Ramanpreet Kaur Journal of Engineering Research and Application www.ijera.com
ISSN : 2248-9622, Vol. 8, Issue 6 (Part -I) June 2018, pp 78-83

RESEARCH ARTICLE OPEN

Fusion Enhanced Image Stitching Using Dct and Dchwt

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ABSTRACT
Image fusion is the process by which two or more images are combined into a single image retaining the important features from each of the original images. In this paper, output of SURF and SIFT are used as input images that are further fused by using fusion algorithms DCT and DCHWT. The hybrid combination of DWT and DCHWT has increased the fusion window for the stitched image, which increased the fusion of visual data for a higher degree. The DCT component based decision mapping improved the fusion factor for combining the images in DWT domain by utilizing cosine energy map for whole image. The DWT with contrast and DCT element utilizes the high spectrum of values from its wide dimension filter bands and ensures frequency isolated fusion.

Keywords - Image Stitching, SURF, SIFT, RANSAC, Image Fusion, DCT, DCHWT

Date of Submission: 01-06-2018 Date of acceptance:16-06-2018

I. INTRODUCTION

Image stitching or mosaicing is a process of combining a number to images with overlapping field of view (FOV) to produce a panorama of high resolution. General cameras, which have low FOV can't generate image with higher FOV while mosaicing can help us achieve it. Two or more images can be stitched with each other uniquely without loss of information in an image with a greater FOV. It is commonly performed through the use of computer software; image stitching requires nearly exact overlap between images and produce seamless results. Various steps of image mosaicing are feature extraction, registration, stitching, warping and blending.

II. PANORAMA IMAGE STITCHING

An image mosaic is composed of a sequence of images and in can only be obtained by understanding the geometric relation between the images. The geometric relations are the coordinate system that relates the different image coordinate system. By warping operation image are transformed in such a way that a single image can be constructed from the input images, covering the entire visible area of the scene. The resultant image is the motivation for the image mosaicing. Various steps of image mosaicing are feature extraction, registration, stitching, warping and blending. For proper stitching it requires some common area between the images that are to be stitches [1].

Image registration is the process of overlaying two or more images of the same scene taken at different times, from different view point, and from different cameras. It is alignment of two images geometrically. It is needed as images may have different coordinates, so registration is used to align images to a single coordinate. Image registration is important for the tasks in which end results are obtained from the combination of information like in image fusion, image mosaicing, change detection and image restoration.

Registration methods can be divided into following types: algorithms that use image pixel value directly, e.g. correlation method [2]; algorithm that use frequency domain, e.g. FFT-based methods [3]; algorithms that use low level features such as edges and corners, e.g. feature based methods [4]; algorithms that uses high level features such as identified objects, or relation between features, e.g. Graph-theoretic methods [4].

Fig. 1: Images (A) and (B) represent Image Acquisition in same scene with different angles [6]

Feature extraction is important step in construction of any pattern and aims at the extraction of relevant information from the images. Feature extraction is process of retrieve most important data from raw data. Feature extraction is finding the set of parameters that define the shape of character precisely and uniquely.

A good feature set contains information which can discriminate one object from other objects. Features are of two types: Local features, which are usually geometric (e.g. number of end points, branches, joints, concave/convex parts etc) and Global features, which are usually topological (connectivity, projection profiles, number of holes etc) or statistical (invariant moments etc) [5].

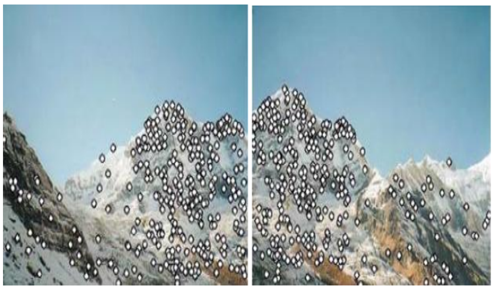

Fig. 2: Images (A) and (B) respresnt feature detection [6]

Homography is the mapping between two spaces which is often used to represent the correspondence between two images of same scene.

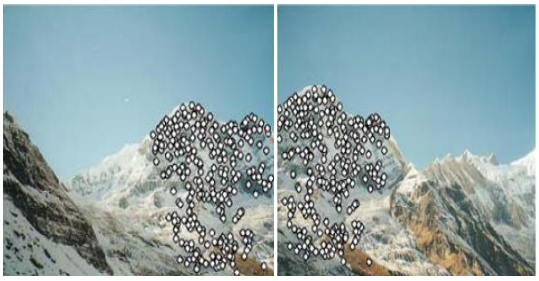

Fig. 3: Inliers after RANSAC between images (A) and (B) [6]

Image warping is used for removing distortion in the image. At this step, two images that are used to create panorama are warped by using the geometric transformation.

Image blending is the technique, which is used to obtain the smooth transition between images by removing the seams and minimize the intensity difference of overlapping pixels. A blended image is created by determining how pixel in an overlapping area should be presented.

Fig. 4: Final images resulting from the blending of the two consecutive images [6]

III. IMAGE FUSION

Image fusion is a process of combining the relevant information from a set of images into a single image, where the resultant fused image will be more informative and complete than any of the input image. Image fusion technique improves the quality and increase the application of these data. It is often not possible to get an image that contains all relevant objects in focus. One way to overcome this problem is image fusion, in which one can acquire a series of images with different focus settings and fuse them to produce an image with extended depth of field. The image fusion methods are broadly divided into two groups:

Spatial domain fusion: In spatial domain methods, it directly deals with the pixel value and every operation is performed on image works at its pixel level. The disadvantage of spatial domain is that it produced spatial distortion in fused image. The techniques that come under spatial domain are given as:

- Average Method
- Principal Component Analysis
- IHS Transform
- High Pass Filtering

Transform domain fusion: In transform domain methods, image is first transferred into frequency domain. It means Fourier transform of the image is computed first. All the fusion operations are performed on the Fourier transform of the image and then inverse Fourier transform is performed to get the desired results. Advantage of frequency domain over spatial is that it handles spatial distortion very well. The techniques that come under transform domain are as:

- Discrete Wavelet Transform
- Stationary Wavelet Transform
- Discrete Cosin Transform

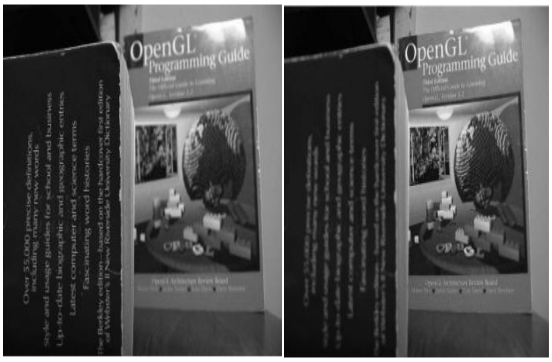

Fig. 5: Input images of same scenario with different planes in focus used for fusion [31]

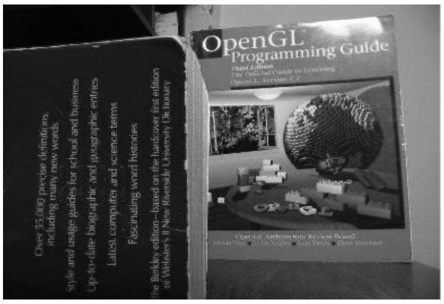

Fig. 6: Output image obtained by fusion [31]

IV. LITERATURE REVIEW

Image moasaicing or stitching combined multiple correlated images to obtain a image of greater field of view (FOV) and it can only be obtained by understanding the geometric relation between images. Generally cameras have low FOV so can't capture a large FOV while mosaicing can help us achieve it. Numerous mosaicing algorithms have been proposed and application of the algorithms depends upon the quality of desired results.

Vimal Singh [8] presented a technique regarding feature-based graphic mosaicing using graphic fusion the spot that the suggestions pictures tend to be stitched jointly when using the popular stitching algorithms. To be able to draw out the most beneficial functions merely from the stitching outcomes, the blending procedure is performed with wavelet Enhance (DWT) when using the greatest collection tip regarding equally approximate and also detail-components. Your robustness and also good quality on the previously mentioned mosaicing methods tend to be examined with three-dimensional rotational pictures. The functional analysis of suggested method is performed with regards to PSNR (peak signal-to-noise ratio), FSIM while High quality Calculate regarding Merged likeness, MI (Mutual Information), EME (Enhancement functionality measure), NAE (Normalized Absolute Error) and also SD.

Barbara et al.[9] classified image registration as feature based and area based methods. Area-based method is preferred, when the images do not have much detail information and if the gray level provided are to be distinctive rather than local objects, shapes and structures. Feature based methods are recommend, when the images may have sufficient image features and predictable objects. In this method, different image features such as region features, line features and point features are used for registration. Line feature has representations of line segments, costal lines, object contours. Manjunath et al.[10] proposed register images from multiple sensors by contour based approach. The success of their method depends on the assumption that the similar structures of images must be preserved well. Therefore their method is efficient only when contour information is well preserved.

H.Bay et al., [11] proposed a novel scale and rotation invariant detector and descriptor called Speeded Up Robust Features (SURF), which is believed to have high speed in the feature detection steps: detection, description and matching. This detector is much faster than SIFT in terms of feature extraction. This algorithm is illuminance invariant. It is mostly used in real time computation without loss in performance, which represents an important advantage for many online computer vision applications.

V. PROBLEM FORMULATION

In proposed research work, the image stitching process is formed using the modified SIFT and SURF feature detectors with RANSAC as an inliers detector for selecting the optimum features in both the images which are to be stitched. In the previous work, the same system was applied for stitching the images but a fusion system based on DWT to enhance the final output results. This system used frequency domain decomposition of both SIFT and SURF to obtain images which were then fused using DWT.

The fusion of the two output images resulted in a better image than the SURF and SIFT alone and is compared with original image. In order to improve the quality of the fusion output, the proposed research work used high end fusion scheme utilizing wavelet with DCT and Hierarchical wavelet with DCT mapping for discrete components. Therefore, applying this technique proposes to improve the spatial match between the images to be fused. It also promises to improve the fusion factor merging the two images and have a better resultant and artifact reduced. The accuracy of the proposed system is measured using different spatial parametric measures.

VI. FUSION ENHANCEMENT TECHNIQUES APPLIED

First step involve the preprocessing of the sub-images i.e. conversion of images from RGB to gray scale. Then decompose the image using wavelet transform in to frequency band namely a lower-frequency band and the other higher frequency-band.

I.1 DCT

Wavelet can be described as the combination of the two scaling functions i.e. f(t), also known as father wavelet and the wavelet function or mother wavelet ψ(t). Mother wavelet goes through several alternations and scaling to give synonymous wavelet families as in Eq. (1).

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}}\psi\left(\frac{t-b}{a}\right) \text{for} (a, b\epsilon R), a > 0 \quad (1)$$

Where a and b are the scale and translation parameters respectively given by Eq. (2).

$$a = a_0^j, b = m a_0^j b_0 \quad \text{for } (j, m\epsilon Z) \qquad (2)$$

Thus wavelet family can be represented by Eq. (3) $\psi_{j,m}(t) = a_0^{-\frac{j}{2}}\psi\left(a_0^{-j} - mb0\ for\ (j,m\epsilon Z)\right.$ (3)

Once the source images are decomposed using wavelet transform, the approximation and detailed coefficients are obtained, DCT is used to fuse them together.

Discrete cosine transform is important transform in image processing. DCT coefficients are highly concentrated in low frequency region, having excellent energy compactness properties. 2D discrete cosine transform of Z (u, v) of an image of size MxN is defined as:

$$Z(u,v)a(u)a(v)\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\frac{z(x,y)}{cos\frac{\pi(2x+1)u}{2M}}cos\frac{\pi(2y+1)v}{2N} \quad (4)$$

where $0 \le u \le M-1\ \&\ 0 \le v \le N-1$

$$\alpha(u) = \begin{cases} \frac{1}{\sqrt{M}}, & u = o \\ \sqrt{\frac{2}{M}}, & 1 \le u \le M-1 \end{cases} \quad \text{and}$$

$$\alpha(v) = \begin{cases} \frac{1}{\sqrt{N}}, & v = o \\ \sqrt{\frac{2}{N}}, & 1 \le v \le M-1 \end{cases}$$

u & *v* are discrete frequency variables and (*x*,*y*) are pixel index

Similarly, the 2D inverse discrete cosine transform is defined as:

$$Z(x,y)a(u)a(v)\sum_{u=0}^{M-1}\sum_{v=0}^{N-1}\frac{\alpha(u,v)Z(u,v)}{cos\frac{\pi(2x+1)u}{2M}}\ cos\frac{\pi(2y+1)v}{2N} \quad (5)$$

where $0 \le x \le M-1\ \&\ 0 \le y \le N-1$

4.2 DCHWT

DCHWT is proposed to retain the visual quality and performance of fused image with reduced computation. Performance of DCHWT is compared with both convolution and lifting-based image fusion approaches and it is found that its performance is similar to convolution and superior/similar to lifting-based wavelets. In DCT, due to the generation of symmetric periodic sequence signal moves smoothly form one period to other. Like DFT, the DCT does not suffer from leakage effects.

Wavelet transform $W_c(a, b)$ of a symmetric signal $x_s(t)$ and a real symmetric wavelet function $\varphi_s(t)$ is given as:

$$W_c(a,b) = \frac{|a|^{\frac{1}{2}}}{2\pi}\int_{-\infty}^{\infty} X_s(\omega)\varphi_s\,(a\omega)\cos(\omega b)\,d\omega \quad (6)$$

Where $X_s(\omega)$ and $\varphi_s(\omega)$ are the cosine transform of $x_s(t)$ and wavelet function $\varphi_s(t)$, respectively. $W_c(a,b)$ is wavelet transform in cosine transform rather than Fourier domain and *a* and *b* are scaling and translation parameters.

Therefore, the WT coefficients for a particular scale *a* can be obtained by inverse cosine transform of the product of $X_s(\omega)$ and $\varphi_s(\omega)$. That is,

$$W_c(a,b) = |a|^{\frac{1}{2}}C^{-1}[X_s(\omega)\varphi_s(a\omega)] \quad (7)$$

$\varphi_s(\omega)$ is zero for all frequencies except for a small frequency band where it is constant, that is,

$$\varphi_s(\omega) = \begin{cases} 1, & \omega_c - \omega_0 < \omega < \omega_c + \omega_0, -\omega_c - \omega_0 < \omega < -\omega_c + \omega_0 \\ 0, & elsewhere \end{cases} \quad (8)$$

In DCHWT, signal is composed by grouping the coefficients of DCT in similar way to that of DFT coefficients except for conjugate operation in symmetrically placing the coefficients.

V. METHODOLOGY

The proposed work (Fusion enhanced image stitching DCT and DCHWT) uses the output stitched image of two different system and then a fusion system which will improve the quality of the image stitching process. The feature extraction, feature matching and image merging are the basic processes for fusing the images. The below given points provide the detail on the flow of the flow of the methodology:

Step 1: To select the images to be stitched which have a common vertical and horizontal plane.

Step 2: To initialize image preprocessing before image stitching.

Step 3: In order to stitch the images SIFT and SURF descriptors are used.

Step 4: To use the common features between two images which are to be stitched.

Step 5: To filter out the common features and reduce the features to a set of two or three inliers for each image.

Step 6: To perform image stitching using RANSAC and homography projection.

Step 7: To perform fusion of the fused data from SURF and SIFT together and obtain a final blur free image data.

Step 8: Repeat the above steps for difference images which have one vertical or horizontal line.

Step 9: Evaluate the fusion result with the original image and perform evaluation on the basis of matrices like PSNR, NAE, FSIM, MD and entropy.

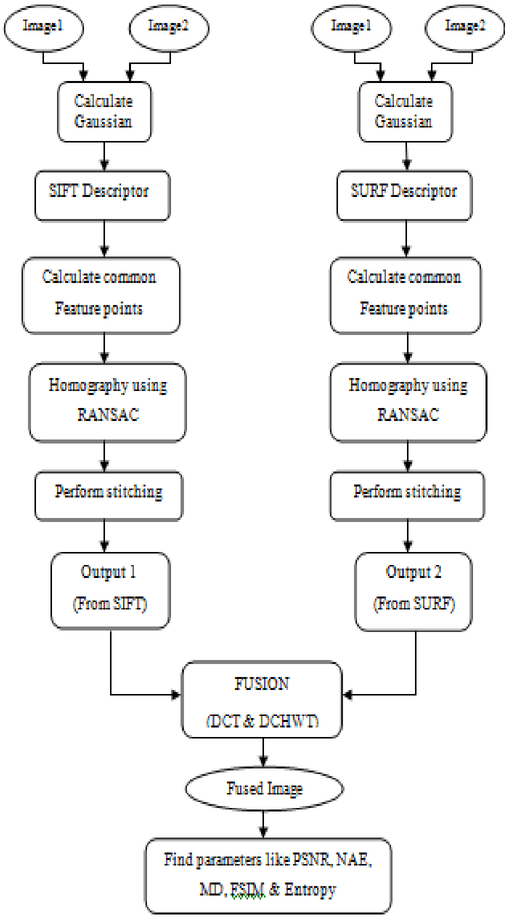

Fig. 7: Proposed methodology

VI. PARAMETERS

Both objective as well as subjective performance evaluation has been a crucial part of image quality evaluation process. Here, the simulation resultant image quality is verified in terms of PSNR, Feature Similarity Index (FSIM), Normalized Absolute Error (NAE) , entropy and maximum difference.

6.1 Entropy

The entropy of a system as defined gives a measure of uncertainty about its actual structure. Shannon's function is based on the concept that the information gain from an event is inversely related to its probability of occurrence.

$$\eta = H(s) = -\sum_{i=1}^{n} p_i \, log_2 p_i \qquad (9)$$

6.2 PSNR as Quality measure

Peak signal-to-noise proportion, frequently condensed PSNR, is a designing term for the proportion between the greatest conceivable force of a sign and the force of tainting commotion that influences the devotion of its representation. Since numerous signs have a wide element range, PSNR is typically communicated as far as the logarithmic decibel scale.

$$PSNR = 10log_{10}\left(\frac{R^2}{MSE}\right) \qquad (10)$$

6.3 NAE (Normalised Absolute Error)

It can be used for image quality metric and formulated as:

$$NAE = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(|A_{ij} - B_{ij}|)}{\sum_{i=1}^{m}\sum_{j=1}^{n}(A_{ij})} \qquad (11)$$

Where, A- perfect image and B- fused image to be assessed.

6.4FSIM (Feature Similarity Index)

For combined similarity

$$S_L(x) = [S_{PC}(x)][S_G(x)] \qquad (12)$$

$$PC_M(x) = \max(PC_1(x), PC_2(x)) \qquad (13)$$

$$FSIM = \frac{\sum_{x \in \Omega} S_L(x) PC_M(x)}{\sum_{x \in \Omega} PC_M(x)} \qquad (14)$$

6.5 MD (Maximum Difference)

The large value of Maximum Difference (MD) means that image is poor quality. It is defines as follows:

$$MD = Max(|x(m,n)| - |\hat{x}(m,n)|) \qquad (15)$$

Table 1: Performance analysis of DWT with proposed methods DCT and DCHWT

Algorithm/ Parameters	DWT	DCT+DWT (Proposed)	DCHWT (Proposed)
Entropy	22699	347548	189566
PSNR	38.9893	62.6895	57.4244
MD	1.0671	0.9996	0.9999
NAE	0.0707	0.0187	0.0103
FSIM	0.9867	0.9703	0.9867

VII. RESULTS

Fig. 8: Input images

Fig. 9: Fused image using DCT

Fig. 10: Fused image using DCHWT

VIII. CONCLUSION

The input images are stitched using the most popular stitching algorithms i.e. SIFT and SURF. The output of both the algorithms is blend by using the fusion algorithms; DCHWT and DCT, to get the most robust results. The panoramic image generated by the fusion algorithm compensates the complementary features and boost up the common features of individual stitched images. SURF algorithm has the distinctive property of illumination invariance along with good scale and rotation invariance property, whereas, SIFT is most effective algorithm for scale and rotate image stitching. But it cannot cope with illumination variation. Therefore, the resultant image proves superior as compared to SIFT as well as SURF algorithms in terms of PSNR, NAE, FSIM, entropy and maximum difference.

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Ramanpreet Kaur "Fusion Enhanced Image Stitching Using Dct And Dchwt "International Journal of Engineering Research and Applications (IJERA) , vol. 8, no.6, 2018, pp.78-83