Improving SAR Image classification In Tropical Region Through Fusion With SPOT Data

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Abstract – This paper investigates various SAR digital filtering techniques to remove speckles for image classification using fused SAR and SPOT XS image. The fused image classification is then compared with the classified SPOT XS image. The result has shown that the use of Enhanced Frost digital filtering technique for SAR image and the fusion with SPOT XS gives a very similar classification with comparison to the SPOT XS image classification.

INTRODUCTION

In the tropical region, there is a limited supply of passive satellite optically sensed images for classification . With the use of SAR, images can be obtained at anytime of the day. Hence, SAR images are readily available. Furthermore, SAR can penetrate through clouds as well as haze due to its longer wavelength, therefore, the present of clouds or haze in the tropical region would not affect the classification through the use of SAR. Hence, the use of clouds detection technique to remove clouds in optical satellite images [1] may not be necessary for classification.

One inherent problem of SAR precision images is that they contain speckles which result in classification inaccuracy. One way to reduce the speckles is to use digital filters. According to Serban [2], Gamma MAP filter could be used to perform on the SAR image before fusion with two different bands of LANDSAT TM image. From the paper [2], the unsupervised classification performed on the fused image was very satisfactory with more classes of the different types of soil contents shown in the classification. In order to gain a better knowledge of the effect of filtering in classification, this paper will provide an investigation to ascertain the best type of SAR filter which could be used for fused image classification

We have selected the six best known and common digital speckle filters [3] for our investigation. These are the Lee filter [4], Kuan filter [5], Enhanced Lee filter [6], Gamma MAP filter [7], Frost filter [8] and Enhanced Frost filter [6]. In addition, SPOT XS image classification would be used as a benchmark for comparison on the effectiveness of this fusion and filtering technique.

DATA AND SYSTEM

ERS-1 SAR image and SPOT XS image of the eastern part of Singapore were used for the investigation. The pixel size of the two images is 704 by 896. This area contains many roads and dense buildings with certain areas still under development at the time of capturing these images.

The system used was a Pentium 133MHz PC. ER Mapper software, which works under Windows 95 environment, was used for the manipulations of the images and the coding of various digital speckle filters.

DIGITAL SPECKLE FILTERS

Many adaptive filters have a common goal of smoothing the images while preserving sharp features and edges in the images. However, the appropriate filtering window size cannot be determined automatically and has to be obtained experimentally. The main reason is due to the fact that if the window size is too small, the filtering will not be effective and if the window size is too large, certain details of the image will be lost after the filtering process. Hence, the filter window size used in this paper is a 5x5 window size which is a reasonably size for filtering purpose. In this paper, the digital SAR filters used for evaluations are the Lee filter, enhanced Lee filter, Frost filter, enhanced Frost filter, Gamma MAP filter and Kuan filter.

Since the digital SAR filters are based on the intensity multiplicative noise model, we have to make sure that all the pixels in the SAR images are in the form of intensity by squaring the pixels of the SAR amplitude images before implementing the filtering processes. After filtering, these pixels have to be converted back to amplitudes before proceeding with fusion with other images.

GROUND CONTROL POINTS

Due to the motion of the scanners, sensor characteristics and many other factors, the images taken would not be properly mapped to one another. As such, ground control points (GCP) have to be chosen so that these points would serve as references for different images to map onto.

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In all, ten GCPs were set for all the images and SPOT XS image which has a spatial resolution of 20 m was used as the main reference for other images. The selection of GCPs on the SAR images was a tedious task due to the speckles on the images, hence most GCPs were chosen at distinct cross junctions of airport runway and the sharp bends of broad roads. Subsequently, polynomial rectification method was used to mapped the images to one another.

DATA FUSION

SPOT XS image consists of 3 bands. However, in this paper, only band 1 and band 3 were used for image fusion. The SAR image occupied the green layer of RGB layers, band 1 of SPOT XS image occupied the red layer of RGB layers and band 3 of SPOT XS image occupied the blue layer. Subsequently, ISOCLASS unsupervised classification was performed on the fused image, and the classes produced were broken down to five main classes - Water Region, Grassland, Bare Soil, Buildings and Roads.

In order to make comparisons between the ISOCLASS unsupervised classification of the SPOT XS image and this fused image, the percentage coverage of each class was being calculated as shown in table 1.

With reference to table 1, the difference (L – C) in the class percentage between SPOT XS image classification and this fused image classification was calculated to determine the accuracy of the fusion image with comparison to the SPOT XS image classification.

RESULTS AND DISCUSSIONS

As it was observed from the classifications of all the images, the roads and the buildings are not classified distinctly. The main reason is due to the proximity of the roads and the buildings. Hence, for these two classes, the difference in percentage, when compare with SPOT XS image classification as shown in table 1, can be quite significant. Hence, it was proposed that the two classes be merged together to form a single class as shown in Fig.1 and Fig.2.

After the combination of these two classes, the class percentage difference ((R+B) – (R'+B')), with reference to table 1, was derived. Table 2 shows the percentage sum of the difference in all classes between the fused image classification and the SPOT XS image classification for the different types of filters used in SAR image.

From table 2, it is noticed that using Enhanced Frost filter, the classification for the fusion of SPOT XS image and SAR image has a minimum percentage sum of the absolute difference of all classes of 8.14% as compare to the other filters. In other words, the classification that uses Enhanced Frost filtering method produces very similar classification to SPOT XS image classification.

By observing the different types of SAR filtered images with comparison to the original SAR images, it could be noticed that Enhanced Frost filter gives an image that preserves the high intensity pixels as well as the edges of the features. Furthermore, with comparison to other filtering techniques, Enhanced Frost filter has a moderately good smoothing effect for the speckles, hence, the fusion classification using this filtering technique is very satisfactory.

Table 1: Statistical Calculations For Classified Images

Land Feature (L) / Type Of Filters	**Roads /%**	**Buildings /%**	**Bare Soil /%**	**Water Region /%**	**Grassland /%**
Gamma Filter	(R) 17.79	(B)9.58	12.29	9.15	51.19
L-C	-3.38	2.48	-3.23	6.10	-1.97
(R+B) - (R1+B1)/ %	-0.9				
Enhanced Frost Filter	(R)9.04	(B)17.92	12.76	3.26	57.02
L-C	-12.13	10.82	-2.76	0.21	3.86
(R+B) - (R1+B1)/ %	-1.31				
Frost Filter	(R)18.96	(B)13.14	8.71	8.21	50.98
L-C	-2.21	6.04	-6.81	5.16	-2.18
(R+B) - (R1+B1)/ %	3.83				
Enhanced Lee Filter	(R)20.24	(B)14.63	8.62	8.94	47.57
L-C	-0.93	7.53	-6.9	5.89	-5.59
(R+B) - (R1+B1)/ %	6.6				
Lee Filter	(R)18.30	(B)13.17	10.76	16.99	40.78
L-C	-2.87	6.07	-4.76	13.94	-12.38
(R+B) - (R1+B1)/ %	3.2				
Kuan Filter	(R)12.82	(B)19.74	12.59	7.66	47.19
L-C	-8.35	12.64	-2.93	4.61	-5.97
(R+B) - (R1+B1)/ %	4.29				
Benchmark Using SPOT XS Image (C)	(R')21.17	(B')7.10	15.52	3.05	53.16

Table 2: Percentage Sum of Absolute Difference Of All Classes

Sum Of Absolute Difference Of All Classes / %	
Gamma Filter	12.2
Enhanced Frost Filter	8.14
Frost Filter	17.98
Enhanced Lee Filter	24.98
Lee Filter	34.28
Kuan Filter	17.8

CONCLUSIONS

The knowledge of the best type of SAR filter is very important in the SAR-SPOT XS image fusion classification. Enhanced Frost filter of window size of 5X5 is found to be most suitable for image fusion as it has a percentage sum of absolute difference of all classes of 8.14 % which is the lowest among the six digital filters.

For future research, with the use of Enhanced Frost filter, it will be possible to increase the features in a classification of a terrain, which has different dielectric constant soil contents, by combining the spectral advantage of high spatial resolution optical SPOT XS image and the penetrative capability of SAR.

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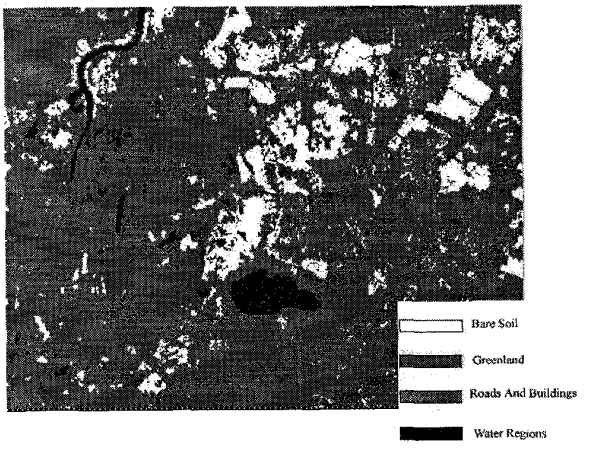

Fig. 1: SAR-SPOT XS Classification

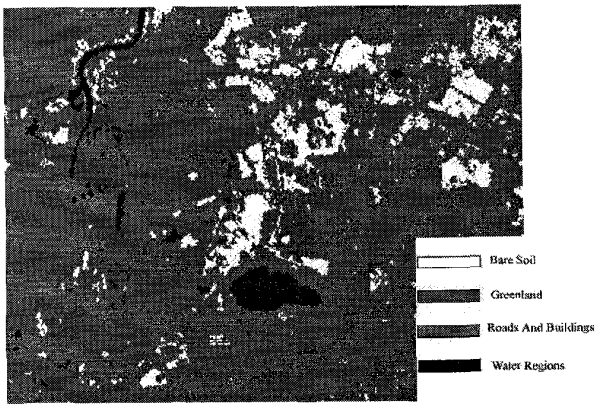

Fig. 2 : SPOT XS Classification