IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Volume-6, Issue-3 E-ISSN: 2347-2693

Image Fusion through Deep Convolutional Neural Network and Laplacian Pyramid

B. Asha Latha[1*], M. Babu Reddy[2]

[1*]Computer Science, KrishnaUniversity, Machilipatnam, India
[2] Computer Science, KrishnaUniversity, Machilipatnam, India

Available online at: www.ijcseonline.org

Received: 21/Feb//2018, Revised: 27/Feb2018, Accepted: 20/Mar/2018, Published: 30/Mar/2018

***Abstract*—** In the technically advanced world image fusion attracts as a considerable assistant for image processing experts. The role of image fusion in processing of images is robust by extracting the best and complementary features from two or more images and integrating that information by using appropriate algorithm in order to provide better recognition characteristics. Image fusion experts have been using images for a long time with machine learning algorithms. It requires very intensive pre-processing steps. Recently experts are very much interested in using long existing deep learning algorithms in processing the image data. This paper presents the deep convolutional neural network based image fusion using Laplacian pyramid method. Firstly the paper concentrates on the existing image fusion techniques and related work. Secondly on convolutional neural networks, deep learning and their features. Thirdly it presented the similarities among Convolutional Neural Network, Gaussian pyramid, Laplacian pyramid models. Lastly our proposed method and discussion on experimental results. It was observed that Deep Convolutional Neural Network and Laplacian pyramid based image fusion method gave better PSNR Values than the existing Laplacian Pyramid fusion methods for various images.

Keywords— Image Fusion, Deep Learning, Convolutional Neural Network, Laplacian Pyramid

I. INTRODUCTION AND RELATED WORK

The main objective of the pixel level image fusion is that extracting best and complementary features from multiple images of same location, and combining those features to get the single image that contains more information than any input image without any loss of information.[1]. Fusion of images attracts the researchers from last 30 years, during this period of time several scientific image fusion papers were published [2]. All these image fusion papers are based on various machine learning image fusion techniques and applications [3]. Recently deep learning attracted image fusion researchers because of its automation in extracting the features of image data [4]. There are already several fields that uses the image fusion through deep learning like digital photography [5][6][7][8],medical image fusion[9],remote sensing[10].Some of them are B.Yang and C,Du worked on Multi focus Image fusion and Image segmentation based multi focus Image fusion using Deep Convolutional neural network[6][7].

A significant work has been presented in the literature survey of image fusion. In that, Zhang and Bluns and Piella presented a literature review on multi scale (pyramid) image fusion approaches [11]. In multi scale image fusion [12] pyramid representation is a critical task. Implementation of image fusion based on laplacian pyramid was presented by Pradeep[13], which is also come under the multi scale fusion approach. This paper uses the advantage of Deep Convolutional neural network and combines these advantages with Laplacian pyramid to gain better PSNR Values of Various images.

II. CONVOLUTIONALNEURAL NETWORK(CNN) AND DEEP LEARNING

CNN is network architecture for deep learning. It is made of several layers that process and transforms the input image to produce an output image. The concept of CNN is obtained as a result of combining the two elements called neural networks and convolutions.
The neural networks are composed of artificial neurons which simulate biological neurons in a limited way.

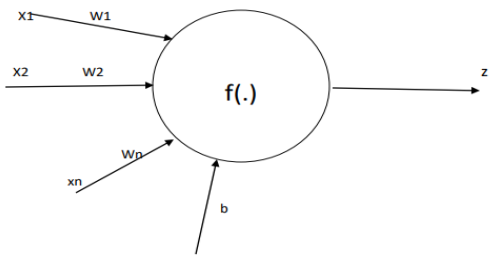


Figure 1. Artificial Neuron

In the artificial neuron structure, set of elements are applied as input from the X as shown in figure. Where X = $(x_1,x_{2,.....}x_{n)}$. The elements are connected to the activation function 'f'. Here the connection is made through set of weights Ω. Ω = $(w_{1,}w_{2,.....}w_{n)}$ along with a bias b. The output of the activation function is Z and Z is given by

$$Z = F\left(\sum_{i=1}^{N} x_i * w_i + b\right)$$

A deep neural network combines multiple nonlinear processing layers, using simple elements operating in parallel and inspired by biological nervous systems. It consists of an input layer, several hidden layers, and an output layer. The layers are interconnected via nodes, or neurons, with each hidden layer using the output of the previous layer as its input.

Convolution: It is a basic operation that we apply on the image to extract features of images. Convolution in Image Processing has some advantages. Those are Sharpening, Edge detection, Blurring, Noise-Reduction, which are not possible with Histograms and transform functions. Mathematically, we can define the convolution in one dimensional form as

$$g(i)=f*h=\int_{-\infty}^{\infty} f(x)h(i-x)dx$$

Two-dimensional Case:

If an image is convolved with a two-dimensional Lattice the result would be a crystal of that unit cell lay down in pattern dictated by the lattice. So, a crystal can be understood as the convolution of two different functions. One is the density of one single unit cell convolved with the lattice of the crystal. Mathematically, we can write the convolution operation as

$$g(i,j)=f*h=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)h(i-x,j-y)dxdy$$

g(i,j) is convolution of two functions f&h.
If we write the Fourier transformation of g, f, h then the equations are

$$F(G)=F\{f\}.F\{h\}$$

Which is a convolution theorem. By using Fourier transformation the 'g' can be computed as

$$g=F^{-1}[F(f).F(h)]$$

Salient features of Deep Learning:

1. Deep Learning can automatically learn features from the images. That means one can absolutely skip the manual feature extraction step.
2. Deep Learning is "black box" technique. In the sense it does not require to learn about the network at all. One can use the network just like a black box.
3. Deep learning updates learned weights at each layer.

III. ANALOGY AMONG CNN, GAUSSIAN PYRAMID, LAPLACIAN PYRAMID MODELS

All the above three models have the similarity of performing convolution operations with the help of filters.

Gaussian pyramid:

Gaussian pyramid represents the image on multiple scales that is image features at different resolutions requires filters at different levels.

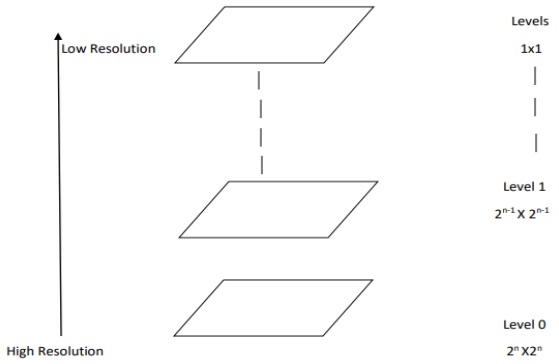


Figure 2. Gaussian pyramid Model

Gaussian pyramid starts its processing with image which is at high resolution and results at low resolution image. Level i of Gaussian pyramid can be computed with a single convolution filter.

h_i=g*g*g*g.....,h_i can be repeated i times.

Laplacian pyramid:

Laplacian pyramid is more closure to the CNN. It helps to represent image on multiple scales, but also it grabs certain frequency information from image. Laplacian pyramid helps to spread the image into different bands of frequencies.

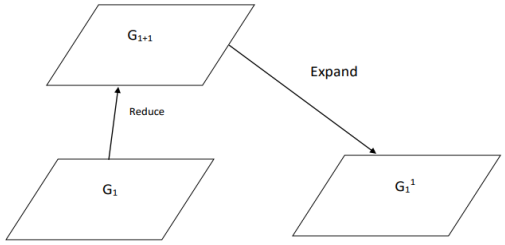


Figure 3. Laplacian pyramid Model

G_1,G_{1+1} are the levels of Gaussian pyramid. Predict level G_1 from level G_{1+1} by expanding G_{1+1} to G_1^1.
Different levels of Laplacian pyramid can be computed as

$$L_1 = G_1 - G_1^1.$$

L_0,L_1 are the levels of Laplacian pyramid.
Level i can be computed from G with single convolution filter.

$$K_i = h_{i-1} - h_i$$

CNN:
CNN's are most representative supervised model in the theory of deep learning. Now a day's CNN producing outstanding results in getting features from the images. CNN is composed by one or more layers of convolution followed by one or more steps of pooling followed by designing of fully connected layer at the end obtain the classification.
The special feature of CNN is usage of multiple filters at the same time instead of using single filter. Convolving with one filter gives one feature and convolving with another filter gives some other different feature. i.e., with each filter the model gets a new feature from the image. Suppose if we are having n*n image with n number of channels and if we want to convolve this image by $f*f*n_c$, here f is a filter and n_c is number of channels. The equation for convolution operation is

$$(n*n*n_c)*(f*f*n_c) \Rightarrow n-f+1*n-f+1*n_c^1$$

IV. DEEP CNN AND LAPLACIAN PYRAMID FUSION METHOD

1. Construction of weight maps for the source image I_1. Weight maps are obtained by combining strongest channels from the Convolutional layers of CNN Model.
2. By using basic average fusion technique source one image weight maps are fused.
3. Construct weight maps for the second source image I_2. Weight maps are obtained by combining strongest channels from the Convolutional layers of CNN Model.
4. Obtain the fused weight map for the second source image using basic average method.
5. Obtain the fused image from Laplacian pyramid by using two source images.
6. Apply average fusion technique on the source one fused weight map, source two fused weight map and pyramid fused images.

V. DICUSSION AND RESULTS

1. One of the Important Quality metric in the Image Fusion is Peak Signal to Noise Ratio and it was computed between source Images I_1, I_2 and Fused Image.
2. Results are compared with the existing pyramid fused image results and our method gave the better results than the existing pyramid fusion technique.
3. For the construction of weight maps from the original source images we took the help of most popular convolutional neural network model Alex net model.

Table 1 Comparison of PSNR Values

Type of Image	PSNR between Laplacian Pyramid Fused Image and I_1	PSNR between Laplacian Pyramid Fused Image and I_2	PSNR between Proposed method Fused Image and I_1	PSNR between Proposed method Fused Image and I_2
Visible	35.32	63.01	68.83	74.01
Lidar	42.08	39.74	67.16	61.16
Thermal	38.27	32.97	61.24	42.33
HDR	41.48	33.58	72.26	73.08

Input and Output Images:

Visible Images:

Image I_1

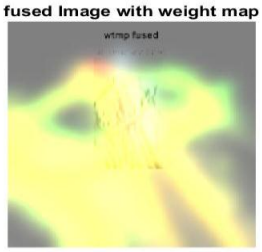
Image I_2

Output Fused Image

Lidar Images:

Image$_1$

Image$_2$

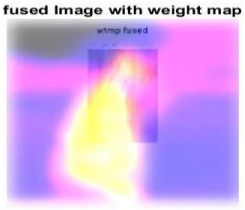


Output Fused Image

Thermal Images:

Thermal Image I$_1$

Thermal Image I$_2$



Output Fused Image

HDR Images:

HDR Image$_1$

HDR Image$_2$

Output Fused Image

VI. CONCULSION

In this paper based on CNN, how deep learning is helpful in extracting the image features was discussed. By using automated extracted features from the Alex net CNN model weight maps for different types of images were constructed. These weight maps are used in getting the final fused image with the help of Laplacian Pyramid along with the original images. The experiments are carried out using mat lab and our proposed method results shown better PSNR values.

REFERENCES

[1]. A Goshtasby, S. Nikolov, Image Fusion: advances in the state of the art, Inf.Fusion 8(2) (2007) 114-118.
[2]. S. Li, X.Kang, L. Fang,J.Hu,H.Yin, pixel-level image fusion: a survey of the state of the art, Inf. Fusion 33(2017)100-112.
[3].A review: Image Fusion Techniques and Applications by Mamta Sharma.
[4]. Deep Learning for pixel-level image fusion: Recent advances and future prospects by Yu Liu, Xun Chen, Zengfu Wang, Z. Jane Wang, Rabab K. Ward, Xuesong Wang.
[5]. Y. Liu, X.Chen, H. Peng, Z.Wang, Multi-focus image fusion with deep convolutional neural network, Inf. Fusion 36(2017) 191-207.
[6].B. Yang, J. Zhong Y.Li, Z.Chen, Multi-focus image fusion and super-resolution with convolutional neural network, Int. J. Wavelets Multiresolut.Inf. Process.15(4)(2017)1750037:1-15.
[7]. C.Du, S.Gao, Image segmentation-based multi-focus image fusion through multi-scale convolutional neural network, IEEE access 5 (2017) 15750-15761.
[8]. N. Kalantari, R. Ramamoorthi, Deep high dynamic range Of dynamic scenes, ACM Trans. Graph, 36 (4) (2017)144:1-12.

[9]. Y.Liu, X.Chen, J. Cheng, H.Peng, A medical Image fusion method based on convolutional neural network, Proceedings of 20th International Conference on Information Fusion,(2017),pp.1-7.
[10]. W. Huang, L. Xiao, Z. Wei, H. Liu, S.Tang, A new pan-sharpening method with deep neural networks, IEEE Geosci. Remote Sens. Lett.12(5)(2015)1037-1041.
[11]. Z.Zhang, R. Blum, A categorization of multiscale-decomposition-based image fusion schemes with a performance study for a digital camera application, Proc. IEEE 87(8)(1999) 1315-1326.
[12]. G. Piella, A general framework for multiresolution image fusion:from pixels to regions, Inf. Fusion 4 (4)(2003) 259-280.
[13]. Implementation of Image Fusion algorithm using MATLAB(LAPLACIAN PYRAMID) by M. Pradeep,Assoc.Professor,ECE Dept,Shri Vishnu Engineering College for Women.

Authors Profile

B.Asha Latha pursuing Ph.d at Krishna University Machilipatnam under the guidence of Dr.M.Babu Reddy,and working as Assistant Professor in CSE Department at SRK Institute of Technology,Enikepadu,Vijayawada since 23-06-2008. Member of CSI(Computer Society of India) . Life Member of ISTE (Indian Society for Technical Education).

Dr. M. Babu Reddy, PhD Working as Asst. Professor & HOD(i/c) of Computer Science, Krishna University, Machilipatnam,Krishna Dt., AP since 04-07- 2013 Rated as one of best teachers in engineering Faculty of Arba Minch University, Ethiopia with *students' feedback of 4.92 in 5 point scale* during the A.Y 2005-06.Member of IEEE. Life Member of CSI(Computer Society of India) . Life Member of ISTE (Indian Society for Technical Education).Member of African Computational Society. He has published more than 23 research papers in reputed international journals and presented 18 National & International conference Papers. His areas of interest are Computer Programming & Data Structures (Teaching experience of 18 batches) Networks & Data Communication (Teaching experience of 7 batches) Database Management Systems (Teaching experience of 8 batches) Artificial Intelligence (Teaching experience of 12 batches) Software Engineering (Research area and Teaching experience of 18 batches) Machine Learning (Research Area) Neural networks (Research Area) Data Mining (Research Area) Computer Graphics & Image Processing (Teaching experience of 6 batches) Design & Analysis of Algorithms (Teaching experience of 15 batches) Operating Systems (Teaching experience of 6 batches) Object Oriented Programming (Teaching experience of 8 batches) System Simulation (Teaching experience of 2 batches) Cryptography & Network Security(Teaching experience of 3 batches) Multimedia & Application Development(Teaching experience of 2 batches) Image Processing(Teaching experience of 4 batches)

