Different Image Fusion Techniques for Multi-Focus Images: A Review

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Abstract - Image fusion is an important technique for various image processing and computer vision applications such as feature extraction and target recognition. Through image fusion, different images of the same scene can be combined into a single fused image. Current image coding with image fusion schemes make it hard to utilize external images for transform even if multi-focus images can be found in the cloud. To solve this problem, we analyze different method of multi-focus image fusion scheme that is different from current image fusion scheme even on the ground. For this purpose, we study of various image fusion techniques with their pros and cons. A fast and efficient image fusion technique is proposed for creating a highly generated fused image through merging multiple corresponding multi-focus images. The proposed technique is implement on a specific tool namely as MATLAB (R2012a) latest version. Analytical results represent that the proposed technique can obtain state-of-the-art performance for image fusion of multi-focus images.

Index Terms - Image processing, Image fusion, Feature extraction, Multi-focus image, MATLAB

I. INTRODUCTION

Multi-focus image fusion is challenging task in the area of digital image processing and as a result has “all- in-focus” image that integrate complementary and redundant information from multiple images. Important applications of image fusion include medical imaging, remote sensing, computer vision, and robotics. Also, image fusion is of particular importance in modern microscopy where the resolution is compromised by the limited depth of focus. Image fusion is the process of combining information of two or more images of a scene into a highly informative image that contains more information than any other original image. That image contains all significant information from multi-focus images that are result of compatible sensors or different depth of focus the same sensor. The actual fusion process can be performed at different levels of information representation. A common categorization is to distinguish between:

(1) pixel level,

(2) feature level,

(3) symbol level.

Image fusion at pixel level means fusion at the lowest processing level referring to the merging of measured physical parameters. This fusion method is also known as nonlinear fusion method. Fusion at feature level requires feature extraction prior, to identify characteristics such as size, shape, contrast and texture. The fusion is thus based on those extracted features and enables the detection of useful features with higher confidence. Fusion at symbol level allows the information to be effectively combined at the highest level of abstraction. The choice of the appropriate level depends on many different factors such as data sources, application and available tools.

The need for better diagnosis and clear interpretation of the obtained images give rise to image fusions. The term fusion means to combine the information acquired in several domains. Image fusion has become a popular technique used within medical diagnosis and treatment.

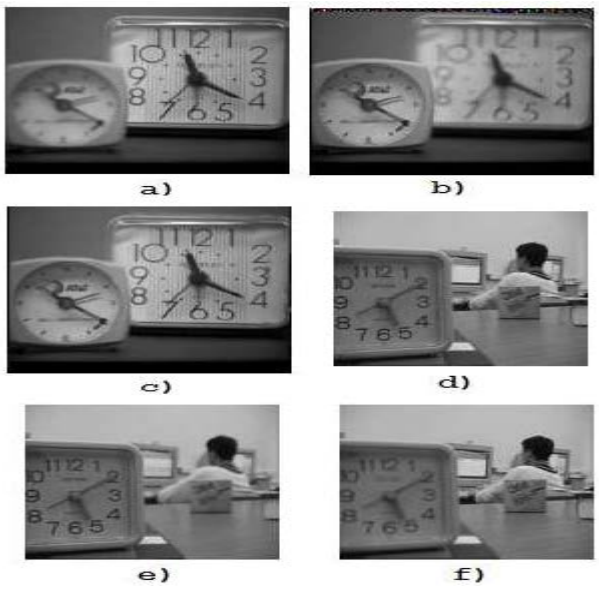

Figure 1: a), b), d), e) Two scene images with different depth of focus, c), f) Fused images

Image fusion is the process of integrating information from two or more images of an object into a single image. The integrated image is more informative for explanation and analysis. It is possible that several images of same object provide different information based on different resolution and viewing angle, to merge the different information and obtain a new and improved image we have a fusion technique. Fused images can be created by combining information from multiple modalities such as magnetic resonance image (MRI), computed tomography (CT),

positron emission tomography (PET) and single positron emission computed tomography (SPECT).

II. RELATED WORK

Following are the image fusion procedures that are implemented in computer vision technologies. The core reason of all these conventional and meta-heuristics image fusion procedures are proper exploitation of possessions. Some of the procedures are considered below with due to the author and their task.

Guided-Filtering based weighted average technique [1]: A novel guided filtering-based weighted average technique is proposed to make full use of spatial consistency for fusion of the base and detail layers. Experimental results demonstrate that the proposed method can obtain state-of-the-art performance for fusion of multispectral, multifocus, multimodal and multiexposure images.

Empirical Mode Decomposition [2]: In this paper, novel multifocus image fusion algorithm based on complex Empirical Mode Decomposition is proposed. Experimental results show that the proposed novel method for image fusion is more effective than other multifocus image fusion methods based on EMD. There are many numbers of procedures that are already practical neither in a private cloud scenario nor in a hybrid cloud scenario.

Non Subsampled Contourlet Transform and An Image Decomposition Model [3]: In this paper, a novel image fusion algorithm based on the non subsampled contourlet transform (NSCT) and an image decomposition model (IDM) is proposed, aiming at solving the fusion problem of multifocus images. In order to select the coefficients of the fused image properly, the selection principles for different sub bands are discussed, respectively.

Local Neighbor Sum of Laplacian in NSCT Domain [4]: The NSCT not only possess the main features of multi-scale, multi-directional and time-frequency localization, but also offer the property of the shift-invariant which is vital to image processing. Firstly, multi-scale decomposition is performed on source images using NSCT to get high-frequency and low-frequency images. Secondly, the Novel Sum-Modified-Laplacian and Local Neighbor Sum of Laplacian are respectively used to select the low pass coefficient and high pass coefficients to combine fused image. Finally, the inverse non subsampled contourlet transform is applied to obtain fused image.

Daubechies Wavelet Transform [5]: The fusion process starts with comparison of block wise standard deviation values of the coefficients. Here the standard deviation can be used to characterize the local variations within the block.

Shift-Invariant Wavelet Transform [6]: In this paper we propose a novel approach to the fusion of spatially registered images and image sequences. The fusion method incorporates a shift invariant extension of the discrete wavelet transform, which yields an over complete signal representation.

Wavelet Domain Using Statistical Properties of Neighborhood [7]: In this paper we present a novel fusion rule which can efficiently fuse multifocus images in wavelet domain by taking weighted average of pixels. The weights are adaptively decided using the statistical properties of the neighborhood.

Bilateral Gradient Based Sharpness Criterion [8]: In this paper we are proposing the method which combines the multi-resolution transform and local phase coherence measure to measure the sharpness in the images. The performance of the fusion process was evaluated with mutual information, edge-association and spatial frequency as quality metrics and compared with Laplacian pyramid, DWT (Discrete Wavelet Transform) and bilateral gradient based sharpness criterion methods etc.

III. IMAGE FUSION TECHNIQUES

Image fusion is the process of integrating two or more images to form one image which is highly informative. The main aim of this process is to extract the features which are perceptually important from all the images and combine them to form a fused image which is more suitable for computer processing and human visual perception. Image fusion is playing a major role in the research areas such as Medical Imaging, Remote sensing, computer vision, Robotics and Microscopic imaging etc. In the process of image acquisition the image quality depends on the focal length or focus of the optical system. If the lens focusing is poor the resultant image will suffer from blurring. Also it is not possible to focus all the objects in a scene equally. Therefore Multifocus fusion techniques are essential to create an image which contains all the objects are in-focus from two or more images.

IV. TOOLS RELATED TO IMAGE FUSION

Image fusion technique can be implements with MATLAB R2010a and R2012a version which is described below.

MATLAB is a high-performance, efficient and interactive language for technical computing environment. It integrates Computation, visualization, graphical, processing and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical syntactic notation and graphical form. Typical uses include mathematical matrix form and other computation algorithm development Data acquisition Modeling, image processing, Data processing, simulation, and prototyping Data analysis, exploration, and visualization Scientific and engineering drawing and

graphics Application development, including graphical user interface building MATLAB(A Technical Computing Tool) is an interactive programming tool whose basic data element is an array (Matrix form) in different dimensional scheme, that does not require to specify dimensioning. This allows you to solve many technical computing problems in different format, especially those with matrix and vector formulations, in a small fraction of the time it would take to write a program in a specific scalar non interactive language like as C or FORTRAN. The name MATLAB is stands for matrix laboratory. MATLAB is used in every facet of computational mathematics. Following are some commonly used mathematical calculations where it is used most commonly: Dealing with Matrices and Arrays, 2-D and 3-D Plotting and graphics, Linear Algebra, Algebraic Equations, Non-linear Functions, Statistics, Data Analysis, Calculus and Differential Equations, Numerical Calculations, Integration, Transforms, Curve Fitting, Various other special functions.

MATLAB has evolved over many periods of years with different input from many more users. In university research environments, it is the standard and efficient instructional tool for introductory and advanced courses in mathematics, engineering, and medical science. In engineering industry, MATLAB is the tool of choice for better high-productivity research, development, proactive and analysis. MATLAB provide basic features a family of add-on application-specific solutions called toolboxes. Very most important to most and licensed users of MATLAB, toolboxes allow you to learn and apply specialized computing technology. The basic features of MATLAB are as follows:

(1) It is a high-level language for numerical computation, visualization and application development.

(2) It also provides an interactive environment for iterative exploration, design and problem solving.

(3) It provides vast library of mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, numerical integration and solving ordinary differential equations.

(4) It provides built-in graphics for visualizing data and tools for creating custom plots.

(5) MATLAB's programming interface gives development tools for improving code quality and maintainability and maximizing performance.

(6) It provides tools for building applications with custom graphical interfaces.

(7) It provides functions for integrating MATLAB based algorithms with external applications and languages such as C, Java, .NET and Microsoft Excel.

MATLAB is widely used as a computational tool in science and engineering encompassing the fields of physics, chemistry, math and all engineering streams. It is used in a range of applications including: Signal Processing and Communications, Image and Video Processing, Control Systems, Test and Measurement, Computational Finance, Computational Biology

V. COMPARISON OF REVIEW TECHNIQUES

Image Fusion Algorithm	Image Quality Parameters	Objective	Tool	Pros	Cons
Guided-Filtering based weighted average technique	Normalized Mutual Information, Structural SIMilarity, Universal Image Quality Index, Gradient Based Index, Phase Congruency	highly informative fused image through merging multiple images	MATLAB	computationally efficient, strong correlations between neighborhood pixels	Complex Calculation
Empirical Mode Decomposition	Intrinsic mode functions, Weights coefficients	More effective image fusion	MATLAB	nonexistent texture in fused image is avoided, calculation is not required	Pixel Saliency is high
Non Sub-sampled	Mutual Information, Quality Image Index	Fusion problem of multi-focus	MATLAB	Less Calculation,	SSIM is high

Contourlet Transform and An Image Decomposition Model		images		Less time execution	
Local Neighbor Sum of Laplacian in NSCT Domain	Mutual Information, Quality Image Index	Combine to form a single image with all objects fully focused	MATLAB	An effective, efficient and feasible algorithm	For the noised image, the fusion result is affected by the noise
Daubechies Wavelet Transform	Entropy (EN), Standard Deviation (STD), Mutual Information (MI) and Fusion Factor (FF)	Fusion of multi-model medical images	JAVA	More efficient image fusion	More time taken in execution
Shift-Invariant Wavelet Transform	temporal stability, temporal consistency, inter-frame difference, mutual information and joint entropy	improved temporal stability and consistency of the fused sequence	MATLAB	high mutual information, instability or inconsistency	Complex implementation code
Wavelet Domain Using Statistical Properties of Neighborhood	Average Pixel Intensity, Average Gradient, Spatial Frequency, Standard Deviation, Entropy, Mutual Information, Fusion Symmetry, Normalized Correlation	An efficiently fuse multi-focus images in wavelet domain	MATLAB	minimum artifacts and maximum edge preservation	More mathematical calculation
Bilateral Gradient Based Sharpness Criterion	Mutual Information, edge-association, spatial frequency, Root Mean Square error and Standard Deviation.	More suitable image fusion	MATLAB	Excellent fusion of multi-resolution images	Low mutual information

VI. CONCLUSIONS

In this paper we elaborate the distinguish kinds of image fusion procedures. Most generalize approach for image fusion is the wavelet approach. Image fusion is one of the most in all, the foremost effective work in image processing atmosphere. During this research paper, we have got discuss varied programming algorithmic strategies and tabulated varied argument. We have notified that high fused image quality index is most important concern in image processing environment. This paper presents a survey of image fusion procedures in image processing environment. Main objective of image fusion procedure is to gain more performance in image processing atmosphere by optimal usage of storage capacity and other resources. This research would next focus on finding optimal approach for better performance of applications running in image fusion.

VII. REFERENCES

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