



Jet Propulsion Laboratory
California Institute of Technology

PRINCETON

School of Engineering
and Applied Science



INDIANA UNIVERSITY

Finding fields fast: A novel approach for mapping agricultural fields across continents

Stephanie R. Debats

Thomas J. Fuchs, David R. Thompson

Lyndon D. Estes, Tom P. Evans, Kelly K. Caylor



Understanding Food Security in Sub-Saharan Africa

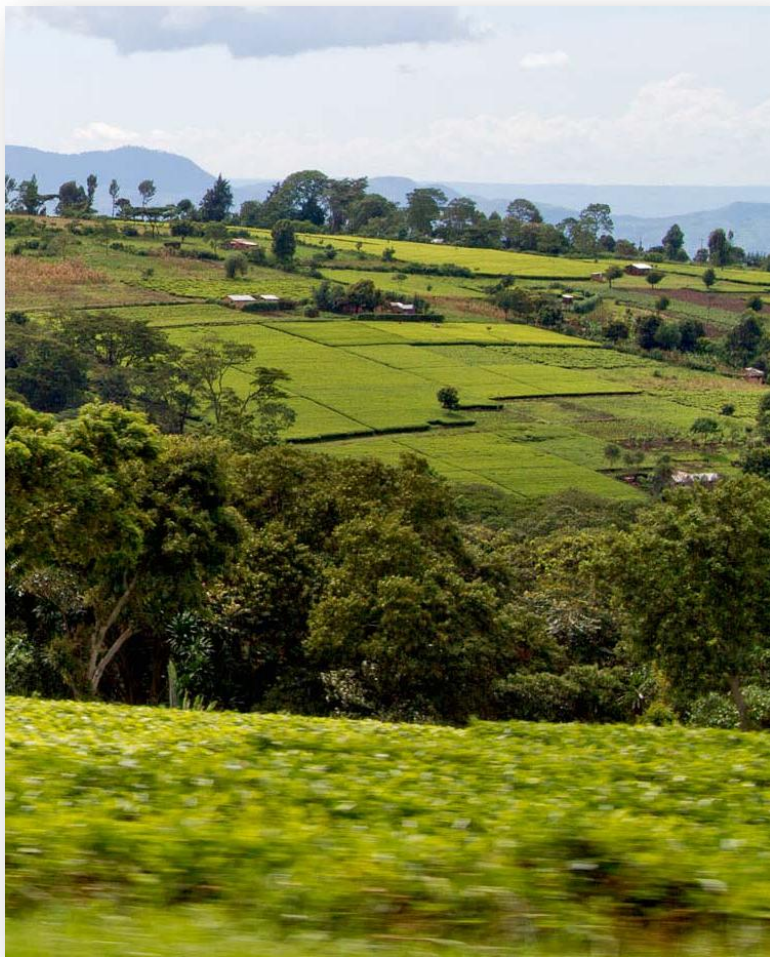
Smallholder-Dominated Agriculture



Fields typically < 2 hectares

Food Security is Determined at Household Level

Developing boundary conditions to study food security

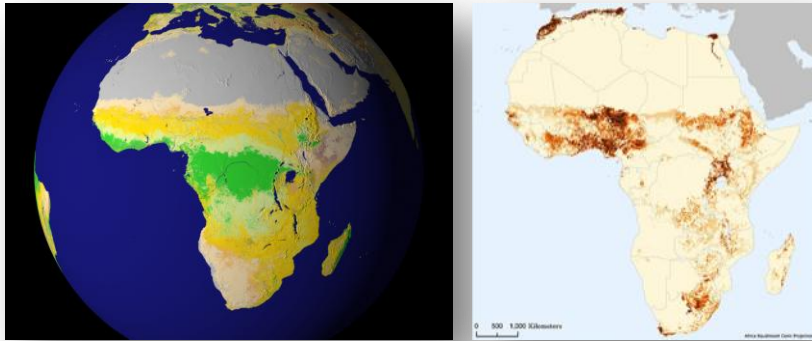


Quantify extent
of agriculture

Provide details of
smallholder
agriculture

Agricultural Land Cover Maps

Gridded Data Sets



Resolution: 30 m – 1 km

Smallholder Agriculture

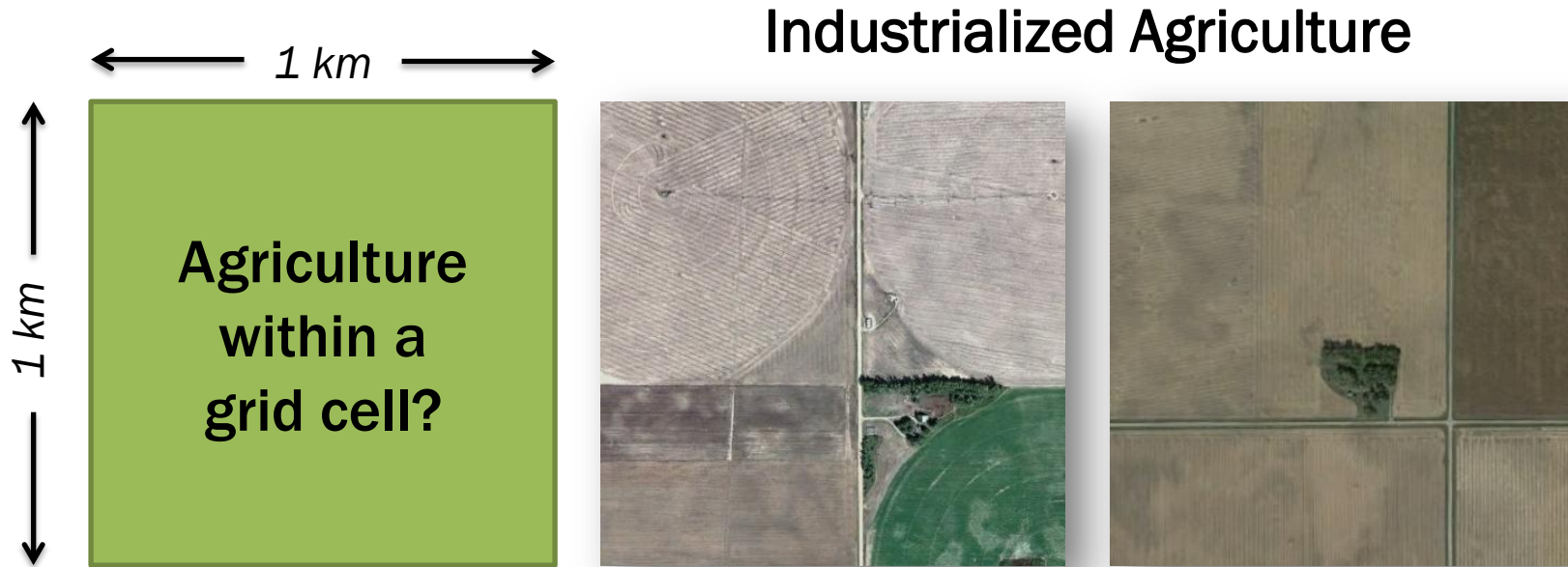


Highly heterogeneous

Ag		Ag	Ag
Ag	Ag		Ag
		Ag	Ag
Ag	Ag	Ag	

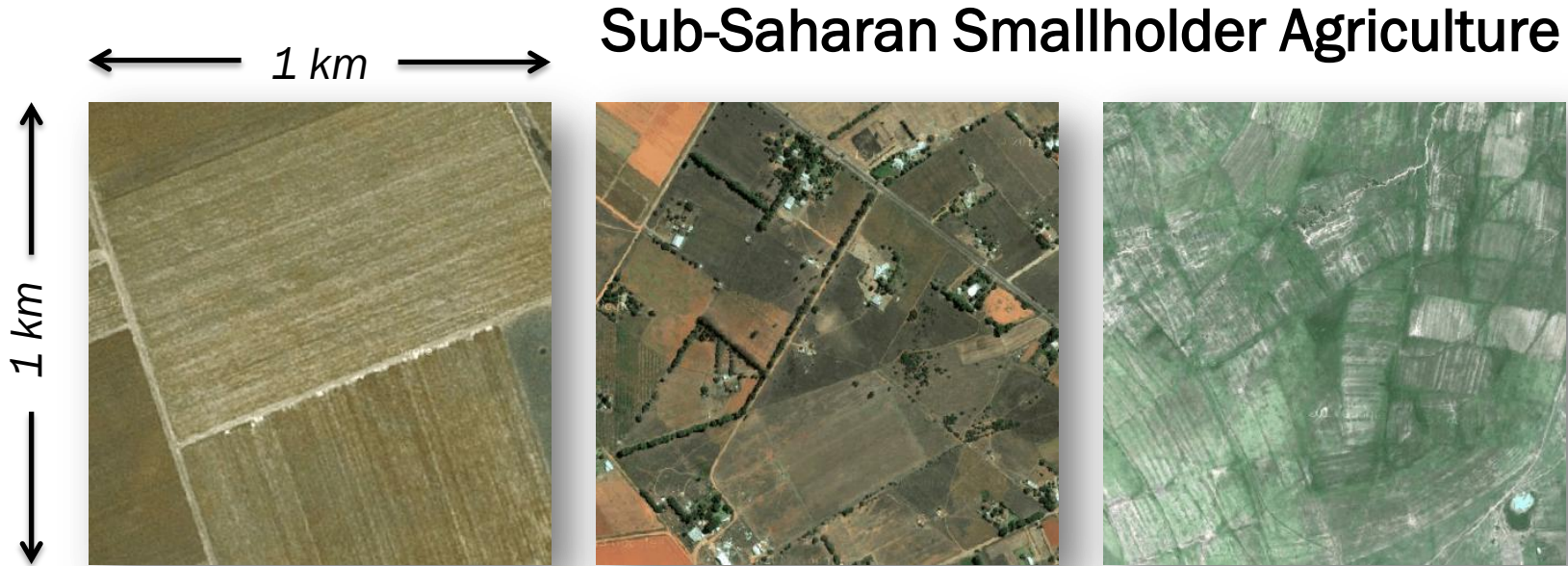
Agriculture
within a
grid cell?

Sub-Grid Cell Detail



High levels of homogeneity between grid cells

Capturing Small-Scale Heterogeneity



High levels of heterogeneity between grid cells

Agricultural Field Boundary Map

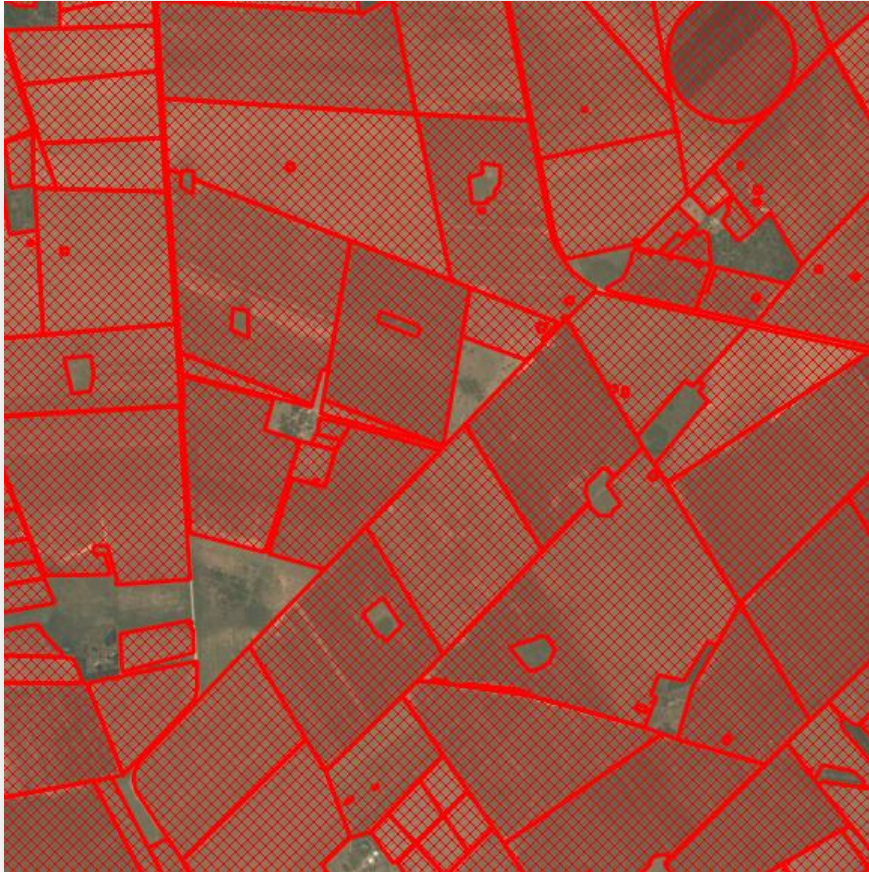


Distribution of
field sizes

Distribution of
agriculture across
landscapes

Village
organization
patterns

Agricultural Field Boundary Map



Distribution of
field sizes

Distribution of
agriculture across
landscapes

Village
organization
patterns

Agricultural Field Boundary Map



Distribution of
field sizes

Distribution of
agriculture across
landscapes

Village
organization
patterns

Agricultural Field Boundary Map



How do we make these maps?

Hand-digitization

- Expensive
- Labor intensive
- Time consuming



Computer Algorithm

Project Goals

Develop field mapping algorithm
based on machine learning and
computer vision techniques
to map agricultural field boundaries
across Sub-Saharan Africa



Field Mapping Algorithm



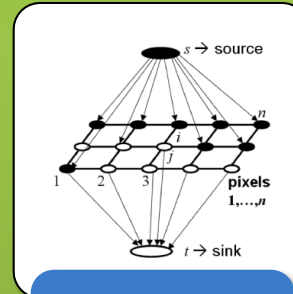
Satellite
Imagery



Algorithm



Random
Forest



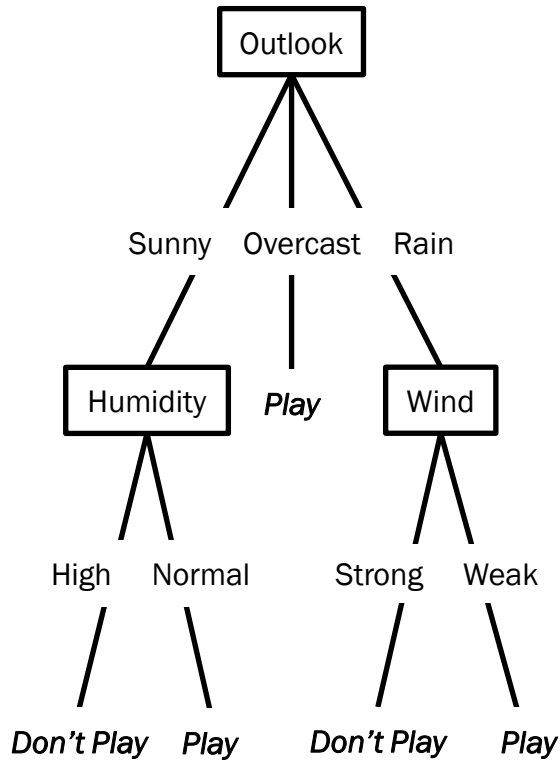
Graph
Cuts



Field
Map

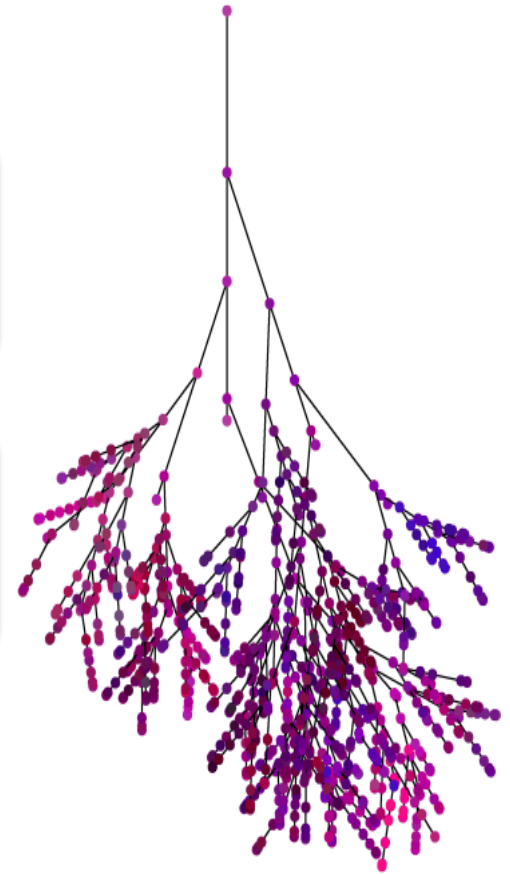
Machine Learning: Random Forests

Example: Play Tennis?

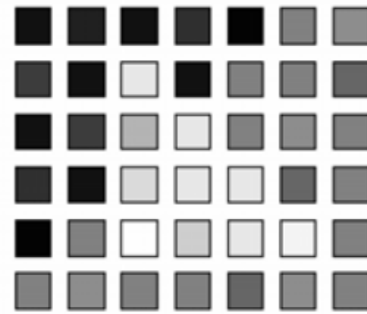
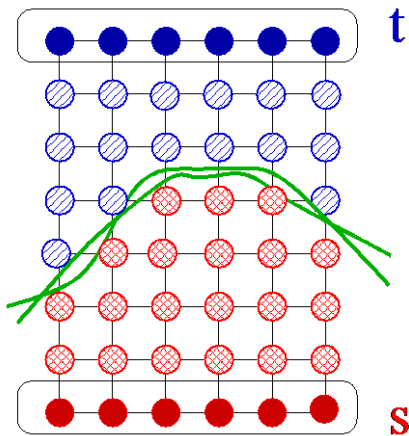


Machine Learning
Pixel-wise Classifier

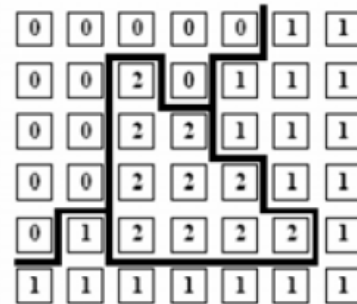
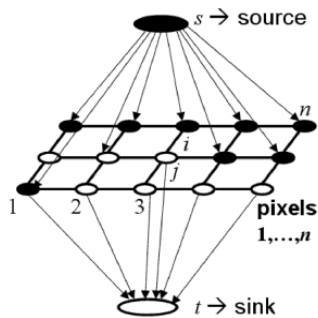
Numerous
decision trees



Computer Vision: Graph Cuts



(a) An image

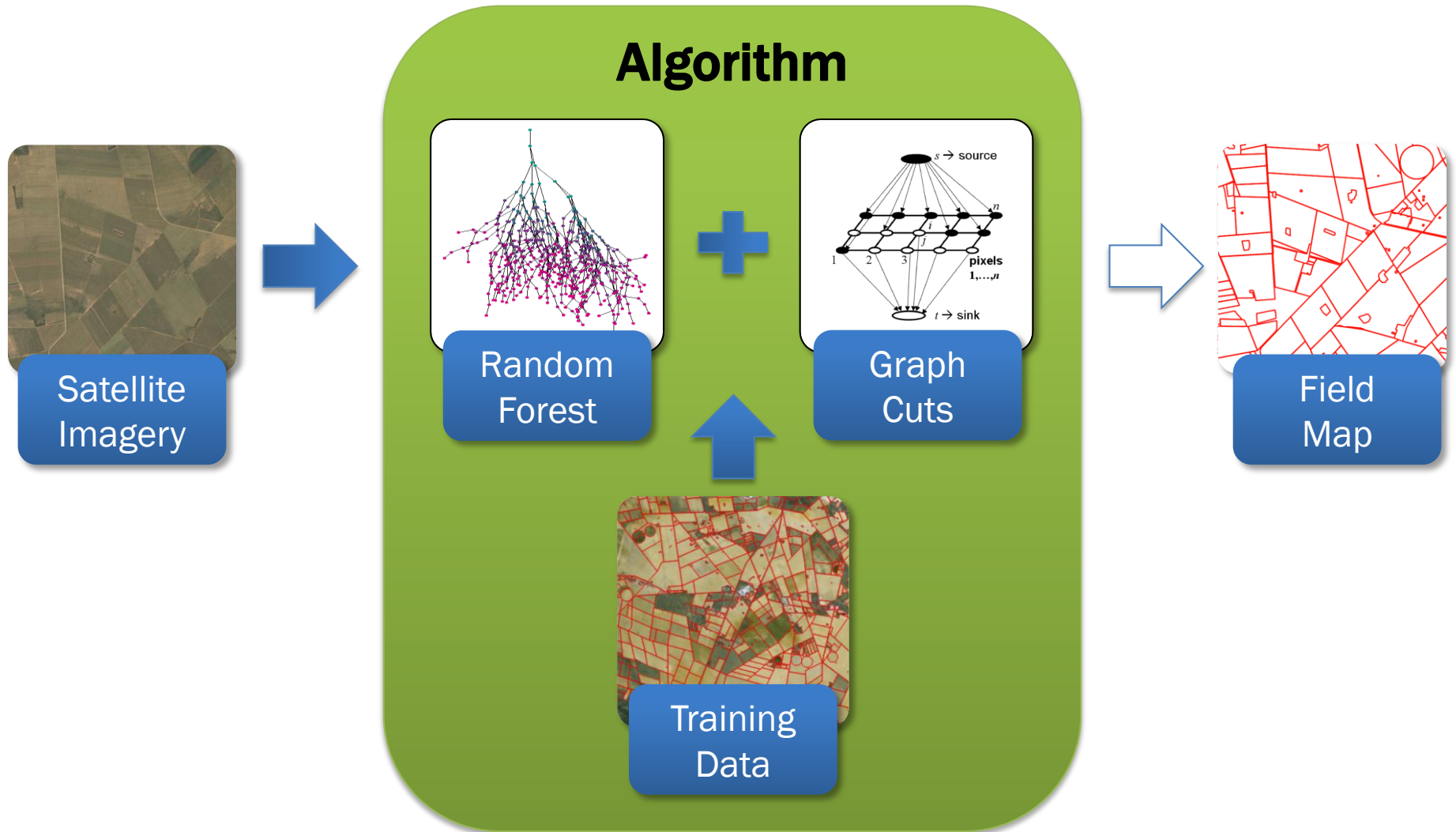


(b) A labeling

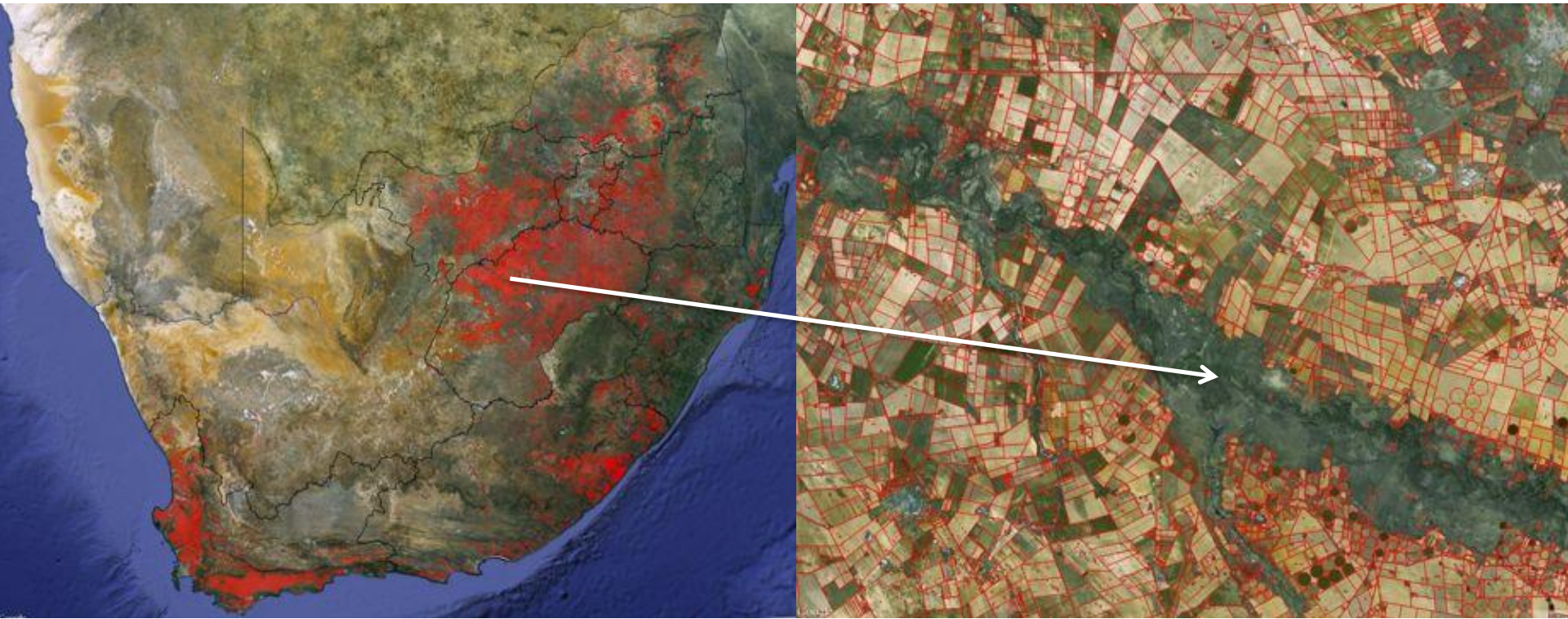
Computer
vision

Image
Segmentation

Field Mapping Algorithm



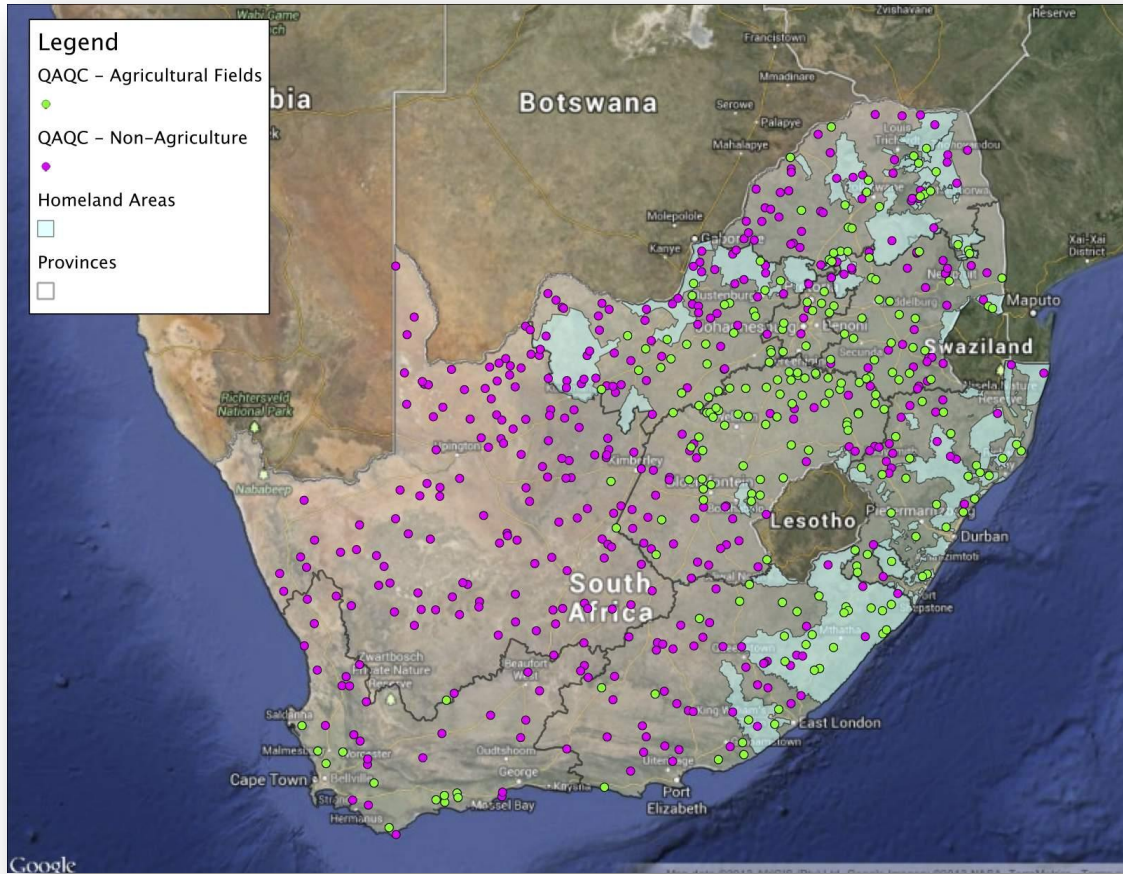
Training Data



Hand-digitization of every agricultural field in South Africa

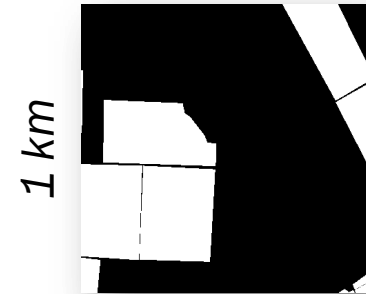
- GeoTerraImage (2008)

Training Data



Example of a scene:

1 km

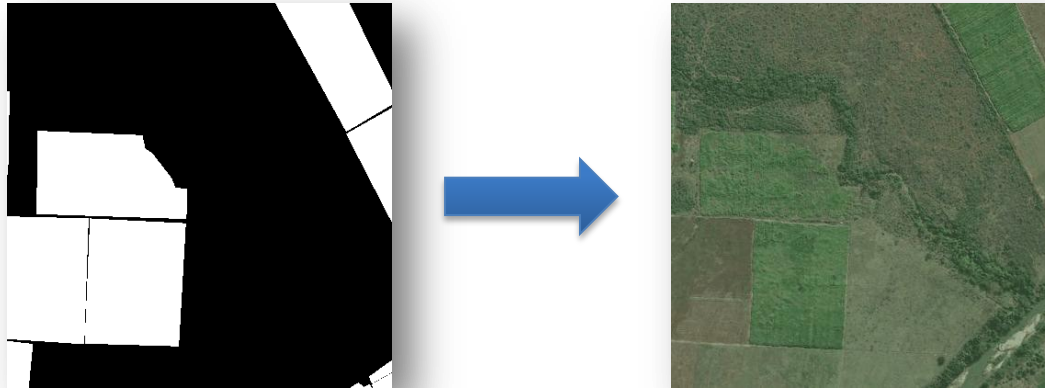


White = Fields
Black = Non-Fields

Training Data

What does a field look like?

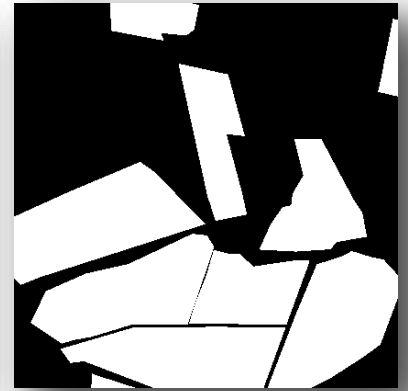
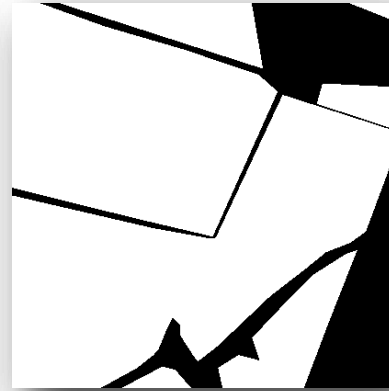
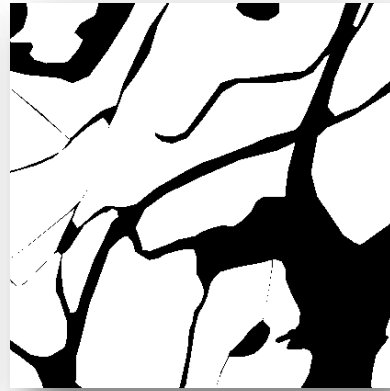
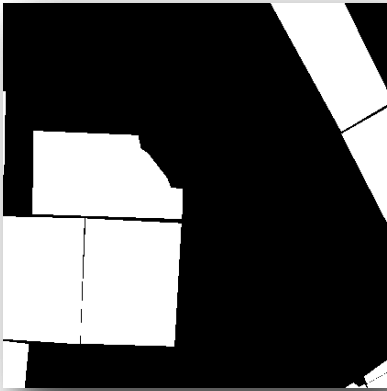
Each labeled scene is matched with a Google Maps image



Building an image library to use as training data

Image Library

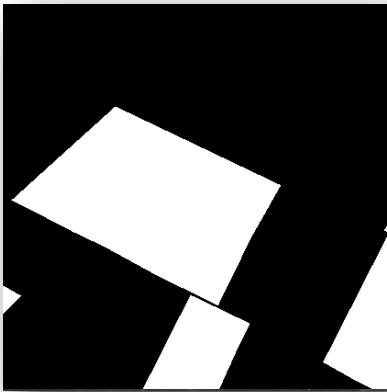
Labels (GeoTerraImage)



Google Maps images (RGB)

Expanding Image Library

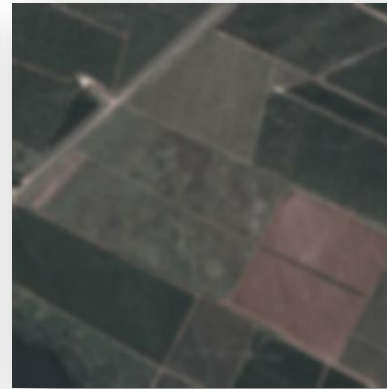
Labels



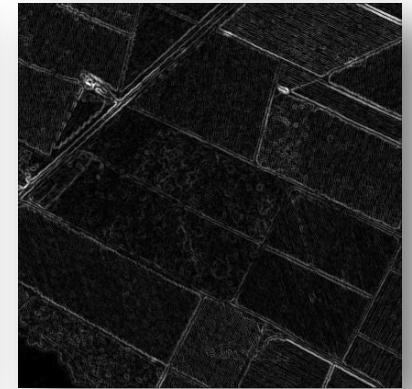
Grayscale



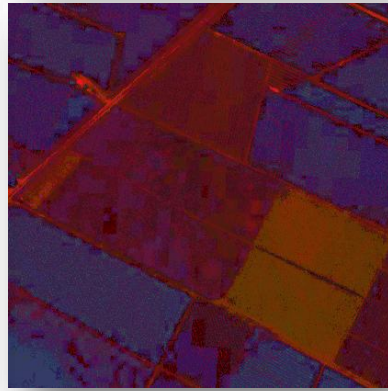
Gaussian Blur



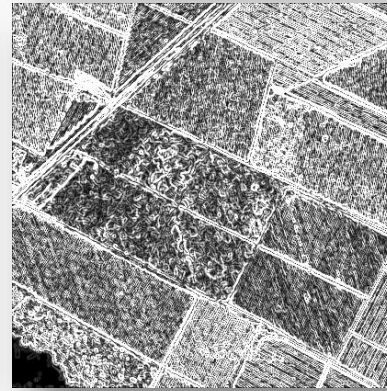
Sobel



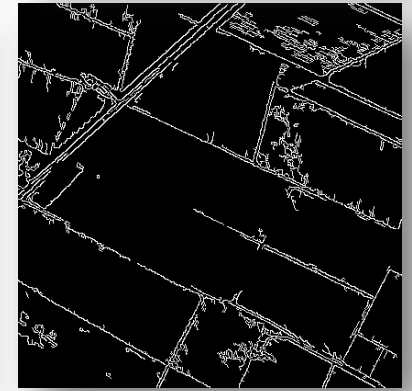
Google Maps - RGB



HSV

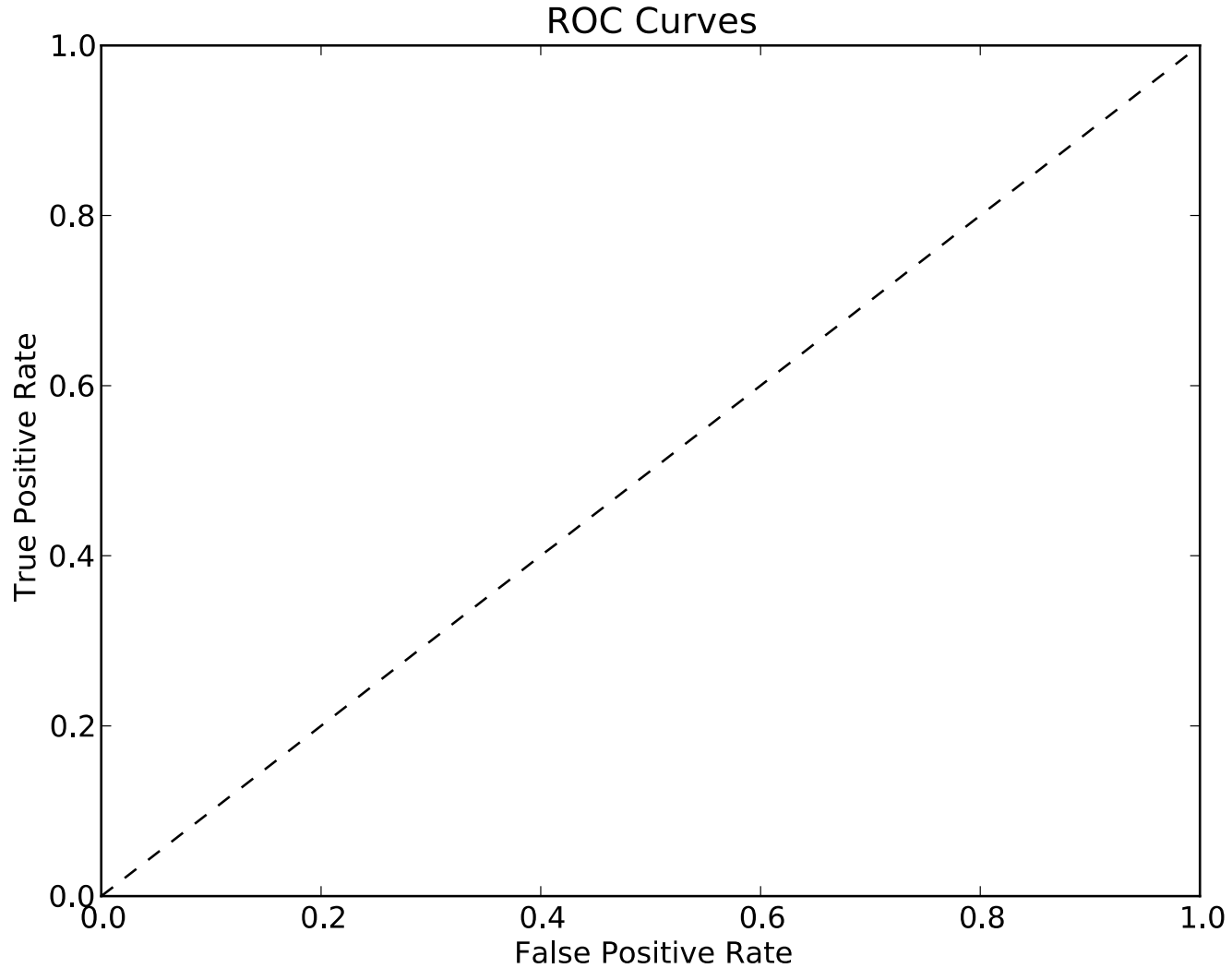


Scharr

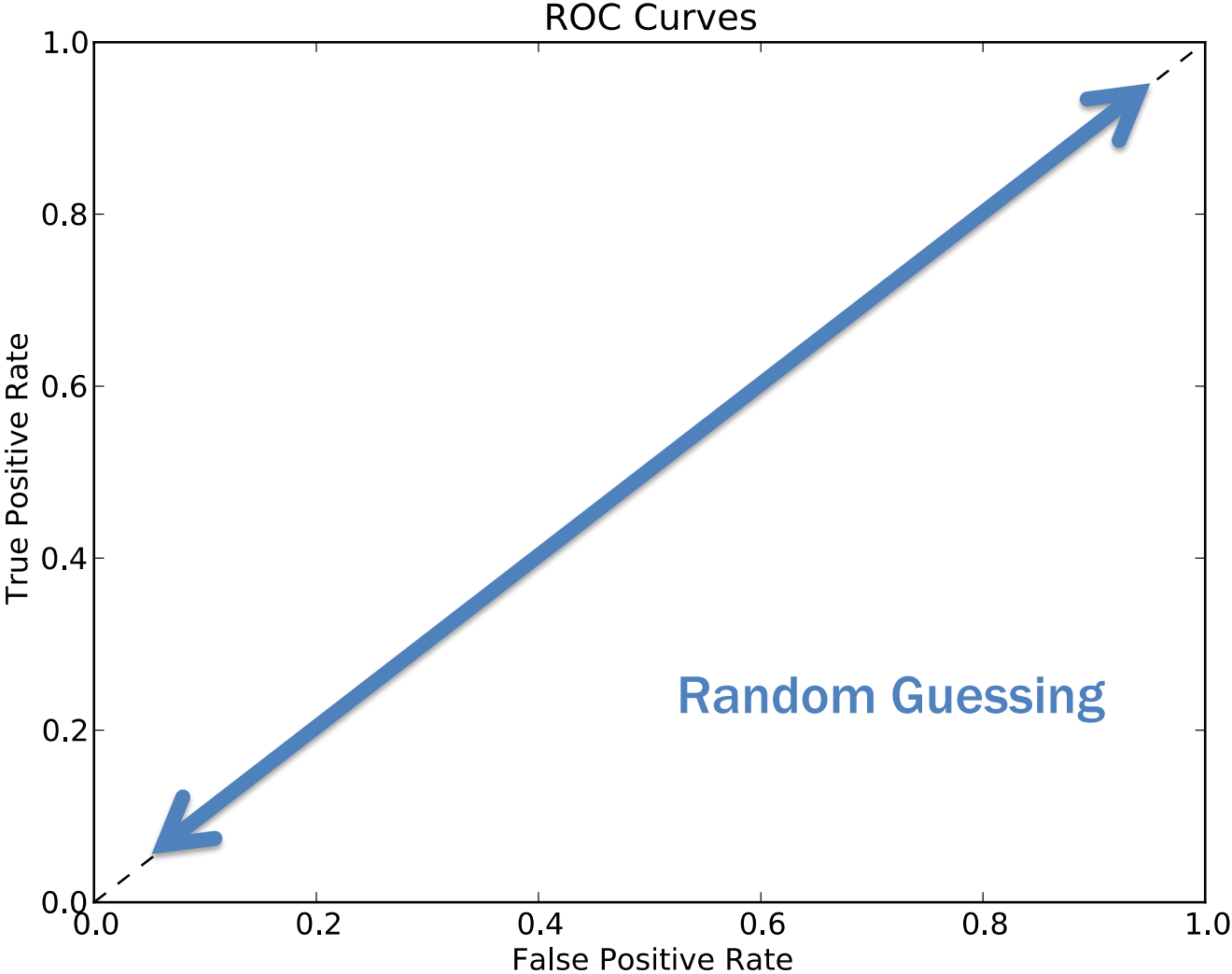


Canny

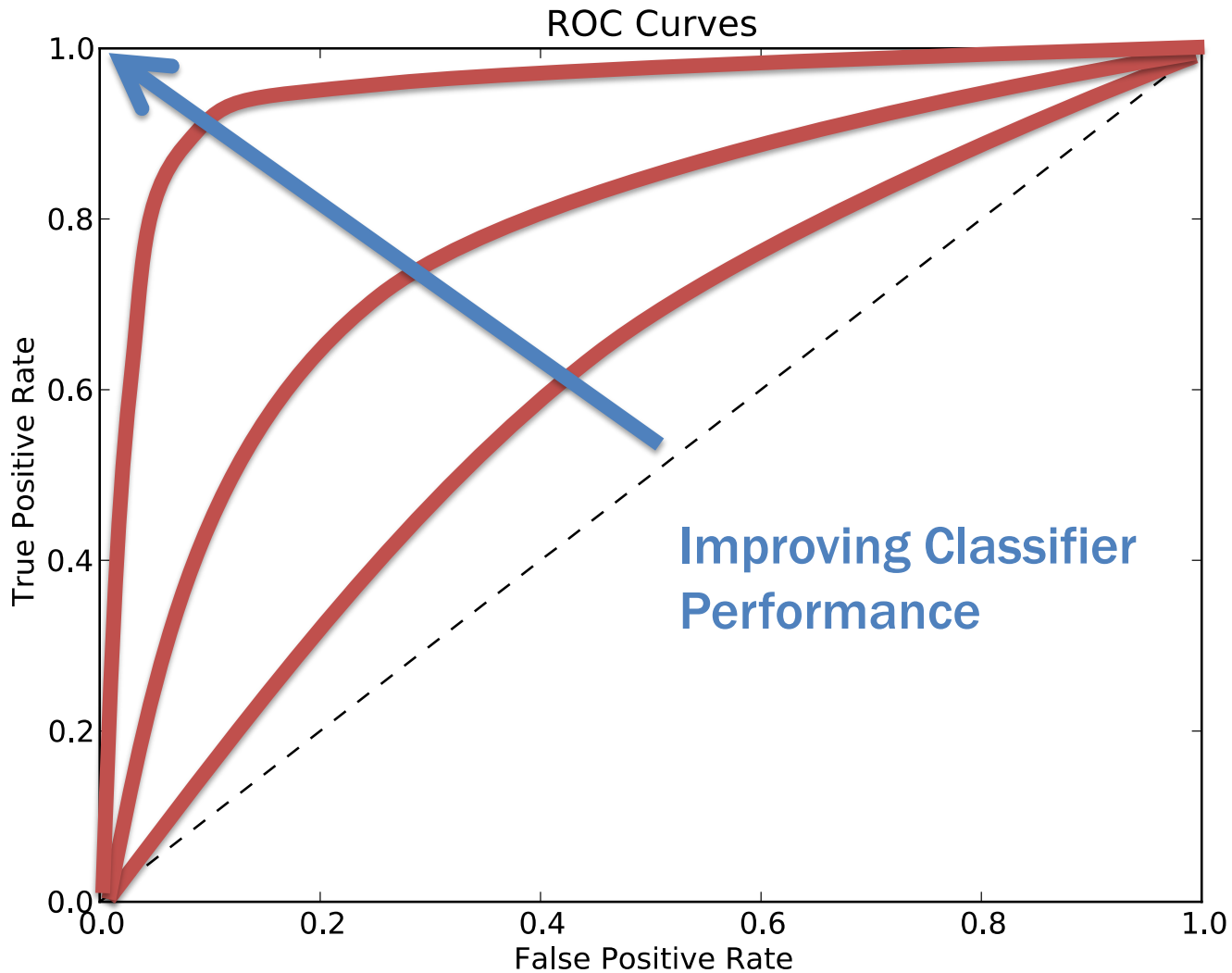
Classifier Results



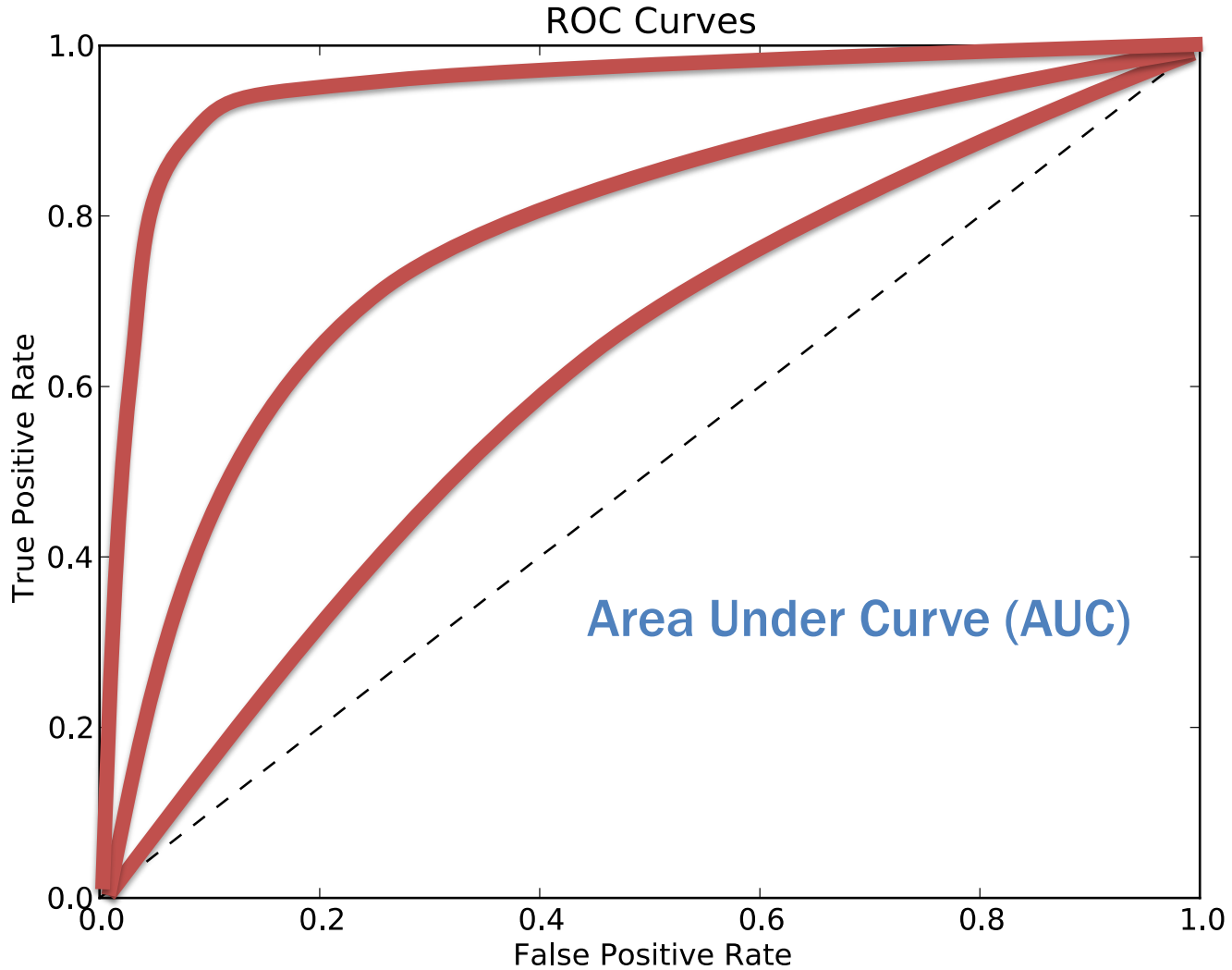
Classifier Results



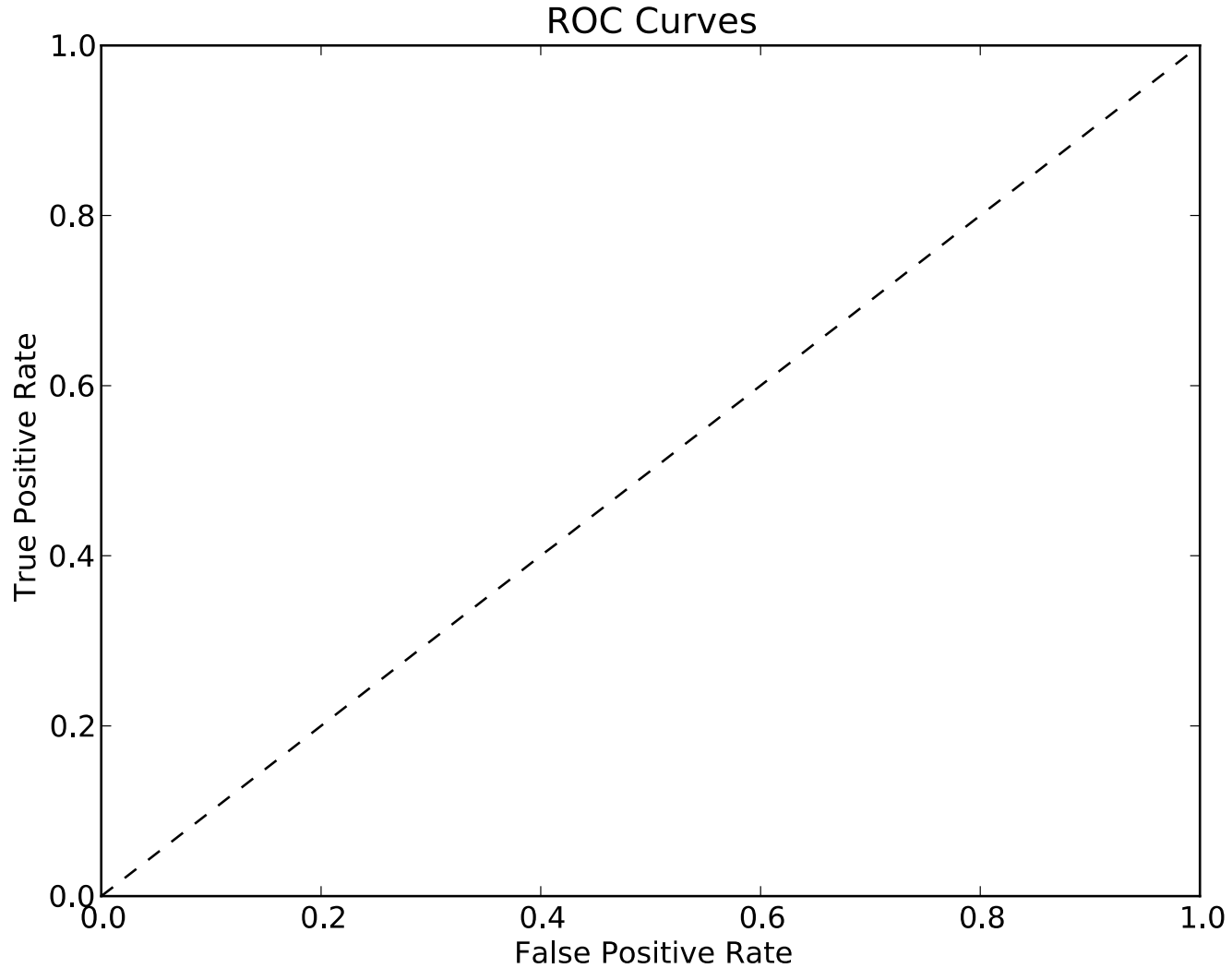
Classifier Results



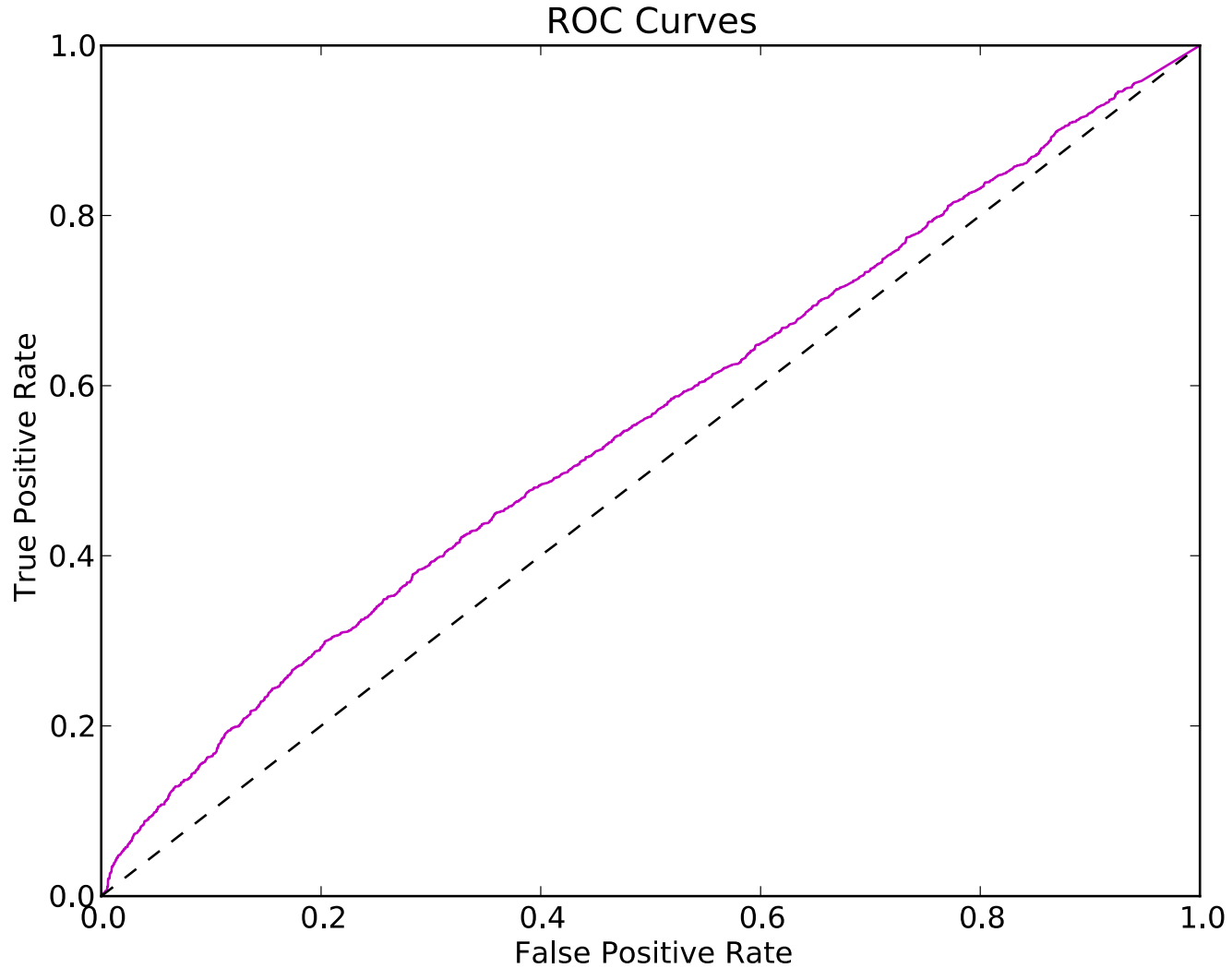
Classifier Results



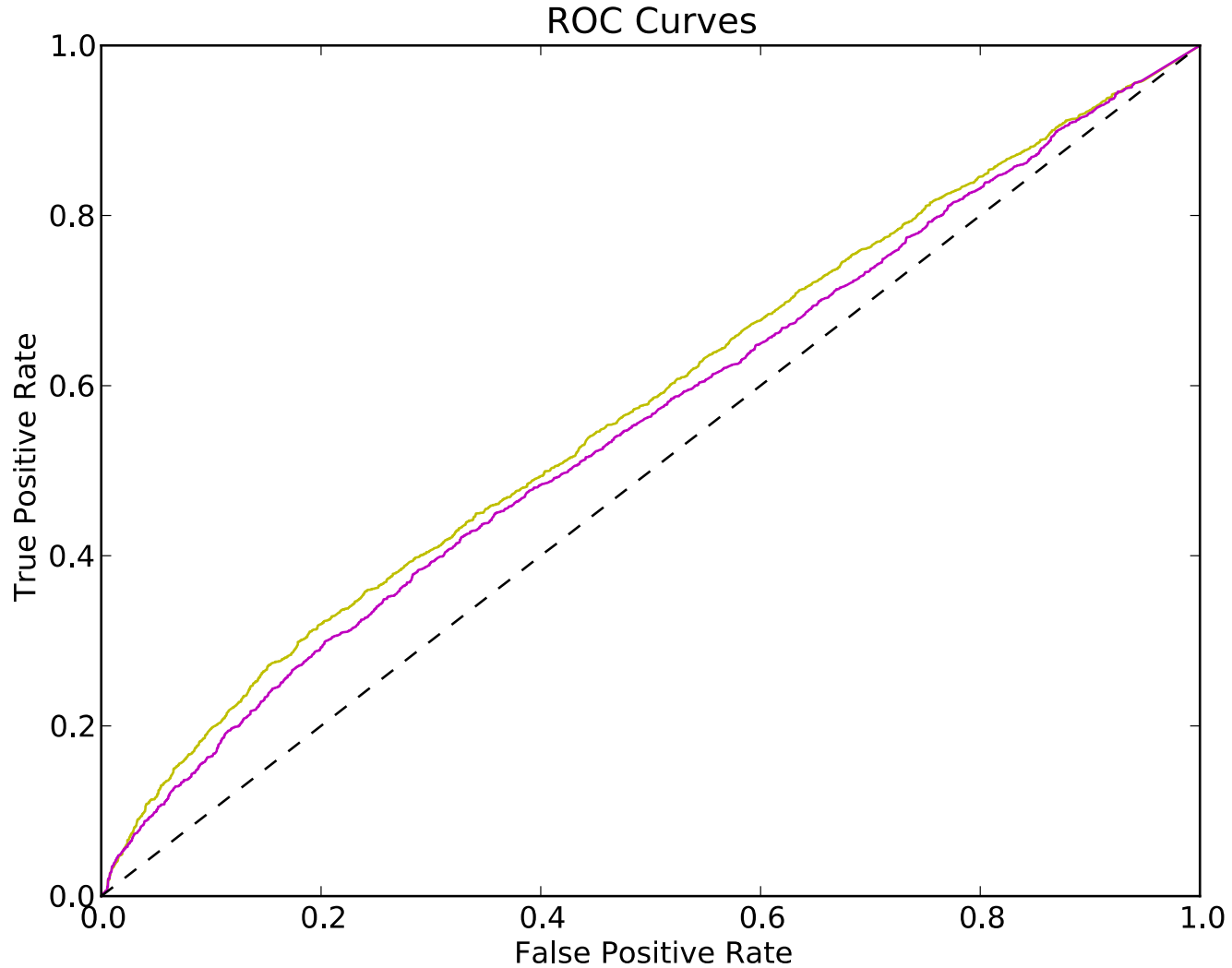
Classifier Results



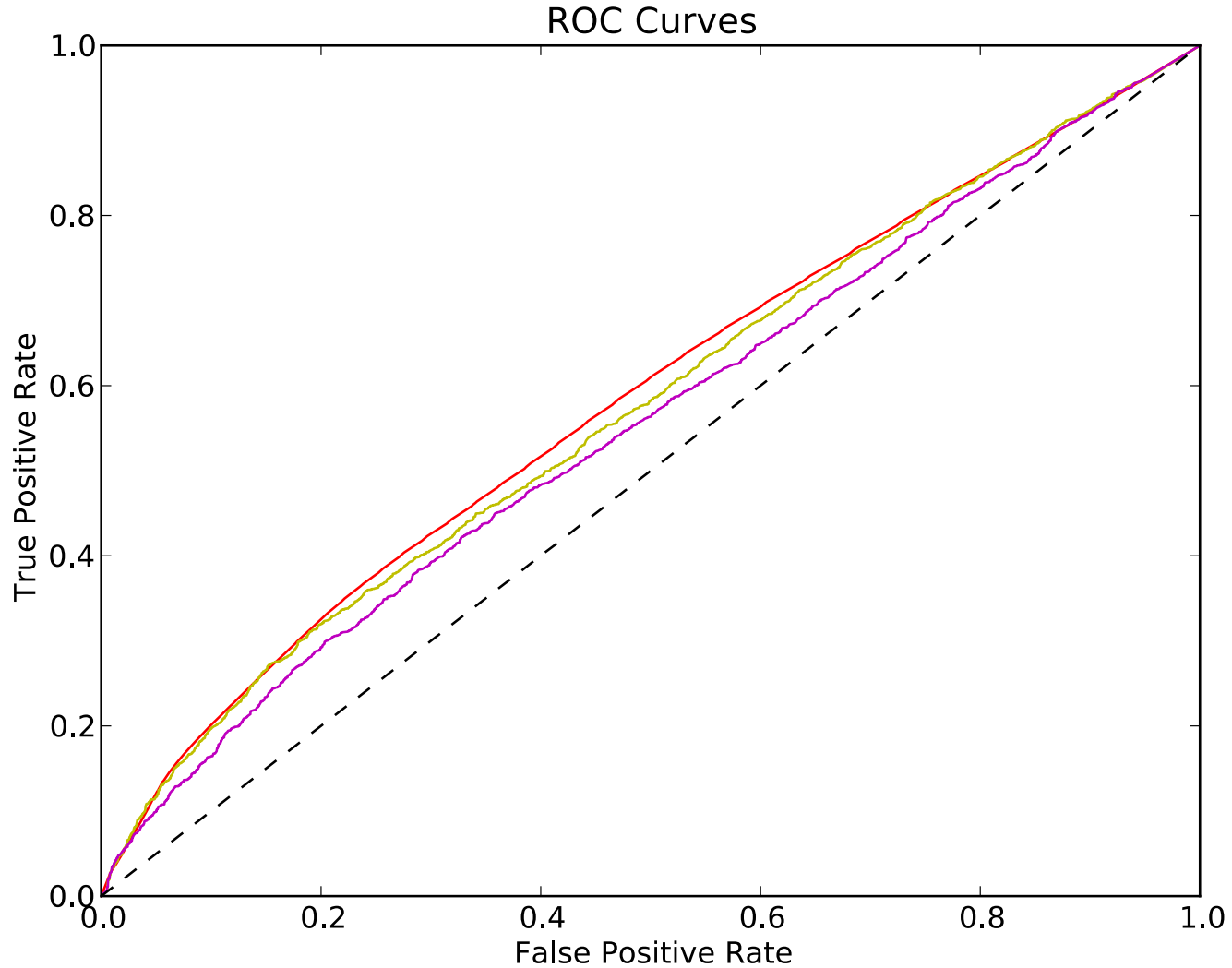
Classifier Results



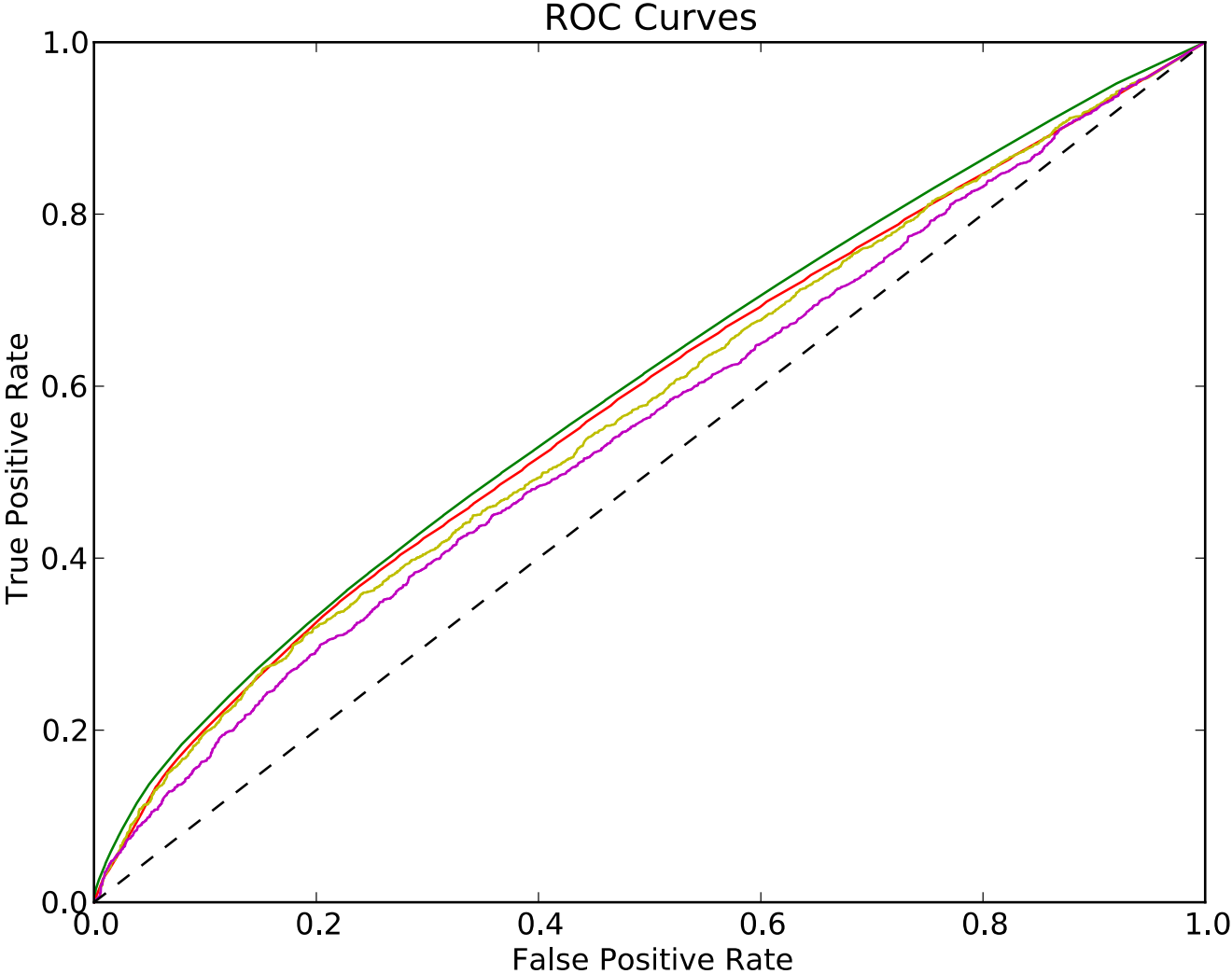
Classifier Results



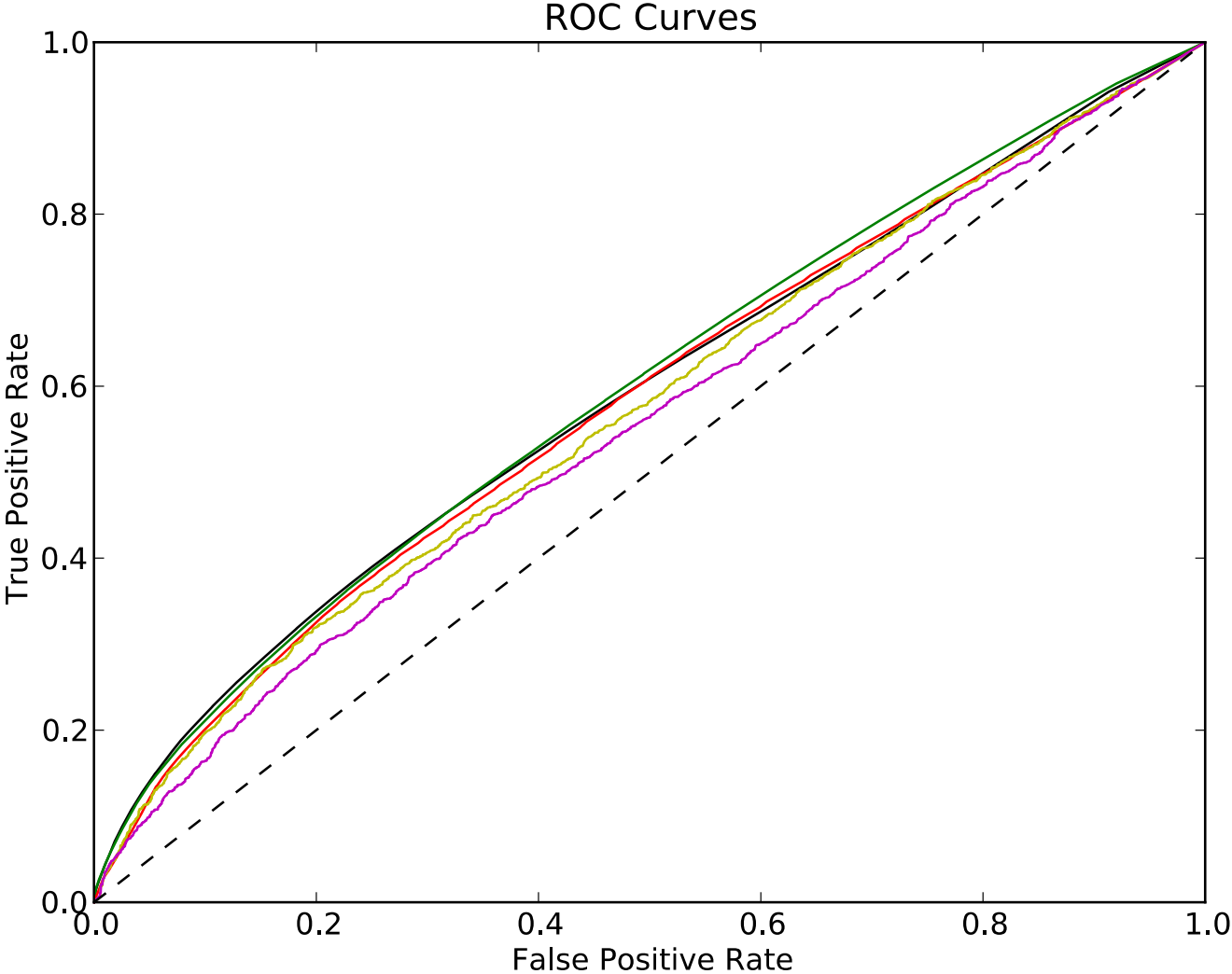
Classifier Results



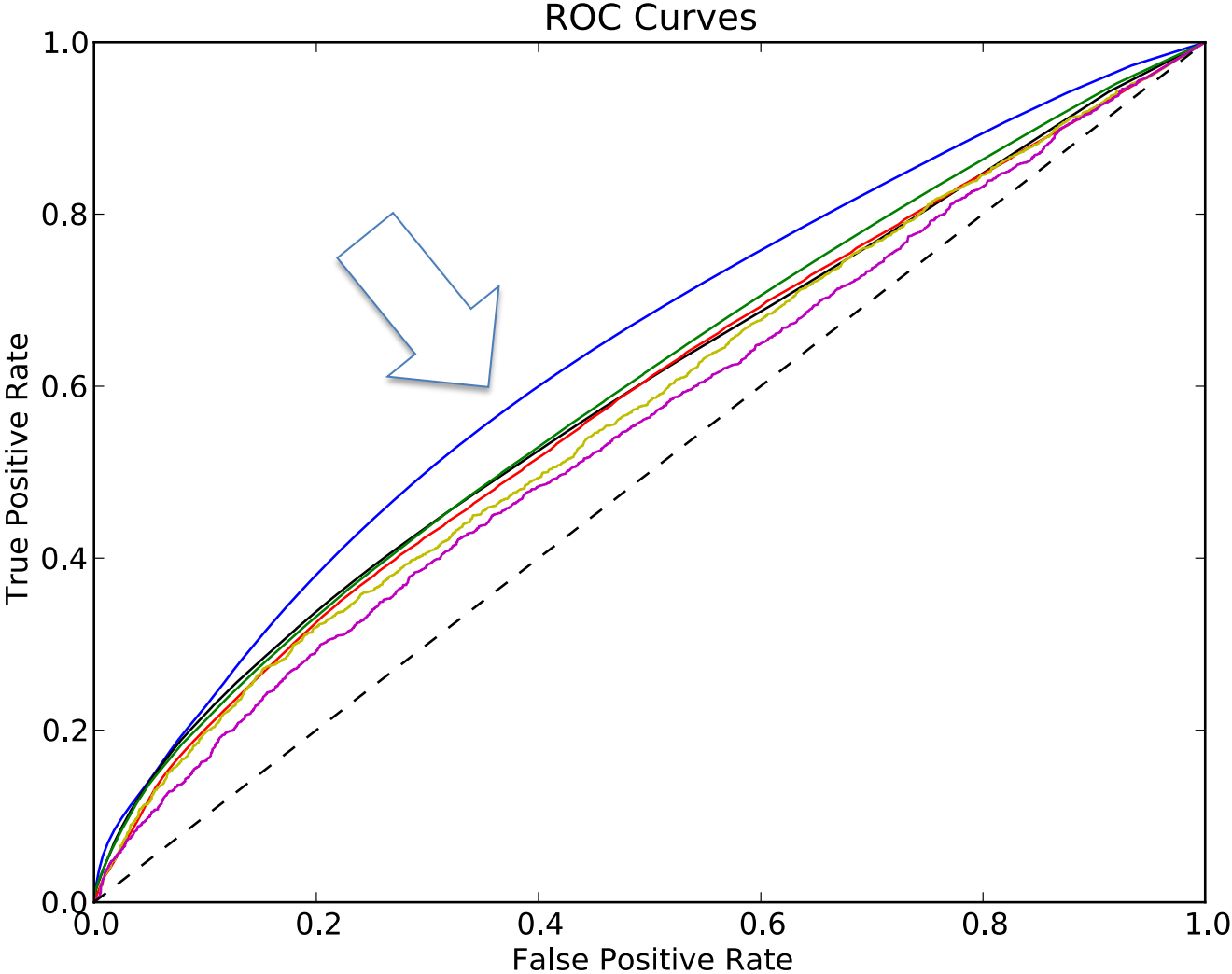
Classifier Results



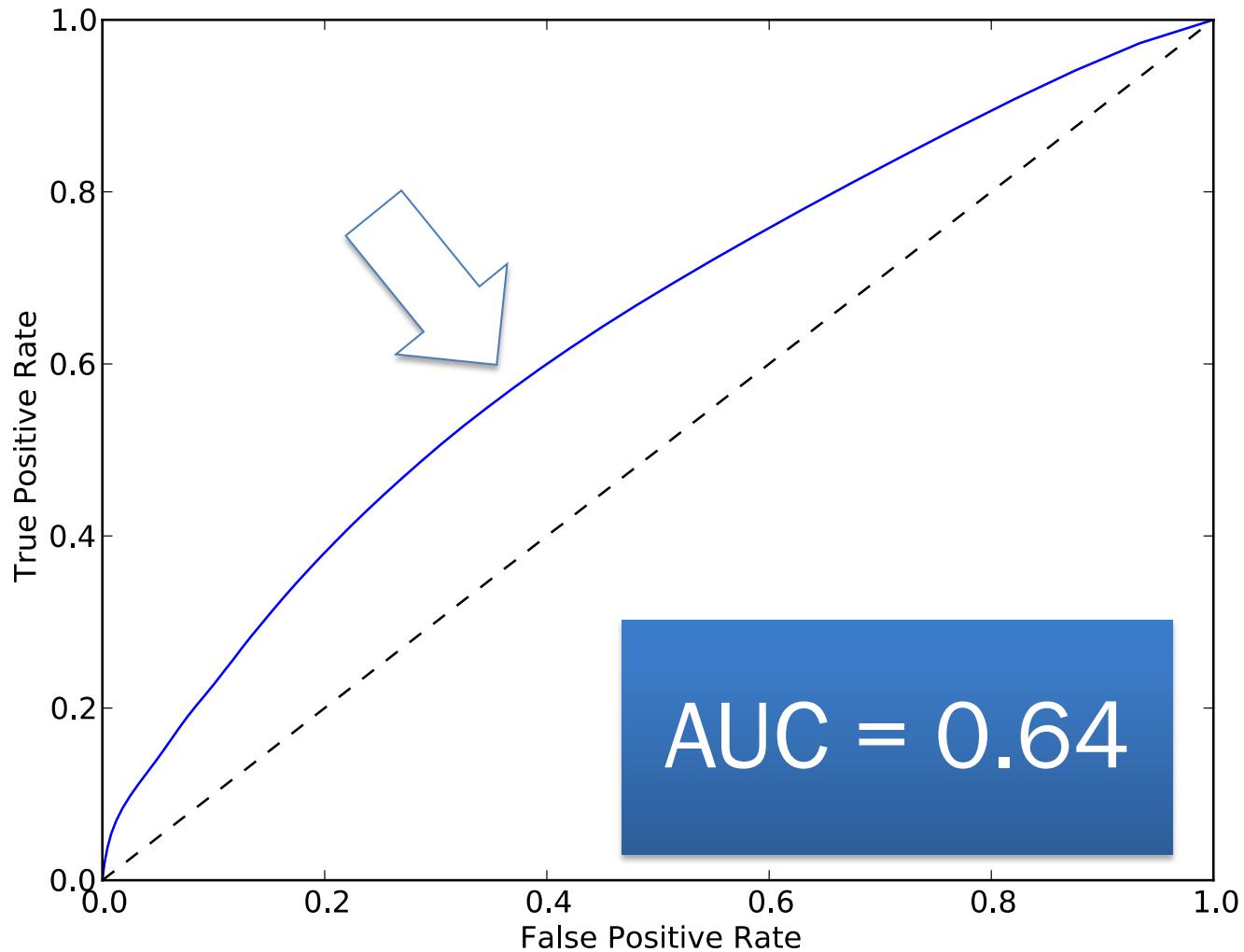
Classifier Results



Classifier Results



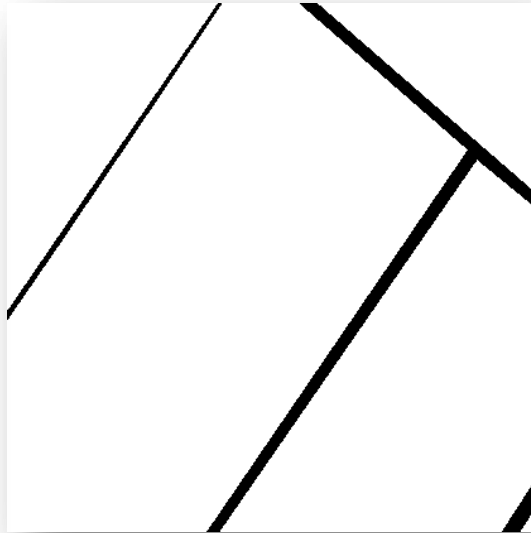
Classifier Results



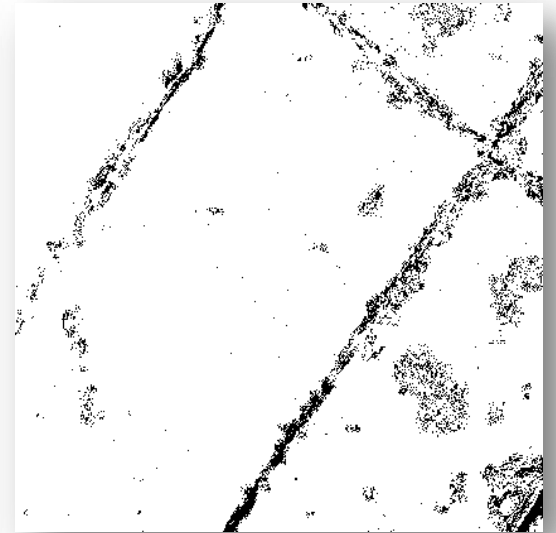
Predicted Labels



Google Maps



True Labels

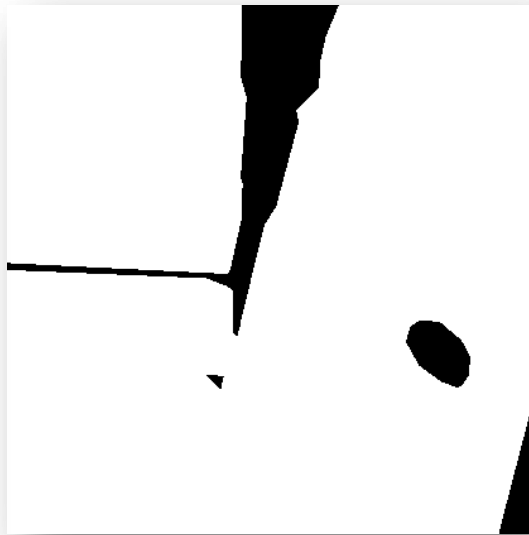


Predicted Labels

Predicted Labels



Google Maps



True Labels

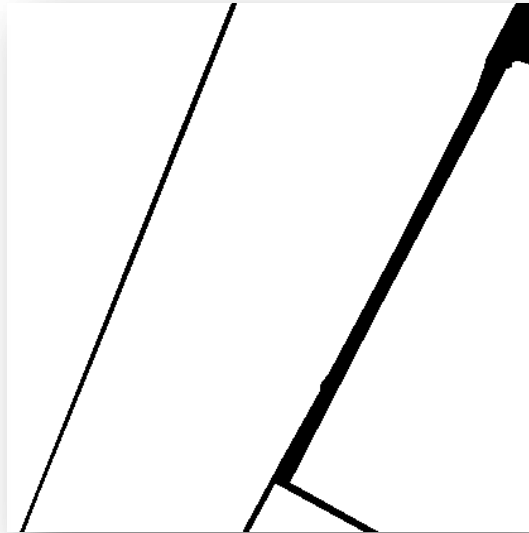


Predicted Labels

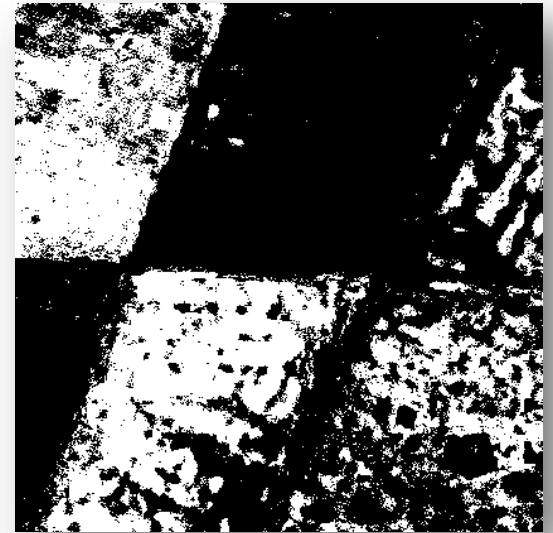
Predicted Labels



Google Maps



True Labels

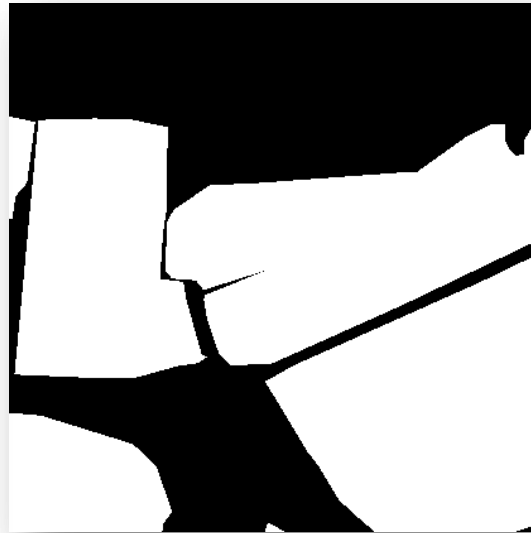


Predicted Labels

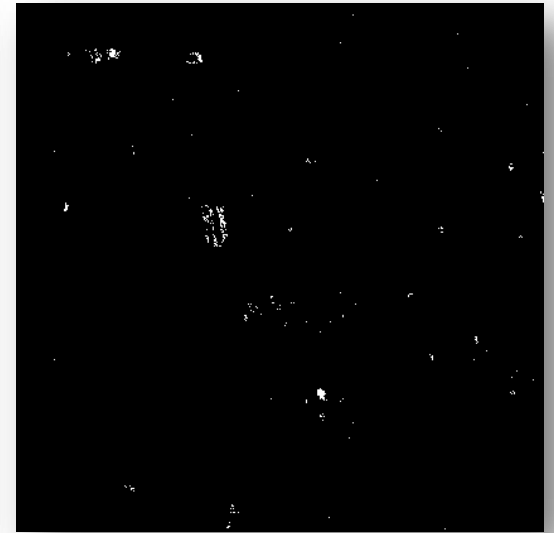
Predicted Labels



Google Maps



True Labels

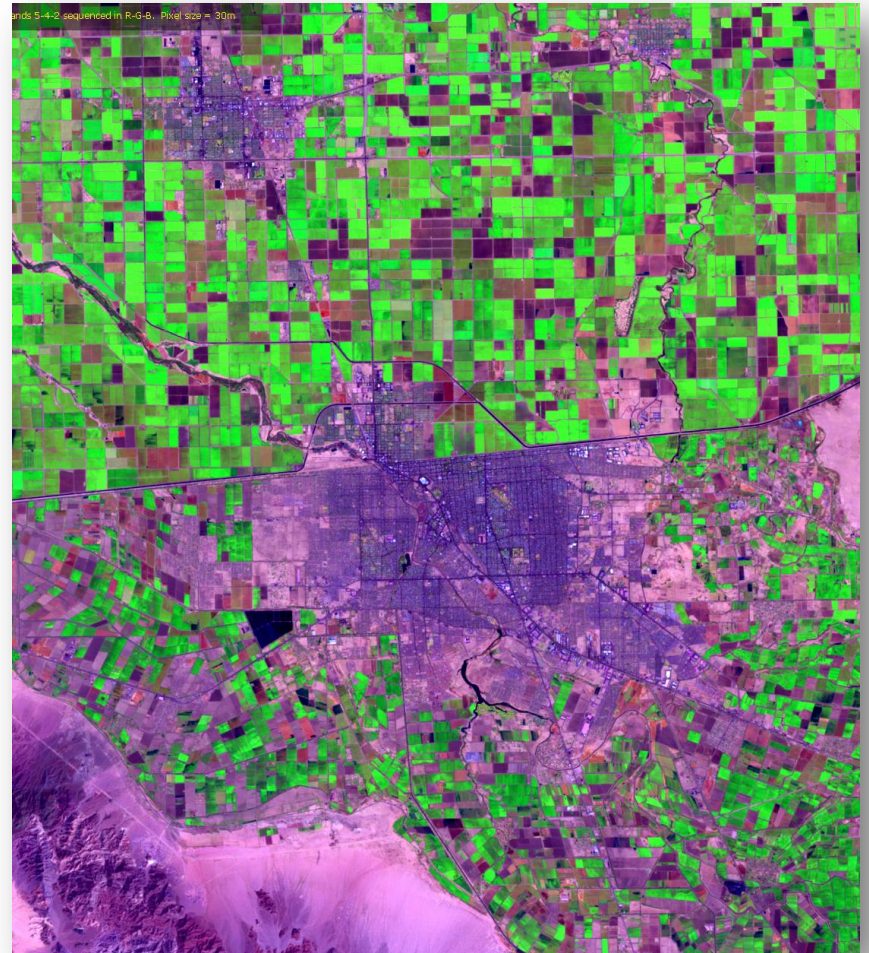


Predicted Labels

Future Work

Continue improving
classifier performance

Multi-spectral data
(Landsat)



Extend Mapping Across Africa

Crowd-sourcing: Users hand-digitize small representative areas



Use as training data to expand algorithm

Extending Mapping Across Africa



Extending Mapping Across Africa



Extending Mapping Across Africa



Extending Mapping Across Africa



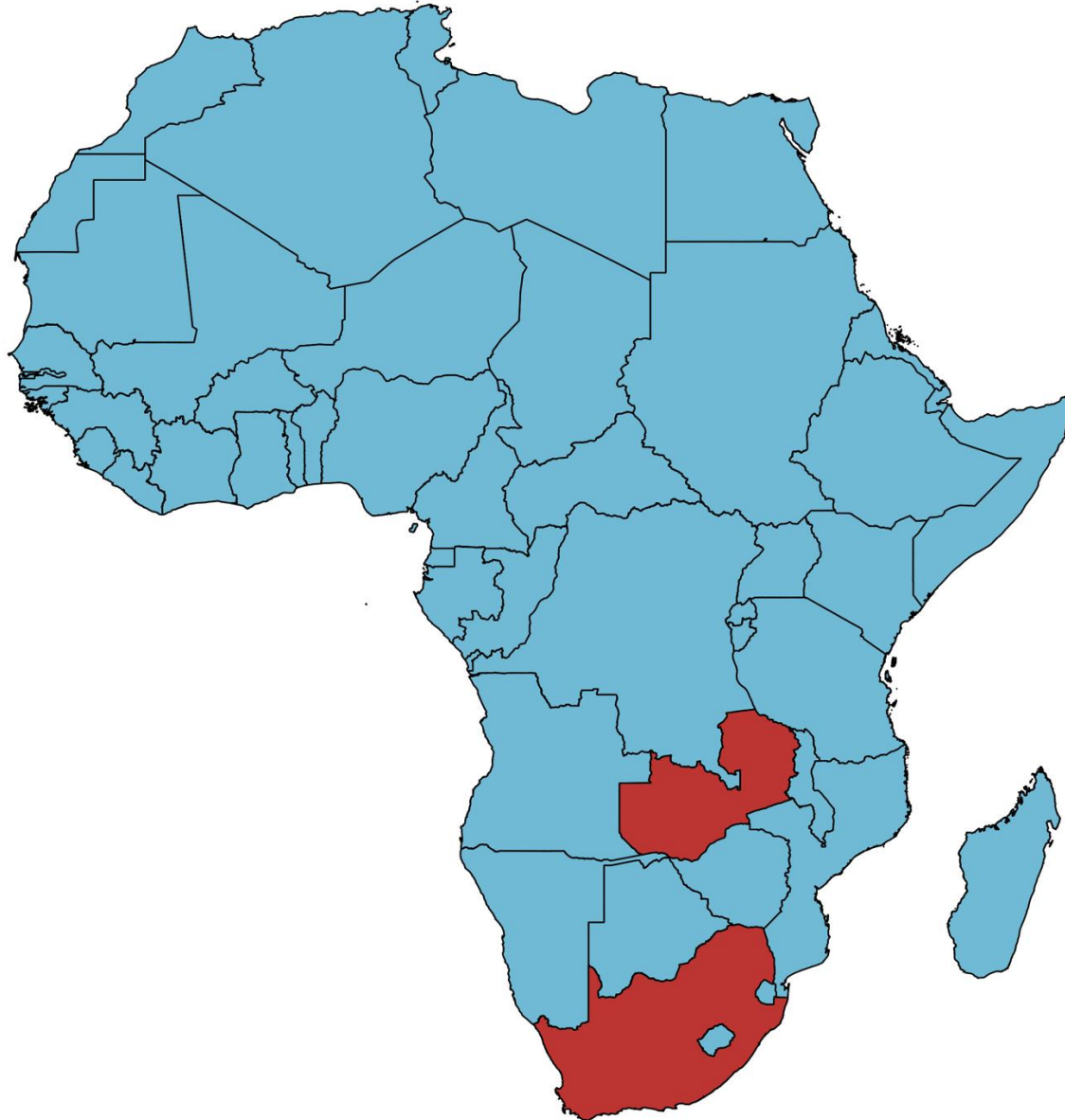
Extending Mapping Across Africa



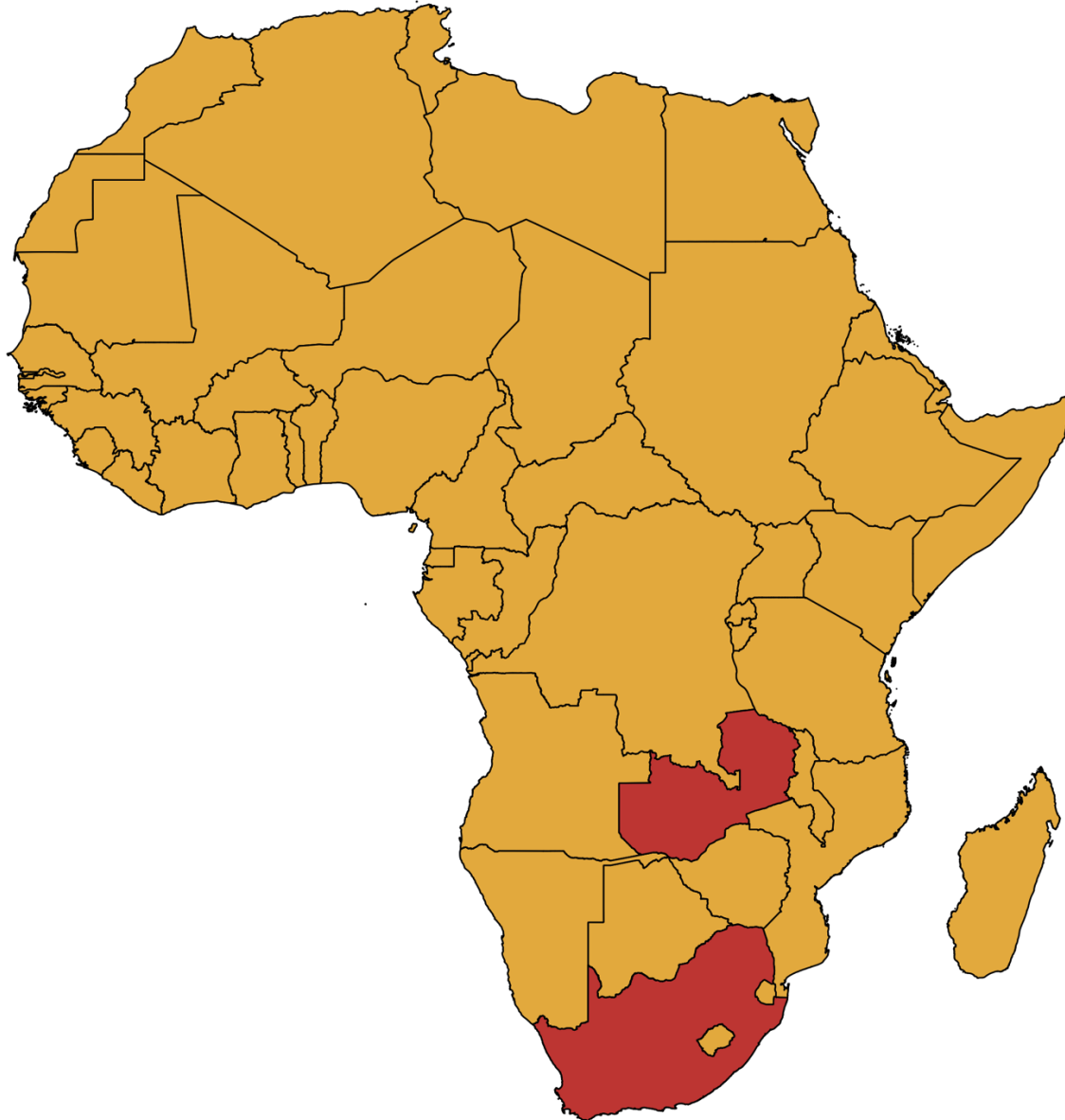
Extending Mapping Across Africa



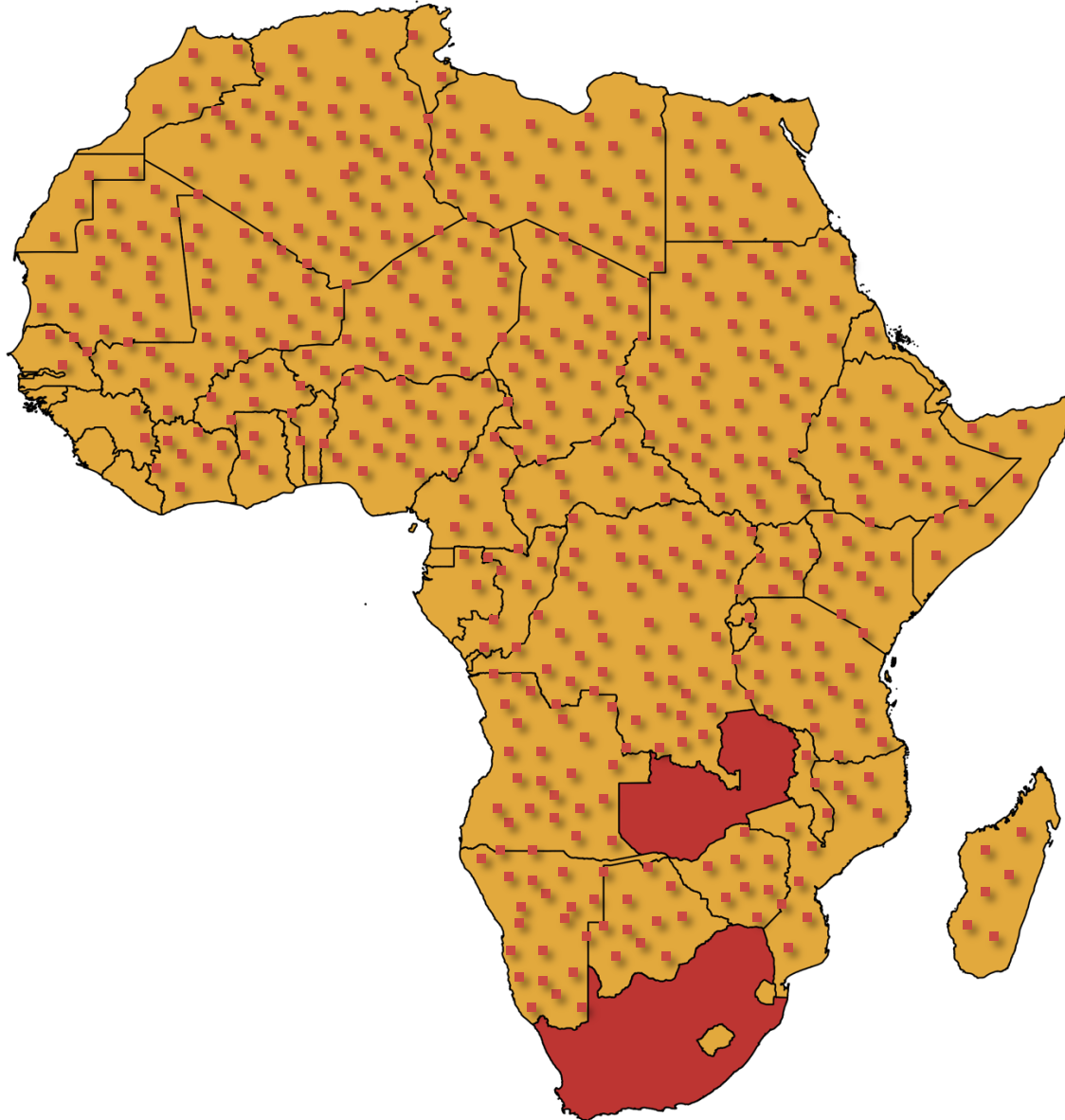
Extending Mapping Across Africa



Extending Mapping Across Africa



Extending Mapping Across Africa



Extending Mapping Across Africa





Thank you