Image Stitching techniques

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Introduction

The field of image stitching has a lot of active research being done as it has vast applications in medical imaging, computer vision, satellite imaging, video conferencing and many others. There are a lot of image stitching algorithms that exist but they mostly fall under two common approaches, direct approach and feature based approach.

The direct approach utilizes all the image pixels of the image to be stitched and applies a lot of very expensive and complex correlation functions comparing each pixel to other pixels. This makes the direct method undesirable as it is quite inflexible and it is greatly affected by exposure differences of the same object in different images to be stitched. This can be because of camera defects that captured the images. It also performs very slowly and makes it undesirable for real time applications where time is a huge factor. Another important disadvantage that makes direct stitching techniques is that they need a lot of initialization which means there must be a lot of human interaction to make sure the stitching occurs correctly. This initialization includes but is not limited to rotation (orientation) of images to be stitched.

Feature based techniques perform much better but depending on what exact feature based technique was implemented the stitching time may vary significantly. Some of the more popular feature based detectors include Scale Invariant Feature Transform (SIFT), Speeded Up Robust Features (SURF), Pyramidal Histogram of Visual Words (PHOW). As feature based techniques are more interesting we will talk a little bit more about them and briefly introduce the advantages of each feature based technique discussed and its disadvantages.

Feature-based Techniques

When a feature detector receives an image, it analyzes it to extract the metadata from the image. Information like how the points in the image relate to each other and other geometric relations from the pixels in the image, form the features extracted by the feature detector.

Of the popular feature-based techniques, the SIFT technique is the most accurate. Key point descriptors are created from gradient magnitude from all the available images points to describe objects. These key points also contain orientation information such that when another image which contains the same object can be matched and the orientation information is used to check if in fact the object in question matches. A nicely stitched panoramic image is obtained when this method is chosen to perform image stitching. The major drawback with this technique however is that it is computation intensive which makes this method unsuitable for real time stitching applications like livestreaming platforms.

A better feature based technique in terms of being less computation intense, is the SURF technique. This method is much faster than the SIFT technique and has a lot of application in real time applications. It is also a robust technique but as implied is not as accurate in terms of the stitched output of the algorithm. Key point descriptors are generated from distinctive locations in the image. These descriptors are then compared over multiple descriptors from other images and the images that have similar descriptors are then stitched together.

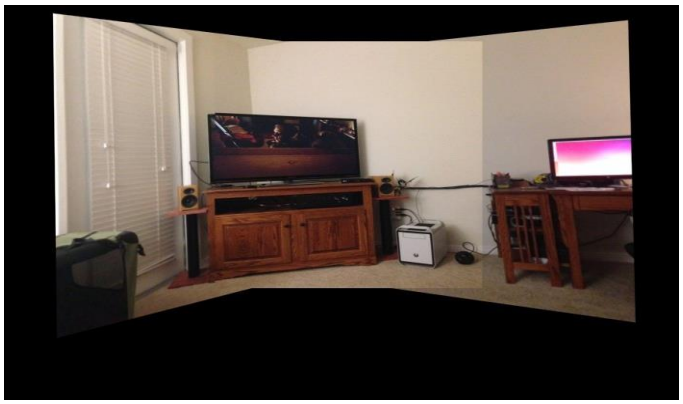

Figure 1 – Shows a stitched image with a leftover seam from stitching the rightmost image with the rest of the image. Source: Vyas K.

Seams

Once two images are joined a seam occurs along the region where the images were stitched together. This is caused by the exposure difference between the individual images. This seam would not exist if two perfect images or more were stitched together with all the images having the same camera exposure. To remove this an optimal seam is needed to be found and a blending algorithm achieves this seam removal to obtain a smoothed out panoramic image. For our 3D livestreaming project, we do not really require a perfect seam removal. This might take more time in computation to do and add an unnecessary delay to the whole system.

For future implementations of the livestreaming platform it is desirable to have all the seams removed as it makes for a more photorealistic output.

Image Stitching in Virtual Reality

As mentioned in the introduction, image stitching has vast practical uses. In the emerging technology of Virtual Reality, it plays a critical role in how content is created and is made to be consumed with the VR headsets. The formatting of normal images and videos is two dimensional and needs to be converted into three dimensional or better put, introduce an illusion of 3D. Image stitching of these two-dimensional media and adding transformations to the 360-degree panoramic image or video enables the creation of the virtual reality experience.

Already there are a couple of products that serve to stitch media content like images and videos into their 360 degree counterparts to be played back on VR headsets like Oculus Rift and Gear VR. These include products like Videostitch and Autopano Video which focus on images and pre-recorded video input. There is development in real-time broadcast to the Virtual Reality platform but the area is largely limited by the speed at which real-time image stitching can occur without introducing significant delays that eliminate the whole concept of live broadcasting. The limits on the real-time stitching are largely due to hardware and the currently available image stitching algorithms.

Figure 2. – Image showing content being displayed on the Oculus Rift headset. The scene being displayed was stitched together by the Yellow team.

Conclusion

Image stitching has an extensive arsenal of use cases. Because of this, there will be more and more research done on improving current algorithms and development of new ones. After analyzing the main types stitching algorithms, it is apparent that a very light weight algorithm is needed to embark on any sort of real-time application. There is also a compromise between the speed of stitching and the quality of the stitched panoramic output.

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