International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 06 | June 2020 www.irjet.net p-ISSN: 2395-0072

Image Fusion using Deep Learning

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ABSTRACT: In last few years, deep learning has become a very active and useful research tool which is used in many image processing fields. Image fusion technique is one of the most significant and useful in medical disease investigative techniques by deriving the supportive information from different multimodality medical images. This paper, proposed an efficient multimodal medical image fusion approach based on convolutional neural networks (CNN) for fusion process. Medical image fusion is the idea to improve the image content by fusing images taken from different imaging tools, like Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET).The objective of image fusion is to combine more useful information and remove redundant information from source registered images. In this paper, we have used image fusion techniques, Pixel level image fusion and transform based image fusion. The medical image fusion process is carried out in a multi-scale manner via medical image pyramids to be more reliable with human visual insight. For analysis purpose we have considered the combination of CT and MRI images. An experimental result of proposed method provides the best fused multimodal medical images of highest quality, best visualization in both visual quality and objective assessment criteria.

Key Words: **– image fusion: deep learning: Convolution neural network:**

INTRODUCTION

Medical image processing is a quickly growing area of research for the last three decades. X-ray, ultrasound, MRI (magnetic resonance imaging), PET (Positron Emission Tomography). and CT (computed tomography) are a few examples of medical imaging sensors which are used for extracting clinical information. These sensors provide complementary information about patient's pathology, anatomy, and physiology. For perfect diagnosis, radiologists have to combine information from multiple image formats that collect all applicable information to specific organ. Different conditions in image fusion demand both high spatial and spectral information in a single image for superior image quality. Image fusion can manage the image quality problem as fusion process collects all the useful information from many images and present it in a combined image called fused image of higher intensity and higher quality.

Medical image fusion is one of the most important subcategory of image fusion. Medical image fusion encompasses a broad range of techniques from image fusion and general information fusion to address medical issues reflected through images of human body, organs, and cells. Generally the multi-modal medical image fusion is the process of combining the information from each of the input medical images that taken from specific organ of the body in to a single image, this resulted image is named fused image. Fused image is more useful than any of the input medical images. Different medical images have different features, for example the origin of Magnetic Resonance Image (MRI) is very powerful magnetic source and radio waves. These images can represent the details of internal body structures and give useful information about soft tissues such as heart, brain tumors, lungs and livers. On the other hand the origin of PET images is based on positron emission. Also this imaging system can provide functional information and metabolisms of specific tissues in addition to anatomical information. This property gives the possibility to the physicians that early diagnose the diseases and progressive of tumor. PET images are colourful and have rather low spatial resolution, therefore we need special fusion method to fuse PET and MRI images to find single fused image that contain both spatial and spectral useful information.

In earlier stage we observe that, the image of body parts was not clear. So that for some time the doctor couldn't gave right decision regarding the diseases. People suffer from deadly diseases. Due to detect wrong diseases patient had to pay lots of many as well as their lives. For example, we observe that due to unclear image of body part of cancer patient, they didn't know about their diseases. After some year by observing the symptoms of their body they realized by their report, they had 3 or 4 stage of cancer. Due to unclear image they were suffering from deadly diseases like cancer. Some time we can't get clear image of body part like brain, bones etc. So doctor couldn't treat

patient earlier. And patient had to pay lots of for it. So image fusion is very beneficial for medical field.

1. LITERATURE SURVEY

Image fusion methods are divided into two domains:

(1) Spatial Domain Fusion

This domain directly deals with the image pixels. The values of pixels are altered to achieve desired result. This domain contains fusion methods like averaging, Brovey method, principal component analysis (PCA) and HIS, High pass filtering.

A) Pixel level:

Image fusion can be performed at three different levels, i.e., pixel level, feature level, and decision level. Compared with others, pixel-level image fusion directly combines the original information in the source images. These methods are not always effective but are at times critical based on the kind of image under consideration. It is used for image fusion of mammography images and used in image quality assessment techniques. Advantage of this method is it is easy and simplest method from other methods and it has potential to decrease noise from image. Disadvantage is it destroys the significant features of the image while decreasing the noise.

B) Brovey Transformations method:

Brovey Transform is devolved by Gillespie et al., 1987. This method is also called the color normalization transform because it involves a red-green-blue (RGB) color transform method. Brovey Transform uses addition, division and multiplication for the fusion of three multispectral bands. The Brovey Transform was developed to visually increase contrast in the low and high ends of an images histogram.
This method was developed to overcome the disadvantages of the multiplicative method. This method Performs image fusion by factor of chromaticity transform. It is also easy and simple method. Disadvantage of this method is it should not be used if preserving the original scene radiometry is important.

C) Intensity Hue Saturation (IHS):

IHS is a color fusion technique. It effectively separates spatial (intensity) and spectral (hue and saturation) information from an image. The fusion method first converts a RGB image into intensity (I) hue (H) and saturation (S) components. In the next step, intensity is substituted with the high spatial resolution panchromatic image. The last step performs the bands. In this method three multispectral bands R, G and B of low resolution. Finally, an inverse transformation from IHS space back to the original RGB space yields the fused RGB image, with spatial details of the high resolution image incorporated into it .The intensity I defines the total color brightness and exhibits as the dominant component . After resolution using the high resolution data, the merge result is converted back into the RGB After applying IHS. It is used to Produce color Shaded Relief images. It's advantage are this is the fastest approach and it have ability to combine the massive information.

D) Principal Components Analysis (PCA):

PCA was invented in 1901 by Karl Pearson as an analogue of the principal axes theorem in mechanics. The method is mostly used as a tool in exploratory data analysis and for making predictive models. PCA can be done by Eigen value decomposition of a data covariance matrix or singular value decomposition of a data matrix, usually after mean centering the data matrix for each attribute. The results of a PCA are usually discussed in terms of component scores, sometimes called factor scores, and loadings. It is used In image color reduction while the three color components are reduced into one containing a major part of information. It's advantage is there is no number of band restricted. It's disadvantage is Sensitive to the area to be sharpen and produces fusion result that may vary depending on the selected image subset.

E) High pass filtering:

The High-Pass Filter model was first introduced by Schowengerdt (1980) as a method to reduce data quantity and increase spatial resolution potential for Landsat MSS data. High Pass Filter is a statistical/numerical method. The HPF method submits the high spatial resolution imagery to a small convolution mask (3 x 3) which acts upon the high-frequency spatial information (Pohl, 1998), effectively reducing the lower frequency spectral information of the high spatial resolution image. The filtered result is then added to the Multispectral data and the result divided by two to offsets.

Increase in brightness values:

$$HPF_{i,j,k}=(MS_{i,j,k}+FP_{i,j})/2 \text{ ------- (1)}$$

Where HPF is the output image and i and j are pixels of band k. FP is the filtered result of High-Pass Filter, This technique preserves the multispectral data while incorporating the spatial resolution of the data. It allows high frequency areas to pass with the resulting image having greater detail resulting in a sharpened image. The disadvantage is it Produce the Spectral degradation.

(2) Temporal Domain Fusion

In frequency domain methods the image is first transferred in to frequency domain. It means that the Fourier Transform of the image is computed first. All the Fusion operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get tresultant image. This domain contains methods like wavelet base method, discrete wavelet transform, etc.

A) Wavelet based method:
Wavelet theory is an extension of Fourier theory. In Fourier transforms the signals are decomposed into sines and cosines whereas in wavelet transforms the signals are projected on a set of wavelet functions. Wavelet transforms decompose an image into different frequency bands and process those frequency bands separately. The decomposition level is usually determined according to the requirement. In this method the original image is divided into four ¼ sized sub images and these sub images are further divided into low frequency components with the same decomposition. Advantage of this method is it has tendency to favor of handle the temporal resolution. Disadvantage is Poor directional selectivity for diagonal features.

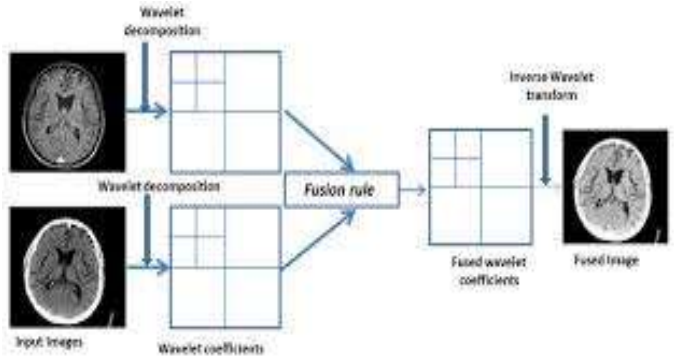

Figure 1.1: Image fusion based on wavelet decomposition

Figure 1: Wavelet Decomposition Based Image Fusion

B) Discrete Wavelet Transform (DWT):
Discrete wavelet transform converts an image from the spatial domain to the frequency domain. A wavelet is a small wave that grows and decays essentially in a limited time period. In order for a wavelet to be small, it has to satisfy two basic properties namely.

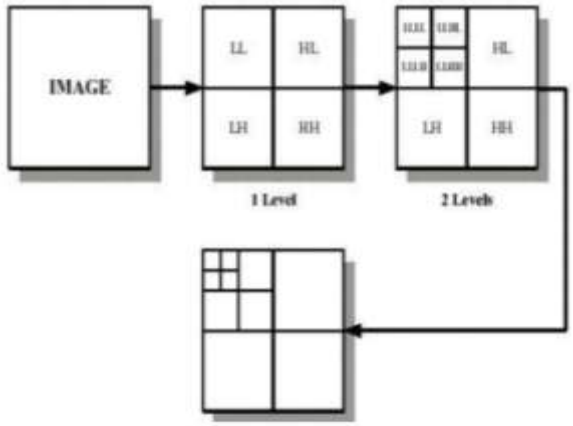

Figure 2: Discrete Wavelet Transform method image Compression level

METHOD	DOMAINS	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Weighted Pixel Averaging	Spatial	-image fusion of mammography images. -image quality assessment techniques.	Potential to decrease present noise	Destroys the significant features of the image
Brovey Transformations	Spatial	Performs image fusion by factor of chromaticity transform.	Simplest and most applicable approach.	It should not be used if preserving the original scene radiometry is important.
Wavelet Transform method	Transform	A digital image is decomposed into a set of multi resolution image.	It's tendency to favor of handle the temporal resolution.	Poor directional selectivity for diagonal features
Intensity-Hue-Saturation	Spatial	For Producing colour Shaded Relief images	-Fastest approach. -Ability to combine a massive.	Only three bands are involved.
Principal component analysis	Spatial	In image color reduction while the three color components are reduced into one containing a major part of information.	-Easiest and simplest form. -No number of band restricted.	Sensitive to the area to be sharpen and produces fusion result that may vary depending on the selected image subset.
High-Pass Filtering	Spatial	Allows high frequency areas to pass with the resulting image having greater detail resulting in a sharpened image.	3 Dimensional details present in image are preserved.	Reduce data quantity and increase spatial resolution potential for landsat MSS data.
Discrete Wavelet Transform	Transform	Medical imaging and speech signals.	Better Signal to Noise ratio	Less Spatial Resolution

Table 1: Comparison Table of Image Fusion Methods

3. ADVANTAGES OF IMAGE FUSION

1. It is easiest to interpret.
2. Fused image is true in colour.
3. It is best for identification and recognition.
4. It's cost is cheap.
5. It has a high resolution used at multi-scale images.
6. Through image fusion we got improved fused images.
7. Image fusion maintains ability to read out signs in all fields.
8. Image fusion has so many contrast advantages basically it should enhance the image with all the perspectives of image.
9. It increases the situational or conditional awareness.
10. Image fusion decreases the data storage and data transmission.

4. DISADVANTAGES OF IMAGE FUSION

1. Images have less capability in adverse weather conditions it is commonly occurred when image fusion is done by single sensor fusion technique.
2. It is not easily visible at night mainly due to camera aspects whether it is in day or night.
3. More source energy is necessary for better visualization of mages based on spatial frequency.

4. Due to rain or fog visualization is not cleared if one click the two source images in this type of weather conditions it will give the worst output.
5. In the process of fusion there are huge chances of data loss.
6. It requires the proper maintenance.
7. The Processing of data is very slow when images are fused.

5. APPLICATIONS AND USES OF IMAGE FUSION

1) Fusion is basically used in remote or satellite area for the proper view of satellite vision.
2) The major use of image fusion is in medical imaging where disease should analyses through imaging vision through spatial resolution and frequency perspectives.

3) Image fusion used in military areas as well where all the perspectives used to detect the threats and other resolution work based performance.
4) For machine vision it is effectively used to visualize the two states after the image conclude its perfect for the human vision.
5) In robotics field fused images mostly used to analyse the variations of frequency in the view of images.
6) Image fusion is used in artificial neural networks in 3D where focal length varies according to wavelength transformation.

6. PROPOSED WORK FLOW

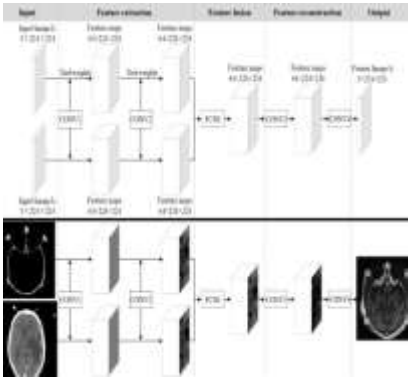

Figure 2: Image Fusion Work Flow

In proposed system One image of patient's CT or MRI and another image of patient's CT or MRI medical tests will be fused using CNN. This fused image is more accurate and efficient than single image. For fusion process images will be passed through different CNN convolution layers. In propose system several images can be fused by pixel level and transform based methods.

7. CONCLUSION

In this project, a multimodal medical image fusion method based on convolutional neural networks is proposed. We have classified image fusion technique into pixel level fusion and transform based fusion .Each fusion methods are discussed with its advantages and disadvantages. It is impossible to design universal image fusion technique applicable to all fusion applications. With CNN we get medium accurate result. Another contribution of this research work is that it exhibits the great potential of some deep learning techniques for medical image fusion. So we concluded that we get better result with CNN.CNN train itself so that it became quit easy.

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