

Optimization of the SPARK Algorithm for Land Use Mapping from Remotely Sensed Data

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The proposed KC-Algorithm

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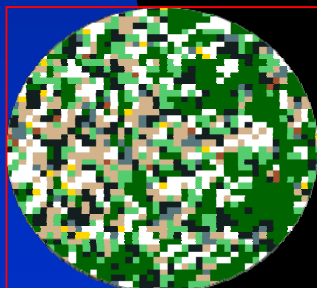
**Results &
Conclusions**

Deficiencies of pixel-based classifications:

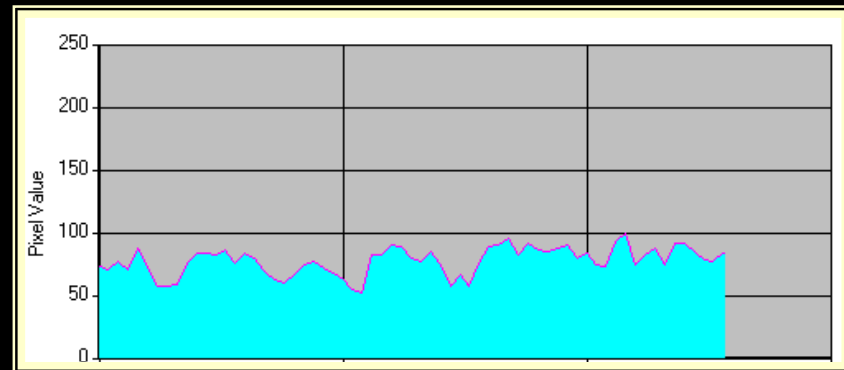
The classes of interest are heterogeneous



SPOT Image



Land Cover



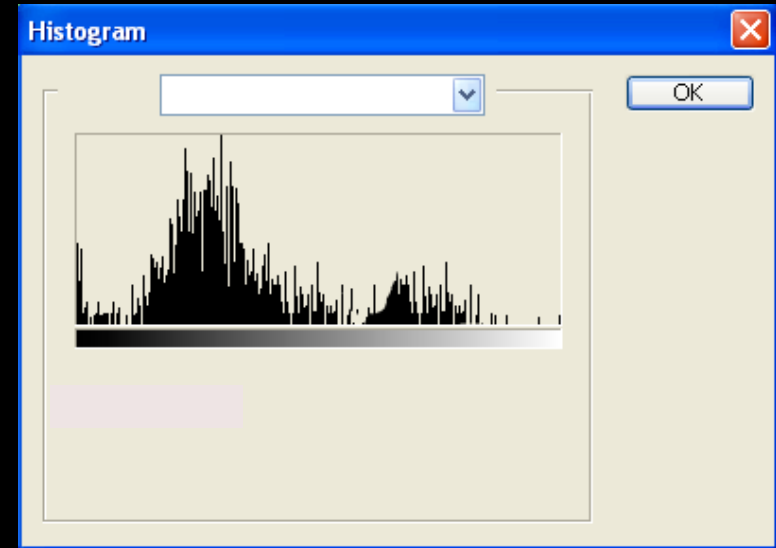
Important problems with pixel-based classifications

Data of a single pixel is not a good - representative!

Contextual data are not used

Definition of pure training data is a hard task!

Most times training data show multi-modal patterns of distribution



With a considerable variation!



Statistics Info:

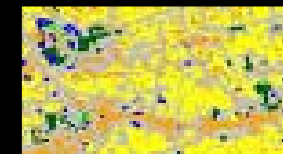
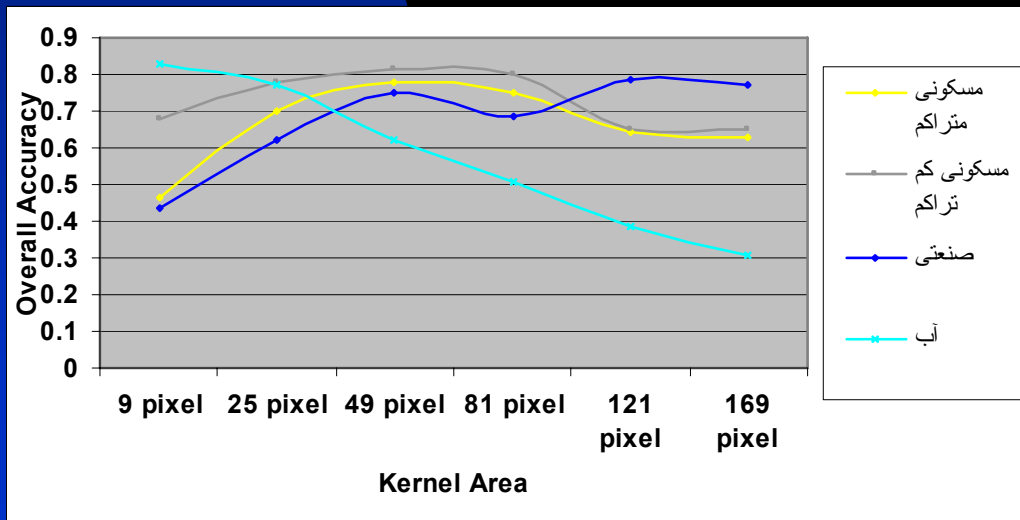
Min:	0	Max:	204	Mean:	75.401
Median:	76	Mode:	76	Std. Dev:	15.679

Problems with the SPARK Algorithm

Definition of the window size is a little difficult!

Small window size is required for homogeneous classes

Larger window sizes are required for heterogeneous classes



3*3



13*13



Reference

Objectives

Evaluation of the SPARK Algorithm

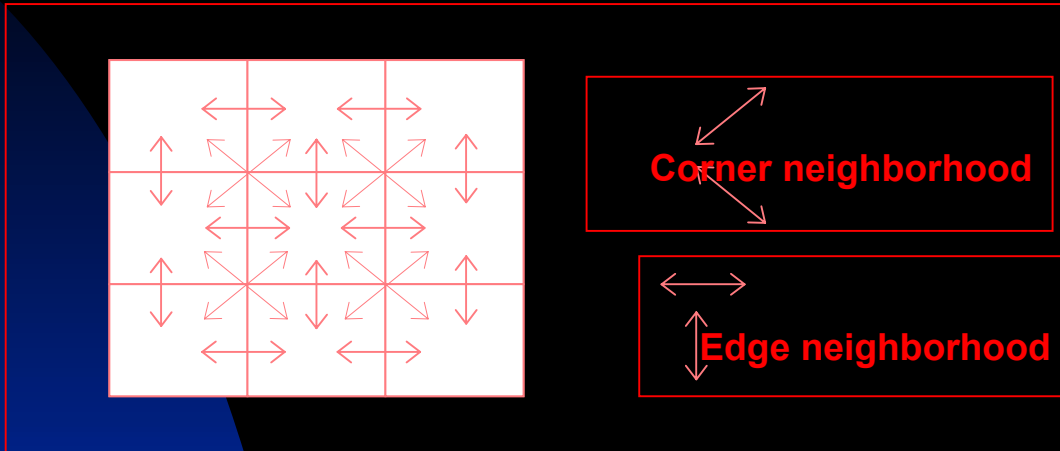
SPARK (Spatial Reclassification Kernel)

Previous works

Wharton (1982)

Barensley & Barr (1996)

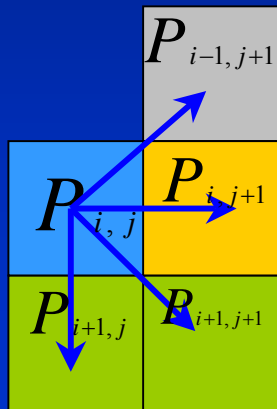
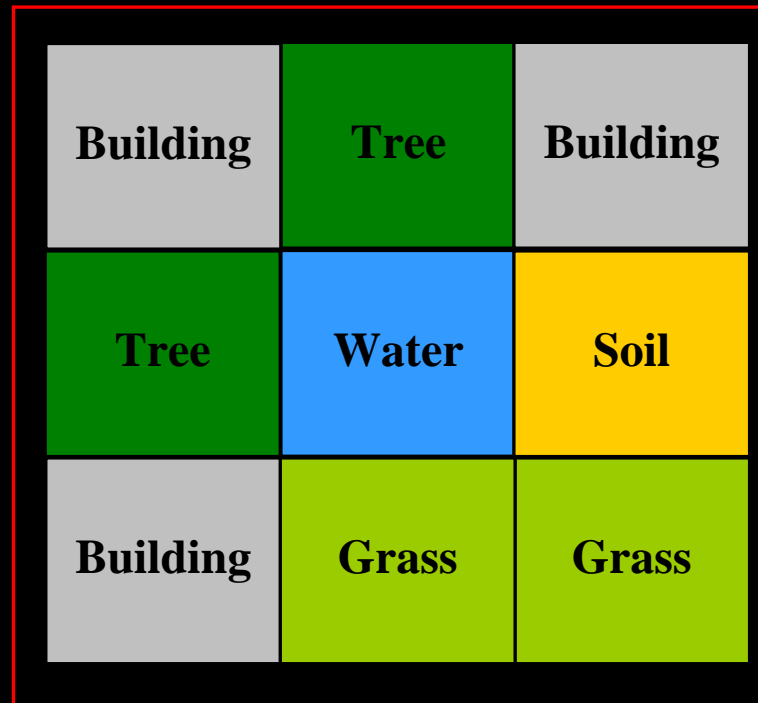
Pair-wised neighborhood data of classes are extracted in windows



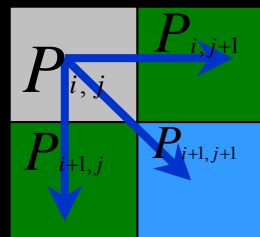
Adjacency Event Matrix

$$M \begin{pmatrix} f_{11} & f_{12} & f_{13} & \cdots & f_{1j} \\ & f_{22} & f_{23} & \cdots & f_{2j} \\ & & f_{33} & \cdots & f_{3j} \\ & & & & \cdot \\ & & & & f_{ij} \end{pmatrix}$$

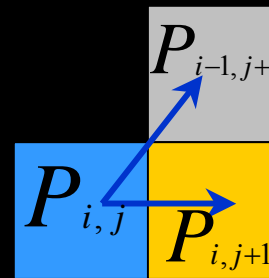
Collection of Different Neighborhoods!



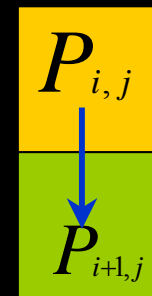
Type A



Type B



Type C



Type D

Calculation of Adjacency Event Matrix

Neighborhood matrix

Building	Building	Grass
Building	Building	Tree
Grass	Tree	Grass

Commercial-industrial

Neighborhood matrix

Building	Tree	Building
Tree	Building	Grass
Building	Grass	Grass

Residential

1)	<i>B</i>	<i>G</i>	<i>T</i>
<i>B</i>	6	4	4
<i>G</i>	—	0	4
<i>T</i>	—	—	1

Frequency Table:

B	G	T
4	3	2

2)	<i>B</i>	<i>G</i>	<i>T</i>
<i>B</i>	3	5	6
<i>G</i>	—	3	2
<i>T</i>	—	—	1

START

Land Cover Image

Adjacency Event Matrix
Calculation (Type A, B, C, D)

Threshold

$$\Delta K = 1 - \sqrt{\frac{1}{2N^2} \sum_{i=1}^C \sum_{j=1}^C (M_{ij} - T_{Kij})^2}$$

Template
Matrix

$\Delta K > \text{Threshold}$

YES

Land Use Class

END

The proposed KC-SPARK

Based on the adaptive and Multi-size windows-1

Discrimination of spectrally similar classes-2

Separation of homogeneous and heterogeneous classes-3

Similarity index in KC- SPARK algorithm

$$\Delta K_{KC} = \underset{\text{for } L=3}{\overset{n}{\text{MAX}}} \left(1 - \left[\frac{1}{2 \left[(L-1) (4L-2) \right]} \sum_{i=1}^C \sum_{j=i}^C (M_{ij} - T_{Kij})^2 \right]^{\frac{1}{2}} \right)^{\frac{1}{2}}$$

Windows Size = L
Elements of adjacency matrix = M_{ij}
reference matrix of classes = T_{Kij}
Number of Classes = C
The Largest Windows Size = n

Implementation

Satellite Data

SPOT XS (Acquisition Date: 2002)

(Scale = 1:10,000 & 1:2000) Digital Land use map of Tehran

Study Area

Part of Tehran Urban Area

Land Use Mapper 1.1 Software

The screenshot displays the Land Use Mapper 1.1 software interface. The main window is titled "Land Use" and features a menu bar with "File", "Run", "Parameters", and "View". A dropdown menu is open under "Run", showing options: "Pre-Classification", "Input Training Data", and "Land Use Classification".

The interface is divided into two main panels:

- Pre-Classified Image:** Shows a grayscale satellite image of a city grid with some green areas.
- Land Use Classified Image:** Shows the same city grid with colors representing different land use classes: red, green, and blue.

At the bottom left, there is a text area showing coordinates and a grid of values:

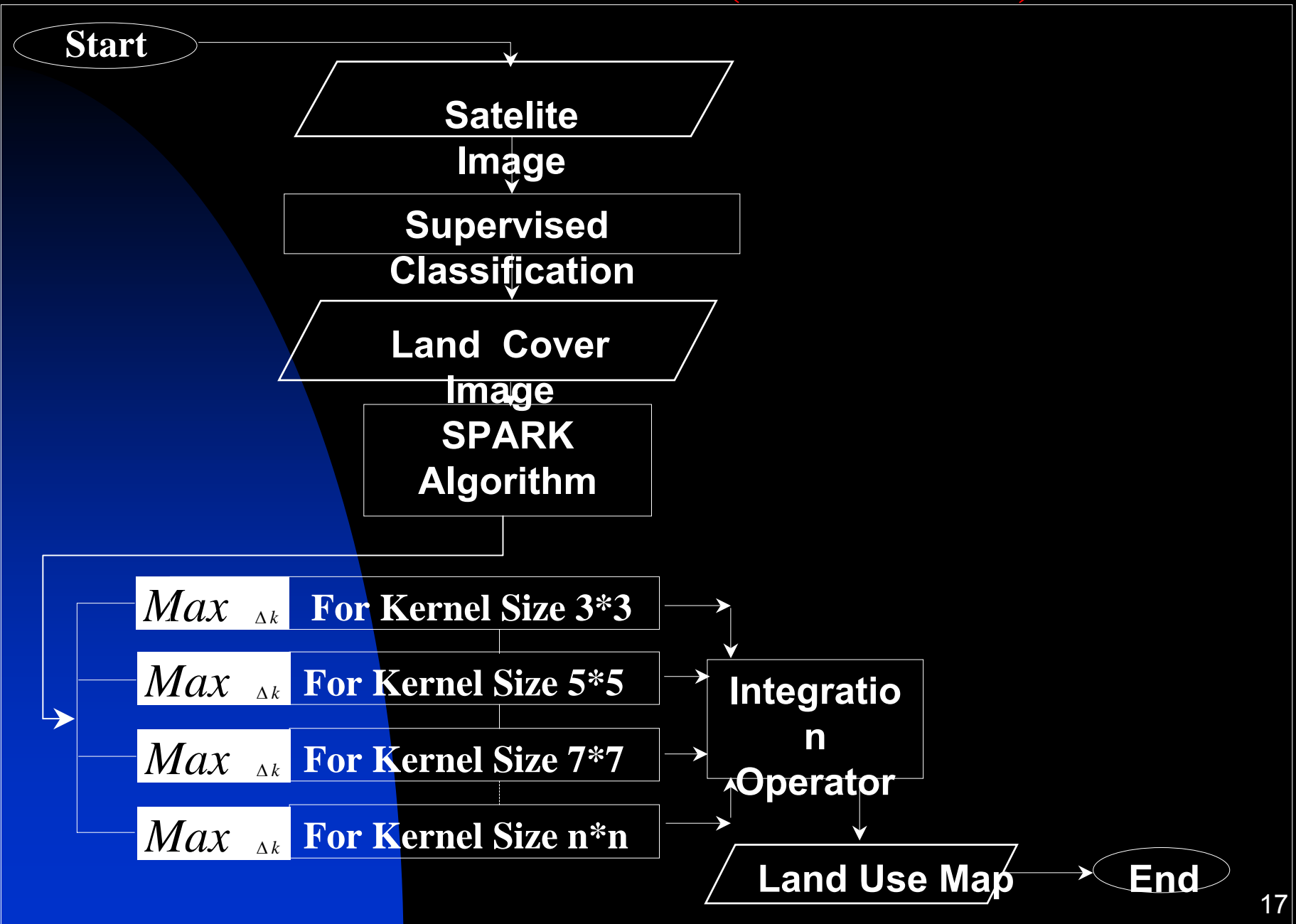
```
ss No.:0 Point No.:0 X=650, Y=768  
0 0 0 0 0 0 0  
0 3 2 0 0 0 0  
3 3 12 0 0 0 0  
2 12 37 14 0 0 0  
0 0 14 1 0 0 0  
0 0 0 0 0 0 0  
0 0 0 0 0 0 0  
0 0 0 0 0 0 0  
0 0 0 0 0 0 0  
0 0 0 0 0 0 0  
ss No.:0 Point No.:1 X=606, Y=774  
0 0 0 0 0 0 0
```

At the bottom right, there is an "Information" window showing the current coordinates and the number of pixels for each color:

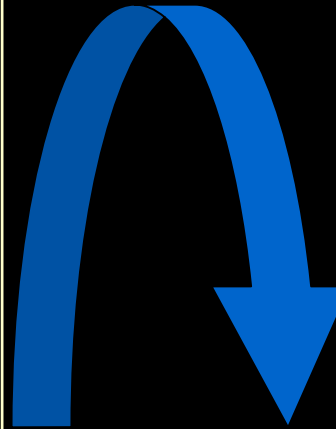
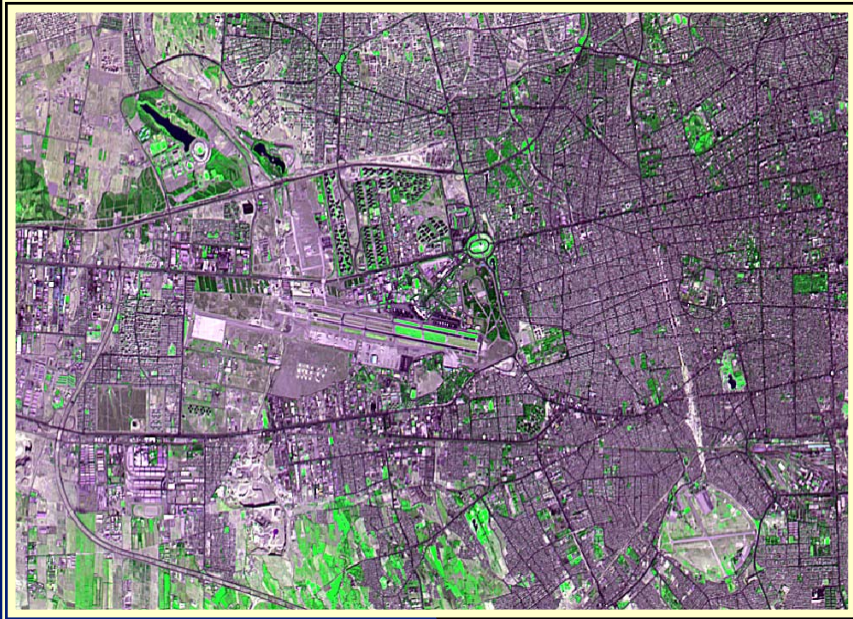
```
X=650 Y=768 Neighbors:  
3 3 3 3 3  
3 3 4 4 3  
3 3 3 3 3  
3 3 2 2 3  
3 3 2 1 3  
  
X=606 Y=774 Neighbors:  
2 2 2 2 2  
2 2 2 2 2
```

Color	Count
RED	159
GREEN	181
BLUE	136

(KC-SPARK)



Primary Classification












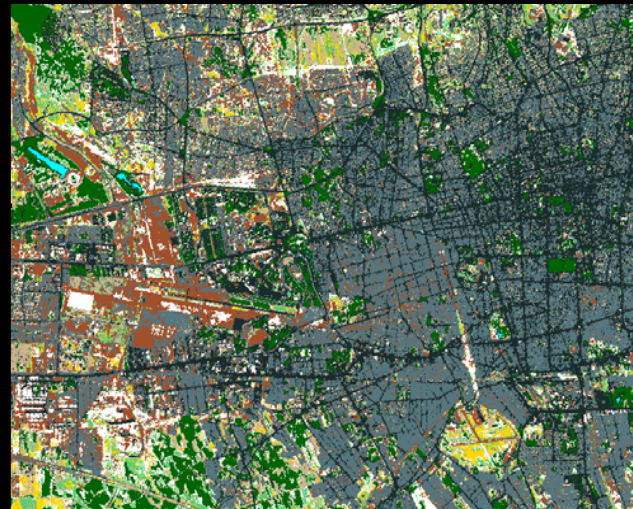
**Maximum
Likelihood
Classification**

0.79 = Kappa

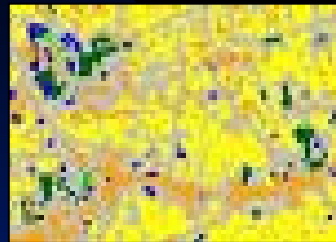
82% = O.A

Legend

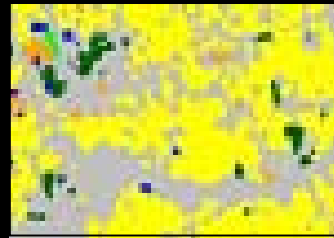
	Smal Building
	Water
	Dry
	Bare Soil
	Street
	Pasture
	Trees
	Cultivated
	Big Building



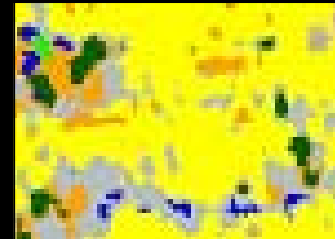
Results of KC-SPARK & SPARK



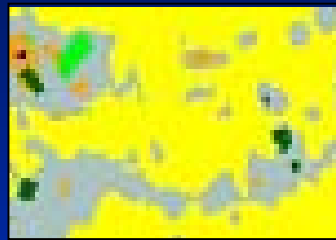
3*3



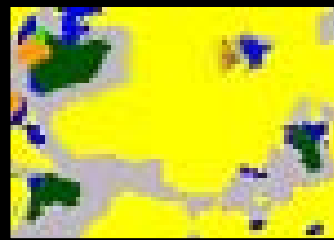
5*5



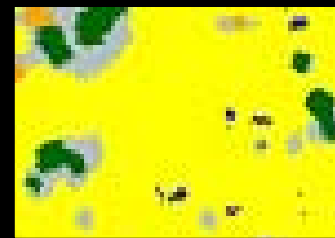
7*7



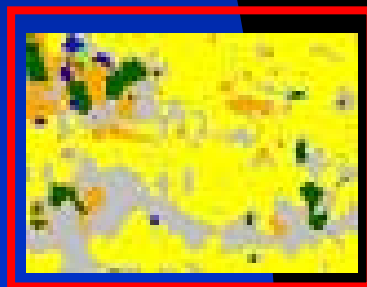
9*9



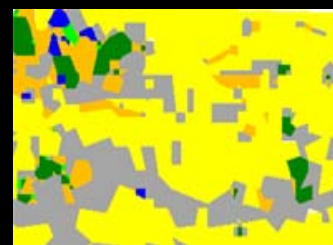
11*11



13*13



KC-SPARK

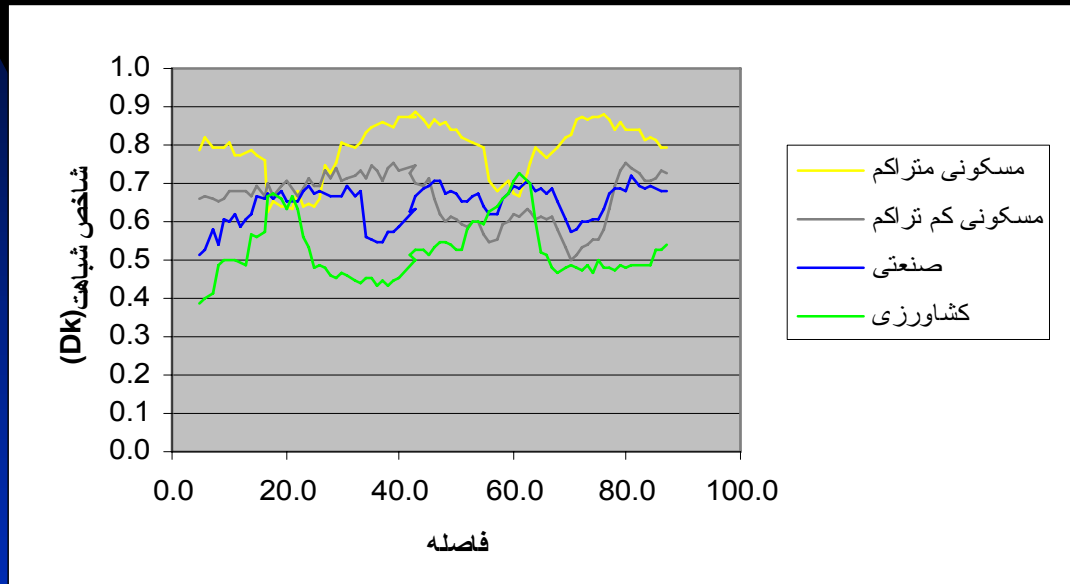


Reference

Legend

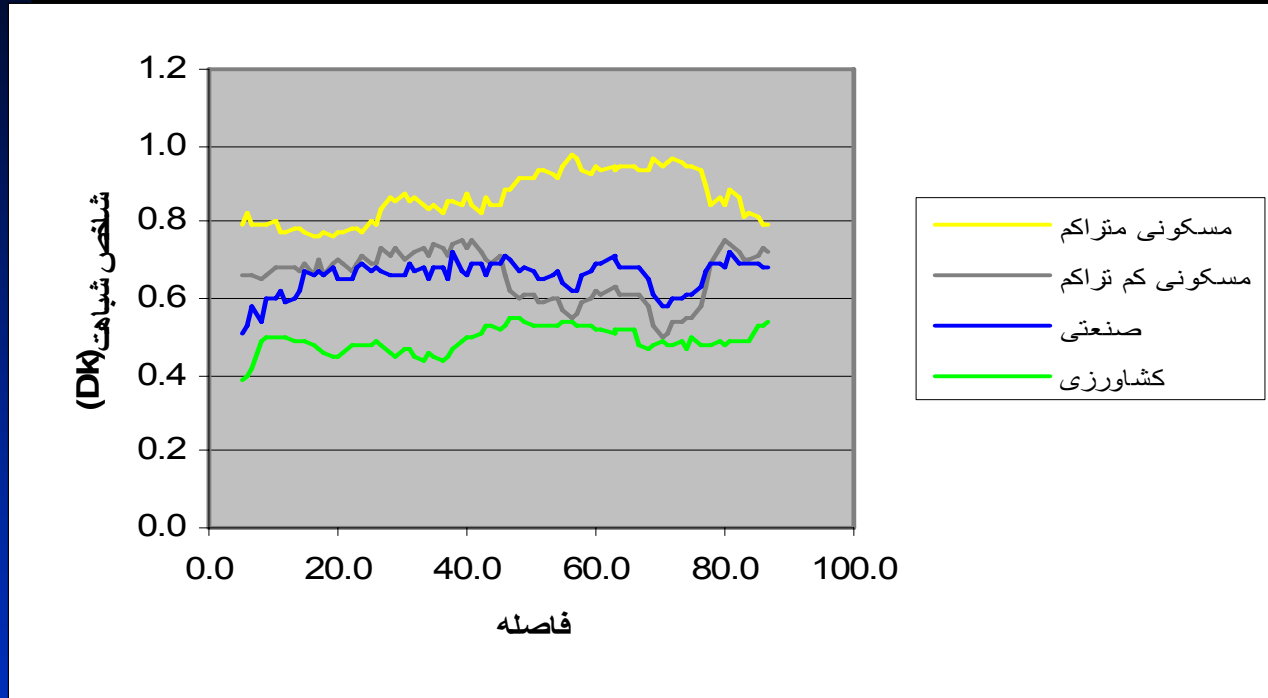
- Dense Res.
- Low Dens. Indust.
- Water
- Agr.
- Trees
- Bare

Profile of Similarity Index in SPARK (DK)



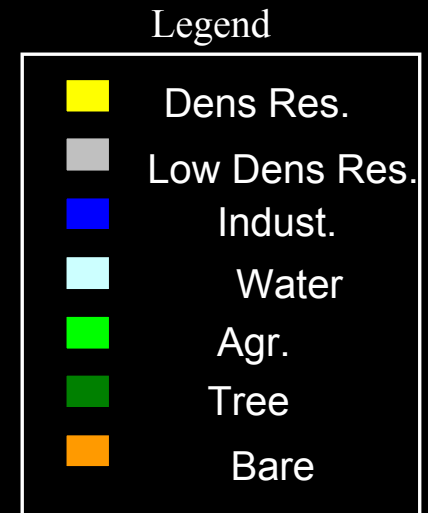
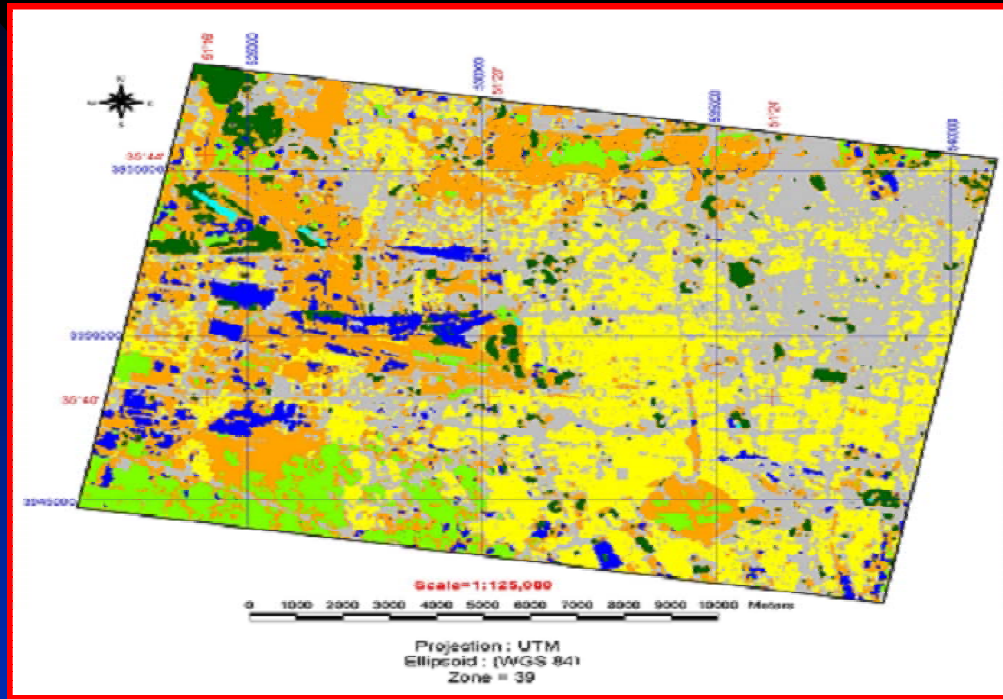
Dense Res.

Profile of Similarity Index in KC-SPARK (DK)



Dense Res.

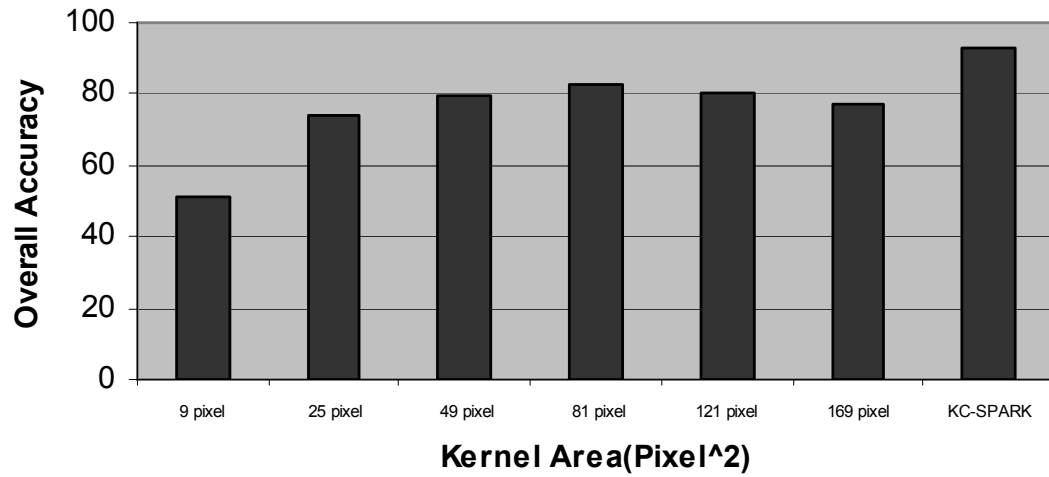
Landuse Map produced By KC-SPARK



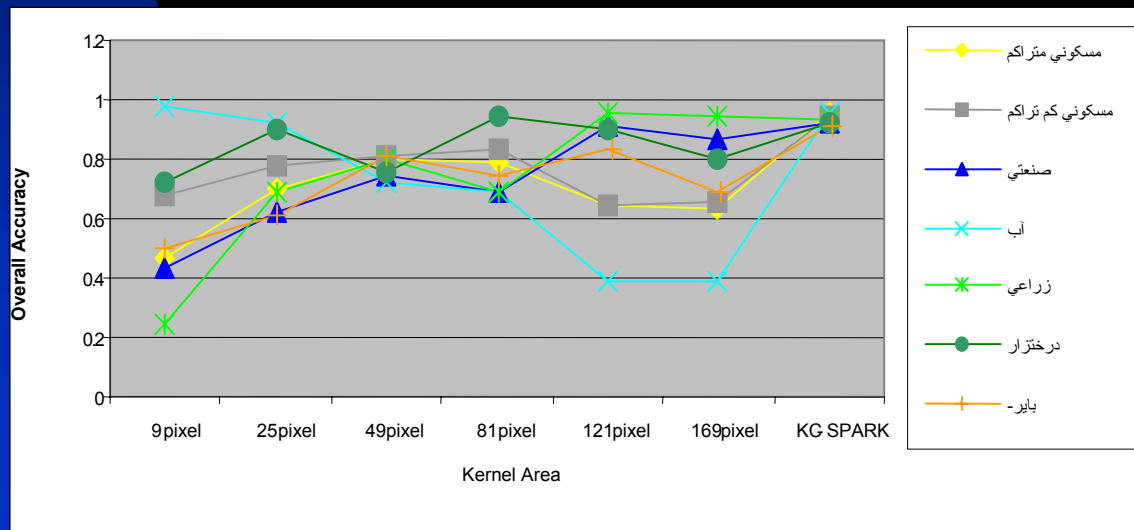
Error Matrix result :

Overall Accuracy = %92.92

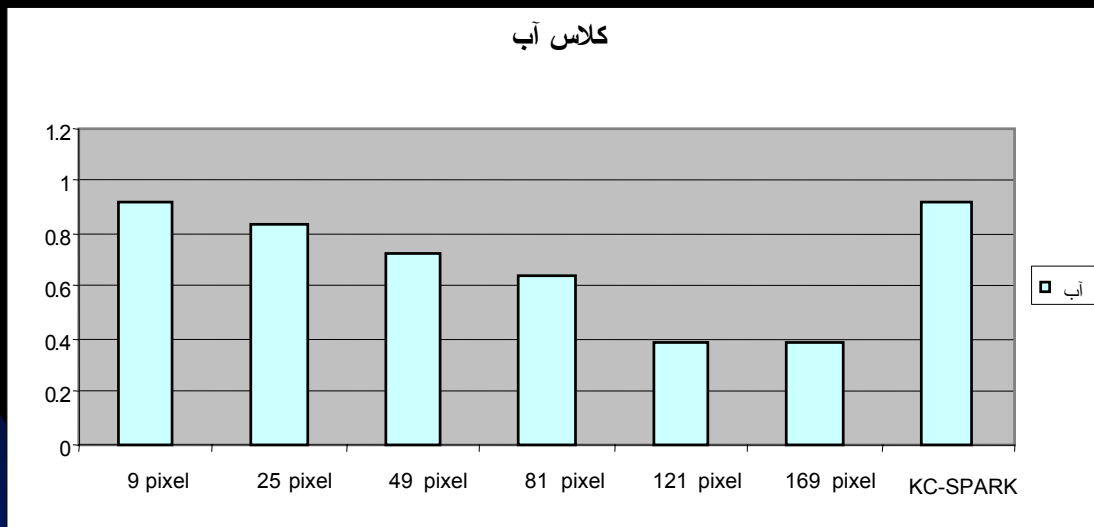
Kappa Coefficient = 0.91



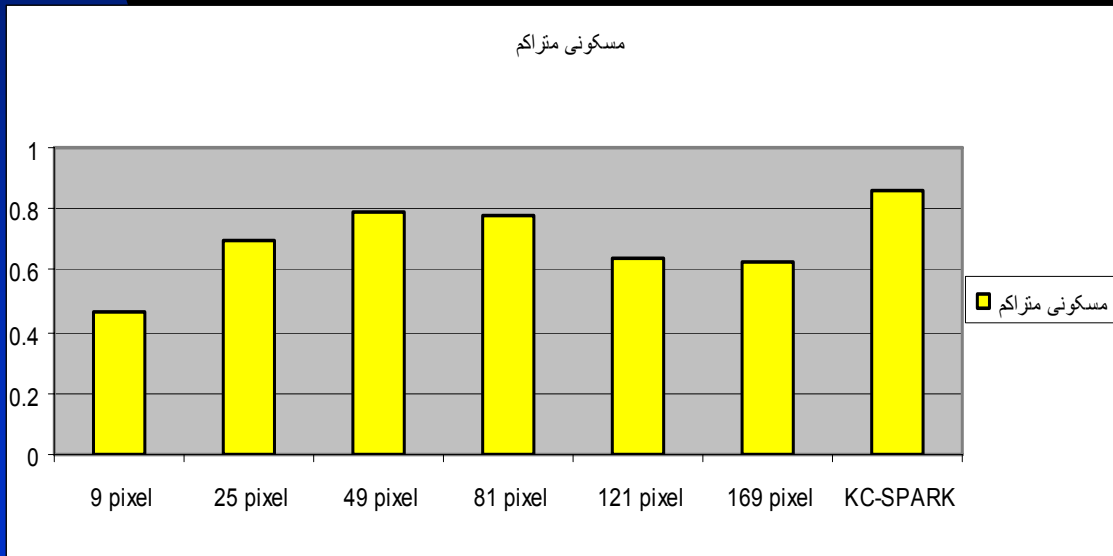
Accuracy in Different Window Sizes



Accuracy in Different Window Sizes



Accuracy of Water in Different Windows



Accuracy of Dens Res. in Different Windows

Results & Conclusion:

1- In SPARK the Highest Accuracy is Obtained in 9*9 Window Size (82.39%)

2- The lowest Accuracy is Obtained in 3*3 Window Size (51.54%)

3- KC- SPARK Shows the Highest Accuracy (92.92%)

4- Wider Test and Application of the proposed KC- SPARK Algorithm is Recommended

The End

