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Panoramic Image Stitching: A Survey

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ABSTRACT

This electronic document is a report on Image Stitching. Image stitching is the process of creating an image panorama from a given set of images that have some common(overlapping) area in them. Previous researches done on this topic show that 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 to be blamed here. 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.

KEYWORDS: *Image Sitching, Image Panorama, SIFT, KNN, RANSAC*

I. INTRODUCTION

In today's world, Image Stitching is a commonly used technique in document mosaicking, Satellite Imaging and even in Medical Imaging. One of the key advantages of stitching images together is that it can overcome the limitations of camera hardware. The cameras don't really 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 seem the most practical/feasible option, also, you will have to compromise on the quality of the image by moving farther away from it. So, Image Stitching can be an option that takes care of the limitations without compromising on the quality of the image. 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.

II. METHADOLOGY

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.

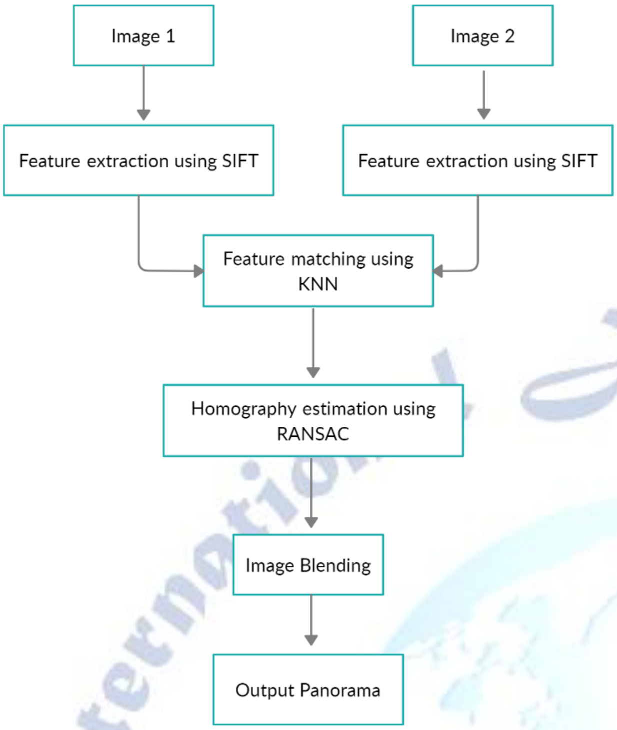

Figure 1: Methodology of image stitching

A. IMAGE REGISTRATION

This is the first step in Stitching images which involves taking the desired images by the user. Once the images have been taken from the user, we need to register them next. Registration is the process of converting the images into a machine-readable form by mapping them from points in one view to points in other. Image Registration is commonly used in Computer vision, Remote Sensing, Image Stitching and even in Medical Imaging.

B. FEATURE DETECTION AND EXTRACTION

The second step in Image Stitching is considered to be the most important step in Image stitching. It involves detection of feature points and extracting them. We can refer to features as the points of interest which are present in two or more images. This is based on the idea that instead of comparing the whole images, it very well may be favorable to choose some unique focuses 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, Keypoint Localization, Orientation Assignment, Keypoint Descriptor.

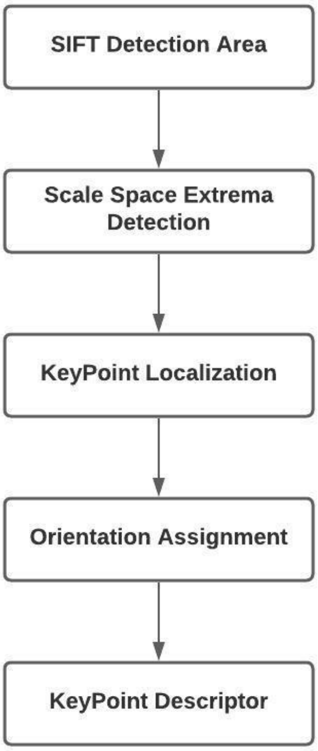

Figure 2: SIFT Algorithm

C. FEATURE MATCHING

Once the Points of interest or the descriptors have been extracted out the images, the next step is to compare those descriptors and to find out matches between them. In order to stitch images together, we need to have some common overlapping area in the images, the idea of feature matching is to find that common area using the descriptors obtained from the SIFT Algorithm. These descriptors can either be matched using the Brute force method or the K- nearest neighbor 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.

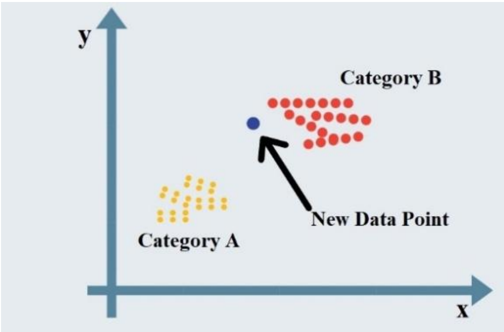

Figure 3: KNN algorithm

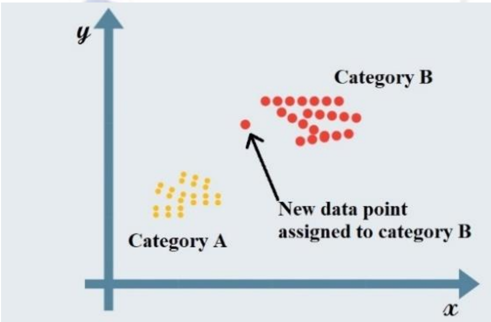

Figure 4: KNN Algorithm

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. There is a name that is given to these unmatched pairs, they are called as “Outliers” while the correct ones are called as “Inliers” in 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.

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 inliers and outliers.

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 he 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.

III. 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.

IV. CHALLENGES IN 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.

V. 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 paper was all about the most common method of image stitching available. Image stitching is a growing area 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 almost in real time.

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