Contribution of Enhanced SAR Imagery for Agricultural Land Use Classification*

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Abstract

This study demonstrated how interpretation of SAR images improved our understanding of surface and signal/terrain interaction which result in terms of textures and other's characters of SAR imagery.
Focusing was placed on visual interpretation of SAR images in order to make a good distinguishes between different tones, textures shapes, patterns and signatures. The next step was the establishment of charts for tones and textures, which were employed together with the signature characteristics of SAR images to develop an "interpretation key" for agricultural land use purposes. We applied supervised classifications on Landsat TM images and on Landsat TM images integrated with SAR images. Then comparisons of tones ,textures and patterns were done between the two kinds of images.
We found that characteristics of SAR images such as tone ,texture signature and pattern are very important elements for visual interpretation of land use types , where the importance to establish an "interpretation key" of SAR images , which is already done . A significant difference in terms of texture and pattern was approved. Also SAR imagery was improved our supervised classification using Landsat TM integrated with SAR images .

1.0 Introduction

On December 8 , 1993 Synthetic Aperture Radar (SAR) imagery band C-HH(5.6cm) was acquired over four sites in Jordan , included by the Globesar project. These data were acquired in order to develop some researches and analysis of SAR imageries .This paper will demonstrate how SAR imageries improved our understanding of surface and signal/terrain interactions which result in the tonal , textural and pattern characters of SAR imageries. The specific objectives of this study are to develop interpretation keys for agricultural land-use from SAR integrated techniques, to interpret management practices from enhanced SAR images, to demonstrate what SAR imagery could add for land use classification and to compare SAR images with Landsat images especially in terms of tone and texture.

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2.0 Methodology

Emphasis was placed on visual interpretation of SAR imagery in order to make a good distinguishes between difference tones , textures ,shapes and others characters of SAR imagery. The next step was the establishment of charts for tones and textures which are employed to develop an interpretation key for agricultural land-use. We applied supervised classifications on SAR and Landsat imagery, and made a comparison between the two classifications .And a comparison of tones, texture and pattern were done between the two kinds of images.

3.0 Elements of Image Interpretation

Due to the longer of wavelength used for sensing , radar is more sensitive to difference terrain elements than visible , near infrared and thermal infrared imagery (i e Landsat, Spot). Radar back scatter is basically a function of surface geometry(topography) , surface roughness defined by bare ground or vegetation canopy and surface dielectric properties (influence of humidity). These elements of the terrain can be highlighted depending how the radar system is configured . Changes in radar look direction , incidence angle , frequency and polarization can have considerable effect on the enhancement or suppression of certain terrain features.
Element of interpretation of radar imagery for land use and agricultural studies are presented in applications of aerial photography's and other remote sensing imageries. These elements of radar imagery interpretation are ; pattern , shape , size , association , tone , textures. Some rules of photo interpretation can be used fòr radar image interpretation , which can be divided into three basic procedures:

- Photo reading , this involves recognition of boundaries on the basic of considering all the elements listed above.
- Photo analysis , this involves the recognition of what is within the boundary previously identified.
- Deductive interpretation of image , in this part the interpreter uses all his thematic knowledge and experience and to interpret the data.

4.0 Results

4.1- Interpretation key

Each kinds of land-use was examined and interpreted in terms of tones, textures and signatures. A chart of tones was created in which we distinguished five degrees of tones from dark to light, then a chart of textures was created where five classes of textures were presented from fine to mottled texture ,and we added a class where is no texture appears on the images. Depending on these charts and the signature characteristics of each class of land-use, an interpretation Key for agricultural purposes was established, **Figure 1** shows this result.

4.2- Management practices

Radar imagery show the reclamation and management made by farmers , we can identify exactly the number , shape and pattern of these management practices. Also the boundaries of agricultural fields unless their is no plantation inside were very well recognized.

4.3-Comparison between TM and Radar imageries

We chose two study areas to compare Radar imagery and Landsat TM imagery(acquisition date April 1994) , first area located in north of Madaba and the second located in Azraq area. In this paper we analyzed the first study area.

4.3.1- Study Area

The study area approximately 60 km2 in extent , on the northern plateau of Jordan and situated just south of Amman . Geological formation occurring within the area consist of limestone and alluvial of Cretaceous , and the dominant soils are Chromoxererts and Haploxeraifs. Morphologically the study area is nearly level to gently sloping . In altitude it range from 700m to 1000m. The climate is classified as semi-arid Mediterranean climate , which it is recognized by four seasons with warm summer and cold winter , and average annual rainfall is about 350 mm.

4.3.2- Spectral characteristics

To achieve this , statistical analysis (**table 1**) for six bands of Landsat TM imagery and the band of Radar imagery was carried out . For selection of three suitable bands for FCC generation , the index factor indicated that band 4 , band7 and the radar band form the best combination. The study of individual bands show that the radar band occupies a greater dynamic range (2-255) , and has high variance when compared to others. Near infrared band 4 is having least covariance with radar band. The scattegram combined band 4 and radar data demonstrates the uncorrelation between them which was explained by the small value of covariance.

4.3.3- Radar Characteristics and IHS Transformation

We remarked that texture in radar imagery has great help for identification and delineation of units contained within boundaries of homogeneity. High intensity returns representing a large interception of back scatter appear as light tones in radar image whereas low signal returns appear as dark tones. Also the spatial arrangement of features in radar imagery was distinguished very well.

Landsat TM data (bands 2 , 3 and 4) was transformed in the IHS space , radar was contrast stretched to replace the intensity component , then the image was brought back to original space (RGB). . This transformation was contributed to the visual and automated interpretation interms of texture, structure, shape, topography, and linear features as benefits of Radar band, especially to extract the isolated settlements and houses, and to delineate the boundaries of forests. On the anther hand Landsat TM bands contributed to the interpretation in terms of tone, shape and multispectral characteristics of features. See **Figure 2.**

4.3.4 Classification

A maximum likelihood classification was used with Landsat TM imagery and with Landsat TM integrated with radar imagery. Over 30 training sets were generated using 1:30 000 aerial photography supplemented by field inventory then digitized , and there were at least two training sets for each class, we could separate twelve land cover classes. Statistical analysis reveal a considerable difference in standard deviations between Landsat TM bands and radar band, this is explained by the existing of speckles in radar imagery which should be removed by multiple filtering.

The accuracy and specificity of classifications were assessed and "pixel by pixel" comparison was made between a reference data set and the automated classification . The training sets were used as reference data set . A total number of 21000 pixels (representing about 8% of total number of pixels) were used for comparison purpose, confusion matrices for both classification were generated , the results for which are given in **table 2** The errors of omission and commission derived from the confusion matrix are considerably reduced.

Classification accuracy performance for the specific classes and overall accuracy performance are given in **table 3**. These statistics indicate that inclusion of radar imagery as an additional band in the classification significantly increased the overall accuracy of the classification (from 77.2% to 81.3%) , for agricultural classes the improvement of accuracy was about 11% in average.

The specificity of any given classification was determined by the number of landuse classes that could be identified without significant confusion with other classes, this was essentially a judgment as to whether the classes were sufficiently separable, the errors of omission and commission assisted this determination by showing what proportion of classes were misclassified into which other classes. To study the inter classes separability, inter-distance signature calculation was generated, the average separability improved from 10.9 to 11.9, the maximum change was observed for the barely and plowed area pair (from 19.5 to 27.3) . **Figure 3** shows the result of classification.

5.0-Conclusion

An interpretation key for agricultural land use was performed from radar imagery, this key will allow users to interpret visually radar imagery. It is found that radar imagery provided interesting information about management practices and other linear features.

Radar imagery and Landsat TM imagery have been combined to produce hybrid image data having the spectral resolution of TM and the spatial resolution of radar , we found that an intensity hue saturation (IHS) transformation based on the combination of radar and TM data did improve the delineation of topographic features, urban area and agricultural fields.

Radar imagery and Landsat TM imagery of the study area have been used to separate twelve classes, statistics indicated that inclusion of radar imagery as an additional band in the classification significantly increased the overall accuracy of the classification , approximately 4% of improvement was achieved.

The radar was shown to be critical in providing explanation of surface cover variability.

6.0- Knowlodgement

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7.0-Bibliography

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Table 1

1-Statistical characteristics of study area(Madaba).

	Band 1	Band 2	Band 3	Band 4	Band 5	Band 7	Radar
Mean	78.8	42.4	55.2	77.5	89.3	47.2	46.8
ST. DV	17.6	11.9	18.9	15.2	24.9	16.4	23.6
Min	51	21	19	31	29	12	2
Max	198	108	146	125	221	126	255

2-Variance-covariance matrix

	Band 1	Band 2	Band 3	Band 4	Band 5	Band 7	Radar
Band 1	305.9						
Band 2	200.7	138					
Band 3	301.5	208.4	329.6				
Band 4	122.2	91.1	113.4	227.3			
Band 5	353.6	245.2	388.1	197.4	607.8		
Band 7	246.2	170.1	274.7	92.9	384.6	266.6	
Radar	84.3	48.9	71.4	-1.2	64.4	55.9	609

3-Correlation matrix

	Band 1	Band 2	Band 3	Band 4	Band 5	Band 7	Radar
Band 1	1						
Band 2	0.977	1					
Band 3	0.949	0.977	1				
Band 4	0.463	0.514	0.414	1			
Band 5	0.820	0.846	0.867	0.531	1		
Band 7	0.862	0.887	0.927	0.377	0.955	1	
Radar	0.195	0.169	0.159	-0.003	0.106	0.139	1

Table2
Confusion matrix comparison

a) Landsat TM

	Wht	Brl	Lnt	Hms	Olv	Frut	Pl A	Rg1	Rg2	Rck	Urb	Fort	Tot	Om	Cm
Wheat	436	7	132	0	3	1	0	33	2	0	0	0	614	178	291
Barely	4	358	5	0	5	0	0	0	13	1	0	0	386	28	271
Lentil	263	24	1326	0	7	0	0	120	67	5	0	0	1812	480	246
Hums	0	0	0	277	14	4	0	0	0	0	0	0	295	18	200
Olives	18	243	35	160	1376	180	100	3	252	1	25	0	2513	1137	486
Fruits	0	0	0	25	160	274	74	0	23	13	0	90	569	295	416
PlowedA	1	5	4	5	107	116	1358	0	1	0	0	0	1692	239	174
RangeL1	2	0	11	0	0	0	0	300	19	0	0	0	332	32	301
RangeL2	0	0	56	0	93	115	0	145	3177	8	14	0	3608	431	430
Rocks	0	0	0	0	0	0	0	0	0	1901	5	0	1906	5	99
Urban A	0	0	0	0	0	0	0	0	16	71	3347	2	3436	89	65
Forests	3	2	3	10	47	0	0	0	7	0	21	3841	3940	99	92

b) Landsat TM and Radar

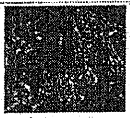
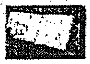
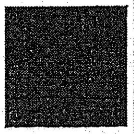
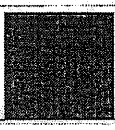
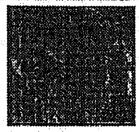
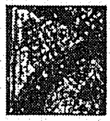
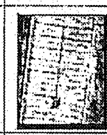
	Wht	Brl	Lnt	Hms	Olv	Frut	Pl A	Rg1	Rg2	Rck	Urb	Fort	Tot	Om	Cm
Wheat	476	3	182	0	7	0	0	38	8	0	0	0	614	156	148
Barely	2	365	5	0	1	0	0	0	11	2	0	0	386	21	159
Lentil	115	35	1077	0	5	0	0	112	62	6	0	0	1812	335	167
Hums	0	0	1	283	9	2	0	0	0	0	0	0	295	12	125
Olives	30	121	22	111	1599	242	49	1	256	0	28	84	2513	944	271
Fruits	0	0	0	13	110	356	55	0	14	11	0	0	569	213	445
PlowedA	1	0	1	1	125	128	1340	0	1	0	0	0	1597	257	104
RangeL1	0	0	12	0	0	1	0	300	19	6	0	0	332	28	300
RangeL2	0	0	40	0	88	66	0	149	3246	8	11	0	3608	362	371
Rocks	0	0	0	0	0	0	0	0	0	1889	17	0	1906	77	92
Urban A	0	0	0	0	0	0	0	0	14	65	3355	2	3436	81	56
Forests	0	0	4	0	41	6	0	0	9	0	0	3860	3940	66	86

Table 3
Classification accuracy comparison

	TM	TM & Radar	Difference
Wheat	48.12	62.1	13.9
Barely	54.5	66.7	12.2
Lentil	64.4	75	10.6
Hums	65.6	68.8	12.8
Olives	46.7	55.6	8.9
Fruits	27.8	40	8.1
PlowedA	77.7	78.8	2.1
RangeL1	47.4	50	2.6
RangeL2	78.	81.2	2.5
Rocks	94.5	96.1	1.1
Urban A	95.6	95.6	0
Forests	95.3	96.1	0.8
Total	77.2	81.3	4.1

FIG.1

LAND USE INTERPRETATION KEY

LAND USE TYPE	TEXTURE	TONE	SIGNATURE MEAN	SIGNATURE ST.DV	EXAMPLE
FORESTS	COARSE	GREY	62	28	
ORCHARDS "OLIVES"	FINE	GREY	51	14	
VEGETA-BLES	FINE	LIGHT	218	37	
ANNUAL-CROPS	FINE	MIXED TONE	35	11	
GREEN-HOUSES	MEDIUM-FINE	LIGHT-GREY	82	22	
GRASS-LAND	MEDIUM-FINE	GREY	45	15	
LOW DENSE FOREST	MEDIUM-COURSE	GREY	51	16	
URBAN AREA	MOTTLED	LIGHT-GREY	91	59	
SALT-PANS	MEDIUM-FINE	LIGHT	156	47	
BASALT AREA	COARSE	LIGHT	136	39	
QUARRIES	MOTTLED	DARK TO LIGHT	71	61	

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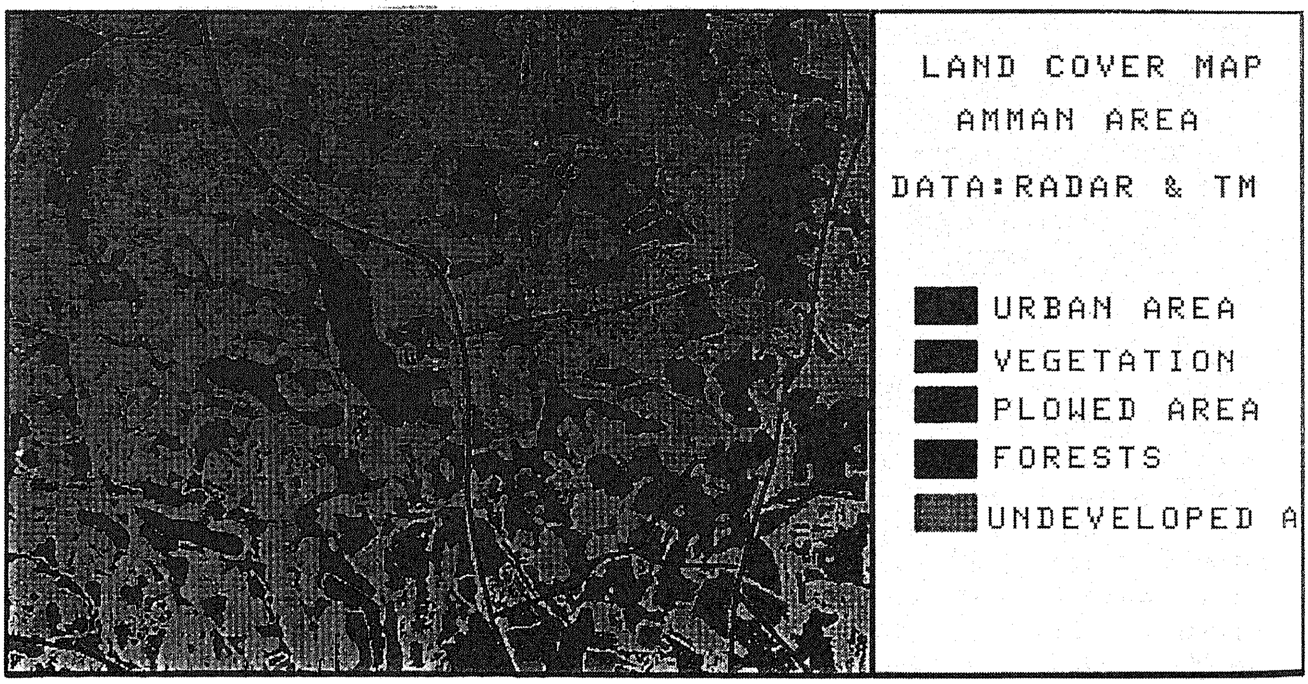

FIG.2

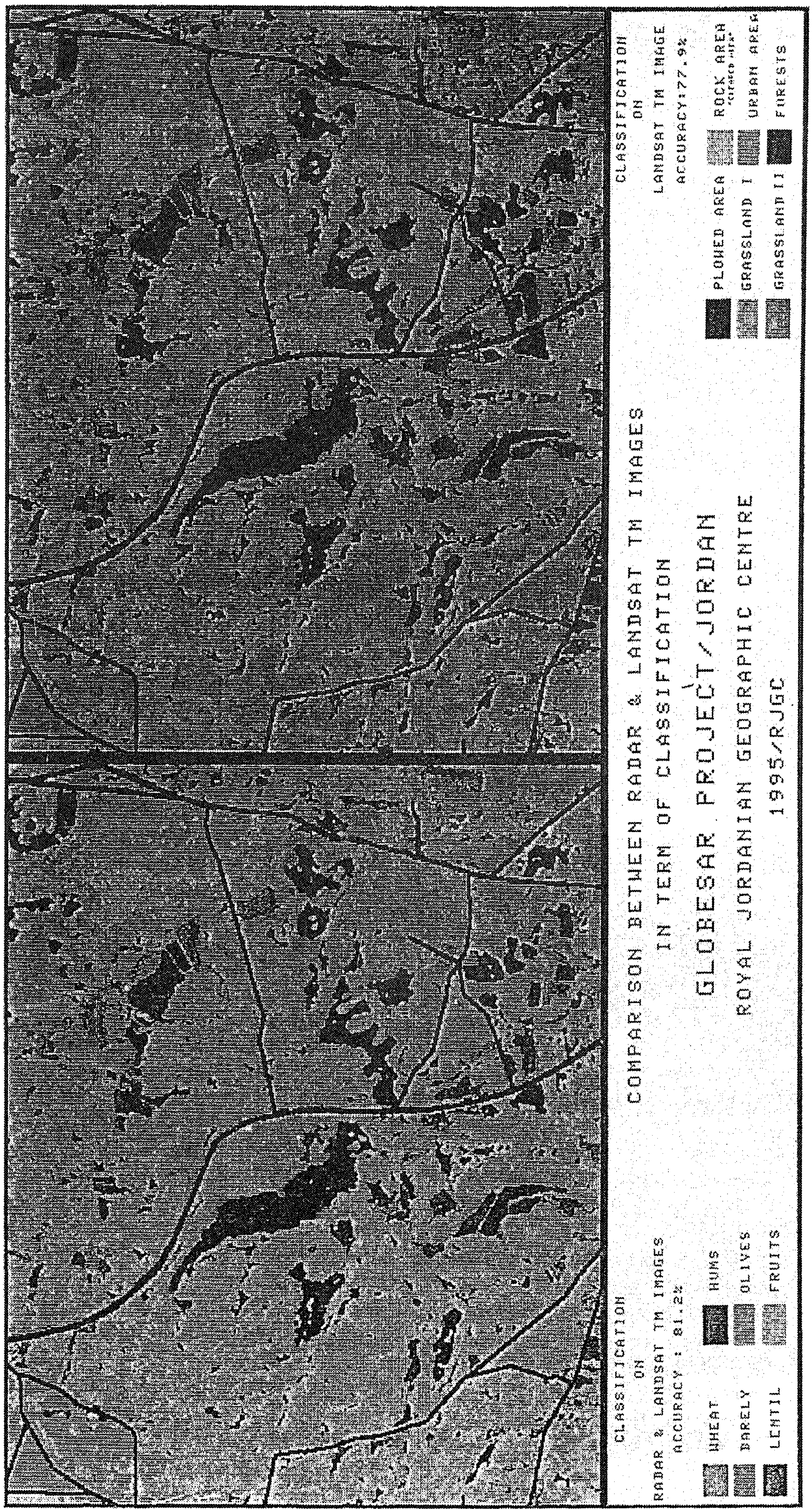
CLASSIFICATION
ON
RADAR & LANDSAT TM IMAGES
ACCURACY : 81.2%
WHEAT
BARELY
LENTIL
HUMS
OLIVES
FRUITS
COMPARISON BETWEEN RADAR & LANDSAT TM IMAGES
IN TERM OF CLASSIFICATION
GLOBESAR PROJECT/JORDAN
ROYAL JORDANIAN GEOGRAPHIC CENTRE
1995/RJGC
CLASSIFICATION
ON
LANDSAT TM IMAGE
ACCURACY:77.9%
PLOWED AREA
GRASSLAND I
GRASSLAND II
ROCK AREA
URBAN AREA
FORESTS

FIG. 3