3.4 HARRIS-LAPLACE Corner Detector: Harris-Laplace is a corner detector proposed by Mikolajczyk and schimd. [16] A few of the feature detection and extraction methods HARRIS methods are used. This depends on a modified version of the Harris corner detector and Gaussian scale representation. Compared to the (LoG) or (DoG) detectors, the Harris-Laplace collects a significantly less number of points. It's invariant to scale, but utterly pointless to affine change.

KAZE: Alcantarilla et al. suggested KAZE algorithm. In the extreme nonlinear scale space, it detects and describes 2D functions. Apart from the Additive Operator Splitting (AOS) method KAZE uses non-linear diffusion filters to adapt to image functions by blurring. This follows the same four major steps as SIFT with significant change [17] for object recognition.

AKAZE: For the relief of the costly computation with implementation of KAZE, AKAZE (Accelerated KAZE) is created [18]. The method used to generate non-linear scale space is FED, an abbreviation of rapid explicit diffusion. In order to speed up the key point description, AKAZE uses the modified copy of the LDB descriptor as a binary descriptor.

SIFT [19] is an innovative method that produces high-quality, gradient-based features and takes great computing effort.

SURF [20] detects key features faster than the original SIFT with no loss of performance and other methods have recently been proposed, such as improving time or reproducibility for processing. The same structures are used for **ORB [21], BRISK [22], SIFT, SURF [20], BRISK [22] and ORB [21]:** the most effective pyramid-type key points are identified by using the gradient or time guidelines shown in figure1.

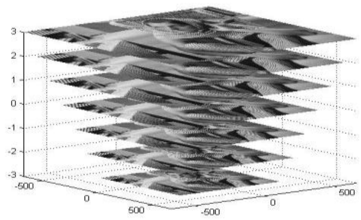

Figure 1: Image Pyramid [20]

Each detector uses an algorithm to detect stable keypoints at every level of the scale. In a Difference of Gaussians applied in each level, for example, SIFT [19] detects SURF [20] on wavelet and integrated images, BRISK [22] detects in an interpolation scale and in a simple pyramid scale, ORB [16]. SIFT [19] extracts scale-invariant features by detecting local DOG extremes over the scale applied to the image. The DoG version is faster than Laplacian of Gaussian (LoG) approximation. The Fast-Hessian detector is proposed by SURF [20].

The Gaussian derivatives of Hessia's rectangle filter matrix are approximated in the second order. In addition, with integrated pictures, the Fast-Hessian detector works 3 times faster than DoG. The STAR [23] Key Point Detector recently used a rotational invariance approximated to the Laplacian of Gaussians (LOG) filter, in scale formed by a bi-level approximation [23].

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ORB [21] detects Harris-filtered FAST features at each level in the image scale pyramid and calculates FAST's new fast and accurate orientation.

MSER: The connected component of an adequately threshold image is a Maximum Stable Extreme Region (MSER) [25]. Extremely, all pixels inside the MSER are of higher intensity (regions of bright extremal) or lower intensity (regions of dark extremal) than all pixels within their outer borders. The' maximum stability' in MSER describes the property optimized during the selection threshold.

IV. EXPERIMENTAL SET UP PROCESS

The method employed in this paper is a method to image selection relying on the characteristics of Python and OpenCV. Some of the Image stitching steps used in this paper involved are:

a. The **extraction** of key video frames.

b. The panorama is formed by **successive stitching** the key frames.

c. The **extracting of key video frame** structure divides video frame sizes into sample sizes of 10 and a total image with these 10 frames is calculated. Then each image variance in the set with regard to the average image is calculated. The key frame for the corresponding set is a minimum variance image. Note that a set is only regarded for one key frame. These key images are appended in a list for each batch.

d**. Stitching The preceding important image frames**: Two consecutive images are used for the processing from this list of key frames. Each image is estimated using a user selection option for its features and descriptors. Functionality is matched with a "Brute Force Matcher" in both pictures. For computing the homography matrix, the corresponding key values are used. One of the two images is fixed and a correct image is added to another image which is the fixed image. This procedure is executed in the list of key images for the subsequent image for successive photographs. You can save the resulting image as a jpg file.

e. **Algorithms used**: OpenCV is configured with 4 distinct detector and descriptor applications. These are: SIFT, SURF and BRIEF-descriptor-STAR detectors and ORB. The Brute Force match is used here to determine matches of key-points between two images in succession. Lowe's test is undertaken to locate excellent matches in key-points. The parameter "ratio" for the test is 0.75. RANSAC is used with reprojThresh=4.0 to determine the homography between two consecutive images.

V.RESULTS

Different systems perform differently with regard to time complexity and image quality. At the expense of computation time, SIFT provides excellent performance image outputs. Although ORB is the fastest of the algorithms above, the performance output quality is not excellent. SURF provides for a good trade-off. Depending upon implementation, the metric for key frame extraction would alter. Table 1 shows the time required for two data sets to be paired with image detectors and descriptors. The time for stitching and time for computation for various combinations of the functional detectors and descriptors used is not same. ORB needs less time to be calculated. The image feature detection and stitching time is slightly different, depending on the type of images. However, as an average, ORB is faster than SIFT, but SIFT extracts more image features. The panorama performance for two data collection sets is shown in Figs 2 and 3. The basic data set image pairs referred from [26] and panorama is developed.

Table 1: Computation Time for Key Feature Extraction and Stitching

Method used		Data set-1		Data set-2		Average value	
Key Feature detector	Key Feature extraction	Key Feature Extraction time (s)	stitching time (s)	Key Feature Extraction time (s)	stitching time (s)	Key Feature Extraction time (s)	stitching time (s)
SIFT	SIFT	18.33	4.34	17.35	5.89	17.84	5.115
SURF	SURF	10.67	3.34	11.34	2.33	11.005	2.835
ORB	ORB	6.89	1.23	6.12	0.89	6.505	1.06
STAR	BRIEF	13.34	4.32	12.33	4.12	12.835	4.22

Fig-2: Dataset-1 (Hill)


Fig 1-HILL: a


b-part2


c-part3


d-part4


e: part -5


F: Final Panorama

Fig-3: Dataset-2 (Institute campus)

			
Fig1:a-Part-11 : Building Part 1: A	b-Part2	c-Part3	d-Part4 E-Part5
			
D: part-5		F: Final Panorama	

VI. CONCLUSION

Different algorithms perform differently in terms of complexity of time and quality image at the cost of computing time, SIFT provides excellent performance results in terms of image quality. ORB does not produce a good quality outcome image while it is faster among the algorithms listed earlier in this paper. SURF can achieve the best compromise for computation time and quality. Depending on the application, the method for the key frame extraction would alter.

Techniques have been discussed for effective image stitching. The gradient domain or the intensity domain may be used in image stitching. Here a brief overview of the two techniques developed by the nobles was presented.

This paper also highlights the methods of image stitching such as registration, calibration and blending. The study findings provide valuable data and new ways of thinking that can be valued in vision-based applications for critical outcomes. SIFT is more precise in comparison with the rest for image rotations. Although the most efficient algorithms can identify a vast number of features, SIFT and STAR extend the entire time of image matching for such a reasonable number of features. ORB and SURF perform the best image match, but their accuracy is impaired. For all types of geometric transformations, the overall accuracy of SIFT and SURF is found to be the highest, and ORB is found be the fastest algorithm. By combining various algorithms, we can develop new and better image mosaicking algorithms according to the application. Image Stitching is an always open area of research for computer vision applications. The work is straightforward and less complicated for programmers to start operating on new algorithms. Image stitching is an inevitable task at this age of 3-D imaging and video. The most common use of image stitching is development of panoramic images.

REFERENCES

1. Jubiao Li and Junping Du, “Study on Panoramic Image Stitching Algorithm”, IEEE 2nd Pacific-Asia Conference on Circuits, Communications and System (PACCS), vol. 1, pp. 417-142, 2010
2. R. Karthik, A. Annis Fathima, V. Vaidehi, “Panoramic View Creation using Invariant Moments and SURF Features”, IEEE International Conference on Recent Trends in Information Technology (ICRTIT), pp. 376-382, 2013.
3. Zhaofeng Pang, Cheng Li, Baojun Zhao, Linbo Tang from Conference Volume 9675 on Image Processing and Analysis.
4. Taeyup Song; Changwon Jeon; Hanseok Ko, "Image stitching using chaos-inspired dissimilarity measure," Electronics Letters, vol.51, no.3, pp.232,234, 2 5 2015 doi: 10.1049/el.2014.0981
5. Yi Zhuang, Xinrong Hu, Jianchun Wang, “The Implement of an Image Stitching Algorithm based on Feature Extraction”, 2009 Second International Conference on Education Technology and Training.
6. Tianzhu Xiang, Gui-Song Xia, Liangpei Zhang "Image stitching with perspective-preserving warping", 17 May 2016.
7. K. Mikolajczyk, T. Tuytelaars, C. Schmid, A. Zisserman, J. Matas, F. Schaffalitzky, T. Kadir and L. V. Gool, “A comparison of affine region detectors”, *Int. J. Comput. Vision*, vol. 65, no. 1, pp. 43–72, Nov. 2005.
8. K. Mikolajczyk and C. Schmid, ‘A performance evaluation of local descriptors”, *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 27, no. 10, pp. 1615–1630, Oct. 2005.
9. O. Miksik and K. Mikolajczyk, “Evaluation of local detectors and descriptors for fast feature matching “, in *2012 21st Int. Conf. Pattern Recognition*, pp. 2681-2684.
10. S. Gauglitz, T. Höllerer and M. Turk, “Evaluation of interest point detectors and feature descriptors for visual tracking “, *Int. J. Comput. Vision*, vol. 94, no. 3, pp. 335– 360, Sep. 2011.
11. Brown, M. & Lowe, D.G. Int J Comput Vision (2007) 74: 59, doi:10.1007/s11263-006-0002-3.
12. Wikipedia contributors. ” RANSAC”. https://en.wikipedia.org/w/index.php?title= RANSAC & old id=709504871, 2016.
13. Shikha Arya,” A Review on Image Stitching and its Different Methods”, International Journal of Advanced Research in Computer Science and Software Engineering, vol 5, no. 5, pp. 299-303, 2015.
14. Rami Kassab, Sylvie Trouville, Franck Marzani, Christian Pieralli, Jean-Christophe Lapayre, “An optimized algorithm of image stitching in the case of a multi-modal probe for monitoring the evolution of scars”, SPIE Photonics West, BIOS, Advanced Biomedical and Clinical Diagnostic System XI, pp. 85721A1-10, 2013.
15. Hetal M. Patel, Pinal. J. Patel, Sandip. G. Patel, “Comprehensive Study and Review of Image Mosaicing Methods”, International Journal of Engineering Research & Technology (IJERT), vol 1, no. 9, pp. 1-9, 2012.
16. 20.M. Hassaballah, A. Abdelmgeid, and H. Alshazly. "Image Features Detection, Description and Matching". Springer International Publishing Switzerland, 2016.
17. Pablo F. Alcantarilla, Adrien Bartoli, and Andrew J. Davison, "KAZE Features", University dAuvergne, Clermont Ferrand, France, 2012.
18. G. Levi and T. Hassner,” LATCH: Learned Arrangements of Three Patch Codes “, arXiv preprint arXiv:1501.03719, 2015.
19. D. G. Lowe. “Distinctive image features from scale invariant key points”, *International Journal of Computer Vision*, pages 91–110, 2004.
20. H. Bay, T. Tuytelaars, and L. Van Gool.” Surf: Speeded up robust features “. In *Computer Vision–ECCV 2006*, pages 404–417. Springer, 2006.
21. E. Rublee, V. Rabaud, K. Konolige, and G. Bradski.” Orb: An efficient alternative to sift or surf “. *Proceedings of the 2011 International Conference on Computer Vision*, 2011.
22. M. C. Stefan Leutenegger and R. Siegwart “Brisk: Binary robust invariant scalable key points”, *Proceedings of the IEEE International Conference on Computer Vision (ICCV)*, 2011.
23. M. Agrawal, K. Konolige, and M. R. Blas. Censure:” Center surround extremas for real-time feature detection and matching”. *European Conference on Computer Vision 2008*.

24. Hetal M. Patel, Pinal. J. Patel, Sandip. G. Patel, "Comprehensive Study and Review of Image Mosaicing Methods", International Journal of Engineering Research & Technology (IJERT), vol 1, no. 9, pp. 1-9, 2012.
25. J. Matas, O. Chum, M. Urban, and T. Pajdla. "Robust wide baseline stereo from maximally stable extremal regions". *Proc. of British Machine Vision Conference*, pages 384–396, 2002.
26. http://web.cecs.pdx.edu/

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