Object Based Classification Based on Hyperspectral AVIRIS Data

1.Purpose: In my project, I evaluate the performance of the AVIRIS sensor using object based classification for delineating landcover to a specific thematic map using a set of classes. Validation of the classification map from object based algorithms was performed through error matrix statistics which are used for evaluating the assessment accuracy using the values of overall accuracy, user's accuracy, producer's accuracy and Kappa statistic.

2.Data: the remote sensing data I use is collected from the AVIRIS hyperspectral sensor which has nearly the highest spectral resolution and spatial resolution, acquiring spectral information of Earth's surface objects in **224** spectral bands in an extremely high spatial resolution of **0.8** m. the original data (Fig.1, Left) was captured in Galveston, Huston, TX at 16:46, 9/2/2010.

3. Methodology

3.1Data preprocessing

All of preprocessing of the AVIRIS imagery was carried out using ENVI (v. 5.1) image processing software. Hyperspectral sensors should be spectrally and radiometrically calibrated before you analyze their data. NASA/JPL has already processed the AVIRIS data to remove geometric and radiometric errors associated with the motion of the aircraft used during data collection. However, the data should be further corrected using FLAASH (Fig.1 Mid) for atmospheric effects and converted to surface reflectance prior to scientific analysis. (Fig.2) After this process, the available bands of AVIRIS reduced to 170 and we will get a corrected

image(subset) using MNF transformation both forwardly and inversely. The inverse transformation will get a final imagery containing 170 bands. (Fig.1 Right)



Fig.1 Original AVIRIS data (left), FLAASH correction result(mid), Inverse MNF result(right)

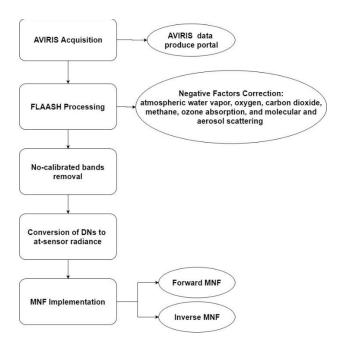


Fig.2 Workflow of preprocessing AVIRIS data

3.2. Object based classification

In my study, the software I use for object based classification is e-cognition. After trying different criterions, finally my AVIRIS image was segmented using all 170 bands with equal weighting, shape parameter of 0.1, compactness of 0.8 and scale of 15. The specific object features I use for my classification are brightness value, band1 value, band12 value, band21 value, band31 value, band52 value, max_difference, area, border length, length, number of pixels, width, asymmetry, compactness, rectangular fit, perimeter, relation border to neighbor objects and distance to neighbor objects. The specific class types for my classification are avenue, brown facilities, healthy trees, shrub/grass, parking lot, river, soil/cement, house, swimming pool, street/ground, wetland and white facilities (12 in total). The workflow (Fig.3, Fig.4) contains all the feature extraction methods. And the result of object based classification (Fig.5, Fig.6) will get.

4. Object based classification accuracy assessment

After classification process, the result was evaluated using accuracy assessment methods such as overall accuracy, user's accuracy, producer's accuracy and Kappa statistic using error matrix based on TTA masks. The assessment accuracy(Fig.7) indicates that object based classification has a higher overall accuracy (89%) and a higher Kappa value (0.86).

```
24.30 Segmentation
2015 dotes Level 1
2015 dotes Level 1
2015 dotes Level 1
2016 dotes Level 1
2014 Telephol compat.0.8] creating Level 1
2014 Callotts Solimning Pool
2014 Callotts understified with Mean Layer 12 > 100 and Brightness > 78 at Level 1 Swimming Pool false
2014 Callotts understified with Mean Layer 12 > 100 and Brightness > 78 at Level 1 Swimming Pool false
2014 Callotts Swimming Pool false with Mean Layer 12 > 100 and Brightness > 78 at Level 1 Swimming Pool false
2015 Swimming Pool false with Mean Layer 12 and Area > 40 Pot at Level 1 Swimming Pool false
2015 Swimming Pool false at Level 1 uncleasified
2015 Swimming Pool false at Level 1 uncleasified
3016 Estact River
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   - 4. «1000: Simming Pool False at Level 1 understreed

10.015 - Estant Simming Pool False at Level 1- Roverfalse

10.015 - Construction and Mann Layer 22 < 29 and Brightness < 23 at Level 1- Roverfalse

10.015 - Roverfalse and Mann > 1000 Pool at Level 1- Rover

10.015 - Roverfalse and Mann > 1000 Pool at Level 1- Rover

10.015 - Roverfalse and Distructs Six Rover < 400 Pol and NOVI > 0.04 at Level 1- Rover

10.015 - Roverfalse and Level 1- under segment

10.015 - Roverfalse and Level 1- understreed

10.015 - Roverfalse and Level 1- understreed

20.015 Dark False at Level 1: merge region

1. <0.0015 Dark False with Area <= 14000 Pxl and Area >= 13500 Pxl at Level 1: Avenue

2. <0.0015 Dark False with Area >= 12900 Pxl at Level 1: ParkingLot

2. <0.001s Dark False with Area >= 12900 Pxl at Level 1: ParkingLot
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                4 < 0.001s unclassified with Rel. border to ParkingLot >= 0.8 at Level 1: ParkingLot
                                    0.031 Extract Wetland
                                 <0.001s ParkingLot with Rel. border to ParkingLot >= 0.7 at Level 1: <- und
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     1. < 0.0015 unclassified with Area = 716 Pzl and Border length = 166 Pzl at Level 1: House • 0.0015 Estract Dark House • 0.0015 Estract Dark House • 0.0015 Estract Dark House • 0.0015 Shrub/Grass with Area = 2465 Pzl and Border length = 476 Pzl at Level 1: House • 0.0015 Dark False with Area = 2405 Pzl and Border length = 120 Pzl at Level 1: House • 0.0015 Dark False with Area = 2000 pzl and Border length = 130 Pzl at Level 1: Unclassified • 0.0015 Dark False with Area = 2000 pzl and Border length = 152 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 2000 pzl and Border length = 430 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 2020 Pzl and Border length = 430 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 2202 Pzl and Border length = 736 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 2351 Pzl and Border length = 736 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 240 Pzl and Border length = 120 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 646 Pzl and Border length = 120 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 440 Pzl and Border length = 120 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 4350 Pzl and Border length = 120 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 4350 Pzl and Border length = 100 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 4350 Pzl and Border length = 100 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 4350 Pzl and Border length = 100 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 4350 Pzl and Border length = 100 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 4300 Pzl and Border length = 200 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 4300 Pzl and Border length = 100 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 630 Pzl and Border length = 100 Pzl at Level 1: unclassified • 0.0015 Dark False with Area = 630 Pzl and Border length = 200 Pzl at Level 1: unclassified • 0.0015 
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             0.015 Wetland at Level 1: merge region
                                 👢 <0.001s unclassified with Rel. border to White Facilities >= 0.7 and Rel. border to White Facilities <= 0.8 at Level 1: White Facilitie
                                    4. <a href="color: doi:10.000%">doi:10.000%</a> of Rel, border to White Facilities >= 0.8 and Rel, border to White Facilities <= 0.9 at Level 1: White Facilities <a href="color: doi:10.000%">doi:10.000%</a> unclassified with Mean Layer 1>= 2 and Mean Layer 1 <= 30 at Level 1: RoofFalse <a href="color: doi:10.000%">doi:10.000%</a> and Rean Layer 2<= 55.5 at Level 1: RoofFalse

A DIS unclusified with Mean Layer 12 = 53.4 and Mean Layer 12 < 53.5 at Level 1: Rooffalse = < < 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0.00 × 0
                         | Dark False at Level 1: House
0.094 Estract Bipti Facilities
| 0.0016 Londassified with Mean Layer 12 >= 0 and Mean Layer 12 <= 70 at Level 1: Bright False
| 0.0078 Estract Road Brown Facilities
| 0.0078 Estract 

    0.062 Extract Dark Facilities

- UNE_ London Shinkles with Bonder length = 30 Phil and Length = 8 Phil at Level 1: Avenue
- 4, 40001s - Should Grass with Bonder length = 40 Phil and Length = 10 Phil at Level 1: Avenue
- 4, 40001s - Should Grass with Bonder length = 40 Phil and Length = 10 Phil at Level 1: Dwk False
- 4, 40001s - Should Grass with Bonder length = 40 and Brightness <= 40 at Level 1: Dwk False
- 401015 - Should Should see Level 1: Brightness <= 40 at Level 1: Dwk False
- 401015 - Should Should see Level 1: Brightness <= 40 at Level 1: Dwk False
- 401016 - Healthy Trees at Level 1: Bringer region
```

Fig.3 Workflow of object based classification

L <0.001	s Bright False with Area = 317 Pxl and Border length = 170 Pxl at Level 1: House s Bright False with Area = 37 Pxl and Border length = 30 Pxl at Level 1: House	Feature	Value
	s Bright False, Street\Ground, unclassified with Area = 442 Pxl and Border length = 142 Pxl at Level 1: House		value
	s Bright False with Area = 81 Pxl and Border length = 52 Pxl at Level 1: Street/Ground	Image Object Related Features	
	s Bright False with Area = 67 Pxl and Border length = 50 Pxl at Level 1: Street\Ground	Object features	Customized
	s Bright False with Area = 70 Pxl and Border length = 54 Pxl at Level 1: Street\Ground	NDVI	-0.017571
< 0.001	s Bright False with Area = 224 Pxl and Border length = 136 Pxl at Level 1: Street\Ground	Layer Values	Mean
< 0.00	s Bright False with Area = 194 Pxl and Border length = 122 Pxl at Level 1: Street\Ground	Brightness	63.38
< 0.001	s Bright False with Area = 496 Pxl and Border length = 118 Pxl at Level 1: Street\Ground	Laver 1	-0.5188
< 0.001	s Bright False with Area = 50 Pxl and Border length = 34 Pxl at Level 1: Street\Ground	Laver 12	58.17
< 0.001	s Bright False with Area = 192 Pxl and Border length = 100 Pxl at Level 1: Street\Ground	Layer 21	72.54
< 0.001	s Bright False with Area = 129 Pxl and Border length = 94 Pxl at Level 1: Street\Ground	Layer 31	77.43
< 0.001	s Bright False with Area = 253 Pxl and Border length = 182 Pxl at Level 1: Street\Ground		
< 0.001	s Bright False with Area = 339 Pxl and Border length = 154 Pxl at Level 1: Street\Ground	Layer 52	74.76
< 0.001	s Bright False with Area = 57 Pxl and Border length = 50 Pxl at Level 1: Street\Ground	Max. dff.	0.5633
0.062	Bright False at Level 1: merge region	Geometry	Extent
	s Bright False with Area >= 13000 Pxl at Level 1: Avenue	Area	72062 Pxl
	s Bright False with Area = 28 Pxl and Length = 7 Pxl at Level 1: Avenue	Border length	10188 Pxl
	s Avenue with Area = 83891 Pxl at Level 1: Street\Ground	Length	601 Pxl
	s Avenue with Area = 16302 Pxl at Level 1: Street\Ground	Length/Width	1.611
	s Avenue with Area = 22708 Pxl at Level 1: Street\Ground	Number of pixels	72062
	s Bright False with Area = 12502 Pxl at Level 1: Brown Facilities		
	s Bright False with Area = 3979 Pxl at Level 1: Brown Facilities	Volume	72062 Pxl
	s Bright False with Area = 2823 Pxl at Level 1: Street\Ground	Width	373 Pxl
	s Bright False with Area >= 1000 Pxl at Level 1: Street\Ground	Geometry	Shape
	s Bright False at Level 1: unclassified	Asymmetry	0.6364
	s unclassified at Level 1: Street\Ground	Border index	9.212
	Street\Ground at Level 1: merge region	Compactness	3 111
	s Street\Ground with Area <= 1000 Pxl at Level 1: Soil\Cement	Density	1.403
	s Soil/Cement with Area = 357 Pxl and Border length = 138 Pxl at Level 1: House	Ellotic Ft	0
	s Soil/Cement with Brightness <= 50 at Level 1: House		
	s House with Area <= 100 Pxl at Level 1: Soil\Cernent	Rectangular Fit	0.3880
	s House with Area = 166 Pxl and Border length = 72 Pxl at Level 1: ParkingLot s House with Area = 221 Pxl and Border length = 126 Pxl at Level 1: ParkingLot	Roundness	2.131
	s House with Area = 221 PxI and Border length = 120 PxI at Level 1: ParkingLot s Avenue with Area = 206 PxI and Border length = 110 PxI at Level 1: Healthy Trees	Geometry	Based on Po
	s Avenue at Level 1: merge region	Area (excluding inner polygons)	71907.50 Pxl
	s Avenue with Area <= 10000 Pxl at Level 1: Soil\Cement	Perimeter (polygon)	5322.27 Pxl
	s Avenue with Area = 13887 Pxl at Level 1: Street\Ground	Object features	Hierarchy
	s Avenue with Area = 1500 FM at Level 1: Street\Ground	Level	Level 1
	s Street\Ground with Area = 3209 Pxl and Border length = 468 Pxl at Level 1: House	Relations to neighbor objects	Rel. border
	s Street\Ground with Area = 3006 Pxl and Border length = 526 Pxl at Level 1: House	House	0.1409
	s Street\Ground with Area = 3209 Pxl and Border length = 468 Pxl at Level 1: House		
	s Street\Ground with Area = 3209 Pxl and Border length = 468 Pxl at Level 1: House	ParkingLot	0.056439
	s Street\Ground with Area = 2516 Pxl and Border length = 630 Pxl at Level 1: House	River	0
	s House with Area = 270 Pxl and Border length = 132 Pxl at Level 1: Soil\Cement	Wetland	0
	s House with Area = 643 Pxl and Border length = 248 Pxl at Level 1: Avenue	White Roof	0.054967
	s House with Area = 107 Pxl and Border length = 78 Pxl at Level 1: Soil\Cement	Relations to neighbor objects	Distance to
	s House with Area = 327 Pxl and Border length = 108 Pxl at Level 1: Soil/Cement	ParkingLot	186.17 Pxl
	s House, Soil/Cement with Area = 98 Pxl and Border length = 72 Pxl at Level 1: Avenue	River	388 21 Pxl
	House, Soil\Cement with Area = 44 Pxl and Border length = 38 Pxl at Level 1: Avenue	1	
	s House, Soil Cement with Area = 225 Pol and Border length = 120 Pol at Level 1: Avenue	White Roof	182.17 Pxl

Fig.4 Workflow of object based classification & object feature(cont.)

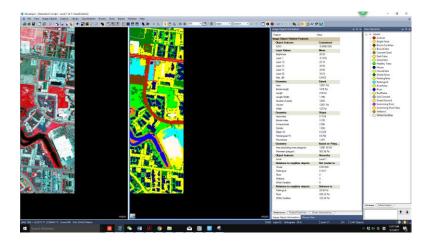


Fig.5 Overview of the original data (False Color Display) and classification result.



Fig.6 Zoomed original data and classification result (above part/below part)

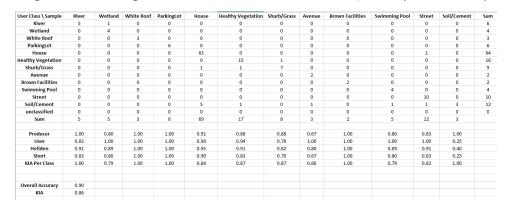


Fig.7 Accuracy assessment of object based classification

5. Reference

Due to the reason that most of my reference sources are from videos, labs and data website, the reference below may not be as formal as paper format.

1-4 Lab7,lab8,lab10,lab11

5.harrisgeospatial.com

6.youtube.com.ecognition

7. https://aviris.jpl.nasa.gov/

8.http://www.harrisgeospatial.com/docs/PreprocessAVIRIS.html

9. Dimensionality Reduction and Classification of Hyperspectral Image Data Using Sequences of Extended Morphological Transformations Antonio Plaza, Member, IEEE, Pablo Martínez, Javier Plaza, and Rosa Pérez

10. Hyperspectral Image Classification and Dimensionality Reduction: An Orthogonal Subspace Projection Approach Joseph C. Harsanyi, Member, IEEE, and Chein-I Chang, Senior Member, IEEE

11.Support vector machines and object-based classification for obtaining land-use/cover cartography from Hyperion hyperspectral imagery