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Image Fusion Using Incremental Higher Order Singular Value Decomposition Method

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***Abstract*—** In this paper, we have implemented singular value decomposition to effectively update the value of decomposition, including the basis images. In this paper two dimensional incremental higher order singular value decomposition (HOSVD) is used for image fusion. Incremental higher order SVD will help us to store the images with less storage requirements and will keep the level of the error that must be acceptable in an application. The prime methods used here are HOSVD and its repetitive application. It is already known that singular value matrix obtained by SVD contains the illumination information. Therefore, we will combine this matrix for two different images. Large number of the variations made to this matrix will not affect the other attributes of the image. The incremental approach will be used to divide the image into sub-bands. When the images are separated on LH, HL and HH sub-bands, the effect of fusion will be smoothened by this method.

***Keywords*—** Singular Value Decomposition, Tensors, Image Fusion, Incremental HOSVD, Reduced HOSVD.

1. INTRODUCTION

Image fusion develops methods to combine multiple digitized inputs for visualization (often as single images) or for processing such as conventional edge detection or data mining to find image-related structure. Work done recently in image fusion includes images from multiple exposures or multiple depths of focus, suppression of cloud covering, pre-fusion registration based on line and point features that are visible and for face recognition using thermal images, multimodal images in non-destructive testing, multispectral and multiresolution data in remote sensing and multimodal medical images are important neurological cases. There are some methods based on wavelets and mathematical statistics which are popular. The images which had been used in this paper describes a method of digital image fusion for applications in which 2-D inputs have been sized, registered, and scaled in pixel intensities appropriately for mutual comparison, and information ensembles in the form of edges and lines which are desired. An example of this type of application is a system with inputs from a multi-lens array that acquires multiple images of the same object or scene through different spectral filters.

The method is a sequence of computations and is used to decompose the input images into a common basis set, analyzes the basis images to extract ensemble edge-line details, and fuses the results of the analysis. The outputs obtained from this pipeline are the sets phase maps that are fused, in the form of 2-D images that are the explicit edge-line information.

At the start of this pipeline, the first task is to organize the input images into a multilinear array which is a third-order tensor A and compute a higher-order generalization of singular value decomposition (SVD) for A. This proposed method of singular order decomposition creates a sub tensor B containing a set of images that are orthogonal, ordered by decreasing norm, and constitute a basis for the input images. Each and every basis image is a linear fusion of the input images. The second task includes phase analysis of each basis image to extract information about edges and lines. The third task fuses the raw phase maps by pixel-wise square root of the addition of the squares—a computation consistent with the role of local energy in image phase analysis. At last, the fused maps are added to input images for purposes of visualization. This method can also be used in other processing in which edge-line information is relevant. [5]

2. LITERATURE CITIED

Andras Rovid, Laszlo Szeidl and Peter Varlaki, "The HYBRID (SVD+DWT) Based Domain and the Related Image Processing Techniques." These techniques used suggest that the block size should be optimized before fusion.

Gagandeep Kour and Sharad P. Singh in "Low Quality Image Information Enhancement Using SVD Fusion Technique" stated that Image fusion is a technique to generate a single high informative image from one or more input images. Pixel level, feature level, signal level and decision level are different stage at which image fusion can be applied.

P. Ambika Priyadharsini, M.R.Mahalakshmi, in "Multimodal Medical Image Fusion Based On SVD", stated that Important applications of the fusion of images include medical imaging, microscopic imaging, remote sensing, computer vision, and robotics.

Asha P Kurian, Bijitha S R, Lekshmi Mohan, Megha M Kartha, K P Soman, in "Performance Evaluation of Modified SVD based Image Fusion," said that Image Fusion begins with the concept of simply averaging the intensities of the corresponding pixels of the input images and produces a fused image.

According to Michael Thomason and Jens Gregor, in "Fusion of Multiple Images by Higher-Order SVD of Third-

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Order Image Tensors," Image fusion method is a sequence of computations. It decomposes the input images into a common basis set, analyzes the basis images to extract ensemble edge-line details, and then fuses the results of the analysis.

Hatte S.C., Shingate V.S in "International Journal Of Engineering Sciences & Research Technology," stated that Image fusion depends on local information of source images, the proposed algorithm picks out informative image patches of source images to constitute the fused image by processing the divided subtensors rather than the whole tensor.

Nadia Kreimer and Mauricio D. Sacchi, "A tensor higher-order singular value decomposition (HYBRID (SVD+DWT)) for pre-stack seismic data noise-reduction and interpolation.

3. MATERIALS AND METHODS

3.1 Algorithm for Incremental Higher order SVD Based Fusion

HOSVD consider the source image as tensors, Tensors are simplifications of scalars, vectors, and matrices to a random number of index. Tensor-based information dispensation methods are more suitable for representing high-dimensional data and extracting relevant information than vector- and matrix based methods. In this paper mainly a competent tensor decomposition technique is used, singular value decomposition (SVD) based image fusion algorithm is projected, it is meaningful idea to highlight several feature of the proposed transform domain-based approach here combined with incremental approach.

i) Since source images refer to the same scene and are somewhat similar (the same physical structures in the ecosystem), and this construct these images into a tensor and employ the SVD technique to extract their features concurrently. The proposed algorithm picks out informative image patches of source images to constitute the fused image by processing the divided subtensors rather than the whole tensor.

ii) A slice of the core tensor yielded from SVD of subtensors reflects the quality of the related image patch. This method employs the sum of absolute values of coefficients (SAVC) as the activity-level measurement of the related patch.

iii) For the adaptation of different activity level dimensions, Incremental approach is applied to get an original and flexible sigmoid-function coefficient-combining scheme, which incorporates the usual choose-max scheme and the weighted average scheme, and simply widens the proposed algorithm to fuse multiple or colour images.

The factorization of rectangular real or complex matrix into diagonal symmetric or Hermitean square matrices using eigenvectors is the basic principle used in linear algebra for SVD [6]. In sequence to divide the system into a set of linearly independent components with all of these components having their own energy components, SVD is the stable and effective technique. The research was carried out to improve the quality of the distorted image using SVD-based fusion technique. Information content of the distorted image is improved using this technique. Digital camera is used for taking standard resolution images. These images are captured and stored for further processing of pictures. Before applying image-based fusion incremental image distortions are added using a circular averaging filter.

3.2 Image fusion and affecting factors:

In the field of image processing, the concept of Image fusion is very promising process which can be useful for certain types of applications and their need to improve the images will always be there. The idea behind this concept is to improve the content of all type of images by combining two or more multimodal images. The significance of having a novel fusion framework which is based on singular value decomposition is important as this framework is simple as well as efficient. As single value decomposition is an image adaptive transformation so it transforms the matrix of the given image into product which allows refactoring a digital image into three matrices which are called tensors. The need of algorithms used for this purpose picks out informative image patches of source images to constitute the fused image by processing the divided sub tensors rather than the whole tensor. In proposed paper a novel sigmoid-function-like coefficient-combining scheme which can be applied to construct the final result. Experimental results prove that the use of algorithms is an alternative image fusion approach.

4. RESULTS AND DISCUSSION

The performance of proposed method of Incremental Higher order SVD image fusion is tested using different levels of images by using different fusion level. The images are blurred using circular averaging with radius taken from 1 to 5. Figure 1 show the blurred image with corresponding enhance image obtained from the designed Incremental Higher order SVD algorithm of image fusion. Figure 1 (a) and 1(b) show the blurred images with the application of circular averaging filter having radius from 1 to 5. Corresponding enhanced images with Incremental Higher order SVD are shown from Fig. 1(c)-1(d).

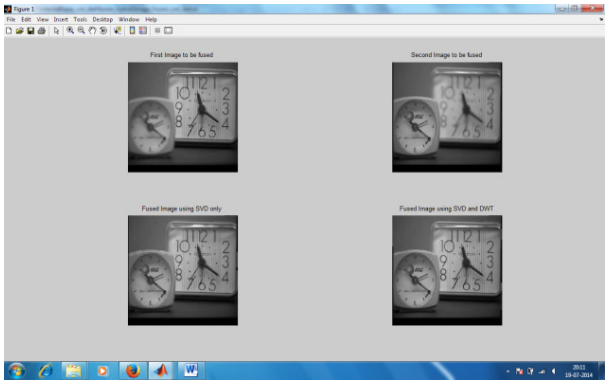

Figure (4.1a-4.1d) Fusion and Fused images

The figure shown below shows that in case of Incremental Higher order SVD, much smaller number of basis functions is enough to represent the image without significant information loss. In case of Fourier based approach a much larger number of trigonometric functions are needed in order to maintain the same quality.

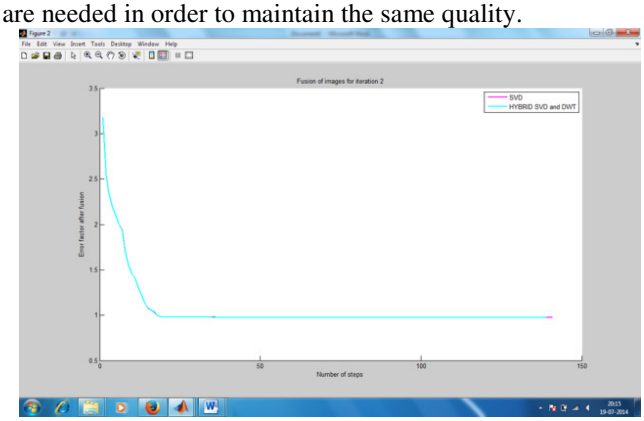

Figure 4.2: Comparison graph represent the images without significant information loss

5. Conclusions

In large number of digital imaging applications, various input images are acquired and some percentage of fusion is needed to make them perfect. An input mix of multimodal, multi resolution images or multispectral is not unusual.

If Incremental Higher order SVD has been computed for an initial set of images and additional images are generated, Incremental Higher order SVD is an effective way to update the decomposition, including the basis images. Reduced dimension Incremental Higher order SVD computed by HOOI results in smaller storage requirements and introduces an error that must be acceptable in an application of images. Most of the empirical results show that substantial reductions cause little degradation in visual quality in some cases. Applications that are under development include multimodal tomography and multi-lens imaging with an emphasis on medical applications.

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