Population Mapping using Image Processing and Ancillary Data to Support Risk and Damage Assessment

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Abstract

We demonstrate a population mapping algorithm that uses image processing techniques for classifying high resolution satellite images of urban areas into residential and non-residential regions using the Minkowski Functionals. Geographic information systems (GIS) data (i.e. barangay boundaries) are then used for the normalization of the population weights per area. The classified locations, along with the ancillary data, shows that redistribution of available barangay level census data more distinctively is possible, despite of the insufficiency of data in the Philippines. The resulting population map may then be used as an ancillary layer for risk and damage maps which may show the possible humanity risks and damages.

Keywords: Image Processing, Population Mapping, Minkowski Functional, Disaster Management, Machine Learning
Outline

• Introduction
  • Spatial Distribution of Population
  • Significance of the Study

• Materials and Methodology
  • Study area and Data
  • Area Classification from Imagery
  • Mapping census population

• Preliminary Results
Spatial Distribution of Population

- “analysis of people’s interaction with their local socio-economic and physical environments”

- “key for a better understanding of human impacts in land and water resources”

- Important for:
  - Resource distribution
  - Healthcare services
  - Urban Planning
  - Economic Development
  - Spatial Interaction Modeling
Spatial Distribution of Population

- Traditionally, population distribution is derived from census data per unit.
- Spatial Analysis on these data may have different purposes:
  - Specific areal unit in which the data are reported may not coincide with the nature of the phenomena under investigation.

Spatial Distribution of Population

- Solution: Interpolation
  - From initial units to target unit

- GIS models based on spatially explicit ancillary information
  - Apply weights based on ancillary data for population redistribution
  - Land cover information; vegetation indices, night-time light imagery
  - Alternative factors: Terrain; road network; river network

Our study explores population mapping at the smallest local sub-unit in the Philippines, i.e. Barangay units.
Significance of the Study

• Risk and Damage Assessment
Typhoon Haiyan in Tacloban City
Significance of the Study

Problems in Damage Assessment:

- Inspection in the Philippines is done visually (ground-truth)
  - Community Assisted remote damage assessment yields 36% accuracy compared to ground-truth assessment [1,4]
- Large-scale disasters covers multiple islands and municipality
- Slow and Tedious process
- Current automatic damage assessment techniques uses SAR (synthetic aperture radar), which is not readily available in the country

What if we focus on the humanitarian part of disasters? What if, instead of looking at the damages in structures, we figure out the damages in terms of human lives affected?
Study Area and Data

- Pre-Haiyan Tacloban City
  - DREAM project
- 2010 Census Population
  - Philippines Statistics Authority
Manual Classification of Images

- Residential
Manual Classification of Images

- Non-residential
Manual Classification of Images

- Foliage
Area Classification Methodology

- Minkowski Functional
  - Binarize Grayscale image at varying thresholds
  - Measure perimeter, area, and Euler number

![Image showing binarization at varying thresholds with corresponding graphs of area, perimeter, and connectivity vs. threshold.](image-url)
Training Data and Feature Extraction

- 275 training samples
- Green: Foliage
- Red: Residential Area
- Blue: Non-Residential Area
Automatic Classification of Images

- 0.4 threshold value
- Use standard deviation for classification
  - $x < 0.04$
    - foliage
  - $0.04 < x < 0.13$
    - nonresidential
  - $x > 0.13$
    - Residential
Automatic Classification of Images

<table>
<thead>
<tr>
<th>Actual</th>
<th>Residential</th>
<th>Nonresidential</th>
<th>Foliage</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>79</td>
<td>21</td>
<td>0</td>
<td>79 %</td>
</tr>
<tr>
<td>Nonresidential</td>
<td>10</td>
<td>69</td>
<td>21</td>
<td>69 %</td>
</tr>
<tr>
<td>Foliage</td>
<td>0</td>
<td>1</td>
<td>99</td>
<td>99 %</td>
</tr>
</tbody>
</table>

- Results for classifying using the simplest classification method.
Automatic Classification of Images
Automatic Classification of Images
Population Mapping

- Barangay boundaries from two different sources
Inconsistent Data
Population Mapping

- Separate the different barangays into different masks
- Use masks on residential areas
Preliminary Results

- Normalize masked areas in terms of total area
- Then multiply with the population for the barangay
Conclusion

• The Minkowski Functional provides a useful texture feature for classification of urban areas into residential and non-residential regions.

• The classified regions, along with the ancillary data, are used as weighing factors to redistribute the available barangay level census data more distinctively.

• Despite the problem of data availability and inconsistencies, we have provided a simple method of reclassifying population. It is recommended that additional GIS and ancillary data be used for remapping the population as well as additional texture features for better area classification.
References


Acknowledgments

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Thank You