IJCSC 0973-7391 Volume 6 • Number 1 Sep - Mar 2015 pp.100-103 available online at www.csjournalss.com

Comparative Study of Image Fusion Techniques for Medical Applications

Sejal Patel[1], Rupal A. Kapdi[2]
[1,2]Computer Science and Engineering Department, Institute of Technology
Nirma University, Ahmedabad, Gujarat, India

Abstract: Process of combining two or more input images into one single image without distortion and/or loss of information is called Image fusion. Image fusion has very wider scope in medical sciences. Medical Images are of different modalities and taken from different type of equipments and, each image carries different information. Multimodal medical images made it tough to produce an image which contains all information from all images. Now, with the help of fusion algorithms available it is possible to fuse the multiple images in order to create a single image which is more complete, informative and accurate than any individual input images. We have algorithms, but the challenge we have to choose them according to our application. Another challenge is to produce an efficient algorithm. This paper also presents categories of basic fusion algorithms for medical images and comparative study of variety of pixel based (spatial domain) methods along with its advantages and disadvantages is covered.

Introduction

Nowadays, in image processing fields, image fusion is one of the major research topics. It is process which combines multiple input images into one image without distortion or information loss. Thus, single image created must have a more complete description of the information than every input image and should be suitable for visual perception for human and machine[1]. It should also support analysis tasks and image processing which may be required. Basically it aims to integrate complementary and disparate data available in to increase the efficiency of information available in the images, and also to enhance the interpretation and readability. It provides more precise and complete description about scene[2]. In other way, we can say that Image fusion is one tool which can combine multimodal images by using several image processing techniques available. The resultant fused image fusion retains the most desirable information and will have characteristics of each input image. It makes detection, reorganization, and identification targets easier and also increase awareness about the situation. Fused image may contain additional clinical information which may not be apparent in the separate images. Other benefit of image it is that it reduces the storage required as now we have to store only the single image, instead of multisource images[3].

Images used in medical application uses different modals like SPECT, MRI, CT, MRA PET, X-ray, etc. Those different images from different modal have their different applications. For example, PET, SPECT provides information about functions. They have spatial resolution comparatively low, but they provide information which concerns blood circulation and metabolism of visceral. An anatomical image such as MRI, B-mode, visceral ultrasonic, contains high spatial resolution [5]. Multimodal Medical fusion is process which combines anatomical and functional image altogether into single image which provide more correct information to physician [6].

Usually medical images from different modality provide information which can be complementary or conflicting. For an instance, CT image provides information about dense structures for example bones. CT image have less distortion, but it can’t support detection of physiological changes, whereas the MRI image provides information about pathological normal soft tissues, but MRI can’t support information about dense structure like bones. In case like this, only one image cannot provide clinical requirements which are accurate to the doctor. Thus, we can say it is important to fuse images (multimodal). As it is known, image fusion can help to enhance quality of medical image and also reduce randomness. It reduces redundancy in order to increase the applicability of medical images for diagnosis and assessment of medical problems. It improves the efficacy of the doctor as it helps to take objective decision in relatively short span of time.

Medical Image Fusion Stages

There are mainly two basic stages are involved in medical fusion

I. Image Registration

This brings correctness in the spatial misalignment between the different image data sets. This can be done using scale changes, rotations, translation, missing features, inter-image noise and outliers make image registration difficult.

It can be defined as mapping from one set of coordinates of image in one space to coordinates of another image in another space, such that those points in two spaces which are mapped to each other correspond to the same anatomical point for combining information from multiple sets of images[10]. They are classified mainly in 3 ways : Which image attributes are matched? , how is it matched? (cost function, parameter variation procedure, etc) and what transformations are allowed on it?(linear, nonlinear; global, local).

II. Image Fusion

It is the process which combines multiple input images into one image without distortion and/or loss of information.

Image Fusion Categories

Image fusion can be categorized by two ways:

I. Based on the input images

Based on the input images image fusion techniques are classified into four parts:

1. Multiview fusion

Input images of the same scene taken from same modal which may be taken at same or different time but their viewpoints must be different i.e the images should not be taken from same places .Or we can take images which are taken from different condition. Goal of this is to provide information(which is complementary) from several views and to get fused image having higher resolution[7].

2. Multimodal fusion

Fusion of images of same object taken from different modalities i.e. images coming from different sensors like CT and MRI and taken at the same time, same viewpoints. Multisource Images from different modal: CT, PET, MRI, infrared, ultraviolet are used in this. Main purpose of this is to reduce the data redundancy, to emphasize information about band-specification, to decrease storage requirement. Common methods used are, transform domains fusion, pixel-wise weighted averaging and fusion at Object-level[8].

3. Multitemporal fusion

Fusion of the images of same object obtained from same modalities, same viewpoints but taken at the different time (seconds to years) in order to detect the changes between them. Main goal of this is to detect the changes occurred, to synthesize images of objects which could not be taken in desired time.

4. Multifocal Fusion

With the available digital cameras, which can focus on a part of object to certain distance only, so it is not possible to focus all subjects not sharply. A possible way to resolve this problem is to acquire a several images with focus regions different and then we can combine those images to generate a single image with each part of object focused. The goal of this is to obtain a single all-in focus image.

II. Based On Domain

Image fusion techniques are categorized mainly into two domains which are:

1. Spatial Domain Methods

In this we directly deal with pixels of images. The image pixel values are used directly to obtain expected improvement in output image.

2. Frequency Domain Methods

In this the first images are transferred into frequency domain. i.e first the Fourier Transform for each image is calculated then on those coefficients now all the operations for enhancement are applied and the resultant image is reconstructed by applying inverse fourier Transform. These improvement operations are applied to improve brightness of image, contrast of the image and to distribute grey levels. Resultant image would be modified as transformation function were applied on input values[9].

Spatial Domain Image Fusion Techniques

In this section fusion techniques are provided for pixel based – spatial domain approach.

1. **Average method**

This algorithm is an easy way to obtain a fused image with all parts of image in focus. The pixel value p(i1 , j1) from every image is obtained and then added. Then obtained total will be divided by number of input images to get average. The obtained value is then assigned to pixel which corresponds to the fused image .This will be repeated for entire image. [10]

Input Images → Take Averaging → Output Fused Image

$$Output(i, j) = [input1(i , j) + input2 (i, j) + \ldots + inputN(i,j)] / \text{no. of images}$$

Where i = 1,2,3….P and j = 1,2,3….. Q , P and Q refers to rows and columns of image.

Both the images are taken from same modal at same time. But in both images some part of images are distorted so to improve quality of image, average method is used. The main advantage of this method is that it is the simplest method to learn as well as to implement. And we can have fused image which have all regions equally focused. The main disadvantage of this method is that it may not give clear fused image because of averaging out bad as well as good parts of input images. Thus, although we are having best information we are taking some bad data into consideration [10].

2. **Selective Maximum method**

This algorithm is an easy way to get fused image with each part of image in focus. It gives image having higher intensity than any individual image. The pixel value p(i, j) from every image is obtained and then compared. The greater value of pixel of image the more in focus that part of the image. Then the pixel having greater value will be assigned to pixel which corresponds to output image. This will be repeated for entire image [10].

Input Images → take maximum pixel value out of all the input images → Fused Image

$$Output(i1, j1) = max[input1(i , j) ,input2 (i2, j2),\ldots\ldots inputN(i,j)]$$

Where i = 1,2,3….P and j = 1,2,3….. Q , P and Q refers to rows and columns of image.

All the images are taken from same modal and at same time. The main advantage of this method is that it results in more focused fused image. Main disadvantage is that blurring effect due pixel based method affects contrast of the image.

3. **Selective Minimum Method**

This algorithm is an easy way to get fused image with all each of image in not-in-focus or we can say less focused. It gives image having lower intensity than any individual image. So this algorithm is rarely used.

Input Images → Take minimum pixel intensity out of all i/p images → Fused image

$$Output(i, j) = min[input1(i, j), input2 (i, j),\ldots\ldots\ldots\ldots inputN(i,j)]$$

Where i = 1,2,3….P and j = 1,2,3….. Q , P and Q refers to rows and columns of image.

Both the images are taken from same modal and at same time. It results in less focused fused image is generated input images as compared to average method. Selective minimum method is pixel level method so sometimes it also give output image having blurring effect.

4. Subtraction Method

In this algorithm, pixel value p(i, j) from every image is obtained and then subtracted value will be assigned to pixel which corresponds to output image. This will be repeated for entire image.

$$Output(i, j) = [\ input1(i, j)\ -\ input2\ (i, j)]$$

Where i = 1,2,3….P and j = 1,2,3….. Q , P and Q refers to rows and columns of image.

Both the images are taken from same modal but at different time. The main advantage of this method is we can easily see changes occurred. But sometimes it may miss very crucial information of the image.

Conclusion

In this paper we have provided comparative study of spatial domain image fusion techniques. To overcome the disadvantages of these methods, frequency domain based methods can be used or can be combined with spatial domain methods.

References

[1] Yong Yang. "Medical Image Fusion via an Effective Wavelet-Based Approach", EURASIP Journal on Advances in Signal Processing, 2010
[2] Zheng, Yufeng, Edward A. Essock, Bruce C.Hansen, Jaakko T. Astola, and Karen O.Egiazarian. "", Image Processing Algorithms and Systems III, 2004.
[3] Sroubek, F.. "Resolution enhancement via probabilistic deconvolution of multiple degraded images", Pattern Recognition Letters, 200603
[4] Yong Yang. "Multimodal Medical Image Fusion through a New DWT Based Technique", 2010 4th International Conference on Bioinformatics and Biomedical Engineering, 06/2010
[5] Wei Li. "A New Algorithm of Multi-modality Medical Image Fusion Based on Pulse-Coupled Neural Networks", Lecture Notes in Computer Science, 2005
[6] Praveena, S. Mary, and Ila Vennila. "Fusion of image scheme based on Mallet algorithm and curvelet transform", 2011 International Conference on Recent Trends in Information Technology (ICRTIT), 2011.
[7] Image Fusion: Principles, Methods, and Applications Tutorial EUSIPCO 2007 Lecture Notes
[8] _roubek, Filip, and Jan Flusser. "Fusion of Blurred Images", Signal Processing and Communications, 2005.
[9] Lin, Kuo-Liang, and Jhih-Long Fang. "Applications of computer vision on tile alignment inspection", Automation in Construction, 2013
[10] Deepak Kumar Sahu and M.P.Parsai – "Different Image Fusion Techniques – A Critical Review", International Journal of Modern Engineering Research (IJMER), Vol. 2, Issue 5, Sep – Oct 2012, ISSN: 2249-6645.