VillageFinder: Segmentation of Nucleated Villages in Satellite Imagery

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1 Problem

Segment nucleated villages from publically available satellite imagery, e.g. from Google Earth™

Useful for developing countries having limited access to satellite imagery

Example Application: Quick disaster assessment, e.g. in case of floods, from pre-disaster images

2 Challenges

Nucleated villages can have huge variability, depending on geographic terrain and location

Images from different satellites: spectral and atmospheric calibration cannot be applied.

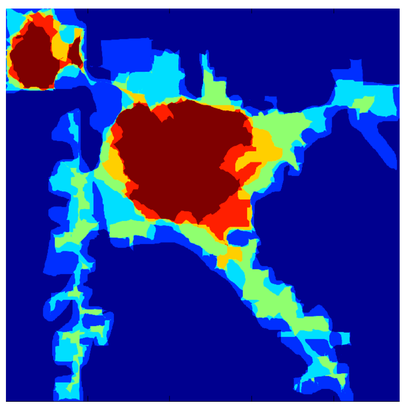
Limited data: Additional spectral layers, other than RGB, not available

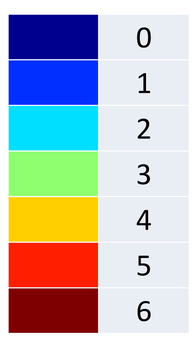
Examples of nucleated villages in our dataset

3 Dataset and Ground Truth

Six human annotators marked villages in 60 images containing more than 345 million pixels, covering more than 100 km² area, containing villages from 15 countries spread over 4 continents

Human annotators disagree significantly in demarcation of village boundaries





# of annotators marking as village

Kalman Filter used to fuse ground truths, by incorporating variance of each annotator over multiple markings of the same image

4 Features

Phase Gradient Features: Decompose image using log-Gabor filters into 6 scales and 10 orientations

$$v_i(\mathbf{x}) = |v_i(\mathbf{x})|e^{j\phi_i(\mathbf{x})}$$

Compute gradient of phase of each component

$$\phi_i'(\mathbf{x}) = j\left[\frac{|v_i(\mathbf{x})|'}{|v_i(\mathbf{x})|} - \frac{v_i'(\mathbf{x})}{v_i(\mathbf{x})}\right]$$

The magnitude of phase gradient gives local frequency in the direction perpendicular to the radial direction of the log-Gabor component

$$|\phi_i'(\mathbf{x})| = \sqrt{\frac{d\phi_i^2}{dx} + \frac{d\phi_i^2}{dy}}$$

'Cornerness' features: Smaller eigenvalue of scatter of image gradient vector, computed on 8 levels of pyramid over a 15 x 15 neighborhood

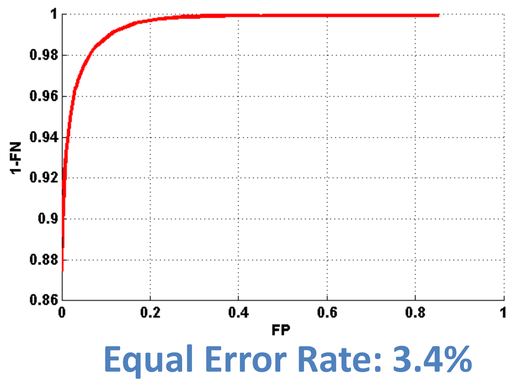
Color Feature: Green component divided by red + blue components

5 Training and Classification

Used Adaboost with thresholds on raw features as weak learners

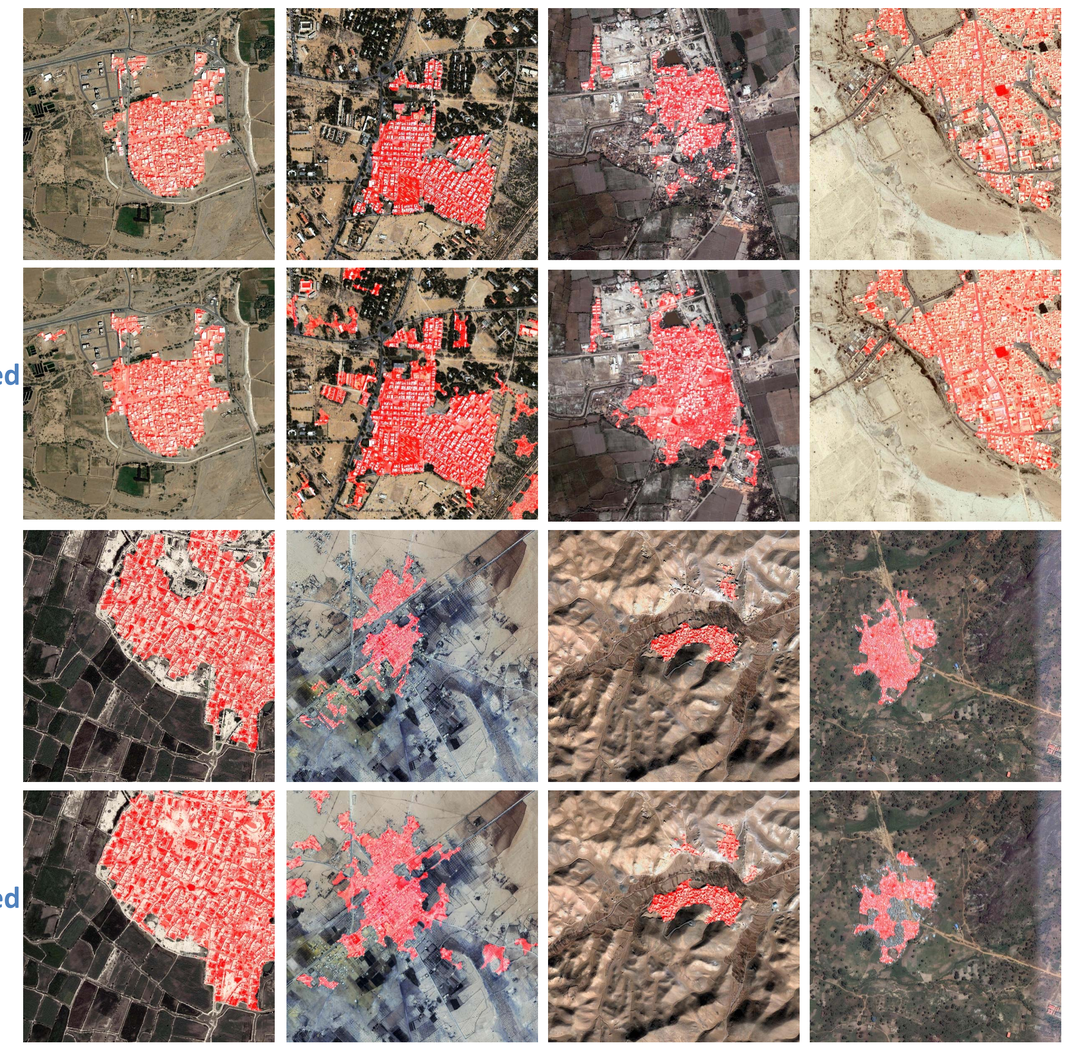
Five-fold cross-validation is used. For each fold 25% of images were kept as testing images

Results of folds averaged to trace the ROC curve



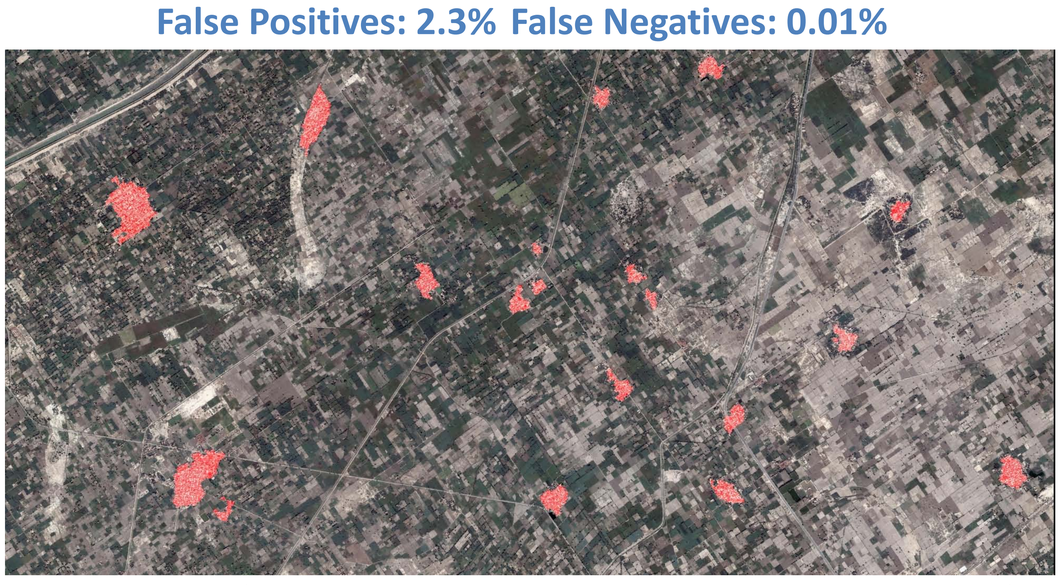
Equal Error Rate: 3.4%

6 Results



Experiments on a large 50 km² image of rural area, 184 million pixels

False Positives: 2.3% False Negatives: 0.01%



Ground Truth ↑ Computed Result ↓