Performance Evaluation of Various Image Blending Algorithms

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Abstract: Image blending is measured as an energetic research part in image processing. It is a field that unifies more than one images of similar view into one blended image which is normally known as panoramic image. Researcher developed various algorithms for getting panoramic image: straight and feature based techniques. Straight techniques transform some selected pixel coordinates values and blend them with each other, whereas feature based techniques aim to set up an association among the images through individual features achieved from the training images. The second method has some perfection of being more robust, quicker, and has the aptitude to automatically determine the overlapping associations among a set of images. In this paper, we optimize the performance evaluation about those straight and feature based techniques of image blending. Through a lot of experiments, we investigate the potential of the algorithms' outcome through the quality of blended images.

Keywords: *Image Blending, SIFT, Harris Corner, SURF, Panorama*

1. Introduction

Basically, a picture blending is an artificial work shaped from a series of pictures. Blending of images can be produced by considerate the geometric association among all input images usually the co-ordinate system that impart to the various image orientation systems. Through using proper integration and transformation of overlying section of warped images, it is clear to make a panorama that is a big viewable picture of that particular scene; sometime it is also called blended image or stitched image, which contains the entire look of the scene.

Creating panorama was also practiced a very long before of digital computers. In 1839 the images were represented on topographical mapping for that images were captured from the top of the hills, were physically joined together. After getting an advance of airplane technology (1903) then it turned into a thrilling new field of aero photography. The early airplanes had very limited flying heights so it forced image processing experts to create panoramic images from overlapping images. As the satellites communication established to earth for sending and receiving images then the need of image blending increased. Finally, to solve such concerned issues it became naturally possible when a very rich development occurs in a field of computer technology [1].

Most general methods of image blending entail accurate overlaps among images and matching contact to produce a seamless panorama. The performance evaluation of panorama is measured by the similarity and the seams quality of the overlapped image with input images. As the utilization of panorama in real-time computing, is a tricky area for CV professionals. It has a broad field of use such as interactive panoramic viewing of images, clinical diagnosis, architectural demonstrations, satellite remote sensing images, geographical analysis and meteorological monitoring using images acquire from the real world [2]. The blended images are produced by images must have some geometrically alignment for better examination to extract the mapping points from input images for image registration.

2. Related Work

Jing Xing, Zhenjiang Miao in their paper [3] proposed an algorithm that exercises SIFT feature to blend two pictures. For that they apply the coordinates of the images as a substitute of interpolation. It reduced the unnecessary calculation. Through a lot of analyses they found that their algorithm has some good results as compared to earlier exercised algorithms.

Mathew Brown and David G. Lowe [4] in their research operate the SIFT algorithm for getting panoramic image. On extracting the key points of all input images; are matched with their overlapped images. Now to recognize the position of key-points, a feature scale and point of reference the DoG function is applied. As we know that SIFT key points are invariant of scale space, so this method can hold pictures with changeable point of reference (orientation) and zoom. To achieve the proper set of inliers the RANSAC algorithm is applied which are well-matched to homography of all images. Once matching pairs of key points are established between images a multi-band blending strategy is applied that guarantee a smooth transition between images, despite illumination difference to generate high-quality seamless panoramic image [5].

Monika B. Varma, Kinjal Mistree[6] proposed a combined method that use the SIFT and Harris corner detector. Harris method extracts the edges, corner and plane reign key points; after getting key points SIFT is applied to those key points [7]. As it is productive to use them mutually to acquire the advantages of both and to condense the disadvantage of each

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other that has shorter computing time. Further to filter out all inliers from key points a Random Sample Consensus homography is used to sense out the immoral matches for improving the constancy of the algorithm so that a faultless panorama is achieved.

Zhu Lin, Zhao Bo, Wang Ying, X Zhang in their paper [8] proposed a very swift image blending algorithm i.e. SURF. It has two stages; the first one is selector and second one is descriptor. In the first section SURF picks the Hessian matrix and calculates the discriminate of Hessian matrix. In second part the SURF descriptor computes the Haar wavelet outcome in both xy directions, for that a 5x5 sampling point must be received from every sub window. Further to condense the calculation and eliminate the repetition the RELIEF-F algorithm is applied [9]. It randomly chooses models from the set of data and modify feature vector to instruct the key point classifier. Finally for panorama a fusion algorithm based on threshold is applied..

3. Methodology

3.1 Projective Transform Algorithm

Projective Transform Algorithm is straight technique method that transforms some selected pixel coordinates values and blends them with each other. These key points are manually assigned by end-user. So for image blending process firstly select the reference points. Since this is a very sensitive work so a better way for this process that contains four pair points from image one and four pair point from second image so the total eight are the reference key points for this process. From all those x-y coordinates of selected reference key points the Projective transform is applied to compute the homography matrix. Through applying this homography, we projected 2nd image on the 1st image coordinate system. Finally, the both images are merged together to get the mosaic image.

Fig. 1. Blended image of MUET Admin Block by Projective Transform.

Fig. 2. Blended image of Muet Gate by Projective Transform

Fig. 3. Blended image of CASW MUET by Projective Transform.

3.2 Bilinear Interpolation

Another Straight technique based on comparing all selected (normally two key point) pixel values of images with each other. Straight technique decreases the compilation time and the complexity of algorithms. They are not scale invariant and can’t overcome the orientation issues. The merit of straight method is that they use selected pixel data obtainable in image association. However, the drawback of this technique is that it has a limited choice of convergence. Same like above method firstly, to select two reference points from image one and two from second image. Using the Bilinear interpolation method for interpolating of parameters (rows, column) on a rectilinear two-dimensional grid and used here as a re-sampling technique that apply the distance weighted average on certain nearest four pixel values to evaluate a reference pixel value. Basically, linear interpolation is applied in one direction and then in second direction. This algorithm is applied wherever image transformation is impossible with pixel matching. Finally, the both images are combined to get the mosaic image.

Fig. 4. Blended image of MUET Admin Block by Bilenear Interpolation

Fig. 5. Blended image of MUET Gate by Bilenear Interpolation

Fig. 6. Blended image of CASW MUET by Bilenear Interpolation

3.3 Harris Corner Detector Method

Here in this section for blending images we use random corner method to detect the Harris key point and apply an algorithm i.e. RANSAC for eliminating all outlier from received Harris key point and map out the all matched inliers finally stitch out that inliers point and get blended image.

A. *Feature Extraction*

To extract feature points by using an extractor after that through any local descriptor the feature points of all images are evaluated. Here the focus points are the lines, key-points, edges, and corners of images. These key-points must be different and expanded properly visible in both the images. The very important thing is that these points are constant with change in time and must not take any change in their locations during the whole process to obtain correct output.

In many applications, the speed of key point detection is critical part; connection between multiple images can be computed reliably and efficiently so the features are described separately. The efficiency of achieved key points of both images is determined by the output of feature extractor i.e. how accurate data it extract from the overlapping section. Here it is noticed that the key-points achieved from images must be suitably high, despite of the occurrence of noise, variation in geometry. Therefore, once all matching feature points are observed it would be helpful to overlap images to get blended image.

B. *Harris Corner Detector*

In 1988, an improved version of Moravec's corner detector was designed by C Harris and M Stephens like a low-level computing phase; to assist scholars struggling to form classification of the learning environment of robots founded on series of images [10]. Harris was attentive to use a CV system based upon motion investigation methods to conclude the situation of images applied by camera. Therefore, he developed a combined corner and edge detector whose outcomes are detecting more desirable in terms of extracting confident features and conclude the contents of an image. Due to the stability of a robust invariance to orientation, noise of image, illumination variation, and the scale; so, most commonly for interest point detector the Harris corner detector is used.

As this method is based on auto-correlation so also refer as auto-correlation. Where native deviations of the signals shifted normally by a tiny amount in different direction are computed by auto-correlation function [11]. The mathematical method is to consider the variation of intensity in all means. As expressed below in equation 1.

$$E(u, v) = \sum_{x,y} w(x, y)[img(x + u, y + v) - img(x, y)]^2 \quad (1)$$

Therefore to decrease the E(u, v), the matrix M should be like

$$M = \sum_{x,y} w(x, y) \begin{bmatrix} img_x img_x & img_x img_y \\ img_x img_y & img_y img_y \end{bmatrix} \quad (2)$$

Note that the Eigen values of matrix may be λI, λ2, we can compute the edge, corner and flat area of the image by using Eigen values. If the Eigen values of both λ1, λ2 are very small the points are called as Flat area, one of the Eigen values of λ1, λ2 is very small and other is bigger than points are called as Edge and Eigen value of λI, λ2 are very higher and mostly are identical to the points are called as corner.

C. *Image Registration*

In image registration stage, it is going to compute out that which image is a neighbor to another image from set of input images. So, in registration stage the set of images of matching target are taken from different sensors. Therefore, the times, Intensity and viewpoint may be different. This procedure builds the input images parameters into a similar co-ordinate system to accomplish a finest matching of pixel level.

Applying 2D arrays, img1(x, y) and img2(x, y), that symbolize the sensed and reference image, therefore the image registration stated as below:

$$img1(x, y) = g(img2(f(x, y))) \quad (3)$$

In above equation, for the 2D co-ordinates the global transformation model *f* is applied. The affine function states that the line of first image must be plotted out in same position of second image.

D. *Homography Computation*

After achieving the identical points from set of pictures know a set of inliers are required, for that mapping is applied to signify the association between two neighbor images of the same scene. Here Random Sample Consensus (RANSAC) technique [12] is applied for assessment of the parameters of image transformation. It selects any four feature pairs randomly then computes how many key-points match with defined tolerance. If the inliers points surpass from threshold value they are assumed as inliers and algorithms terminates otherwise it repeats it up to 500 times. .

E. *Image Blending*

In the closing stage to warp all matched images geometrically, is one of basic stage of concatenation along pair wise Homography. This is done by reference image defined by one of them. As the warping should be clean which means the points of reference image must mapped out to the points of candidate image without varying the parameters. Finally, the images are blended and adjust the gray levels to achieve a smooth output of panoramic image.

F. ***Results:***

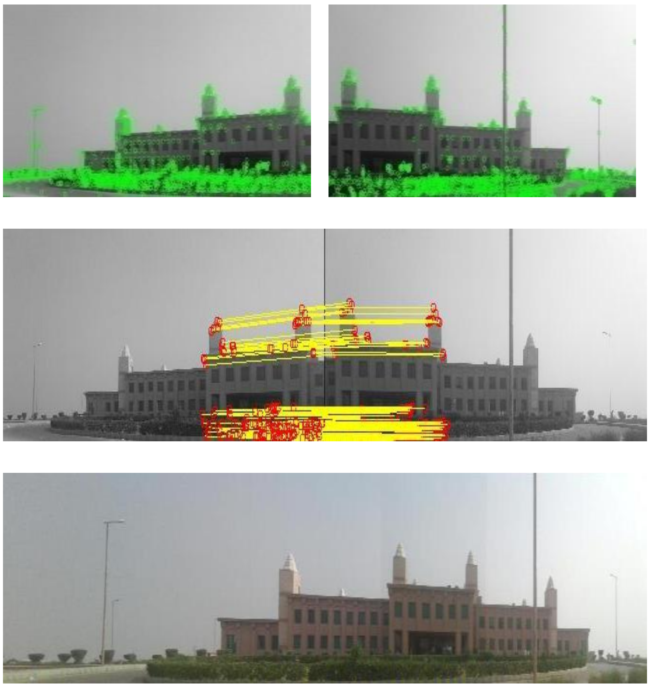

Fig. 7. Blended image of MUET Admin by Harris Corner

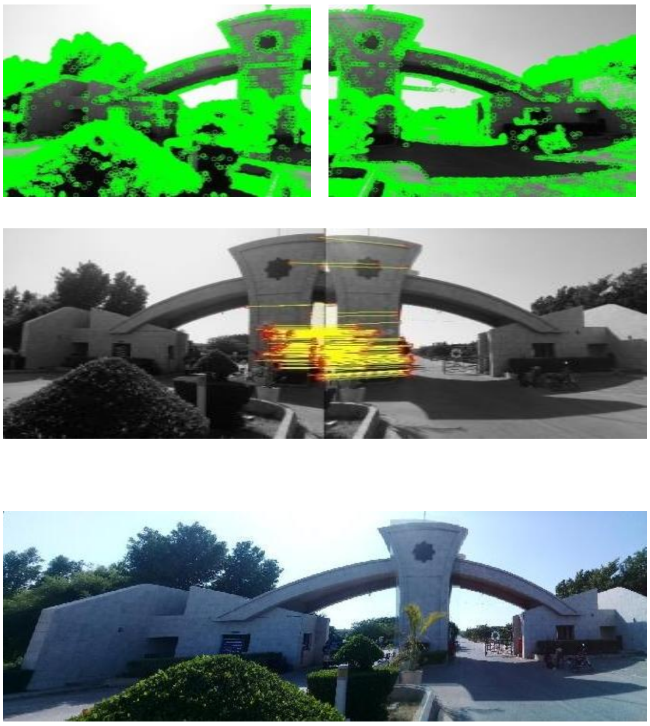

Fig. 8. Blended image of MUET Gate by Harris Corner

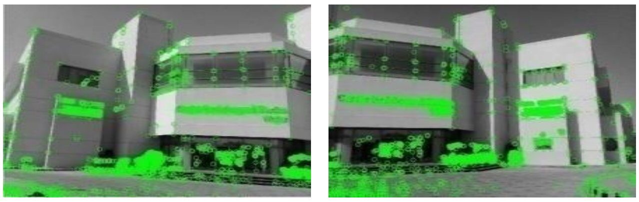

Fig. 9. Blended image of CASW MUET by Harris Corner.

3.4 Scale Invariant Feature Transform

Mr. D.G. Lowe has developed a feature extractor algorithm named as SIFT is in short. For local features of the image this algorithm is used to the detection and description. The detected feature points are perfect and solid; besides that, it is invariant about rotation and size.

A. ***Scale-Space Detection***

Here we have to find out the key points which are identifiable from different observation of same image by using scale space theory. It happens by applying convolution of Gaussian with given image. Therefore, to spot the constant key points from scale space; various methods are applied among them one is DoG method. The DoG is computed through the distinction of two nearby pictures having nearest scale difference one has likely *k* scale while other one has $D(x,y,k\sigma)$ scale.

B. ***Key Point Localization***

To find out the local maxima or minima from DoG; that are the model points individually match up with 9 neighboring in scale-up and down and 8 neighboring pixels of candidate image as shown in figure 10.

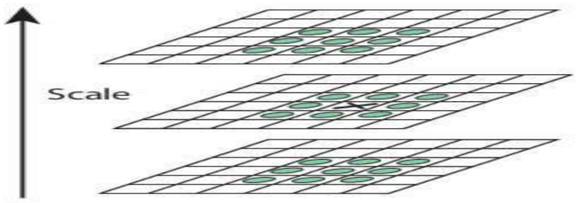

Fig. 10. Neighboring Pixels

Once local maxima or minima are detected the succeeding stage is to supervise the detail-fit of the position and scale. Therefore Taylor series is used and the apertures are perfectly examined as shown in equation 4.

$$D(x) = D + \frac{\partial D^T}{\partial x}x + \frac{1}{2}x^T\frac{\partial^2 D}{\partial x^2}x \quad (4)$$

Here the position of the extremum, $\hat{x}$, is calculated by getting the functions' derivative with respect to x as given below in equation 5.

$$\hat{x} = -\frac{\partial^2 D^{-1}}{\partial x^2}\frac{\partial D}{\partial x} \quad (5)$$

C. Orientation Assignment

It is observed that each key point has various orientation based on the gradient direction of image. All these orientation features are helpful when the object image has a rotation as compare to the reference image [13]. To accomplish the orientation; pixel differences is applied as described in equation: 6 and equation 7 simultaneously.

$$m(x,y) = \sqrt{(L(x+1,y) - L(x-1,y))^2 + (L(x,y+1) - L(x,y-1))^2} \quad (6)$$

$$\Theta\ (x,y) = \arctan\left(\frac{L(x,y+1)-L(x,y-1)}{L(x+1,y)-L(x-1,y)}\right) \quad (7)$$

D. Matching Points

Here in this stage for every feature points we have to generate a descriptor vector. The descriptor technically uses those set of 16 histograms having 4x4 grids, each of one has 8 bins and the range of each bin is 0-44 degrees. Therefore all 16 histograms of 4x4 grids have to collect 4x4x8 numbers of random orientation of bins; all these 4x4x8 bins points form descriptor vector [7]. The outcomes vectors are considered as SIFT key points are used k-d Tree Nearest Neighbor Search tactic to recognize probable objects in an image as shown in figure: 11. Finally, Alpha technique is used that create smooth blended panoramic image.

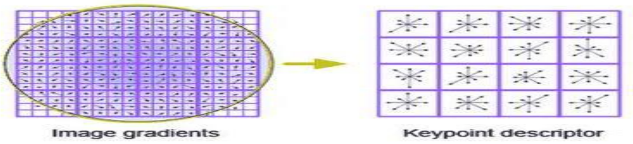

Fig. 11. DescriptorVector

E. Results

Fig. 12. Blended images MUET Admin Block by SIFT

Fig. 13. Blended image MUET Gate by SIFT

Fig. 14. Blended image CASW MUET by SIFT.

3.5 Surf Method

It is a feature extractor and descriptor also somewhat stirred by SIFT. In ECCV 2006 (European Conference on Computer Vision), H Bay represented SURF algorithm and the fundamental job of it is to select association between pictures of same view or anything which may be the component of any CV applications. 3D reconstruction, Camera calibration, image registration etc. SURF algorithm is faster than SIFT and more robust then other feature descriptor algorithms. Now a day SURF applied most of computer vision fields for image retrieval, object recognition, image stitching etc.

A. Interest Point Detection

Interest points are chosen from individual positions in the picture and SURF exercises Hessian-Matrix which is more constant and use local maximum to detect the features of image at their own scale. Furthermore, these candidates feature points are now tested and if the outcome is larger than the threshold value, then candidates feature point is evaluate with its 26 neighboring pixels. However, the excessive point is larger than the neighboring values then it is considered as a key point. Usually, picture with size of 1Mp have several key points. Let suppose $j = (x, y)$ in a picture $\boldsymbol{I}$ are the points, the Hessian result $H\ (j,\ \sigma)$ at j point and scale σ, is shown as equation 8:

$$H(j,\sigma) = \begin{pmatrix} Lxx(j,\sigma) & Lxy(j,\sigma) \\ Lxy(j,\sigma) & Lyy(j,\sigma) \end{pmatrix} \quad (8)$$

B. Matching Features

At the stage of matching features, SURF descriptor generates a window with feature points and partitions it in 4x4 secondary windows. Using that secondary window, it takes 5x5 sampling points for calculation of Haar wavelet response in x-y direction [14]. The basic idea is to break up the key points into two major modules; firstly, is the key feature points which are known for two objects to be stitched and secondly is the non- key feature points that have no effect on feature points so they are excluded from registration process. Therefore, two features set of binary features of the images are compared with each other for blending process. The method shows how nearest neighbors between features set one and features set two are found. However, to reduce the redundant key point from feature points because it causes low efficient results in image blending process. To overcome that issue distance limits are applied among extracted key points. So, the two feature vectors are going to be matched when the distance between them is found larger than the critical value and the key points are excluded if the distance between two key points is less than value here distance means Euclidean. By default for binary key points it is assigned as 10.0 or 1.0 for non-binary key vectors. This is donning for selecting perfect matches it shows the accurate distance from the perfect matched points as shown in figures 15.

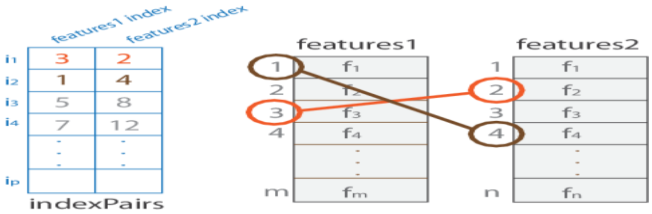

Fig. 15. Features set with index pairs of matched points

C. *Estimate Geometric Transform*

Geometric Transform is used to get 2-D geometric transform object. It maps the all inliers in matched points of image one and matched points of image 2. So now in geometric transform we have to overcome orientation issues for key points. For that, initially to calculate the Haar wavelet feedback in x-y directions of circle having radius 6scale where key points are detected. After the wavelet are examined and are weighted along with σ = 2s of Gaussian. The major responses are calculated to sum up all outcomes or point of reference window having π/3 in size as publicized in Figure 16.

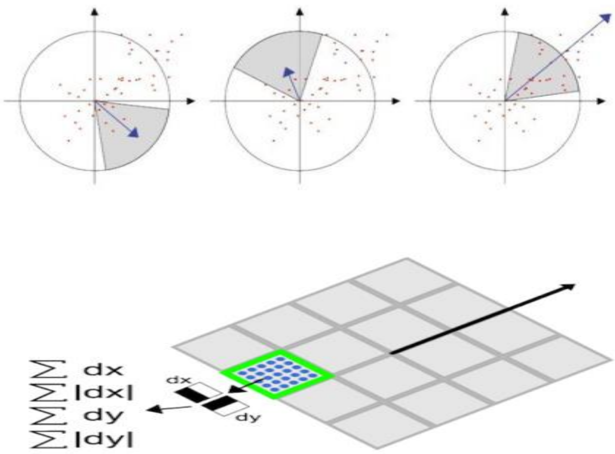

Fig. 16. Haar wavelet of π/3-degree circle

From 5x5 windows, the sampling values are chosen to calculate the wavelet coefficient of dx and dy. For more accurate toward localization errors and geometric deformation, the wavelet results are weighted with Gaussian. After that sum up the wavelet outcomes over each candidate region and generate the sets of entries in key vectors. For making that more helpful regarding the polarity in intensity alteration to examine the sum of absolute i.e |dx| and |dy|; here each candidate window has four dimensional vectors, and therefore a 64-dimensional vector (4x4x4) is found [15] as shown above in figure 16.

D. *Results*

Fig. 17. Blended image of MUET Admin Block by SURF Algorithm

Fig. 18. Blended image of MUET Gate by SURF Algorithm

Fig. 19. Blended image of MUET CASW by SURF Algorithm

4. Conclusion

The hope of this research is a performance evaluation of various image blending algorithms. Here various image blending algorithms have been compiled and evaluated their results in terms of SD, PSNR and SSIM.

Table.1. Evaluated Results of Projective Transform Algorithms

Sr. No	***Algorithm***	***SD***	***PSNR(dB)***	***SSIM***
Fig:1	***Projective Transform***	65	28	0.8
Fig:2		83	28	0.8
Fig:3		65	27	0.8
Fig:4	***Bilinear Interpolation***	62	29	0.8
Fig:5		83	29	0.8
Fig:6		56	28	0.9
Fig:7	***Harris Corner***	56	29.6	0.9
Fig:8		82	30	0.87
Fig:9		61	28	0.8
Fig:12	***SIFT***	60	30	0.9
Fig:13		70	31	0.9
Fig:14		57	28	0.9
Fig:17	***SURF***	41	32	0.98
Fig:18		65	32	0.99
Fig:19		53	33	0.97

Here it is found that some algorithms are consumed less time rather than other techniques i.e.

Projective Transform (PT)
Bilinear Interpolation (BT)
Speeded-Up Robust Features (SURF)

While among these algorithms Bilinear Interpolation (blend images by manually assign two key-points from each image) has poor results because their Standard Deviation is very high and Peak Signal to Noise Raton (PSNR) is low and Projective Transform (blend images by manually assigning four key-points directly from each image) has some satisfactory result but couldn't overcome the seams issues of blended image.

At the same time HCD is one of the most commonly used algorithms. It jointly detects the edges and corners but here it used for detecting only the corner points of images are the interest points. So, by using these points the pictures with same field of views are matched with each other. HCD is proficient algorithm and a rotation invariant but at the same time it fails to handle scale variation of pictures. It is jointly detecting the both edges and corners so it consumes some more time as compare to all other algorithms.

The SIFT algorithm, its most robust capability is that it enables reliable image matching with slight modifies in point of view, also towards the orientation and the zoom of the picture because it is scale invariant. It also detects highly unique properties of the set of pictures. That leads to the right entity recognition with minimum chance of mismatch.

But for illumination difference, the algorithm was observed the best is SURF. SURF also contains minimum time to implement. It also has good rotation and scale invariance property. Therefore, the resultant image verifies the superiority of SURF as compared to the SIFT and all other algorithms as in terms of PSNR, SSIM and SD.

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