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A Survey on Image Fusion Techniques

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***Abstract*—The intention of image fusion is to assimilate complementary and redundant information from innumerable images to create amalgamated image which holds a superior justification of the extract (original image) than any of the individual home images [20]. The subsequent and final fused image will be added helpful for individual pictorial perception and visualization. Image fusion shows imperative roles in different fields such as remote sensing, biomedical imaging, computer vision, security system, satellite imaging, and cybernetics [26]. This paper offers a literature review on diverse types image fusion techniques both in spatial and transform domain. The performance metrics used to measure the image quality after fusion is also discussed.Judgment of all the techniques concludes the better advancement for the future investigation.**

***Index Terms*— Image fusion, performance metrics, spatial and transform domain.**

I. INTRODUCTION

An image seized by the camera, the captured image only have the precise entities within the depth of field of the camera are absorbed, while supplementary bits and pieces are blurred and it will be out-of-focus. Some visual lenses with extended pivotal lengths will suffer the problem of restricted depth of field so most of the times getting all-in-focus image is slightly difficult. To overcome this problem one of the feasible solution is to gather numerous pictures captured at different focus points to output all-in-focus image by using image fusion techniques. Image Fusion technique defines a procedure of extracting the statistics from 2 or more different image, where the resultant fused image will be more revealing and absolute than any of the input source images. The image fusion methodologies will helps in getting better quality and boost up the fused image features with enhanced consistency and a reduced amount of volume to store the final image. Resultant fused image will have more information than the statistics in the multiple image sources. In addition, merged image will be responsible for robust operational presentation such as improved assurance, condensed ambiguity, better trustworthiness, decreased uncertainity and enhanced taxonomy. There are 3 altitudes for image abstraction i.e. pixel, block (region based) and feature level [19] but associate to all the levels of image abstraction block for region based abstraction contributes better outcome.

A. Image Fusion Forms

Image fusion methods are characterized [23] based on the fusion progression and function.

- *Multi-view fusion***:** In this procedure images from the identical modality are in use at the same interval but from different viewpoints under dissimilar circumstances to stream corresponding

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information from diverse views.

- *Multimodal fusion***:** In this system of fusion process images are fused by taking from different modalities.
- *Multi-temporal fusion***:** Images occupied at different intervals predominantly to distinguish fluctuations among them or to blend with convincing images. The goal of fusion is to incorporate complemenatry and redundancy to provide a composite image which helps in better understanding of the entire scene.[27]
- *Multi-focus fusion***:** Images captured constantly with different focal lengths so that the resultant fused image will have the all feature in one all-in-focus image.

Image fusion process goes with 3 major phases i.e. image registration, pre-processing and post-processing. Fusion algorithm is usually applied after the pre-processing step such that sources used for fusion process should always refer to familiar fundamental event [25]. Any image fusion algorithm must convince two main necessities. First- identification of the supreme significant features in the input images and during the fusion process no data should be misplaced or lost. Next requirement is the fusion method should not transmit any inconsistency or artifacts, which would distract the spectator. The applications of image fusion are object identification, classification, change detection, medical imaging, intelligent robots, military and law enforcement.Section 2 delivers the literature survey on different image fusion practices both in spatial and transform domain. Section 3 discusses the metrics to measure the quality of image after fusion. Section 4 concludes the improved approach for further research work.

II. Review of Recent Literature

[1] T.Wan, C. Zhu and Z. Qin, proposed a technique where source image will be decomposed into primary and sparse conditions using RPCA. This method is smeared and verified on both gray scale and colored images. RPCA technique helps to differentiate concerning concentrated and dweak states by sinking the artifacts which is blocking the image quality during the fusion process. Image quality is evaluated using MI, SSIM and PetroVic's quality metrics

[2] TanishZaveri and MukeshZaveri projected a region based merging technique which tracks 2 steps with different fusion rules and it is functional at 2 stages. This 2-step method avoids the data damage and increases the robustness of the image with a reduced amount of noise disturbing to the resultant image and performs better than pixel based methods. This method helps extract more information from distracted area using segmentation. And the image quality is assessed by subsequent metrics such as Entropy, SSIM, QI, MI, and RMSE.

[3] Y.Liu et al. describes a multi-focus fusion technique using dense SIFT descriptor for feature recognition, taxonomy, image based matching and tuning rule. Dense SIFT can do detection only in densly sampled locations apart from identified interest points, which intends to split the image into intersecting cells before smearing Histogram of oriented gradients(HOG) to pronounce them. During the post-processing phase the tentative pixels which do not fit to any of the concentrated regions that will be pass on to the indefinite regions from the final image will give better visual perception. The technique is evaluated by the following metrics such as QMI, QNCIE, QG, QP)s, Yang's fusion metric (QY), Chen-Blum metric (QCB).

[4] Q.Ziang and B.Guo proposed a multi-focus merging procedure using NSCT technique because of the resulting benefits such as multi-scalability, property for localization, multi-directionality, and shift-invariance. By using these Quality metrics like Emse, difference coefficient (dDC) and mean structural similarity (MSSIM) which helps in the comparsion with other wavlet based methods. From the comparsion result NSCT based method will give better end result even though image is not enumerated accurately.

[5] NishaGawari, Dr. Lalitha.Y.S describes proportional study of PCA, DCT and DWT fusion techniques by evaluating by the following metrics such as emse, PSNR, average difference, structural content, normalized cross correlation, maximum difference and normalized absolute error. From the comparsion learning PCA& DCT established image blending technique can be used for presentations which do not need extraordinary eminence & accuracy. But DWT based techniques offers high feature in the final image which is not obtained in PCA & DCT methods.

[6] UjwalaPatil, examined on 3 major types of image fusion techniques. The performance analysis describes out of 3 types of image fusion method multi-modal image fusion gives better outcome. This result is obtained by combining pyramid, wavlet and PCA fusion algorithm. This combination benefits for good resolution and

multi-scalablity. The following metrics used for evaluation are SF, ENTR, SD, cross entropy, FMI, SSIM, quality metrics (QM1 and QM2).

[7] Sruthy S, Dr. LathaParameswaran and Ajeesh P Sasi proposed dual-tree CWT instead of DWT because of its shift invariance and directional selectivity. The square off degree of a specified complex wavelet coefficient delivers an accurate measure of spectral energy at a particular location in space, scale, and alignment. It also means that CWT-based algorithms will automatically be almost shift invariant, thus sinking many of the artifacts of the critically tested DWT.Directional properties of DT-CWT will be attained with 2 level disintegration. And the excellence of the fused image has been evaluated using a set of quality metrics i.e, mse, psnr, md, lmse, ncc, ssim.

[8] H.Li projected multi-focus image fusion procedure by disintegration of sparse and morphological filtering. During the decomposition process sparse features in the source images are removed in the foundation stage so that blocking artifact will not be induced in the final image. Then to eradicate the patched or blacker region is tarnished by morphological filtering procedure. This 2 step method consumes moderately less runtime interval and results fused image with senior distinction. Performance evaluation is carried out based on altitudinal frequency, mean gradient, statistical entropy and mutual information.

[9] R.Vijayarajan and S.Muttan proposed a scheme based on averaging of principal components. Through DB3 wavelets the base image is disintegrated to 2 or more ranks. Middling the principal constituents at the decomposition stage every part will get the weight and it is equated and interrelated to the decomposed components. This decomposition stage is achieved using DWT based methods. Finally performance evaluation is done by using MI, QI, PSNR & Hossny, Nahavandi-Creighton metrics.

[10] Pinakin Suryavanshi planned an algorithm using bi-orthogonal wavelets by associating with scaling functions and filters for evaluation. This algorithm is applied mainly to get all-in-focus image.To calculate fused pixel value, weighted average of the source pixels determined by launching parent-child affiliation among the pixels at diverse planes of multi-resolution decomposition. This work considerably increases the feature of the fused image using Petrovic parameters.

[11] S Rajkumar, S Kavitha describes the benefit of using RDWT and contourlet transform methods. DWT based methods give raise to many consequences like shift variance and accumulation of redundanat noise in the final image.RDWT fusion method can overcome the disadvantages of DWT and efficiently performing registration for dissimilar modality seized at dissimilar instances.Contourlet transform fetch softness in fused image which was not achieved in DWT method.The algorithm are assessed with different quantifiable metrics such as SD, EN, OCE, RSFE, and PSNR.

[12] Jing Tian, LiChen, Tian J and Li Chen decribes the algorithm and compared with 4 prototypes i.e Gaussian, Laplacian, Gaussian mixture, Laplacian mixture model. The adaptive laplacian blend model is used for allotting the wavelet coefficients and sharpness score which helps in putrefaction in turn achieve the fusion process adaptively in the wavelet domain. Trials are accompanied by means of three groups of test images under three intention metrics to reveal the superior execution of the projected methodology.

[13] Shutao Li, Bin Yang, Shutao L, Yang B combined wavelet and curvelet tranform to attain multi-focus image fusion. Wavelets will not give promising result for protracted curves and curvelet techniques are not good at undersized features. In proposed algorithm fused image is obtained from 2 platforms starting with decomposition of registered images via curvlet and extracted coefficients are fused using wavlet.Original image is reconstructed by performing the converse curvelet transform. Performance metrics used for excellence assessment are EN and SF.

[14] Parul Shah, Srikanth.T.V, S.N.Merchant and U.B.Desai, proposed a fusion rule by means of average weights which helps in combining multi-focus image in wavelet domain. Weights are deliberated for each pixel in the image which are in the enriched resolution bands. Proposed algorithm has a bigger impression on contour part of the image for which more weightage with sharper locality is obtained.Metrics used for quality assessment are entropy, MI, fusion symmetry, SD, QABF, LABF, NABF, MSE, and CORR.

[15] Kusum Rani, Reecha Sharma, describes multi Resolution fusion using wavelet which helps in renovation at multi-scale for the demonstration of the resource images. Multi-wavelet investigation can contribute more fixed image scrutiny than wavelet multi-resolution analysis. Two dissimilar modality images are fused using the highest fusion rules based on the Multi-Wavelet and wavelet transforms. Qualitatively multi-wavelet transform furnish superior performance than wavelet by providing fine edge and periphery trails.

[16] XiangzhiBai, Yu Zhang, Fugen Zhou and BindangXu, planned a proficient disintegration strategy where, the base images are putrefied into wedges with finest sizes in a quadtree composition. The focused

regions are detected by using sum of the subjective modified Laplacian. At last, the concentrated regions could be well extracted from the resource images and reassembled to fabricate solitary focused image.

[17] SilviuIoanBejinariu, Florin Rotaru, Cristina Diana Niţă, Ramona, projected an equivalent stratergy for the multifocus image fusion schemes based on the morphological wavelet transform and spatial occurrence. It is based on the shared memory parallelization representation which may be effortlessly implemented on the general multicore processors and can process more than two multifocus source images at a time.

[18] Haochen Pang, Ming Zhu and LiqiangGuo proposed multi-focus color image synthesis algorithm constructed on quaternion wavelet transform to resolve the image clouding trouble. Anticipated procedure is compared with SWT, IHS and SML methods via objective actions i.e., image sharpness metric (ISM) and image contrast metric (ICM).The multipart color image is obtained from converse quaternion wavelet transform.

TABLE I: ASSESSMENT OF DIFFERENT IMAGE FUSION TECHNIQUES

Methods	Advantages	Limitations	Domain
[1]Robust PCA	• Better illustration perception. • Robust and flexible • Can handle both grayscale and color images. • Outperforms the state-of-art fusion approaches	• High computational cost	Spatial
[2]Region based image fusion	• More clarity in resultant image • sensitive to noise • problem of misregistration is avoided	• complex • high computational time	Spatial
[3] SIFT	• can be applied at every location of the image • better performance in object categorization and alignment • extended to spatio-temporal video • Better direction of camera and intensity of illumination.	• High memory required • Time consuming	Transform
[4] NSCT	• Superior visual perception. • Avoid preamble of synthetic and artificial information. • Better object assessment • Best method for Image enhancement.	• High redundant data • Computational complication • High cost.	Transform
[5] PCA, DCT & DWT based Image Fusion Techniques	• DWT techniques persisently offer better outcome. • Time saving in real time system	• suffers from color deformation problem • Suffers from spectral degradation.	PCA-Spatial DWT-transform DCT-Tranform
[6] hierarchical PCA	• Provides better end result for multimodal images.	• Single all in focus feature is not achieved	Spatial
[7] DT-CWT	• Better visual estimation • Better orientation towards 3D surfaces • Best results for images under criteria like natural manifestation.	• Artifacts will be added during base image reconstruction.	Transform
[8]Sparse feature matrix decomposition and morphological filtering	• Output images with elevated disparity • Fewer running time.	• Do not defend original pixel values of source images. • Problem of the irregular illumination	Spatial
[9]DWT based PCA	• Output with detailed information • Improved background enhancement	• Output with spatial distortions.	Transform
[10]Biorthogonal Wavelets	• accomplished to conserve edge information • Less misrepresentation of data in the merged image.	• major information is lost during fusion	Transform
[11] RDWT	• Overcome the shift variance crisis of DWT.	• It produces some additive noise in the fused image	Transform

	• conserve the precise edge and spectral information • fewer spatial distortion • reduces the volume and cost • resourceful retrieval		
[12]adaptive image fusion in wavelet domain	• Less clouding consequence in the fused image.	• High memory requisite	Transform
[13] curvelet and wavelet transform	• Simpler • faster • less redundant	• Output with spatial noise • High complex	Transform
[14]Pixel Significance using wavelet Transform	• excellent sharpness • perimeter preservation with improved mutual information • major reduction in artifacts	• Complexity of technique increases.	Transform
[15]DWT and Multi-wavelet Transform	• Resultant fused image give reliable information. • Multi-wavelet gives better product	• Frequency localization possessions due to scalar wavelets	Transform
[16]Quadtree-based image fusion using a weighted focus-measure	• Focus universally feature • Reconstruction gives better result • Less computational time.	• performance is not that much well-organized in assorted region	Transform
[17]Parallel Approach for Multi-focus Image Fusion	• effortless implementation • Unique hardware is not required to fuse the image.	• Morphological decomposition accepts only integer values.	Spatial
[18] Quaternion Wavelet Transform	• solving the image blur trouble • re-enactment is done by inversing QWT	• Gives better result only for color images	Transform

III. Performance metrics

Image fusion quality assessment is done by two possible ways. One is quality test which is tested by visual interpretation. Second type of assessment is quantative- statistical test which is done in two ways i.e spectral evaluation and spatial evaluation.The broad-spectrum necessities for the image fusion method are it should safeguard all applicable and beneficial prototype evidence from the base images, at the equal period it should not pledge new artifacts that hinder with succeeding analysis.The quantitative and qualitative metrics are used for performance evaluation for different image fusion process. Energy of image gradient, variance, power of laplacian of the image, spatial frequency and sum-modified-laplacian is some of the focus procedures for evaluation. Quantitatively, numerical investigation is used. Reference and non-reference metrics are used for qualitative assessment. Peak signal to noise ratio, mean square error are the orientation based metrics. Spatial frequency, Mutual information, Quality index and structural similarity index are non-oriented based metrics.

IV. Conclusion

Image fusion techniques are extensively used in numerous applications such as computer vision system, remote-sensing etc.Compartive study on a range of image fusion methods briefs that Pixel-based algorithms leads to misregistration, additional sensitive to noise and causes blurring tribulations. Where as region-based procedures are compound than pixel based algorithms, but stretches upright performance and eradicates difficulties of pixel-based algorithms.Problem of static image block size is solved by using quad-tree organization.From the literature analysis it has been found that most of the accessible fusion techniques have focused on gray scale images. Therfore there is a need to expand the fusion algorithms which works on color images and also under diverse ecological factors.

References

[1] T.Wan , C. Zhu and Z. Qin, “Multifocus image fusion based on robust principal component analysis”, *Pattern Recognition Letters*, vol. 34, no. 9, pp. 1001-1008, 2013.

[2] TanishZaveri and MukeshZaveri, “A Novel Two Step Region Based Multifocus Image Fusion Method” vol. 2, pp. 86-91, February, 2010.

[3] Y. Liu, S. Liu and Z. Wang, "Multi-focus image fusion with dense SIFT", *Information Fusion*, vol. 23, pp. 139-155, 2015.
[4] Q. Zhang and B. Guo, "Multifocus image fusion using the non-subsampled contourlet transform", *Signal Processing*, vol. 89, no. 7, pp. 1334-1346, 2009.
[5] NishaGawari and Dr. Lalitha.Y.S, "Comparative Analysis of PCA, DCT & DWT based Image Fusion Techniques", *International Journal of Emerging Research in Management &Technology*, Vol3, Issue-5.
[6] UjwalaPatil,"Image fusion using hierarchical PCA", *International Conference on Image Information Processing*, 2011.
[7] Sruthy, S, LathaParameswaran, and Ajeesh P. Sasi. "Image Fusion Technique using DT-CWT" *International Conference on AutomationComputing, Communication, Control and Compressed Sensing*, pp.160-164, 2013.
[8] H. Li, L. Li and J. Zhang, "Multi-focus image fusion based on sparse feature matrix decomposition and morphological filtering", *Optics Communications*, vol. 342, pp. 1-11, 2015.
[9] R. Vijayarajan and S. Muttan, "Discrete wavelet transform based principal component averaging fusion for medical images", *AEU - International Journal of Electronics and Communications*, vol. 69, pp. 896-902, 2015.
[10] PinakinSuryavanshi, "Multi-focus Image Fusion based on Pixel Significance using Bi-orthogonal Wavelets", *Proceedings of 2015 Global Conference on Communication Technologies* ,2015.
[11] S Rajkumar and S Kavitha, "Redundancy Discrete Wavelet Transform and Contourlet Transform for Multimodality Medical Image Fusion with Quantitative Analysis", *Third International Conference on Emerging Trends in Engineering and Technology*,pp. 134-141, 2013.
[12] Jing Tian,LiChen, Tian J and Li Chen, "Adaptive multi-focus image fusion using a wavelet based statistical sharpness measure" *School of Computer Science and Technology, Wuhan University of Science and Technology*.
[13] Shutao Li and Bin Yang, "Multi-focus image fusion by combining curvelet and wavelet transform", *Pattern Recognition Letters*, pp.1295–1301,2008.
[14] Parul Shah,Srikanth.T.V, S.N.Merchant and U.B.Desai, "A Novel Multifocus Image Fusion Scheme Based On Pixel Significance Using wavelet Transform", 2011.
[15] Kusum Rani and ReechaSharma, "Study of Image Fusion using discrete wavelet and Multi-wavelet Transform", *International Journal of Innovative Research in Computer and Communication Engineering*,vol. 1, Issue 4, June 2013
[16] XiangzhiBai , Yu Zhang , Fugen Zhou and BindangXue, "Quadtree-based multi-focus image fusion using a weightedfocus-measure", 2014 Elsevier
[17] SilviuIoan Bejinariu, Florin Rotaru, Cristina Diana Niţă and Ramona Luca, "Parallel Approach for Multifocus Image Fusion", 978-1-4673-6143-9/13/$31.00, 2013 IEEE
[18] Haochen Pang, Ming Zhu and LiqiangGuo, "Multifocus Color Image Fusion Using Quaternion Wavelet Transform" , *5th International Congress on Image and Signal Processing*, 2012
[19] D. EgfinNirmala and Dr. V. Vaidehi, "Comparison of Pixel-Level and Feature Level Image Fusion Methods", 978-9-3805-4416-8/15/$31.00, 2015.
[20] RishuGarg, Preeti Gupta and HarvinderKaur, "Survey on Multi-Focus Image Fusion Algorithms", *Proceedings of 2014, RAECS UIET Panjab University Chandigarh*, 2014.
[21] GurpreetKaur and PrabhpreetKaur, "Survey on multifocus image fusion techniques", *International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT)*, pp. 1420-1426, 2016
[22] BincyBavachan and Dr.PremKrishnan, "Survey on Image Fusion Techniques", *NATCOMM* , pp. 48-52, 2014.
[23] Rajvi Patel, Manali Rajput and Pramit Parekh, "Comparative Study on Multi-focus Image Fusion Techniques in Dynamic Scene", *International Journal of Computer Applications*, Volume 109 – No. 6, pp. 5-10, 2015.
[24] ShavetaMahajan and Arpinder Singh, "A Comparative Analysis of Different ImageFusion Techniques", *IPASJ International Journal of Computer Science (IIJCS)*, Volume 2, Issue 1, pp. 8-16, 2014.
[25] Dr. Vijay Kumar Banga and AsthaMahajan, "Comparitive Study of Various Multi-focus Image Fusion Techniques", *IJCTA*, pp. 677-687, 2016.
[26] Deepak Kumar Sahu and M.P.Parsai, "Different Image Fusion Techniques –A Critical Review", *IJMER*, Vol. 2, Issue. 5, pp. 4298-4301, ISSN: 2249-6645, 2012.
[27] Sanjay Kumar jain, "Multi-temporal image fusion of earthquake satellite images", *IJARCS*, volume 3,ISSN No:0976-5697, pp.251-255,2012.