FILTERS AND INFORMATION EXTRACTION

Jayagobi K., Nagarathinam V., Maruthachalam M.,
Palanivelu R.
Institute of Remote Sensing,
Anna University,
Madras - 600 025,
India.
Commission Number III

ABSTRACT:

The linear feature and edge extraction is more useful for the effective utilization of Remotely Sensed data. A methodology is demonstrated in this paper for preparing a thematic list which states the appropriate filters for extracting any particular information in any particular band of particular satellite data. Various aspects of the technique are analysed with the help of complete comparison made between TM and SPOT data.

INTRODUCTION:

The extraction of edges in Remotely Sensed data is most important from the application point of view. Despite the large volume of continuous research appearing in literature, effective extraction of any particular thematic information has remained a difficult problem in many situations. Edges are defined as local discontinuities or rapid changes in some image feature such as image luminance or texture[1]. Linear features are normally defined as collections of local edges that are continuous in the image. The process of linear feature extraction is done in two steps. They are: detection of local edges and identifying the continuity between local edges. Figure of merit rating factor is reported to evaluate the edge detection techniques[2]. However the availability of various satellite data with different resolution and different spectral bands along with the feature size make the problem of choosing and extracting linear features a complex one. Various configuration of median filters was reported but they are not tested for the Remotely Sensed data[3]. The comparison of performance of edge detectors for Landsat MSS and RBV camera was studied[4].This paper discusses the suitability of various bands of SPOT and Landsat Thematic Mapper data to extract the information using various filters.

THEMATIC INFORMATION:

The major linear features commonly extracted from Remotely Sensed data are Roads, Railways, Rivers and Lineaments.

Because of the spectral complexity and limited width of these features, edges of pixels representing these features appear in satellite data most often as ramp edges, hence there is a need for isolating such features for clarity. However in one particular band, it is not always possible to extract the different kinds of linear features. For example, roads may behave as a sensible edge in one band but not in another band. Similarly, a river may be extracted more clearly in a particular band than in another band. The capability of the operator to detect the ramp edges is therefore important in thematic mapping and the list which can suggest the suitable spectral band along with suitable operator for extracting the information may be more useful for an analyst. Road, river and railway are the features selected for preparing the thematic list and different familiar operators were tried to extract the features and to assess the performance of the operators.

ALGORITHM:

Algorithms chosen for the analysis were:

Sobel
Kirsch
Roberts

Data with and without noise were used to extract the features and the above alogrithms. Median filters of different size were used to smooth a noisy data and the restored data was used to extract information using the above algorithms. Two level bidirectional median filters of various size were used to restore the striped data and the extracted edges were compared with the edges extracted with the simple median filters. The algorithm of the two level bidirectional median filter of size 5x5 is given below

$$Y_{2LM+}(m,n)=\mathrm{MEDIAN}[Y_{1LM+}(m,n),Y_{R1LM+}(m,n),x(m,n)]$$

$$Y_{1LM+}(m,n)=\mathrm{MEDIAN}[x(m-2,n),x(m-1,n),x(m+1,n),x(m+2,n),x(m,n+1),x(m,n+2),x(m,n-1),x(m,n-2),x(m,n)]$$

$$Y_{R1LM+}(m,n)=\mathrm{MEDIAN}[x(m-2,n-2),x(m-1,n-1),x(m+1,n+1),x(m+2,n+2),x(m-2,n+2),x(m-1,n+1),x(m+1,n-1),x(m+2,n-2),x(m,n)]$$

Where $Y_{2LM+}(m,n)$ is the output pixel value

$x(m,n)$ is the pixel value of the m'th row and n'th coloumn

Operators of different size were used to compare the quality of the output. The results of the performance of these operators are discussed in the analysis part.

ANALYSIS:

The algorithms were implemented in VAX 11/780 system and tested on SPOT Multispectral(Scene ID:S1H1860322052339), SPOT Panchromatic (Scene ID:S1H1860322052337), and Landsat TM data(Scene ID:T511420518671201) The possibility of extracting particular feature is graded as suitable, can be used and not suitable. The relative performance of the different algorithms is also compared. Rows one to six of figure 1 show the intersection of a railway track with a metalled road. The horizontal line represents the railway track, and the vertical line represents the road. First coloumn of figure 1 represents the original TM data of all the bands except thermal band. Coloumn two, three and four represent the edges extracted using ROBERTS,KIRSCH and SOBEL operators correspondingly. Bands 1 to 5 and 7 are shown in rows one to six respectively. Row seven represents the SPOT Panchromatic channel data used to extract the road feature and the features extracted using the three operators. Row eight represents the SPOT Panchromatic channel data used to extract the river feature and the features extracted using the three operators. Rows one to three of figure 2 represent bands 1,2 and 3 of SPOT Multispectral data which shows the intersection of a railway with a metalled road. First coloumn of figure 2 shows the original data and coloumns two to four show the extracted edges using the three operators. Coloumn one of rows three to six of figure 2 shows the SPOT Multispectral data used to extract the river feature. Coloumns two to four of rows four to six represent the feature extracted using the different operators. Figure 3 represents the original data and extracted edges of the river feature from bands 1 - 5 and 7 using the ROBERTS, SOBEL and KIRSCH operators respectively. Figure 4 represents the various configuration of median filters used to restore the degraded data.

Noise was simulated in the TM data and the extraction of the above thematic information was attempted. The noisy data was smoothed with median filters of various configuration and the two level bidirectional median filters. Edges were extracted from this restored data and the output was compared to see the relative merit of the median filter configuration along with the size.

RESULTS:

Table I illustrates the suitability of various operators along with the pixel resolution. The relative performance of the operators from the application point of view is also graded. Band 1 and band 2 of SPOT Multispectral data equally offers good solution for the extraction of river feature. Among the operators used ROBERTS offers best extraction. SOBEL offers good extraction and KIRSCH operator is not better than ROBERTS and SOBEL in this particular feature extraction. SOBEL operator is performing very well compared to other operators in the river feature extraction in the SPOT Panchromatic data. Band 3 of Landsat TM is more advantageous than other bands for river feature extraction. Band 2 of SPOT Multispectral data is relatively better to other bands for extracting road features. ROBERTS operator is performing very well in the extraction of road feature from SPOT Panchromatic data. Band 3 of Landsat TM data is more useful to extract the road feature information. Band 3 of SPOT Multispectral data is more useful to extract the road feature. Band 4 of Landsat TM is quite useful to extract the railway feature information. Table II gives the relative performance of the various configuration of the median filters along with the size and relative computaional time.

CONCLUSION:

KIRSCH, SOBEL and ROBERTS algorithms perform differently for different feature extraction and their relational performance is tabulated. This thematic list may be useful to applied scientists in Remote Sensing area in selecting appropriate filters and bands of Landsat TM and SPOT data. Of the median filter configurations attempted bidirectional rotational filters are good in preserving the smallest width features such as roads and railways.

REFERENCES:

1. Brian Burns, Allen R Hanson, Edward M.Riseman., 'Extracting straight lines', "IEEE Transactions of Pattern Analysis and Machine Intelligence" Vol. Pami-8,No 4, July'83.

2. Anuta P.E, Davallou F., 'Comparison of Edge Detection Methods for Landsat Imagery', "Machine processing of Remotely Sensed data symposium" LARS, Purdue University, 1982.

3. Pratt K William., 'Image Feature Extraction', "Digital Image Processing" Wiley Interscience Publication, John Wiley and Sons, Newyork,1978.

4. Ari Nieminen, Pekka Heinonen, Yrjo Neuvo 'A New Class of Detail-Preserving Filters for Image Processing', "IEEE Transactions of Pattern Analysis and Machine Intelligence" Vol. Pami-8,No 4, July'83.

Table I

Resolution: Landsat TM:30 m
SPOT Multispectral:20 m
SPOT Panchromatic:10 m

FEATURE	SATELLITE	OPERATOR	BAND 1	2	3	4	5	6	7
RIVER	SPOT Multispectral	ROBERTS	a1	a1	c				
		SOBEL	a2	a2					
		KIRSCH	a3	a3					
RIVER	SPOT Panchromatic	ROBERTS	a2						
		SOBEL	a1						
		KIRSCH	a2						
RIVER	Landsat TM	ROBERTS	b	b	a3	c	b		c
		SOBEL			a1				
		KIRSCH			a2				
ROAD	SPOT Multispectral	ROBERTS	b	a2	c				
		SOBEL		a3					
		KIRSCH		a1					
ROAD	SPOT Panchromatic	ROBERTS	a1						
		SOBEL	a2						
		KIRSCH	a2						
ROAD	Landsat TM	ROBERTS	c	b	a2	c	c		c
		SOBEL			a1				
		KIRSCH			a3				
RAILWAY	SPOT Multispectral	ROBERTS	c	c	a1				
		SOBEL			a2				
		KIRSCH			a3				
RAILWAY	Landsat TM	ROBERTS	c	c	c	a3	b		c
		SOBEL				a1			
		KIRSCH				a2			

a : suitable — 1:best
b : can be used — 2:good
c : not suitable — 3:ok

TABLE II

Configuration	Effect	Computational Time(Relative)	Remarks
Simple median 3x3	Smoothing	1.0	Discontinuity in in the linear features
Simple median 5x5	Smoothing	5.3	Blurring of features and discontinuity of linear features.
Simple median 7x7	Smoothing	18.66	Blurring of features and disappernce of linear features.
Two level bidirectional median filters 3x3	No Smoothing	1.74	Discontinuity in the linear features.
Two level Bidirectional median filters 5x5	Not much smoothing	2.37	Almost all linear features are restored
Two level Bidirectional median filters 7x7	smoothing over 5x5	4.25	Higher computational time but output is not good as from 5x5

Figure 1

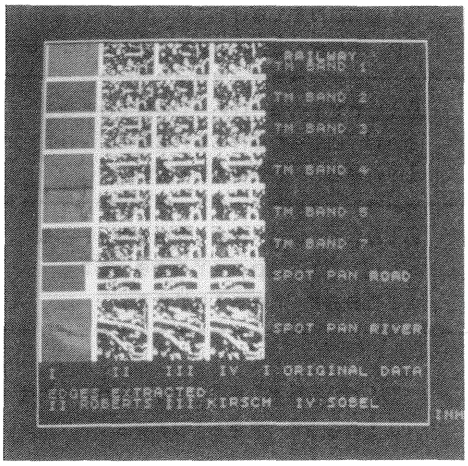


Figure 2

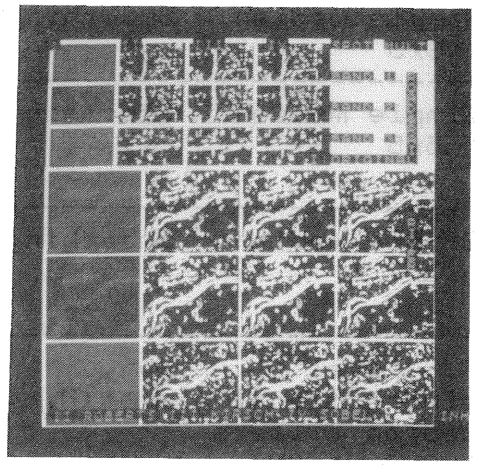
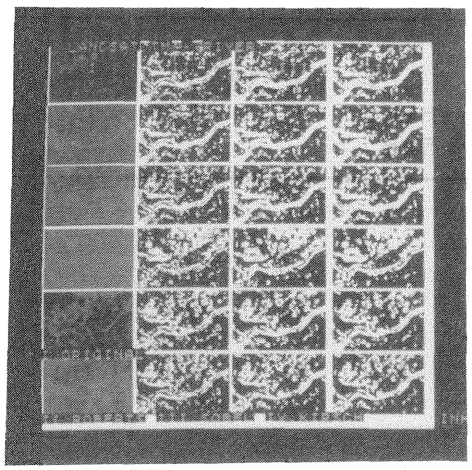


Figure 3



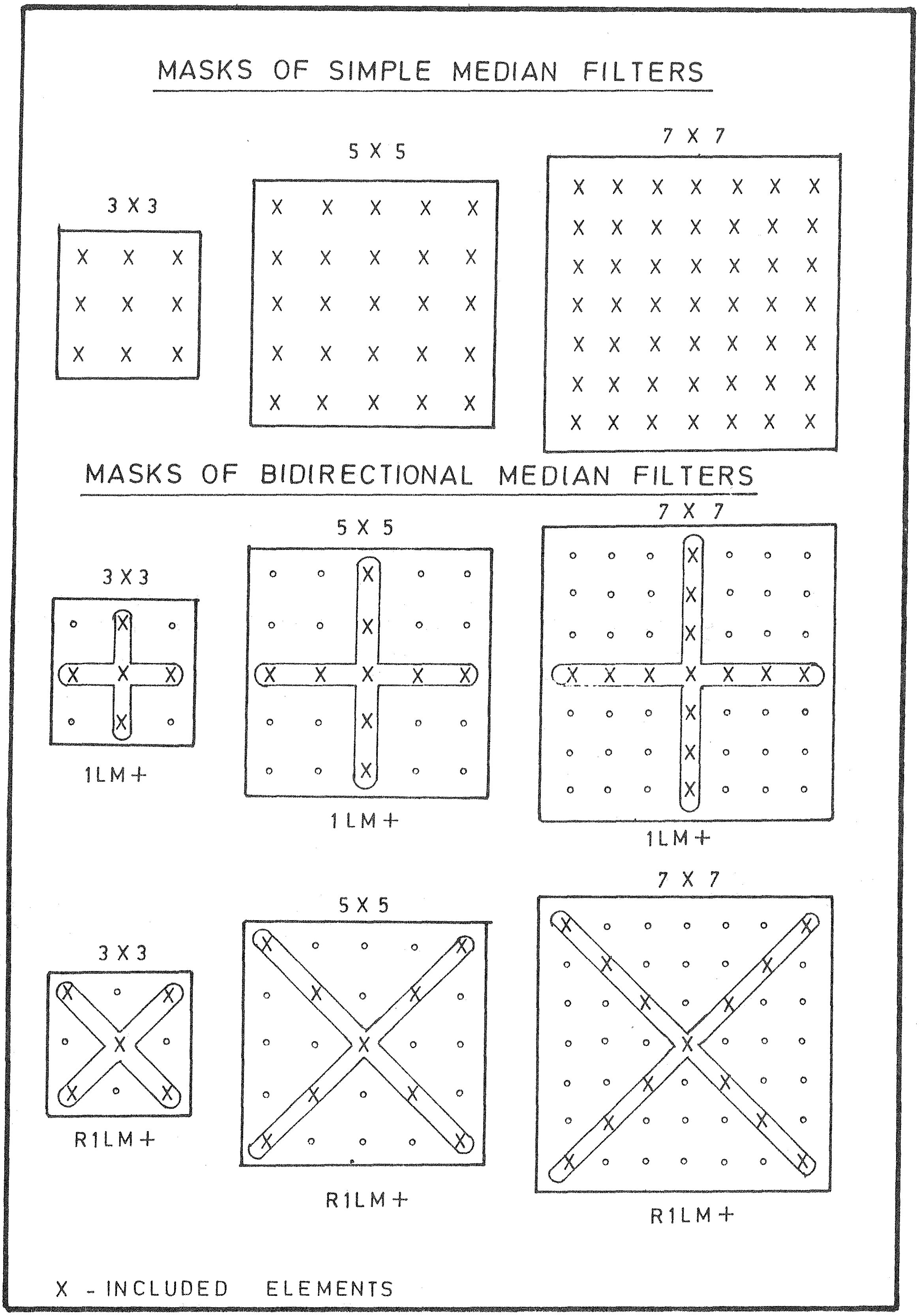

MASKS OF SIMPLE MEDIAN FILTERS
3 X 3
5 X 5
7 X 7
MASKS OF BIDIRECTIONAL MEDIAN FILTERS
3 X 3
5 X 5
7 X 7
1LM+
1LM+
1LM+
3 X 3
5 X 5
7 X 7
R1LM+
R1LM+
R1LM+
X - INCLUDED ELEMENTS

Fig 4