Panoramic Image Construction Using Edge Pixels Connectivity

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Abstract

Panorama means constructing of high resolution images with large field of view than that could be obtained with a single photograph. The basic idea is to capture frames of different parts of a scene and then fuse the data from these frames, to obtain a larger image that includes additional information without any feasible seam or distortion in the overlapped area. The data is acquired by a relative motion between the camera and the scene, so each frame captures different scene part. Panoramic image construction includes three stages: image registration, focus sensing for the registered images, and image fusion that stitch the images at the overlapping location. To find the location of overlapping among the original images, this work suggests using the probability of similarity which is obtained through XORing the edge pixels of the images to be stitched. The modified method is tested with different image examples and the result show that this approach is successful in panorama construction with less time than the panorama image construction using correlation coefficient method.

1. Introduction

The photographs obtained from a camera may have a limited field of view (FOV). There may be data at the scene cannot be appeared at one image. Panorama creation in image processing is used to construct an image with a large field of view than that could be obtained with a single photograph. It refers to transforming and stitching multiple images capturing different scene parts into a new aggregate image without any visible seam or distortion in the overlapping areas. Some applications require complete panoramic image covering a large field of view. Panoramic image can be obtained by mainly two ways. First method is hardware intensive in which specialized lens cameras is used to directly capture panoramic views. The better method is to take many regular photographic images in order to cover the whole viewing space. These images then must be aligned and composited into complete mosaic (panoramic) images using an image stitching methods [STA08] [KEK08].

Panorama has long been used in variety of fields, such as optical observational astronomy, remote sensing, underwater research and photography computer vision, medical image processing, computer graphics and biometrics [STA08] [KEK08].

Panoramic image construction includes three stages: image registration, focus sensing for the registered images, and image fusion that stitch the images at the overlapping location.

Different approaches are suggested to construct the panoramic images; one of these approaches is image fusion. The source images are fused together to produce a panoramic image of the scene. All the objects of the fused image (resultant image) should have the same degree of clarity and sharpness. Kekre and Thepad [KEK08] suggest using Correlation Coefficient as a statistical test method to find the overlapping between two images, the panoramic image construction approach that is used is the block matching according to some test of similarity. Block matching requires block size adjustment, otherwise the panoramic image will be distorted. Li, Xu, Morrison, Nightingale and Morphett [LIY03] suggest constructing the panoramic image from MPEG Video using motion estimation. Forster, Ville, Sage, and Unser [FOR04] suggest using Wavelet as the fusion method of multichannel of microscopy images.

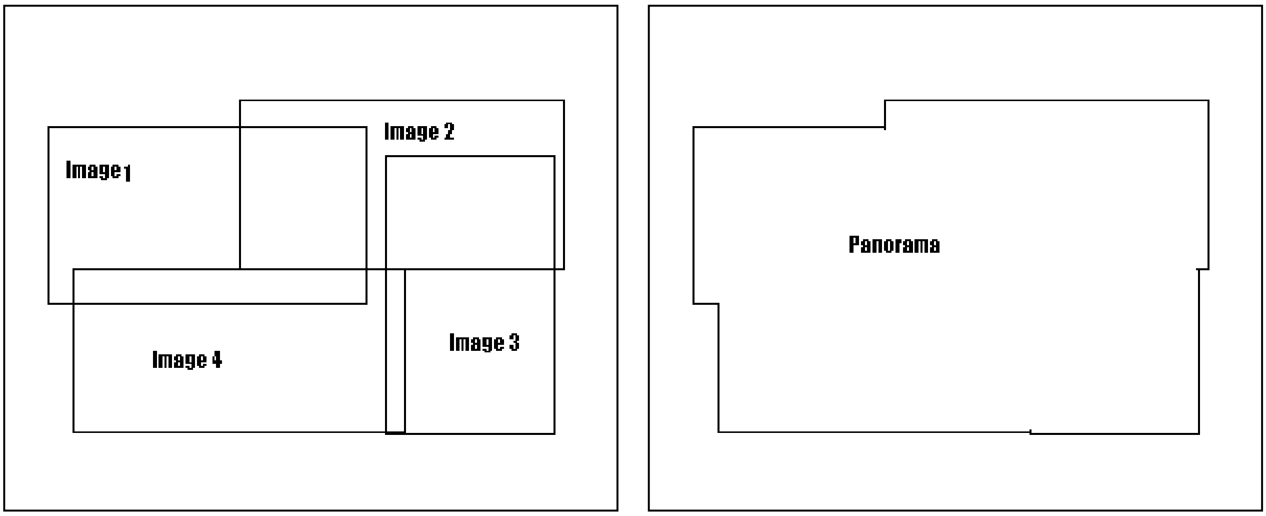
In this work, a row by row (column by column depending on the position of overlapping between stitched images image) fusion approach is used to perform the comparison among N of source images with low field of view and different depth of field to find the overlapping locations of images and then the overlapping location are compared together to find the sharpest overlapping location of these images later these images are stitched at the sharpest locations. The comparisons among the corresponding rows at all the consecutive images are achieved by the probability of similarity. The test of similarity that is used in this work is the probability of similarity which is obtained by XORing the edge pixels of each row after applying Sobol operator and thresholding to obtain binary image.

2. Camera's Limitations

There are two types of limitations can be seen in most cameras [JOH02] [STA08] :

2.1 Field of View

Most cameras cannot make very wide panoramas. The way to make a panorama is to take a series of photographs and connect them. This connection technique allows you to make an image with wide field of view (panorama) as shown in figure 1.



a)original overlapped images b) panoramic image

Figure (1) Panoramic Image construction a)original overlapped images b) panoramic image

2.2 Depth of Field

Depth of field refers to the region of proper focus that is available in any photographic image. When the camera is focused, it is not possible to get a paper-thin region of proper focus in an image; instead, there's some distance in front and behind the subject that will also be in focus. This entire region of sharp focus is called the depth of field, or sometimes the depth of focus. The region that is out of depth of field will be blurry. There are three factors determining the depth of field:

- **Aperture** which means the size of the lens opening that determines how much light reaches camera's imaging sensor.
- **Focal length** is the second factor which means a measure of the lens's ability to magnify a scene.
- **Subject distance** is the distance from the subject determines how much depth of field can be obtained in the scene.

These three factors work together in any shooting situation. Hence, depth of field is an extremely important element in the overall composition of photographs.

3. Panoramic Image Construction

The panoramic image can be constructed using three issues:

3.1 Image Registration

Image registration is a process of transforming two or more images into a geometrically equivalent form. The process brings into correspondence individual pixels in the images. Therefore, given a point in one image, the registration process will determine the positions of the same point in all the images. The key in achieving a highly accurate registration is to accurately locate corresponding landmarks in the images and use a transformation function that truly represents the geometric difference between the images. The transformation function either being linear so the methods were extended to handle translational and rotational differences between images, or nonlinear transformation function which were introduced to enable registration of images with local geometric differences by optimization methods through approximation, piecewise, or means [GOS07].

3.2 Focus Sensing For the Registered Images

As the second stage of panoramic image construction, the frame which is focused at each mosaic coordinate is needed to find. First, the focus criterions have to be defined. Since focus is associated with high sharpness, the sharpness criterion is maximized. Typically, an image that is in focus has a maximal number of visible details, while the defocused images are blurred [STA08] [FOR04].

3.3 Image Fusion

In this stage the mosaic image will be constructed by aggregating the sharpest images at each coordinate of the mosaic image which are selected at the second stage of processing. The location of overlapping estimation is the important step in panoramic image construction. The main goal of this step is to compare the consecutive source images to find the common regions. The block matching based technique for image fusion and a test of agreement to determine the location of similarity are commonly used for this purpose [STA08].

4. Proposed Panoramic Image Construction

In this work image fusion approach is performed by computing the probability of similarity to find the best overlapping locations among the source images to be stitched at these locations and the panoramic image is constructed.

The calculation of best overlapping location is achieved by the comparison between the reference image and the current image. If the current image is to the right of reference image then the last 10 columns of the reference image will be considered to be compared with the current image, otherwise if the current image to the left then compares the first 10 column of the reference with the current image. The comparison is performed by taking a vector of 10 elements along the 10 columns at the reference and current image and the test of agreement is applied on these vectors to compute the similarity between each corresponding vectors at the images, the sum of probabilities will be computed and the average value of these probabilities will be taken which represent the probability of overlapping to the current column, the current column probability in the first location in a vector and the 10 columns of current image is shifted one column to the left and the comparison is repeated until the end of the current image. At this point we will have a vector of columns probability. The largest probability value will be selected which determines the best overlapping location. Then the reference image and the current image are stitched together at this location to produce the new reference image and another current image is considered.

The proposed approach can be analytically described as follows:

The fused image is constructed by the union of the images:

$G(x, y) = \bigcup_{i=1}^{n} \left(F_{(i)}(x, y) \right)$

Where $i <= N$, N is the number of source images and $N > 1$.

The Fusion approach for panoramic image construction can be shown in the following algorithm:

Algorithm (1) : Panoramic image construction
Input: number (N) of source images Output : a panoramic image.
Step 1: determine the location of the reference image and determine the location of other images according to the reference image location. Step 2: apply edge detection method (Sobol) for N source images and threshold the gradient magnitude of the images to determine the binary image. Step 3 : select the reference image Step 4: for k=1 to N-1 (N:number of source images) Step 5: Current image=source image(k) Step 6: Compare current image and reference image to find the location of overlapping between them. Step7: Fuse the current image and the reference image at the location of overlapping to find a new image. Step 8: reference image= new image Step 9: goto step 6 Step 10: end.

The comparison between the reference and current images are achieved as shown in figure (2) and figure (3) :

……..	1	1	1	0	0	1	0	1	0	0	……..
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……..	1	1	0	1	0	1	0	1	1	1	……..
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Figure (2) two binary images representing current image and reference image

1	1	1	0	0	1	0	1	0	0

XOR

1	1	0	1	0	1	0	1	1	1

Result

0	0	1	1	0	0	0	0	1	1

NOT

1	1	0	0	1	1	1	1	0	0

Probability of similarity = 0.6

Figure (3) probability of similarity computation

5. Results

The proposed approach for panoramic image construction has been tested on example images.

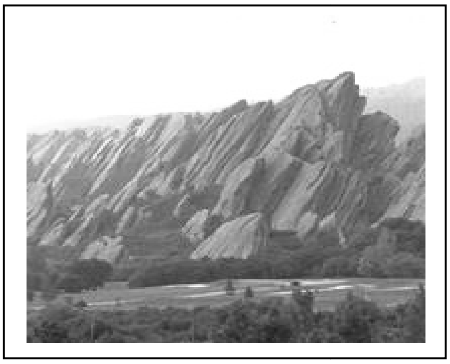
Figures (4-a and 4-b) show the original buildings images with size 200*200 pixels for each one of them. These two images have parts of the view. These two images are fused together to construct a panoramic image with wide field of the view. The resultant panoramic image is of size 345 * 200 pixels, and the overlapping between the two original views is found at the columns 45 the two Images are stitched at location to produce the panoramic view as shown in the figure (5).

a) reference building1 b) current bulding2

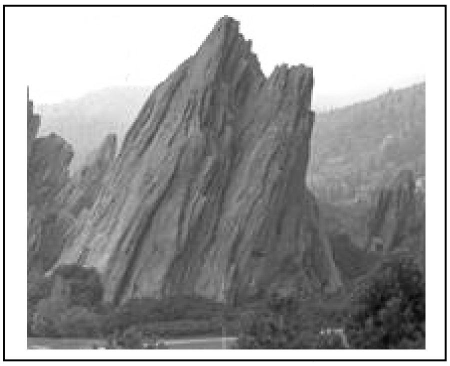
Figure (4) Source Images a) reference building1 b) current building2

Figure (5) Panoramic Buildings Image

Another example is the mount images, figures (6-a and 6-b) show the original mount images with size 200*200 pixels for each one of them. These two images have parts of the view. These two images are fused together to construct a panoramic image. The resultant panoramic image is of size 362 * 200 pixels, and the overlapping between the two original views is found at the columns 28 the two Images are stitched at location to produce the panoramic view as shown in the figure (7).



a) Reference mount



b) current mount

Figure (6) Source Images a) reference mount b) current mount

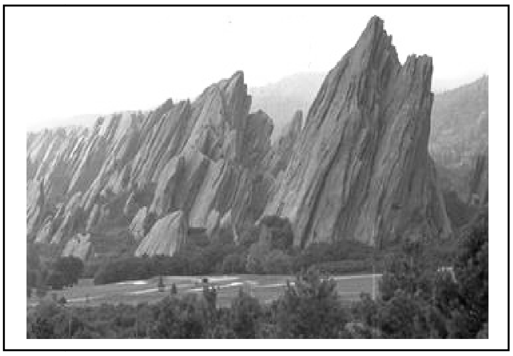


Figure (7) mount Panoramic Image

The example of mount is resolved using another approach where the test of similarity based upon the correlation coefficient with block size (3*3) and the result as shown in figure (8). This result shows that this approach requires block size adjustment.

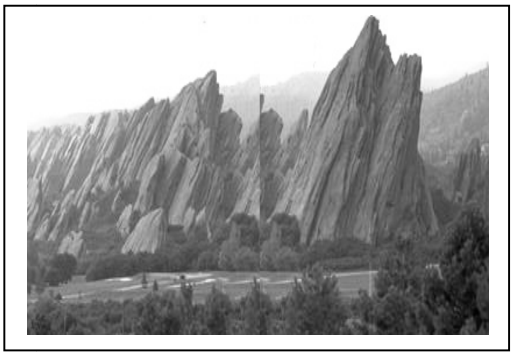


Figure (8) Mount Panoramic Image using auto correlation method with block size 3*3

There are some artifacts at the image in figure (8) as a result of the selection of improper value of the block size. Therefore, it is important to adjust the block size to reduce the artifact as much as possible.

The following example is the plain images, figures (9-a and 9 -b) show the original plain images with size 400*400 for each one of them. These two images have parts of the view but with blurring in one of them that is resulted from multi focusing on the main object of the image. The sharpest image is selected to be the reference image and overlapping will be selected according to sharpest part. These two images are fused together to construct a panoramic image. The resultant panoramic image is of size 597 * 400 pixels, and the overlapping between the two original views is found at the columns 197 the two Images are stitched at location to produce the panoramic view as shown in the figure (10).

a) plain reference Image

b) plain current image

Figure (8) Source Images a) plain reference Image b) plain current image ount2

Figure (10) plain result image

Table 1 shows the details of the different tests that are applied to the modified method of panoramic image construction:

Example	No. of images	Location of overlapping	Panoramic image size in pixels	Time using XOR	Time using correlation coefficient
building	2	45	345*200	3.32	5.61
mount	2	28	362*200	3.19	5.45
house	2	37	353*200	3.06	2.12
UAE	3	69 and 66	436*200	6.18	9.93
Plain	2	197	597 * 400		

6. Conclusion

To construct a panoramic image, this work suggests using the probability of similarity which obtained through XORing the edge pixels of the images to be stitched. The results that are obtained from this image is constructed with no seam due to brute transition between the data at the stitching location that could be occur if block matching approach is used instead of pixel matching approach which is used in this work. Therefore a precise determination of overlapping location is achieved in this work. The modified method is tested with different image examples and the result show that this approach is successful in panorama construction with less time than the panorama image construction using correlation coefficient method.

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