Image Stitching Based on Corner Detection

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Abstract: An image stitching is a method of combining multiple images which are overlapping images of the same scene into a larger image. Mostly used methods are Harris corner detection method and SIFTS (Scale Invariant Feature Transform) method. In this paper, a study of Harris corner detection algorithm and SIFT algorithm is done by comparatively in image stitching using similarity matrix matching scheme. Total 30 pairs of different images have been used for their simulation and comparison. The algorithms have been compared with more number of corners detected in images, number of matching pairs and number of matching time. From the results of simulation it has been observed that SIFT corner detection method is most efficient in image stitching.

Keywords*: Image stitching, Corner detection, Harris corner, SIFT*

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I. INTRODUCTION

Image stitching is the sub branch of the computer vision. It combines two or more different types of images to form one single image that is called as panoramic image. The word panorama is derived from the Greek words “pan” and “horama”. “Pan” means everything part of image and “horama” means to view that part, and thus it means all round view. Panorama images can be created in a many ways, from the first round painting in the 18th and 19th centuries. The aim of stitching of images is to increase resolution of image as well as the field of view; people used image stitching technology in topographic mapping. A topographic map is a type of map which is characterized by large-scale detail and quantitative representation of relief, using contour lines. Typically, a camera is able to taking pictures within the scope of its view only; it cannot take a large picture with all the details of image fitted in the one single frame.

Panoramic image resolves this problem by combining images which are taken from different sources into a single image. Such type of images are useful for surveillance applications, remote sensing etc. Image stitching algorithms create the high resolution photo mosaics used to produce digital maps and satellite photos. Creating the high resolution images by combining smaller parts of images are popular since the beginning of the photography.

To stitch images and form a panoramic image, the similar part of the overlapping portion among adjacent images needs to be calculated in the first place. Intensity-based algorithms usually contains a large amount of computation and therefore they are not appropriate for image alignment when there is image in rotation motion and scaling. On the other hand, algorithms based on frequency-domain are in general faster and can handle well small translation, rotation, and scaling. Unfortunately, the performance of frequency domain-based algorithms will be degraded when dealing with scenarios where smaller overlapping regions exist.

Feature-based algorithms contains a small number of invariant points, lines, or edges to align images. One significant advantage of these algorithms is that the computational complexity will be decreased due to less information that needs to be processed. Additionally, feature-based algorithms are robust to changes intensity of the image.

Here, Firstly detect corner of the input images, then perform stitching of image by matching the corners.

II. LITERATURE SURVEY

In the last few years many researchers have implemented and proposed various panorama image stitching systems.

Chia Chen **[4]** has given comparisons of different new techniques of Image Stitching. Along with image stitching, the paper also describes methods which can be used for image mosaicing. Different acquisition techniques of images such as image acquisition by rotations of the camera, image acquisition by camera translations, and image acquisition due to a hand held camera and their properties in detail are discussed. The mathematics of image registration is discussed in detail in the paper. Different methods of the image registration using different similarity measures such as images registration using sum of squared differences, image registration using sum of product, image registration using standard deviation of differences, by restricting the search set, image registration with step search strategy have been discussed in brief. D.L.Milgram have been given the image merging method of differences of linear distribution of intensity which uses a linear ramp to spread the intensity differences of the pixels which are immediately next to the seam for blending pairs of grey level satellite. The paper gives an idea that the concept of image stitching or panorama production can be used.

Pranoti Kale et al. **[10]** has given a analysis of image stitching algorithm. The paper gives a brief review on the image registration techniques used in the past as well as in the present area. It has been discussed that the image stitching process can be divided into three main steps of image calibration, image registration and image blending. The main approaches involved in image stitching viz. direct and feature based techniques are discussed. The direct techniques work by directly minimizing pixel to pixel dissimilarities.

And also they are not invariant to image scale and rotation. Whereas the advantage of direct techniques is that they make the use of the information available in the image alignment. The feature based techniques work by extracting a sparse set of features and then matching them to each other. This technique is applied by establishing correspondences between points, lines, edges, corners or other geometric entities. The techniques namely Harris corner detector, SIFT, SURF, FAST, PCA-SIFT and ORB come under this technique.

Uyttendaele et al. [9] presented two main contributions of image stitching problems. The first one is a method for dealing with objects that move between different views of a dynamic scene. The other is a method to eliminate visible shifts in brightness. They presented a method of block-based adjustment, which changes the pixel values using a weighted average of lookup tables from close parts of the image.

Rankov et al. [10] proposed an approach for establishing high resolution, edgeless, and composite image using cross-correlation and blending. One image is correlated at a time with a composite image. The blending is performed, when the image is registered. The presented method is fast because of using a lookup table technique.

Zomet and Peleg [11] studied the cost functions and compared their performance to different scenarios both theoretically and practically. Their approach can be used in many applications, such as building the panoramic images, object blending, and removing of compression artifacts.

Bind et al. [12] proposed a panoramic image stitching technique for three-dimensional, rotational images with a variation of the illumination. The input overlapping images are passed through two strong stitching algorithms, that are SIFT and SURF. SIFT algorithm is invariant towards scale and rotational variation. It is also robust towards the noisy environment. SURF algorithm has very similar properties as SIFT. It has the properties of illumination invariance and good computational speed. The blending process was done using Discrete Wavelet Transform (DWT).

Antony and Surendran [13] implemented a stitching technique to create panoramas of satellite images which are based on image registration. They geometrically aligned one input image into other image. Then, image stitching algorithm takes the alignment estimation that is produced by the registration algorithm to blend the images in a seamless manner. Their image stitching system was well suited for all types of images including the satellite images. The system supported images of different formats, such as JPEG, TIFF, GIFF, and PNG.

Suen et al. [14] show that how the curvature values can eliminate the effect of non-uniform inconsistency. They generated a method that is minimized the curvature value variations between the input images and the mosaicing image. The experiment showed that it could reduce conspicuous cutting curves. Moreover, even when there is severe geometric misalignment, by choosing an optimal cut between the input images, the induced artifacts become invisible. In addition, their methods provide an easy control of fidelity and transition smoothness by simply determining the area of using the minimization.

III. METHODOLOGY:

For stitching two images, need to detect the corners of each image. For corner detection we are using Harris corner detector and SIFT which is explained below :

1. Harris corner detector:

Harris corner detection algorithm was proposed by Harris C and Stephens MJ in the year 1988. It is an algorithm based on still image used for combined corner and edge detector. Reasonable amount of corner features are extracted which gives a better quantitative measurement by using a stable operator. A local detecting window in image is designed.

The average variation in intensity is determined by shifting the window by a small amount in different direction. The centre point of the window is extracted as corner point. The point can be recognized easily by looking at the intensity values within a small window. Shifting the window in any direction gives a large change in appearance. Harris corner detector is used for detecting corners.

On shifting the window if it's a flat region than it will show no change of intensity in all direction. If an edge region is found than it will show no change of intensity along the edge direction. But if a corner is found than there will be a significant change of intensity in all direct ions. Harris corner detector gives a mathematical approach for determining the region is flat, edge or corner. Harris corner technique detects more features and it is rotational invariant and scale variant.

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To extract corner can give prominence to the important information. Those can be described by equation below.

$$E(u,v) = \sum_{x,y} W(x,y)[I(x+u,y+v)I(x,y)]^2$$

.....(1)

......

Where,

- E is the difference between the original and the moved window.
- u is the window's displacement in the x direction .
- v is thewindow's displacement in the y direction .
- w(x, y) is the window at position (x, y). This acts like a mask. Ensuring that only the desired window is used.
- I is the intensity ofthe image at a position (x, y).
- I(x+ u, y+ v) is the intensity of the moved window.
- I(x, y) is the intensity of the original.

We've looking for windows that produce a large E value.

To do that, need to high values of the terms inside the square brackets. expand this term using the Taylor series.

$$E(u,v) = \sum_{x,y}[I(x,y) + uIx + vIy - I(x,y)]^2$$

...........(2)

tucked up this equation into matrix form

$$E(u,v) = [u\ v]\begin{bmatrix} Ix^2 & IxIy \\ IxIy & Iy^2 \end{bmatrix}\begin{pmatrix} u \\ v \end{pmatrix}$$

...........(3)

After that rename the summed-matrix, and put it to be M:

$$M = \sum W(x,y)\begin{bmatrix} Ix^2 & IxIy \\ IxIy & Iy^2 \end{bmatrix}$$

...(4)

Harris corner can be defined as the maximum in local area by the following formula:

$R = Det(M) – k\ Trace\ (M)^2$ .....(5)

Where,

$Det\ (M) = \lambda_1\lambda_2$ ....(6)

$Trace\ M = \lambda_1 + \lambda_2$ ....(7)

2. SURF (Speeded Up Robust Features):

As for the different methods of stitching, image registration fall broadly into three methods: gray information based, transform domain based and feature based. Among them, the feature-based image stitching technology is widely used because it has the quality of high time efficiency, maximum matching accuracy and good robustness.

Point feature is an important feature of the image in a various image features; it has the benefits of rotational invariance, not varying with changes in light conditions and high speed.

The common feature points are Harris corner detection, SIFT (Scale- Invariant Feature Transform) and SURF (Speeded Up Robust Features). For all above features has compared the commonly used local invariant features and found SURF feature detection is more effective than other feature detection. So in this project, we propose a fast stitching method based on SURF. It can be majorly divided into four steps: feature points extraction, feature points matching, determining the transformation relationship and image fusion.

3. SIFT descriptor :

SIFT was first presented by David G Lowe in 1999. SIFT algorithm is very invariant and robust for feature matching with scaling, rotation, or affine transformation.

We utilize SIFT feature points to find correspondent points of two sequence images. The SIFT algorithm is described through these main steps:

scale space extrema detection, accurate key point localization.

1) Scale space extrema detection:

First, we build the pyramid of image by continuous smooth with Gaussian mask. DoG (Difference of Gaussian) pyramid of the image will be obtained by subtraction adjacent smoothed images. By comparing each pixel of current scale with upper and lower scales in the region 3 x 3, i.e. 26 pixels, find the maximum or minimum value among them. These points are also considered as candidate of key point. The equations below will be used to describe Gaussian function, scale space and DoG.

$$(x,y,\sigma) = \frac{1}{2\pi\sigma^2 e^{-(x^2+y^2)}} \text{....(8)}$$

$$L(x,y,\sigma) = G(x,y,\sigma) * I(x,y)\text{....(9)}$$

Where * is the convolution operation in x and y.

$$D(x,y,\sigma) = G(x,y,k\sigma) - G(x,y,\sigma) \times I(x,y)$$
$$= L(x,y,k\sigma) - L(x,y,\sigma)$$
......(10)

2.Accurate key point localization:

The initial result of this algorithm, considers key point location is at the central of sample point. However this is not the correct maximum location of key point then, needed a 3D quadratic function to fit the local sample points to determine the true location, i.e. sub-pixel accuracy level of maximum value.

Taylor expansion of the scale space function is shifted so the original is at the sample point.

$$D(x) = D + \frac{\partial D^r}{\partial x} \times x + \frac{1}{2x^T \partial^2 D} / \partial x^2 \times x$$

.....(11)

Where, D and its derivatives are evaluated at the sample point and $x = (x, y, \sigma)\ T$ is the offset from this point.

The location of the extremum, $\hat{x}$, is determined by taking the derivative of this function with respect to x and setting it to zero, giving

$$\hat{x} = -\partial^2 D^{-1} / \partial x^2 \times \partial D / \partial x$$

.........(12)

The next stage attempts to eliminate some unstable points from the candidate list of key points by finding those that have low contrast or are poorly localized on an edge. For low contrast point finding, we evaluate $D(\hat{x})$ value with threshold. By substituting two equations above, we have: $\hat{x}$

$$D(\hat{x}) = D + \frac{1}{2} \times \partial D^{-1} / \partial x \times \hat{x}$$
....(13)

If the value of $D(\hat{x})$ is below a threshold, this point will be excluded. To eliminate poorly localized extrema, use the fact that in these cases there is a large principle curvature across the edge, but a small curvature in the perpendicular direction in the difference of Gaussian function.

A 2x2 Hessian matrix, H, computed at the location and scale of the key point is used to find the curvature. With these formulas, the ratio of principle curvature can be checked efficiently.

$$H = \begin{bmatrix} Dxx & Dxy \\ Dxy & Dyy \end{bmatrix}$$
.... (14)

$$(Dxx + Dy)^2 / Dxx \times Dyy - (Dxy)^2 < (r+1)^2 / r$$
......(15)

So if inequality (15) fails, the key point is removed from the candidate list.

IV. CONCLUSION

In this research work we have performed image stitching using two corner detection method namely Harris corner detector and SIFT descriptor.

The image stitcher provides a cost effective and flexible alternative to acquire panoramic images using a panoramic camera. The panoramic images stitched by a stitcher can also be used in applications where the camera is unable to obtain a full view of the object of interest. The full view of the object can be constructed using the image stitched using overlapping regional images acquired for the object.

Based on extracting invariant scale features, get potential feature matches for SIFT algorithm than that for Harris algorithm. SIFT can give better performance and when there are less rotations Harris corner detection algorithms can perform better.

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