Detailed urban object-based classifications from WorldView-2 imagery and LiDAR data: supervised vs. fuzzy rule-based

Alireza Hamedianfar¹
Assoc. Prof. Dr. Helmi Zulhaidi Mohd Shafri¹²
Prof. Dr. Shattri Mansor¹²
Assoc. Prof. Dr. Noordin Ahmad³

¹Department of Civil Engineering, Faculty of Engineering, Universiti Putra Malaysia (UPM)
²Geospatial Information Science Research Centre (GISRC), Faculty of Engineering, Universiti Putra Malaysia (UPM)
³National Space Agency, Bangunan Komersil PJH, 62570 Putrajaya, Malaysia

hzms04@gmail.com
ali.hamedianfar@gmail.com

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Introduction

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☐ Methodology
☐ Results and Discussions
☐ Conclusion
Introduction

Urbanization Phenomenon:

- Growth of built-up area and man-made structures
- Rapid transformation of natural environment to Impervious Surfaces (IS)
- IS distribution as a major contributor to urbanization and environmental condition (Arnold & Gibbons, 1996; Weng 2012).
- Roofs as the 25% coverage of urban areas (Akbari et al. 2003)

Roofing materials:

- Concrete tile
- Clay tile
- Metal
- Asbestos
- Polycarbonate

How roofing materials can affect environmental condition and quality?

- Pollution
- Health
- Heat/energy
Introduction

Pollution:
Roof runoff as a source of **water pollution** (Ballo et al. 2009)

Factors affecting surface water quality (Göbel et al. 2007; Gikas and Tsihrintzis 2012):

- Roofing materials
  - Heavy metals such as zinc, copper and cadmium have been reported to be a source of contamination for surface water (Van Metre and Mahler 2003).

Other factors
- Conditions and slope of roofs
- Differences in usage of buildings (e.g. residential or industrial)

Health:

**Asbestos roofs** as contributor to Lung Cancer

- In 2004, 107,000 deaths and 1,523,000 Disability Adjusted Life Years (DALYs) (Frassy et al 2012)
- **Asbestos roofs** marketing and use was banned in **European Union** on January 1, 2005 (following the directive 76/769/CEE) (Frassy et al 2012).
- A consensus was achieved on banning of asbestos by **Department of Occupational Safety and Health (DOSH)** on 28 March 2011 in **Malaysia** (Safitri et al 2013).
- Complete ban in Malaysia is under negotiation and process (Safitri et al 2013).
Introduction

✔ How we can get information about roof material types in large study area?

1- Field visit, but
  • too labor intensive
  • very time consuming for large study area.

2- Hyperspectral Remote sensing offer great potential to map surface materials, but
  • Provides limited coverage
  • too expensive

3- New generation of Very High Resolution (VHR) satellite imagery
  • WorldView-2 image
  • much more efficient and cost effective

Current trends with land cover classification

<table>
<thead>
<tr>
<th>Classification Approach</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>spectral-based Image analysis</td>
<td>✔ Sufficient for medium spatial multispectral image and hyperspectral imagery (Weng 2007; Envi-zoom tutorial 2010)</td>
<td>o Only based on pixel-values (DNs). o Poor performance in handling VHR imagery. o Not able to utilize spatial and textural information (Blaschke and Strobl, 2001; Myint et al. 2011).</td>
</tr>
<tr>
<td>Object-based image analysis (OBIA)</td>
<td>✔ Change the classification element to image object. ✔ Utilization of all spatial, spectral, and textural information. ✔ Able to provide advanced rule-sets to map different target (Myint et al. 2011; Bhaskaran et al. 2012; Hamedianfar and Shafri 2013).</td>
<td>o Often results in unclassified and mixed objects when dealing with intra-urban targets (Pinho et al 2012, Hamedianfar and Shafri 2013)</td>
</tr>
</tbody>
</table>
Objectives

- To identify optimal object-based rule-sets for roof material detection and other urban features
- To provide cartographically pleasing outline of roof infrastructure by using LiDAR and very high spatial resolution imagery of WorldView-2
- To compare the accuracy and efficiency of rule-based classifier and supervised SVM classifier in utilizing of LiDAR and WorldView-2 image

Study area and data
Data for this research rely on World-view2 (WV-2) imagery. WV-2 sensor includes:

- Panchromatic channel (0.5m spatial resolution)
- Eight multispectral channels (1.8m spatial resolution)

LiDAR (Light Detection and Ranging) data

LiDAR is an active remote sensing technology that measures distance with reflected laser light (Jensen 2005)

3D view
LiDAR (Light Detection and Ranging) data

2D view

Ancillary data: LiDAR products (DSM, DEM, nDSM¹)

nDSM image

WorldView-2 image

¹nDSM = Normalized Digital Surface Model
Methodology

**Land-cover classes**
- Asbestos roof
- Concrete tile roof
- Metal roof
- Road
- Sidewalks
- Grass
- Trees
- Pond
- Swimming pool
- Shadow

RBF Kernel was used for SVM classifier. SVM parameters (C and γ) have been optimized using parameter selection technique. (The cross validation determined the optimal parameter $C = 0.5$ and $\gamma = 0.0078$ with 5 fold function rate = 99%)

Results and Discussions

Supervised SVM object-based classification of LiDAR data and WorldView-2 image
Accuracy assessment of supervised SVM object-based classification

<table>
<thead>
<tr>
<th>class</th>
<th>Reference total</th>
<th>Classified total</th>
<th>Correct classified</th>
<th>Pa %</th>
<th>Ua %</th>
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<tbody>
<tr>
<td>Mr</td>
<td>80</td>
<td>58</td>
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<tr>
<td>Cr</td>
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<td>81.03</td>
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<td>34</td>
<td>29</td>
<td>74.36</td>
<td>85.29</td>
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</table>

Overall Accuracy = 85.02%  Kappa Coefficient = 0.82

Note: Mr =metal roofs, Cr: concrete tile roofs, Ar: asbestos roofs, R= roads, S=sidewalks, G=grass, T=trees, P=pond, Sp= swimming pool, Sh=shadow, P= producer accuracy, and Ua= user accuracy

Rule-sets of object-based image analysis

(Adapted from ENVI-Zoom Tutorial (2010))
<table>
<thead>
<tr>
<th>Attribute</th>
<th>MR</th>
<th>CTR</th>
<th>AR</th>
<th>Roads</th>
<th>SDW</th>
<th>Trees</th>
<th>Grass</th>
<th>Lake</th>
<th>SP</th>
<th>SD</th>
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<tr>
<td>std band6</td>
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<td>[-0.05, -0.03]</td>
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<td>nDSM</td>
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<td>&gt;9.5</td>
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<tr>
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<td>[0.66, 1.24]</td>
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<tr>
<td>min band7</td>
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<td>&gt;0.82, 2.32</td>
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<td>tx entropy area</td>
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<td>&gt;161</td>
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<td>&lt;0.82</td>
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Note: MR= metal roofs, CTR= concrete tile roofs, AR= asbestos roofs, SP= swimming pool, SDW =Sidewalk, and SD= shadows
Accuracy assessment of Rule-based object-based classification

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Overall Accuracy = 93.07%  
Kappa Coefficient = 0.92

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Conclusion & Recommendations

- Improvement of rule-based classification by nDSM and WorldView-2 data fusion (93.02% overall accuracy)
- Higher accuracy by using the developed rule-sets from spectral, spatial, texture and elevation information
- Effective reduction of misclassifications
- Increase the productivity and efficiency of OBIA

Future study can be done to explore the transferability of established rule-sets.

Expand the work to larger study areas, and explore the performance of different object-based classifiers.


Safitri Zen, R. Ahamad, K. Gopal Rampal, and W. Omar. 2013 "Use of asbestos building materials in Malaysia: legislative measures, the management, and recommendations for a ban on use”. INT J OCCUP ENV HEAL. 19(3), 169-178

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¹Department of Civil Engineering, Faculty of Engineering, Universiti Putra Malaysia (UPM)
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