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# An Automatic And General Approach For Pansharpened Image Generation.

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*Abstract*— Remote sensing is the domain which is improving rapidly day by day. It mainly deals with the monitoring and detecting the geographical characteristics. This fast-growing remote sensing takes a huge part in image fusion, which is carried out in this paper. We mainly perform image fusion to obtain desired characteristics from two images. One of the applications of image fusion is: Panchromatic images have high resolution but it has only one band, hence any colour information is not present in this image. On the other hand, multi-Spectral image contains colour information, but the resolution is very low here. In that case, we need to fuse both the images to achieve a desired image which has colour information as well as high resolution. To fuse the two images, we need to bring both the images to same size. For that we need to scale them. Since we mainly aim for achieving the best result in the final image, hence we need the final image to have higher resolution. Hence, we need to upscale the multispectral image. After that we fuse the two images by injecting the intensity information. The fusion in our paper is done using wavelet. Our paper mainly aims for a generic approach, which is used to fuse the two images having any number of bands

Keywords— ***Panchromatic image, multi-spectral image, spatial resolution, spectral resolution, pan-sharpening, interpolation***

## I. INTRODUCTION

Our paper proposes the method where we get a satellite image having both spatial and spectral resolution [1]. In our paper we deal with a Panchromatic image having no colour information (one band) but high spectral resolution and Multispectral image having spatial information (multiple band) but low resolution. In order to get an image having the desired characteristics, that is high resolution and colour information, we need to perform fusion. Since the resolution of both the images differ, the pixel number also differs and hence the size. In order to fuse the two images, we need to bring them to same sizes. So, we need to perform upscaling for the multispectral image [5].

A new method of upscaling an image based on the concept of Mathematics is proposed in this paper. The upscaling can be performed with interpolation factor which is the ratio of the resolution of the Panchromatic image and the resolution of the multispectral image. The method proposed can upscale a multi-Spectral image consisting of any number of bands. Upscaling is required because the multi-Spectral image needs to be upscaled to the size of the Panchromatic image, as it has a higher resolution [2]. Also, as we are aiming for an image where the better resolution needs to be preserved.

The next step is fusing the upscaled multi-Spectral image and the Panchromatic image. The fusion will give us the image we want, which has high spectral and spatial information. The fusion of the two images is done using Wavelet Fusion technique [6], PCA (Principal component Analysis) [7], HIS (Hue Intensity Saturation) [8] and many more.

This fusion method is generic and simple and can be done with the multi-Spectral image containing any number of bands.

## II. RELATED WORK

An enormous number of researches is done in the domain of remote sensing. Work on image fusion has also been performed before. The aim of image fusion is mainly to fuse the desired characteristics of two separate images.

As discussed previously in this paper, in order to perform fusion, upscaling is needed to be performed. There are

numerous methods executed to perform upscaling. One of the papers has done upscaling based on Convolution Neural Network. Neural Network takes up a huge lot of time. Upscaling has also been done using Nearest Neighbour. Over here one of the draw-back is the simpler approach of the technique has led to degradation of the quality of the image. Bilinear technique is also used. But all these are a bit complex to perceive.

There are many techniques used for fusion.

*Image fusion techniques are divided into two categories mainly: Multiresolution Analysis (MRA) and Component Substitution (CS). In both, the fusion is done by the up-scaled image and the detail extraction of the image using injection method.In Multiresolution Analysis (MRA) the techniques are: à trous, Ripplet, Discrete Wavelet Transform (DWT), High-Pass Filter Additive (HPFA).*

In Component substitution (CS) the methods are Brovey Transform, General IHS, Principal Component Analysis (PCA), Intensity Hue Saturation (IHS), Gram-Schmidt (GS).

## III. METHODOLOGY

This paper aims to generate a new interpolation technique. Interpolation is a vital part of image fusion.
In image fusion, two images can be fused only if the two images have the same size. However, MS image has a lower resolution than PAN image, so by default, the number of pixels representing the PAN image is more extensive than MS image. Image interpolation means making the two images equal in size so that we can fuse them. There are many interpolation algorithms available like bilinear interpolation, bicubic interpolation, and many more. Our interpolation algorithm is easy and fast, and it will work for any image.

**Interpolation Technique**

We will represent our method in Algorithm 1.
Algorithm 1: Interpolation of MS image.
Input: The original MS image.
Output: The interpolated MS image (MS´)

1. BEGIN
2. Read the MS image band wise.
3. Find the interpolation factor (λ) that is resolution of PAN with respect to resolution of MS.
4. Take an empty matrix of the size PAN.
5. Distribute the MS pixels evenly in the empty matrix.
6. The intermediate pixel values will be filled by the mean of boundary values.
7. Do this process for all MS bands.
8. END.

Our process is straightforward and fast. If we can make a fast interpolation technique, then image fusion will work efficiently. We fill the intermediate unknown pixels with mean values, the probability of generating artifacts decreases. We have also done quantitative and visual analysis with our interpolation methods with some commonly known interpolation methods.

## IV. RESULTS AND DISCUSSION

This particular segment in the paper analyses the designated outputs and the analytical comparison between different pan sharpened images. This is the part where the comparison factors or the methods and the visual outputs of the input dataset will be displayed and with the help of the analytical values the following conclusion will be justified. The following output will be collated with different quantitative methods for justifying the concluded results.
For the contrasting of the proposed method output with the other established output certain setup and requirements has to be fulfilled the following are the set of the requirements: -

(1) Editor: Spyder (Anaconda-3)
(2) Coding Language: Python 3.9.0
(3) Operating System: Windows (Version: 10)
(4) Processor: Intel(R)-CoreTM-i5-L16G7-3.0GHz
(5).RAM: 16 GB

QUANTITATIVE ASSESMENT

There are certain methods that are used for the validation of the different outputs generated by the particular datasets. These methods imply or gives the comparative results to determine that how close is the generated output deferrers from the actual or the targeted outputs. This type of analysis is known as the quantitative analysis. These analyses comprise of certain predefined methods with which we can compare the output results with the targeted output in certain fields.
In this paper also we have chosen six different quantitative methods for the same, these methods will help in the analysis purpose of the generated output, the following are the six different quantitative methods that are used for this purpose: -

1. Correlation Coefficient (CC)
2. Peak Signal to Noise Ratio (PSNR)
3. Structural Similarity Index Measure (SSIM)
4. Universal Image Quality Index (UIQI)
5. relative dimensionless global error (ERGAS)
6. Root Mean Square Error (RMSE)

These are the six different approaches that are chosen for this purpose. Correlation Coefficient (CC) this is the parameter that determines the degree of the movement of the two coordinates [3].
Higher the comparison factor better will be the performance, in this case we use a particular formula, for the determination of the Correlation Coefficient (CC) factor.

$$CC = \frac{\sum_i (r_i - r_m)(f_i - f_m)}{\sqrt{\sum_i (r_i - r_m)^2 (f_i - f_m)^2}}$$

Peak Signal to Noise Ratio (PSNR) this factor determines the changeable quantity. Higher the value better will be the quality of the output it is determined by the following formula [4].

$$PSNR = 10 \times log_{10} \left( \frac{P^2}{\frac{\sum_{i,j=1}^{mn} (R_{ij} - F_{ij})^2}{mn}} \right)$$

Structural Similarity Index Measure (SSIM) this factor determines the similarities, higher the value of the comparative analysis better will be the generated output in this factor.

$$SSIM(R,F) = \left( \frac{2\mu_R\mu_F + C_1}{\mu_R^2 + \mu_F^2 + C_1} \right) \left( \frac{2\sigma_{RF} + C_2}{\sigma_R^2 + \sigma_F^2 + C_2} \right)$$

Universal Image Quality Index (UIQI) this index measures the quality of the generated outputs, higher the value better will be the quality of the generated output, it is generated by the following formula.

$$UIQI(R,F) = \frac{\sigma_{RF}}{\sigma_R\sigma_F} * \frac{2\mu_R\mu_F}{\mu_R^2 + \mu_F^2} * \frac{2\sigma_R\sigma_F}{\sigma_R^2 + \sigma_F^2}$$

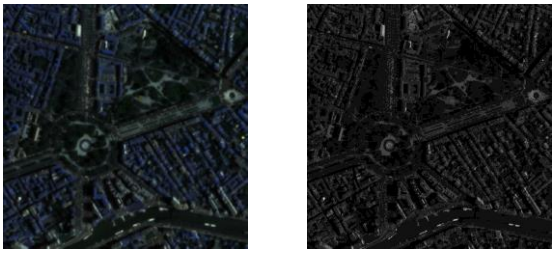
Relative dimensionless global error (ERGAS) it is the quantitative method which is dependent on the rmse factor less the error better will be the result.

Root Mean Square Error (RMSE)- this is the quantitative method which determines the error in an output image. Less the error better will be the result.

$$RMSE = \sqrt{\frac{\sum_{i,j=1}^{mn} (R_{ij} - F_{ij})^2}{mn}}$$

EVALUATION AND VALIDATION

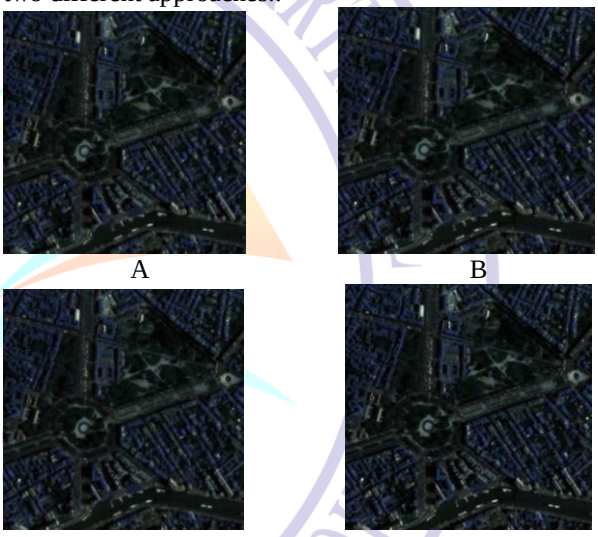
In this area we will showcase the comparison factor between the different results generated by the different approaches used in the project. In this part we will be comparing the output generated by the proposed algorithm and the output generated by the other established algorithm. The main aim of the project is to define an algorithm that will upscale the MS image in a better form than the other established methods. For the validation purpose we have taken an input MS image and the PAN image. The following is the input PAN and the MS image dataset in which the different approaches had been done: -



A B

**FIG 1**- A-MS IMAGE, B-PAN IMAGE

These are the two images that are taken as the input the MS image comprises of 256X256 number of pixel and the PAN image is having 1024X1024 number of pixels. The MSI image is first upscaled by the proposed algorithm and then by the Nearest Neighbour interpolation technique, Bilinear interpolation technique and bicubic interpolation technique. The following is the results for the upscaled MS image by two different approaches.: -



A B C D

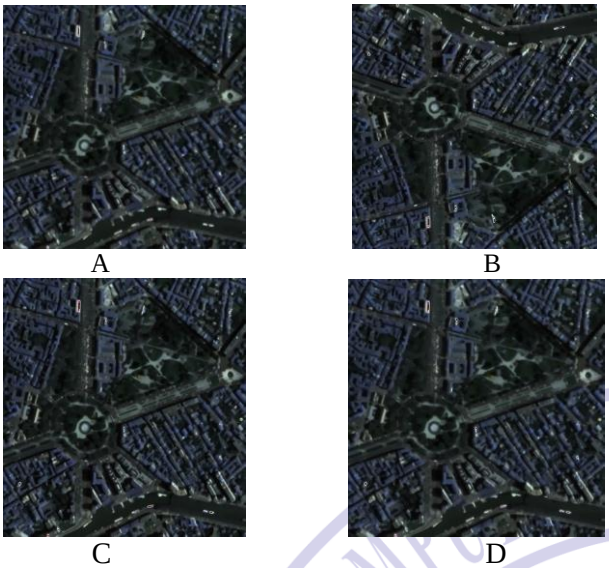
**FIG 2**- A-PROPOSED UPSCALED, B-NEAREST NEIGHBOUR INTERPOLATION TECHNIQUE, C-BILINEAR UPSCALED, D- BICUBIC UPSCALED

These are the following output after the upscaling of the MS image the following output contains 1024X1024 numbers of pixels and after that fused with WAVELET fusion algorithm to get a PAN sharpened image.

WAVELET FUSION ALGORITHM

This is the algorithm in which the input PAN image and the input MS image is decomposed into four different coefficient and then again recomposed to get the final output.

The following images are the output after the application of the WAVELET fusion algorithm: -



A B C D

**FIG 3**- A- PROPOSED UPSCALE AND FUSED, B- NEAREST NEIGHBOUR AND FUSED, C -BICUBIC AND FUSED, D- BILINEAR AND FUSED

After the following output obtained the validation part is done. The validation part is done by comparing the following outputs with the help of the stated quantitative methods the following is the table that depicts the comparative results of the quantitative methods: -

| Quantitative Parameter | Propose method And fused | Nearest neighbor and fused | Bicubic and fused | Bilinear and fused |
|---|---|---|---|---|
| Correlation Coefficient (Red) | 0.994 | 0.981 | 0.987 | 0.991 |
| Correlation Coefficient (Green) | 0.994 | 0.983 | 0.986 | 0.991 |
| Correlation Coefficient (Blue) | 0.994 | 0.983 | 0.986 | 0.991 |
| Average Correlation Coefficient | 0.994 | 0.982 | 0.986 | 0.991 |
| RMSE | 0.064 | 0.072 | 0.072 | 0.073 |
| PSNR | 28.523 | 29.063 | 29.118 | 28.961 |
| ERGAS | 0.036 | 0.041 | 0.042 | 0.041 |
| UIQI | 0.846 | 0.816 | 0.820 | 0.807 |
| SSIM | 0.809 | 0.842 | 0.847 | 0.824 |

TABLE 1

**TABLE 1**- QUANTITAVE VALUES AFTER THE UPSCLING AND THEN FUSION WITH THE WAVELET FUSION ALGORITHM

The following TABLE 1 is the representation of the all the analytical result after the ongoing of the different quantitative methods. From the above table and the visual outputs generated we can observe that on an average the proposed method stated in the project gives the better result than the other techniques.

## V. CONCLUSION AND FUTURE SCOPE

In the following project we have proposed a new approach for the upscaling of the image. This project validates the work by fusion of the proposed algorithm with the Wavelet fusion algorithm with three different other fused images that have been upscaled by three different upscaling algorithms that are bicubic interpolation, bilinear interpolation and the nearest neighbour [interpolation technique and then fused with the Wavelet fusion algorithm. After the validation it has been observed that some of the factors in proposed algorithm is not satisfactory as compared to the other approaches, these all will surely take a place for the future betterment. But after observing the stated outputs and the analytical results and taking consideration of all the failures we can conclude that on an average the method proposed by the project gives the better results that the other approaches.

FUTURE SCOPE

The project is having some future scopes that is excelling all the quantitative factors that have been mentioned.

Implementation of the new fusion algorithm with the proposed interpolation technique.

Defining better image quality modifying the algorithm to gain a better interpolated image.

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