GLOBAL SLUM ANALYSIS ACHIEVEMENT AND CHALLENGES

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HUMAN PLANET FORUM
12-15 September 2017
THE URBAN DIVIDE

What are slums - how to define?

Source: Johnny Miller - http://unequalscenes.com/nairobi

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WHAT DO WE KNOW ABOUT GLOBAL SLUM DEVELOPMENTS

- 15 years of slum mapping using remote sensing (Kuffer, Pfeffer and Sliuzas, 2016)
- Based on 87 publications selected and reviewed

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WHY DO WE NEED DATA ON SLUMS?

A planned road will bisect Kibera slum in Nairobi, displacing thousands of people.

Source: Johnny Miller - http://unequalscen.es.com/nairobi
WHERE ARE THE POOR – DEPRIVED – SLUMS?

MUMBAI

- Municipal data often not up-to-date

WorldView – 2
- VNIR: 1.8 m (8 bands)
- PAN: 0.5 m
MAPPING SLUMS FROM SPACE

VERY-HIGH-RESOLUTION SENSORS

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### MORPHOLOGY OF SLUMS – FROM SPACE

<table>
<thead>
<tr>
<th>Features</th>
<th>Slums</th>
<th>Planned areas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>• Small building sizes</td>
<td>• Generally larger building sizes</td>
</tr>
<tr>
<td><strong>Density</strong></td>
<td>• High densities (roof coverage)</td>
<td>• Low – moderate density areas</td>
</tr>
<tr>
<td></td>
<td>• Lack of public (green) spaces</td>
<td>• Provision of public (green spaces)</td>
</tr>
<tr>
<td><strong>Pattern</strong></td>
<td>• Organic layout structure</td>
<td>• Regular layout pattern</td>
</tr>
<tr>
<td><strong>Site Characteristics</strong></td>
<td>• Hazardous locations</td>
<td>• Formal development with services and infrastructure provision</td>
</tr>
<tr>
<td></td>
<td>• Access to livelihood opportunities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Etc...</td>
<td></td>
</tr>
</tbody>
</table>
WHAT IS SPECIFIC TO SLUMS – AN HOW MUCH DO THEY DIFFER?

Dar es Salaam
Tanzania

Cairo, Egypt

Vizag, India

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DYNAMICS OF SLUMS – BANGALORE (DYNASLUM PROJECT)

Decision Support System for policy makers and urban planners to understand how, when and where slums grow in developing countries.

Emergence and Growth of a slum in Huidi, Bangalore (red polygon).

a) Slums emerge near a construction Site in 2008.

b) Slum grows near the same site.

c) Slum disappear when construction is complete in 2013.

d) A slum re-emerge at the same site in 2014 (Images– Google Earth).


https://www.esciencecenter.nl/project/dynaslum
# Achievements and Challenges

<table>
<thead>
<tr>
<th>Information levels</th>
<th>Image / spatial feature</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUPs (Patches)</td>
<td>Spatial/Environ</td>
<td>OBIA</td>
</tr>
<tr>
<td>Objects Level</td>
<td>Geometry</td>
<td>Statistical Models</td>
</tr>
<tr>
<td>Window/Segments</td>
<td>Texture/Morphology</td>
<td>Machine Learning</td>
</tr>
<tr>
<td>Pixels</td>
<td>Spectral</td>
<td>Class. Pixel Classifier</td>
</tr>
</tbody>
</table>

**Examples..**
- Slope
- Accessibility
- Proximity
- Shape
- Size
- Aggregation
- GLCM
- LBP
- Morph. filtering
- NDVI
- Soil indices
- Band stats
REPORTED ACCURACIES OF AUTOMATED SLUM DETECTION METHODS

UNCERTAINTIES IN THE REFERENCE DATA FOR CLASSIFICATION ACCURACIES

Higher agreement: poor building material, high density and located in the riverbank

Misclassifications: high density and have a roof from asbestos

SLUM ONTOLOGY

- Object Level
  - Building Characteristics
  - Road Layout
- Settlement Level
  - Shape
  - Density
  - Connectivity
- Neighborhood Level
  - Hazardous Location

MACHINE LEARNING
Deep learning methods such as Convolutional Neural Networks can automatically learn spatial features from the input image.


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DENSE POINT CLOUD FROM UAV IMAGES, KIGALI, RWANDA
(IMAGE BY C. GEVAERT)
MULTIPLE KERNEL LEARNING

Overall Accuracy:
Single-kernel SVM: 85.4%
Random forest: 86.5%
MKL: 90.6%


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CLASSIFICATION RESULTS EXTENDED STUDY AREA

- Extended study area (Kigali, Rwanda)
DETECTING SLUMS WITH BOVW FRAMEWORK (DYNASLUM)

1. Set Up Image Category Sets
2. Create Bag of Features
3. Train an Image Classifier with BoVW
4. Classify an Image or Image Set

DETECTING SLUMS WITH BOVW FRAMEWORK (DYNASLUM)

**CHALLENGE 1:**
UNDERSTANDING SLUMS/POVERTY NOT AS BINARY PROBLEM

- Mapping the diversity of deprived areas (multi-class approach): *Kuffer, Pfeffer, Sliuzas, Baud, van Maarseveen (2017)*

<table>
<thead>
<tr>
<th>TYPE 1</th>
<th>TYPE 2</th>
<th>TYPE 3</th>
<th>TYPE 4</th>
<th>TYPE 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slum pocket *</td>
<td>Slum area, small buildings (slum small *)</td>
<td>Slum area, mix small/larger buildings (slum mix *)</td>
<td>Basic formal and chawl (basic/chawl *)</td>
<td>Formal areas (formal *)</td>
</tr>
<tr>
<td>Geometry: Small roofs</td>
<td>Geometry: Small roofs</td>
<td>Geometry: Small-medium roofs</td>
<td>Geometry: Medium roofs</td>
<td></td>
</tr>
<tr>
<td>Density: High</td>
<td>Density: High</td>
<td>Density: Mix</td>
<td>Density: High-mix</td>
<td></td>
</tr>
<tr>
<td>Pattern: Organic</td>
<td>Pattern: Organic</td>
<td>Pattern: Diverse</td>
<td>Pattern: Some str</td>
<td></td>
</tr>
<tr>
<td>Environment: Pockets along roads or within formal areas</td>
<td>Environment: Large areas with diverse uses</td>
<td>Environment: Some areas in more elevated terrain</td>
<td>Environment: Litt vegetation within</td>
<td></td>
</tr>
</tbody>
</table>

- Relationship between image features and urban poverty:


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CHALLENGE 2: CAN WE COMPUTE A GLOBAL SLUM MAP?

- What are the most robust image features?

- How can we incorporate different slum development stages, dynamics and typologies?

- Feature selection – training – assessment – which algorithms and reference data?

- Towards global slum mapping - reference cases, e.g.
CHALLENGE 3:
INFORMATION NEEDS AND ETHIC CONSIDERATIONS

Shall we make slum maps and images publically available ????

(image by C. Gevaert)
CHALLENGE 4: UNDERSTAND BETTER ENVIRONMENTAL CONDITIONS OF SLUMS

WANG, J. et al. Characterizing the thermal patterns of informal urban settlements. Forthcoming.
THANKS FOR YOUR ATTENTION