Panoramic Image Stitching using Feature Extraction: The Current State of the Art

Vanshul Bhasker[1]

[1]*Department of Information Technology, Maharaja Agrasen Institute of Technology, Delhi, India*

---***---

Abstract - This document is a report on Image Stitching and its current state of the art. Image stitching is the process of creating one contiguous image from a given set of images that have some common overlapping region in them. Previous researches done on this topic show that this is an evolving technology and there is still a lot of scope for improvement in this field as although we are able to achieve good results but we haven't really been able to achieve perfection. There are a lot of factors that are responsible for the same. While Stitching Images, there could be many challenges such as images being corrupt by noise and/or presence of parallax in the images. Image Stitching process is divided into 5 major steps: Image Registration, Feature Detection, Feature Matching, Homography Estimation and Image Blending. In this document we are going to discuss the current status of image processing techniques and what are the challenges being faced.

*Key Words***:** Image Stitching, Image Panorama, SIFT, KNN, RANSAC, Homography Estimation

1.INTRODUCTION

In today's world, Image Stitching has a wide variety of uses, it is a commonly used technique in Satellite Imaging, Medical Imaging and also in creating mosaics especially document mosaicing. One of the key advantages of stitching images together is that it uses the power of certain algorithms to process the images that are already clicked, also it can overcome the limitations of camera hardware that is the cameras that don't have a wide field of view, if in case you need a wider field of view in the image from the same camera, you will have to get farther from the object which might not be the most practical option, also it compromises on the quality of the image. Hence, Image Stitching can be an option that takes care of these limitations. Image stitching has become a really hot topic in the field of image processing because of its immense use. With the advancements in technology, the applications that could only be made for computers can now even be made for mobile devices. Smartphones today are all equipped with great cameras, Processors and displays which opens gates for all types of developers. Hence, Image stitching also becomes a very practical option for mobile phones too. Image stitching is widely used for producing today's digital maps and satellite photos, it is also one of the most important aspect of creating mosaics, however it was first used in photogrammetry fields. One of the most common way of stitching images is by dividing the whole process into 5 steps: Image Registration, Feature Detection, Feature Matching, Homography Estimation and Image Blending.

2. METHODOLOGY

The image stitching model used consists of five stages: Taking images as Input, features Extraction, feature matching, Homography estimation, and image blending as shown in the Figure. Each step has its own significance and all of them together produce a good quality panorama.
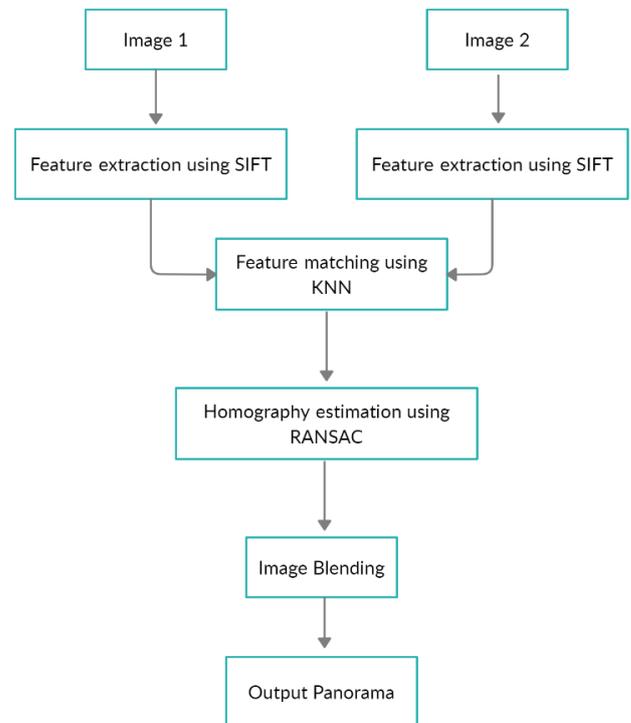

Figure 1: Methodology of image stitching

A. IMAGE REGISTRATION

Image registration is the first step in Stitching images which involves getting the desired images by the user. Once the images have been taken, we need to get them registered so that the algorithm can be applied on them. Registration is the process of converting the images into a machine-readable form by mapping them from points in one view to points in the other. Image Registration is commonly used in Computer vision, Remote Sensing,

Image Stitching and even in Medical Imaging and is always the first step before applying any algorithm.

B. FEATURE DETECTION AND EXTRACTION

The second step in Image Stitching is considered to be the most important step. It involves the detection of feature points and extracting them. We can refer to features as the points of interest which may be common and are present in two or more images. The whole idea is to then get these common points. This is based on the idea that instead of comparing the whole images, it may very well be favorable to choose some unique points of focus in the picture and play out a nearby examination on these ones. Feature extraction could be done by many algorithms like the Haris Corner Detector, SIFT, SURF, etc. but the most popular one out of all of them is the classical SIFT (Scale Invariant Feature Transform) algorithm.

The SIFT algorithm can detect the feature points very quickly and efficiently and gives an invariant property when the image is Tilted, rotated, illuminated or even resized. There are 4 steps of the SIFT algorithm: Scale Space Extrema detection, Key point Localization, Orientation Assignment, Key point Descriptor.
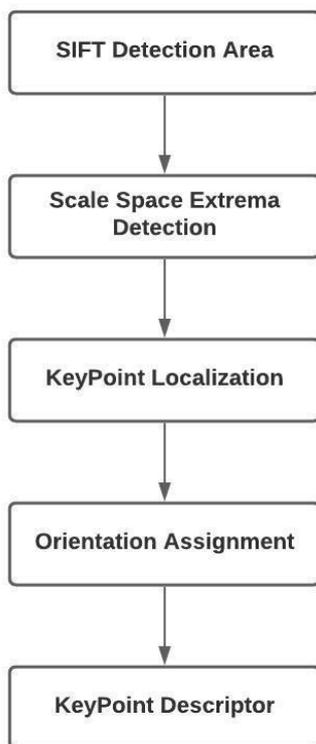

Figure 2: SIFT Algorithm

C. FEATURE MATCHING

The Whole idea of extracting features using the SIFT Algorithm was to then compare them to find the common points. We are doing this to find the common overlapping region between the images. Once the Points of interest or the descriptors have been extracted out from the images, the next step is to compare those descriptors and to find out matches between them. These descriptors can either be matched using the Brute force method or the K-nearest neighbor algorithm (KNN Algorithm). When we match the descriptors using brute force method, we calculate the Euclidian distance between all the descriptors of image 1 and image 2 and for every descriptor in Image 1 we return the closest descriptor in the other image. By doing so, we get the best possible match for every feature point.

However, the more popular algorithm is the KNN (K-nearest neighbor) algorithm.

The Idea of KNN algorithm is that usually the similar descriptors would be close to each other so in KNN algorithm, instead of giving one match which is the best match for any particular descriptor, we return the k best matches. Firstly, we calculate the Euclidian distances from one descriptor to all the other descriptors putting the values into an ordered collection which is usually sorted in ascending order, next we pick the first k elements from this collection, based on these values we can decide that the new data point belongs to which set. The value of 'K' can be decided by you.
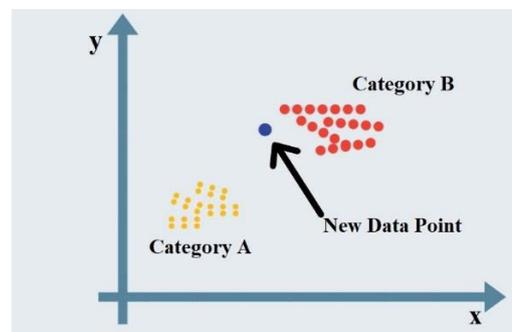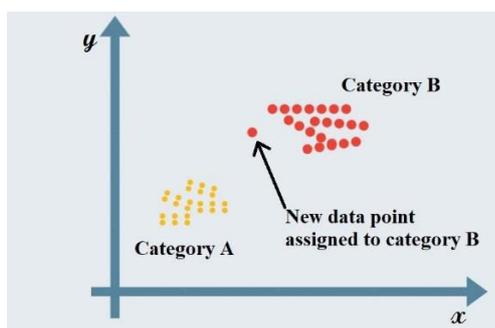

Figure 3: KNN algorithm

Figure 4: KNN Algorithm

D. HOMOGRAPHY ESTIMATION USING RANSAC

Often times, on applying SIFT and KNN algorithm we will get mismatched pairs. In order to estimate for the homography calculations, we should eliminate these mismatched pairs. The main motive of applying RANSAC (Random Sample Consensus) algorithm is to eliminate these incorrect matches out of our observations. These non-matched pairs are called as "Outliers" while the matched ones are called as "Inliers" according to the RANSAC algorithm. RANSAC will estimate the outliers from the available data. It randomly selects some points out of all of the selected points and keeps the largest set of inliers to later recompute the least-squares homography estimate on all of the inliers. Since it is randomly selecting these points, hence the name 'Random Sample Consensus', also it since the data is random, there is no guarantee of a correct result.

The more will be the data, the better will be the results produced by the RANSAC algorithm. Doing so, we will eventually have a solution that has the best consensus with the images. An important thing to note here is that RANSAC is a non-deterministic algorithm, so it does not guarantee you with the correct results all the time. It is only used to estimate the homography parameters from the given set of data which contains both the matched and non-matched pairs.

In simple terms, consider the example of 2 images of the same object but taken from different angles, the idea of homography estimation is to identify that both the images are same or some part of the images is same by mapping the points of one image to the other.

E. IMAGE BLENDING

On applying RANSAC algorithm, we obtain the homography matrix which can be applied on the image to implement image warping. Warping is the process of distorting the objects in an image. To create the panorama, the corresponding descriptors between the two images are selected to find a homographic warping one image into the other, doing so, we will get a single continuous panoramic image if there was some common overlapping area in the two images.

Although this gives us a panoramic image but there will still be some flaws in it and image blending will be used to remove these flaws. These flaws could be distortion in the overlapping area of the images or the exposure/lighting may not be even throughout the image. These flaws can happen because of numerous reasons like different camera perspective of the two images, varying exposure levels of the images, etc. If the input images were taken from the same angles with the same exposure levels, then any combination of pixels would do this task for us. There are various image blending techniques that could be used in the case of image stitching like alpha blending, image pyramid blending, gradient domain, feathering Image blending etc.

The feathering image blending is one of the most commonly used blending methods available to us, the idea behind this method is that our main flaw was poor exposure/lighting in the common region so to fix the lighting, we keep the pixel values of the common region as the average of the pixel values of both the images in that region but this does not guarantee us the best results every time, however if we shoot the shots in a controlled environment then it can almost guarantee you the best possible results. Another approach is the multi band blending where we do not directly work with the pixel color values, rather we work on the gradient of images which are copied and then an image which will match these gradients is reconstructed and that does the job for us.

3. PREVIOUS WORKS

In the last few decades, with the increase in the computational methods, many researchers and mathematicians have proposed the several image stitching methods. Levin and Weiss [1] introduced several formulas and algorithms to calculate the quality of image stitching. Similarly, other researchers had also contributed significantly towards this.

John F Canny in 1986 [2] proposed an algorithm which detect the wide range of edges in image. To calculate the intensity of the gradient it uses a filter based on the derivative of Gaussian. The general criteria for detecting the edges are:

It should mark maximum number of real points on the image. All the marked edges should be as close as possible to that of

the real edges. One edge should be marked only once and to avoid the creation of false points because of image noise.

Deepak Jain [3] came up with another method based on the edge detection in which he divided the complete process in three stages. First, he took two image and marked the edge points on both, once this is over, he removed all the false points that were created due to image noise. Once this gets over, he used homography to find matched corner and get stitched images.

Vimal Singh Bind [4] proposed a method for feature-based image stitching where he used the image stitching algorithms for stitching the images together. Then, to extract the best image out of the stitched image he used Discrete Wavelet Transform using maximum selection rule for detailed as well as approximate component during image blending. The quality and robustness of this method is tested using three-dimensional rotational image.

Yanfang [5] examined about automatic image stitching which applies the picture arrangement in any event even for noisy images. So, he used invariant features for fully automatic image which mainly had two parts which were image matching and image blending. Due to the larger difference between normal and noisy image, when he used SIFT method to realize the robustness and correctness of image, it supplies a probabilistic model and stitched by looking at the similarity of the stitched image to the input images and by visibility of seam of two stitched image. For better optimization and quality of the image there are several cost function algorithms. In these cost function algorithms, the visibility of seam and similarity of input images are defined in gradient of the image, minimizing the misalignment along the edges.

4. CHALLENGES FACED WHILE IMAGE STITCHING

- Parallax error: The most common challenge in image stitching is of parallax error. Parallax error is when you click images of the same object from two different points, this actually changes how your images look as the objects might seem displaced in the two images
- Spherical aberration: Spherical aberration is a type of aberration caused due to the curvature of the lens of the camera. It reduces the quality of the image which eventually effects the stitching procedure too.
- Scene motions: Consider the example of you clicking photo of mountains and a flying bird comes in one of your mages but not in the second, this can lead to issues in the algorithm.
- Noise in the images: If even one of the images is noisy, it would be difficult to extract the descriptors from the image which is the first step of image

stitching, hence we get the best results from high quality images

- High processing time: More number of images will need more time to extract the descriptors and perform the other steps, hence the processing time becomes a point of concern too.

5. CONCLUSIONS

Panoramic image stitching is an active field of research in image processing. The method discussed in this document is definitely not the only method of achieving good quality panoramic image. For example, instead of using SIFT algorithm for feature extraction we could have used other algorithms like the SURF algorithm or the Harris feature algorithm, every algorithm has its own pros and cons. This document was all about the most common method of image stitching available. Image processing is a growing field especially because of its immense use in today's world and with every advancement in technology, we aim to overcome all the limitations that are being faced today. Today we have achieved enough to be able to stitch fully automated 360-degree panoramas using a number of images and we now aim to be able to create dynamic panoramas by being able to stitch not just photos but also videos while being able to remove large parallax errors in real time.

REFERENCES

1. Anat Levin, A. Z., & Weiss, Y. "Seamless Image Stitching in the Gradient Domain", School of Computer Science and Engineering, The Hebrew University of Jerusalem (2000).
2. J. Canny, "A Computational Approach to Edge Detection," in *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. PAMI-8, no. 6, pp. 679-698, Nov. 1986, doi: 10.1109/TPAMI.1986.4767851.
3. Deepak Jain, G. S. "Image Mosaicing using corner techniques". International Journal of Engineering Research & Technology (IJERT) (2012)
4. Vimal Singh Bind, P. R. "A Robust Technique for Feature based Image Mosaicing using Image Fusion" (2013).
5. Yanfang Li, Yaming Wang, Wenqing Huang and Zuoli Zhang, "Automatic image stitching using SIFT," *2008 International Conference on Audio, Language and Image Processing*, Shanghai, 2008, pp. 568-571, doi: 10.1109/ICALIP.2008.4589984.
6. J. Beis and D. Lowe. Shape indexing using approximate nearest-neighbor search in high dimensional spaces. In Proceedings of the International Conference on Computer Vision and Pattern Recognition (CVPR97), pages 1000– 1006, 1997.

7. M. Brown, and D.G. Lowe, "Recognizing Panoramas, " In Proc. ICCV, vol.2, pp. 1218-1225, 2003

8. M. Brown, and D.G. Lowe, "Automatic Panoramic Image Stitching using Invariant Features, " International Journal of Computer Vision, vol. 74, pp. 59-73, 2007.

9. D.L. Milgram, "Computer Methods for creating Photomosaics", IEEE trans. Comput., vol. C-24, no.11, pp. 1113-1119,1975.

10. R. Szeliski, "Image Alignment and Stitching. A Tutorial, " Foundations and Trends in Computer Graphics and Computer Vision, vol.2, no.1, pp. 1-104, 2006.

11. Rupali Chandratre and Vrishali Chakkarwar, "Image Stitching using Harris Feature Detection and Random Sampling", International Journal of Computer Applications (0975 – 8887), Volume 89 – No 15, March 2014

12. M. Fischler and R. Bolles. Random sample consensus: A paradigm for model fitting with application to image analysis and automated cartography. Communications of the ACM, 24:381–395, 1981.

13. Y. Xiong and K. Pulli, "Color matching for high-quality panoramic images on mobile phones," IEEE Trans. Consumer Electron., vol. 56, no. 4, pp. 2592–2600, Nov. 2010.

14. Yingen Xiong and Kari Pulli, "Mask based image blending approach and its applications on mobile devices," in the Sixth International Symposium on Multispectral Image Processing and Pattern Recognition. 2009, SPIE.

15. V. C. S. Chew and F.-L. Lian, "Panorama stitching using overlap area weighted image plane projection and dynamic programming for visual localization," in Proceedings of the IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM '12), pp. 250–255, July 2012.

16. David G. Lowe, "Object recognition from local scale invariant features", proceedings of the Seventh International Conference on computer Vision, pp. 1150-1157, 1999.