FEATURE ENHANCEMENT FROM REMOTE SENSING IMAGES WITH MODIFIED FILTERING TECHNIQUES USING INTERACTIVE DATA LANGUAGE PROGRAMMING ENVIRONMENT

A.H. K. K. Pathmadewa[1], Jagath Gunatilake[2] and K. K. S. A. Withanage[1]

[1]Postgraduate Institute of Science, University of Peradeniya, Peradeniya, Sri Lanka
Email: pathmadewa@gmail.com
Email: amindika.kks@gmail.com
[2]Department of Geology, University of Peradeniya, Peradeniya, Sri Lanka
Email:jagathpgis@gmail.com

ABSTRACT:
High resolution remote sensing images form IKONOS MSS and WorldView-3 are used in many fields. Commercial Image Processing software enhance feature from satellite images using convolution filtering methods. Existing filters for the feature enhancing (especially point features) from remote sensing images does not have the feasibility to work on the image at the user defined levels. In this scope the objectives of this study focuses to create a software using Interactive Data Language (IDL) programming environment to enhance features (Mainly focus on point features) from satellite images, to enhance features from High resolution satellite images (especially point features), through filtering techniques using IDL programming environment and to compare existing filtered image with PSF filtered image and their feature extraction level. The whole filter process can be divided in to two phases and those are built-in filters in ERDAS IMAGINE software and user defined filters. Two separate satellite images were taken from two different satellites were used in this study to evaluate the coding system. The study discovers the effect of existing filtering techniques applied on satellite images to enhance point and line features. The needs for development of a filter capable for enhance line and point features were visualized after these experiments. For the study, it was used by Point Spread Function as a convolution filter and applied it in to satellite images. The results indicate that the method proposed in the literature is more effective and intelligent than that used previously. Interactive Data Language (IDL) coding used to create software called GM Solutions and applied convolution filters on images, and showed a few different filters and their results. The study indicated the Point Spread Function (PSF) is not much supported for very high resolution images such as WorldView-3 Satellite images. However, it can be used to get better result for IKONOS MSS images.

1.0 INTRODUCTION

With the development of Remote Sensing (RS) technology, an increasing amount of very High-Resolution Imagery (HRI) of astonishing quality provided by new space-borne sources has entered in to the RS market. It is characterized by high user interpretability, rich information content, sharpness, accuracy, high image clarity, and integrity. The common RS image processing software systems (for example, ERDAS IMAGINE, ENVI, PCI, ERMAPPER) are not suitable for HRI (Gu and Chen, 2005). The calculations of many commercial software systems are black box and user cannot understand what really is happening in inside. In the present study, it is expected to implement a computer based coding system to enhance image features.

The actual ground features have their unique shape, size and orientation. However, RS images do not have such features, they are originated in Digital Numbers (DN). Enhancing features from images are not an easy task due to several reasons such as resolution limitation, mixed pixel problems and spectral integrity. Many filtering techniques are used to enhance features from satellite images by identifying their spectral uniqueness of particular feature. However, those common filters do not assist to enhance point features. A high-pass filter is a filter that passes high frequencies well, but attenuates (reduces the amplitude of) frequencies lower than the cut-off frequency and this filter is not capable enough to enhance point features. Point Spread Function (PSF) defines as a measure of the geometrical performance of an optical system, defines the apparent shape of a point target as it appears in the output image. A plot of illuminance of the image is as a function of distance in the image plane (CRS Canada, 2015).

Interactive Data Language (IDL) is the trusted scientific programming language used across disciplines to extract meaningful visualizations from complex numerical data. With IDL you can interpret your data, expedite discoveries, and deliver powerful applications. Additionally, IDL is a truly cross-platform solution, providing support for today's most popular operating systems, including Microsoft Windows®, Mac OS X, Linux, and Solaris (IDL, 2015 (a)).

The IDL Virtual Machine is a freely distributed, cross-platform utility for running complied IDL code, designed to provide IDL users with a simple, no-cost method for distributing IDL applications (IDL, 2015(b)).

Existing filters for the feature enhancing (especially point features) from RS images does not have the feasibility to work on the image at the user defined levels. In this scope the objectives of this study lead to create software using IDL programming environment for enhance point features from satellite images, to enhance features from High Resolution Satellite Images (especially point features), through filtering techniques using IDL programming environment and to compare existing filtered image with PSF filtered image and their feature extraction level. The study only consider 2D filters which are similar to the one included in IDL programming language as User Defined Filter and Custom Filters in ERDAS IMGINE.

2.0 METHODOLOGY

2.1. Development and analysis of filters

The whole filter process in this study can be divided into two phase. Those are already applying filters built in ERDAS IMAGINE software and User defined. Figure 1 shows the methodology of development and analysis of feature enhancement.
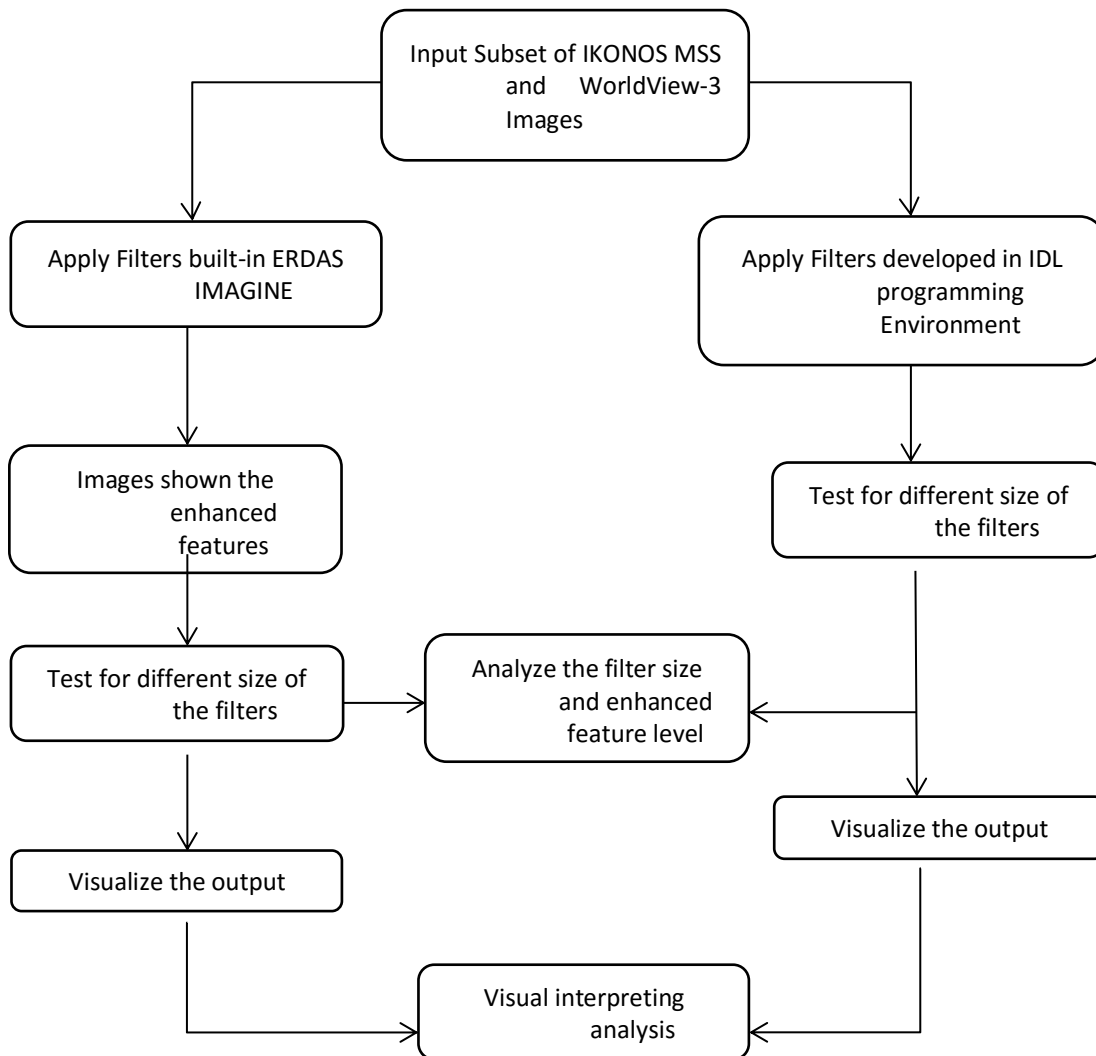

Figure 1: Methodology of development and Analysis of feature enhancement

2.1.1. Input Subset of IKONOS MSS and WorldView-3 Images: Two separate satellite images which taken from two different satellites are used in this study to evaluate the coding system. The IKONOS multispectral image acquired over Dehradun, India on 25th December 2001 and WorldView-3 multispectral image acquired over Bandaranayke International Airport at Katunayake, Sri Lanka on 3rd January 2015 were used in this study.

High resolution Satellite images consume large size of memory. Therefore, it is suitable to use subset of images. It is used ERDAS IMAGINE 2011 software to create subset image by applying layer stacking function. Figure 2 (a) image consists of 4.0 m ground resolution. Figure 2 (b) shows Pan-Sharpened image and it was created by using fusion technique, therefore it has 1 m ground resolution.

Figure 2(a): Layer stack image   **Figure 2(b):** pan-sharpened images

WorldView-3 is the first multi-payload, super-spectral, high-resolution commercial satellite. WorldView-3 provides 31 cm panchromatic resolution, 1.24 m multispectral resolution, 3.7 m short-wave infrared resolution, and 30 m CAVIS resolution. It is used ERDAS IMAGINE 2011 software to create subset image from WorlView-3 Satellite Image (Figure 3).

Figure 3: WorlView-3 Satellite Image

2.1.2. Apply Filters built-in ERDAS IMAGINE: ERDAS Modeler can be used built-in filters in ERDAS IMAGINE 2011 and user defined filters. Many filters can be defined for many purposes. They give results according to the filter kernel values, filter size and number of iterations.

2.1.3. Apply Filters developed in IDL programming Environment: Firstly, coding of IDL programming environment is done. The filter calculation, itself is a 4-double loop that has to go through every pixel of the image, and then through every element of the filter matrix (Figure 4). The location image X and image Y is calculated, so that the center element of the filter will be x, y, but for the other elements, it'll be a pixel from the image to the left, right, top or bottom of x, y.
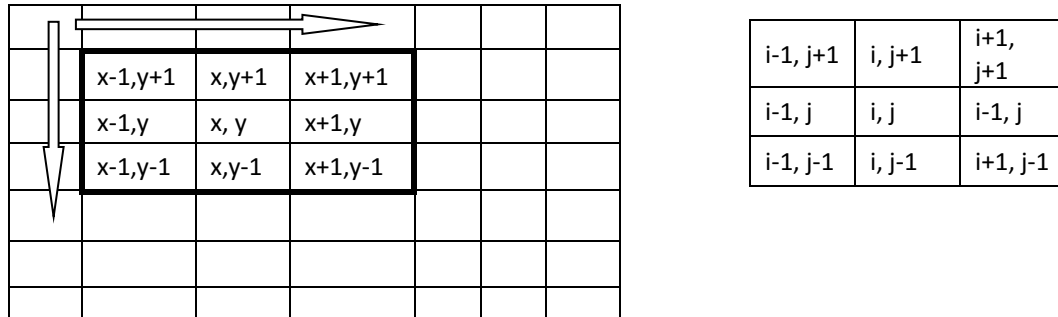
	x-1,y+1	x,y+1	x+1,y+1			
	x-1,y	x, y	x+1,y			
	x-1,y-1	x,y-1	x+1,y-1			

i-1, j+1	i, j+1	i+1, j+1
i-1, j	i, j	i-1, j
i-1, j-1	i, j-1	i+1, j-1

Figure 4: Moving window of image scene

Following IDL coding shows 4-doble loop used in convolution filtering.

```
FOR x = 0, xsize-1 DO BEGIN
        FOR y = 0, ysize-1 DO BEGIN
                FOR i = 0, 2 DO BEGIN
                FOR j = 0, 2 DO BEGIN
                Statement...
                ENDFOR
                ENDFOR
        ENDFOR
ENDFOR
```

GM Solutions Software Coding created by Fanning (1997). It was modified by the author using IDL programming language coding is used in this research project for applying filter techniques to the satellite images. Figure 5 shows a modified image which is created for the better visualization by editing pixel values. This image will show the effect of the filters used in this study.
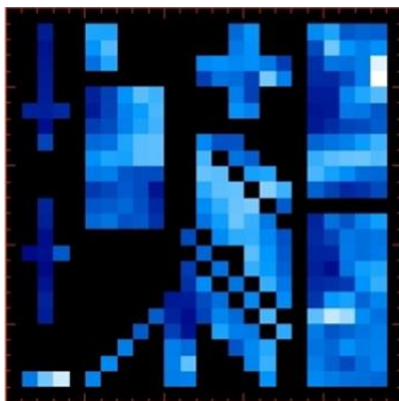
Figure 5: Modified image

Following paragraph illustrates the GM Solutions software and it's General User Interface (GUI). Figure 6 shows GUI of GM Solutions software.
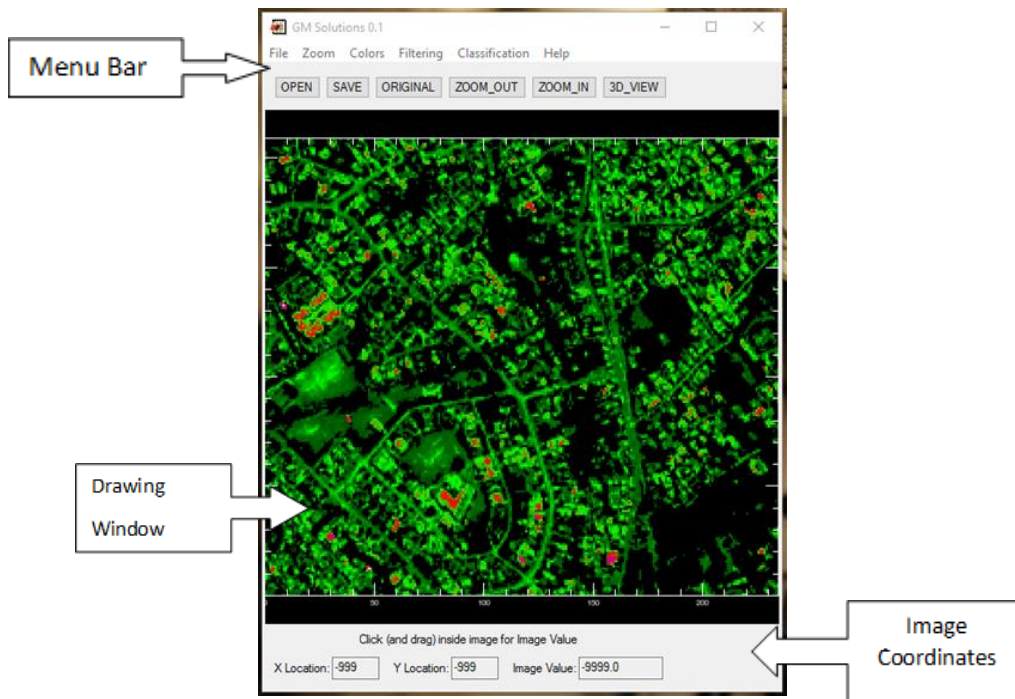

Figure 6: GUI of GM Solutions software

IDL has facility to call select image function, to load different color tables, to save image in different format. This software has many built-in functions for filtering. GM Solutions software has the facility for 3D plot image scenes.

4.0 RESULTS AND DISCUSSION

The results which taken from GM Solutions software are discussed. Many filters are being applied to the images for different purposes.

4.1. Filtered images from GM Solution software

Figure 7 shows normal filter and the filter filled in currently, does nothing more than returning the original image because the center value is 1. Therefore, every pixel is multiplied with 1.

0	0	0
0	1	0
0	0	0

Figure 7: Normal filter

. Figure 8(a) shows modified image used in this study and Figure 8(b) shows 3D plot of view in modified image.
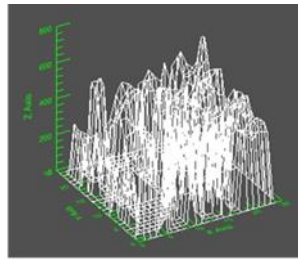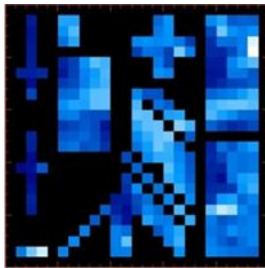
Figure 8(a): Modified images

Figure 8(b): 3D plot of Modified image

 The results images of several filters are shown as below.
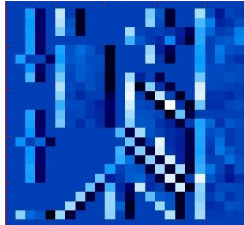
4.2. Edge Detecting Filters
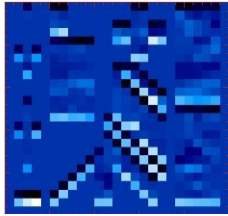
Edge detecting filters are emphasized the image scene that has high spectral value difference. There are many edge detecting filters and according to the purpose they can be used in different ways. In image enhancing purposes, common edge detecting filters can be found as Horizontal, Vertical, Diagonal, Laplacian and Edge-dog.

The reason why these filters can find horizontal edges is that the convolution operation with this filter can be seen as a sort of discrete version of the derivative. It takes the current pixel and replace the value of the new one to it, so it will get a value that represents the high frequency horizontal edges. As the same, the vertical edge filter and diagonal edge filter emphasize high spectral values of image.

The Laplacian function applies a Laplacian operator to a 2D image array to generate an array containing difference values that represent edges in the original image. When Laplacian filter is applied it gives edge enhancing according to filter kernel and surround pixel values. EDGE_DOG filter is IDL library filters and it enhances the edges and bluer the image area. The EDGE_DOG function applies the Difference of Gaussians filter to a 2D image array to generate an array containing difference values that represent edges in the original image.

4.3. Edge Detecting Filters on Images

Figure 9 shows Edge detecting filters used to enhance feature in modified image.

Horizontal	0 0 0 / -1 1 0 / 0 0 0	
Vertical	0 -1 0 / 0 1 0 / 0 0 0	

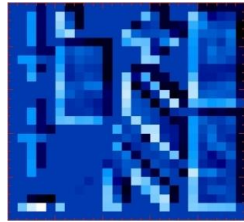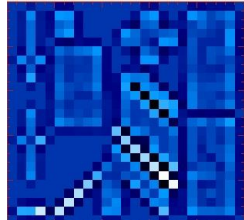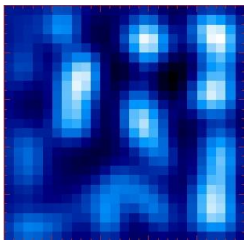|		
Diagonal	<table><tr><td>-1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>0</td><td>0</td><td>0</td></tr></table>	
Laplacian	<table><tr><td>-1</td><td>0</td><td>-1</td></tr><tr><td>0</td><td>**4**</td><td>0</td></tr><tr><td>-1</td><td>0</td><td>-1</td></tr></table>	
EDGE_DOG	Edge_dog filter is IDL library filter	

Figure 9: Filter kernels and Filtered images

4.4. Sharpening Filters

Sharpening of the image is very similar to finding edges, adding the original image and the image after the edge detection to each other. The result will be a new image where the edges are enhanced, making it look sharper (Figure 10). Adding image is done by taking the edge detection filter from the previous image, and incrementing the center value of it with 1. Now the sum of the filter elements is 1 and the result will be an image with the same brightness as the original, but sharper.
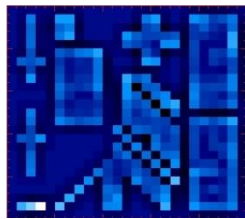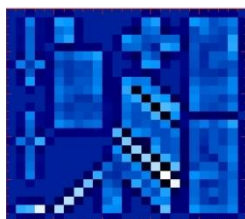
Filter1	<table><tr><td>-1</td><td>-1</td><td>-1</td></tr><tr><td>-1</td><td>9</td><td>-1</td></tr><tr><td>-1</td><td>-1</td><td>-1</td></tr></table>	
Filter2	<table><tr><td>0</td><td>-1</td><td>0</td></tr><tr><td>-1</td><td>5</td><td>-1</td></tr><tr><td>0</td><td>-1</td><td>0</td></tr></table>	

Figure 10: Sharpening Filter kernels and Filtered images

4.5. Image Smoothing Filters

Simple spatial smoothing such as filtering the image through an averaging mask has the disadvantage of blurring edges. Therefore, there has been much interest in edge-preserving smoothing which eliminates noise while retaining significant (edge) features (Freddy and Paul, 1994). Figure 11 shows Boxcar and Median filters are applied to the modified image.
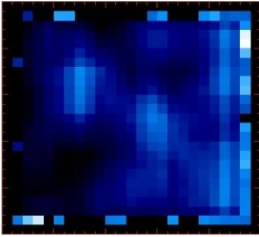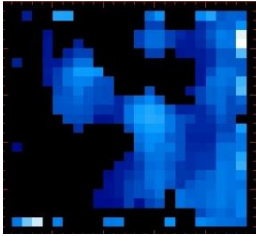
Boxcar	<table><tr><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td></tr><tr><td>0</td><td>0</td><td>0</td></tr></table>	
Median	Used IDL library filters	

Figure 11: Filter kernel and Filtered images

A classical Boxcar liner filter may be applied to the data to reduce the effect of the speckle but it results, into spatial resolution loss and, additionally, it will not be valid near contours, for instance, due to the mixture of heterogeneous samples (Alberto *et el.,* 2013). Median Filter can be used to remove noise from an image. The median is found by sorting all the values from low to high, and then taking the value in the center. If there are two values in the center, the average of these two is taken. A median filter gives better results to remove salt and pepper noise, because it completely eliminates the noise.

The median filter also reduces the image quality however. Such a median filter can't be done with a convolution, and a sorting algorithm is needed, in this case COMB SORT was chosen, which is a relatively fast sorting algorithm. To get the median of the current pixel and its 8 neighbors, set filter Width and filter Height to 3, but we can also make it higher to remove larger noise particles.

4.6. PSF Filter

Figure 12 shows 5x5 PSF filter kernel used in this study and it has high center values in this filter and it emphasizes high spectral frequency areas.

0.25667	-0.12555	-0.21336	-0.12553	0.25666
-0.12553	-0.62658	0.35240	-0.62660	-0.12553
-0.21338	0.35243	2.92779	0.35244	-0.21338
-0.12553	-0.62659	0.35241	-0.62659	-0.62659
0.25667	-0.12554	-0.21337	-0.12553	0.25667

Figure 12: PSF 5X5 filter kernel

Figure 13(a) and Figure 13(b) show before and after applying PSF filter kernel in to modified image and it shows emphasize areas.
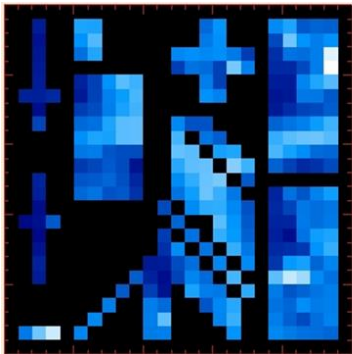

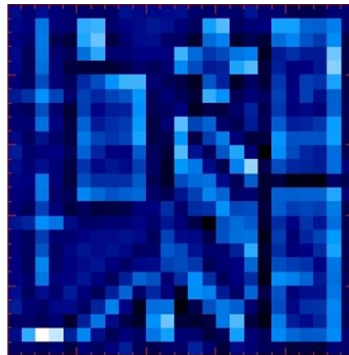**Figure 13(a):** Modified image   **Figure 13(b):** PSF filtered image

Figure 13(c) and Figure 13(d) show the 3D plot of images of before and after applying filter to the modified image. It shows high value goes higher and it has changed values of the Z-axis.
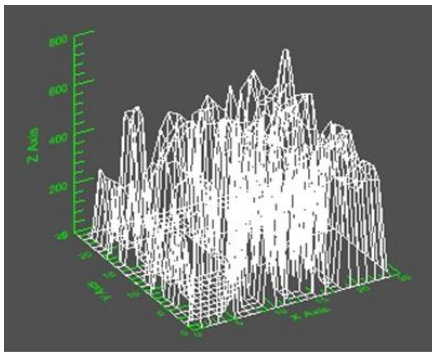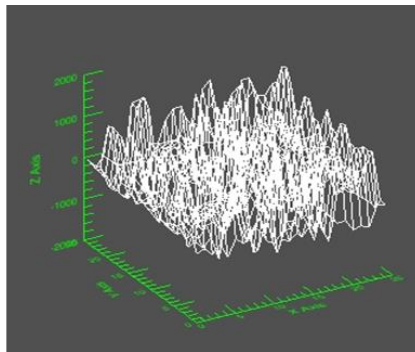

Figure 13(c):3D plot of Modified image   **Figure 13(d):** 3D plot of PSF filtered image

Point Spread Function emphasizes homogeneous point features. Figure 5.14(a), Figure 5.14(b), Figure 5.14(c) and Figure 5.14(d) show before and after applying PSF filter to the satellite images.
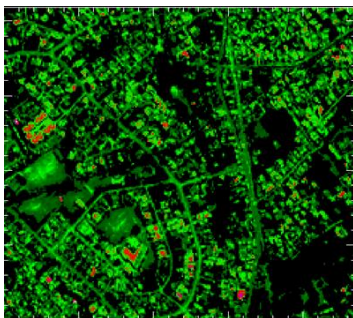
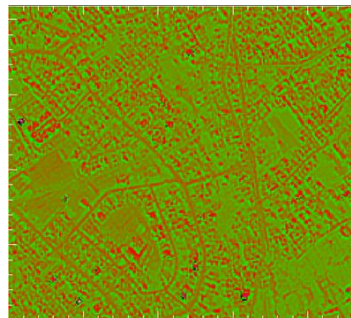

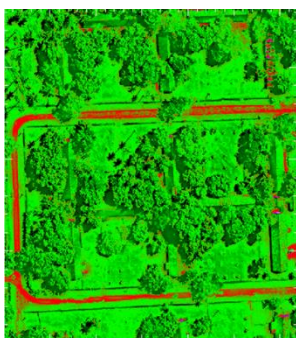**Figure 5.14(a):** IKONOS MSS Subset image   **Figure 5.14(b):** PSF filtered image

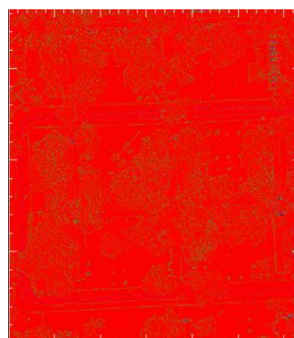**Figure 5.14(c):** WorldView-3 Subset image   **Figure 5.14(d):** PSF filtered image

CONCLUSIONS

The study was mainly focused to creating a software called GM Solutions and it was coded by using IDL programming environment. This software is using convolution filtering methods to enhance features form the satellite images. This research revealed that Point Spread Function can be used as convolution filter. The Point Spread Function (PSF) plays an important role in the image formation theory of the Fluorescence Microscope. It is the main brick that builds up the whole acquired image. This Point Spread Function used as convolution filter for the enhancement of the point feature from images. It increases the DN value of the homogeneous image area and high spectral frequency area. Point Spread Function is not much supported for very high resolution images such as WorldView-3 Satellite images. However, it can be used to get better result for IKONOS MSS images.

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