Possibilistic, Robust, Ambiguity-preserving (PRAM) Classification & Regression

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Major Point

For Large Scale Processing
Algorithms Need to

(1) Know when they don't know
(2) Represent all Possibilities

SVM, MLPs
too confident and binary

Overview

- Problem
  - Large Scale Processing
  - Definitions
  - Historical Examples
- Approach
  - Possibilistic Classifiers
  - Self-Organizing Map + Gaussian Process Classifiers
- Experimental Results

Large Scale Processing

- Not just real-time
- More automated processing
  - Accuracy
  - System level development
  - Integration of knowledge sources
  - Management of uncertainty

Definitions

- ***Robustness*** – Accurately estimating the likelihood that a pattern is not from any class of interest
- ***Ambiguity-preserving*** – Accurately estimating the likelihood that a pattern represents each class
  - particularly if a pattern could be from multiple classes (e.g. Oaks)
- ***Possibility Distribution*** – like Probability Distribution but not constrained to sum to 1
  - Mathematically rigorous

NEEDS

- Many Unseen Patterns (Need Robustness)
- Many Ambiguous Patterns (Need Representation)

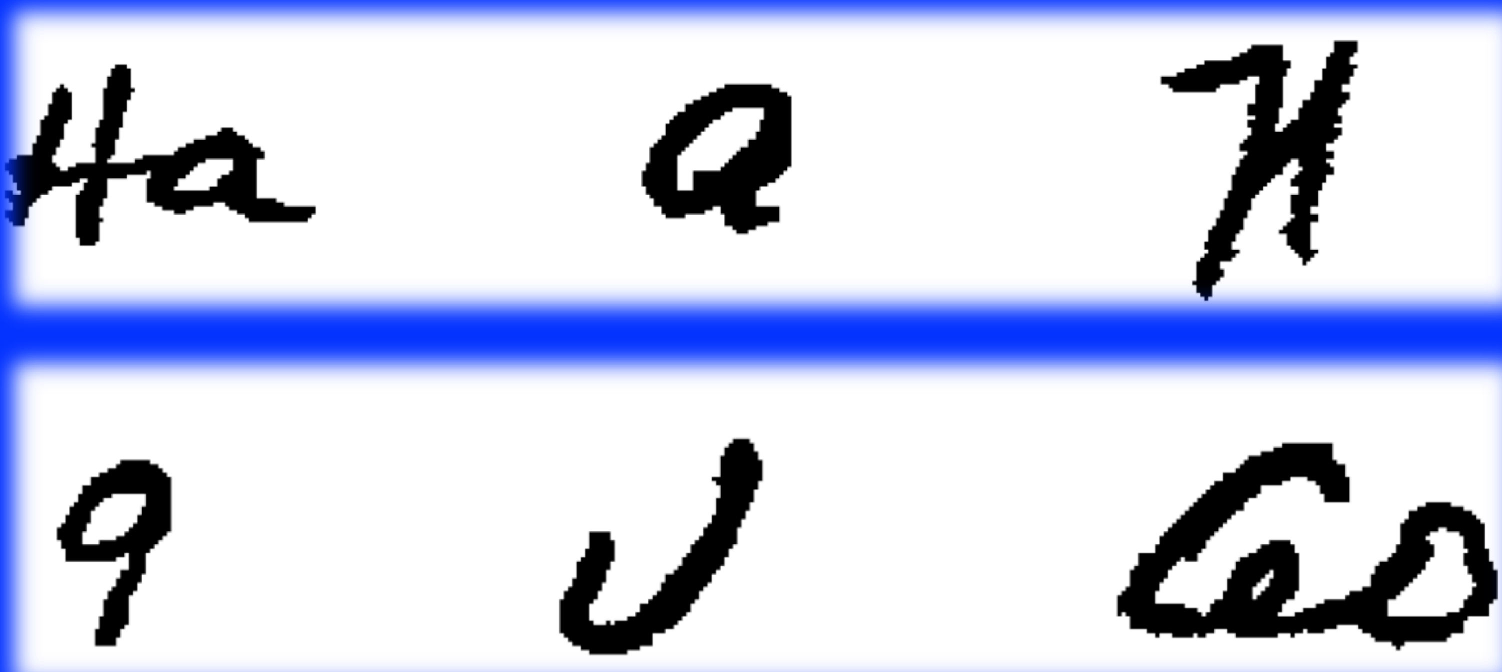
Self-Organizing Map

Improves Robustness and Ambiguity Preservation 1990s

- Suitable for High Speed Processing
- Handwritten Word Recognition (Optical)
  - Blind Tests of end-to-end systems
- Landmine and IED Detection (Multiple Sensors)
  - Fielded systems (Radar), Many km per day
  - Featured in
    - National Geographic TV: Bomb Hunters Afghanistan
- **Spectral Analysis – Classification and Regression**

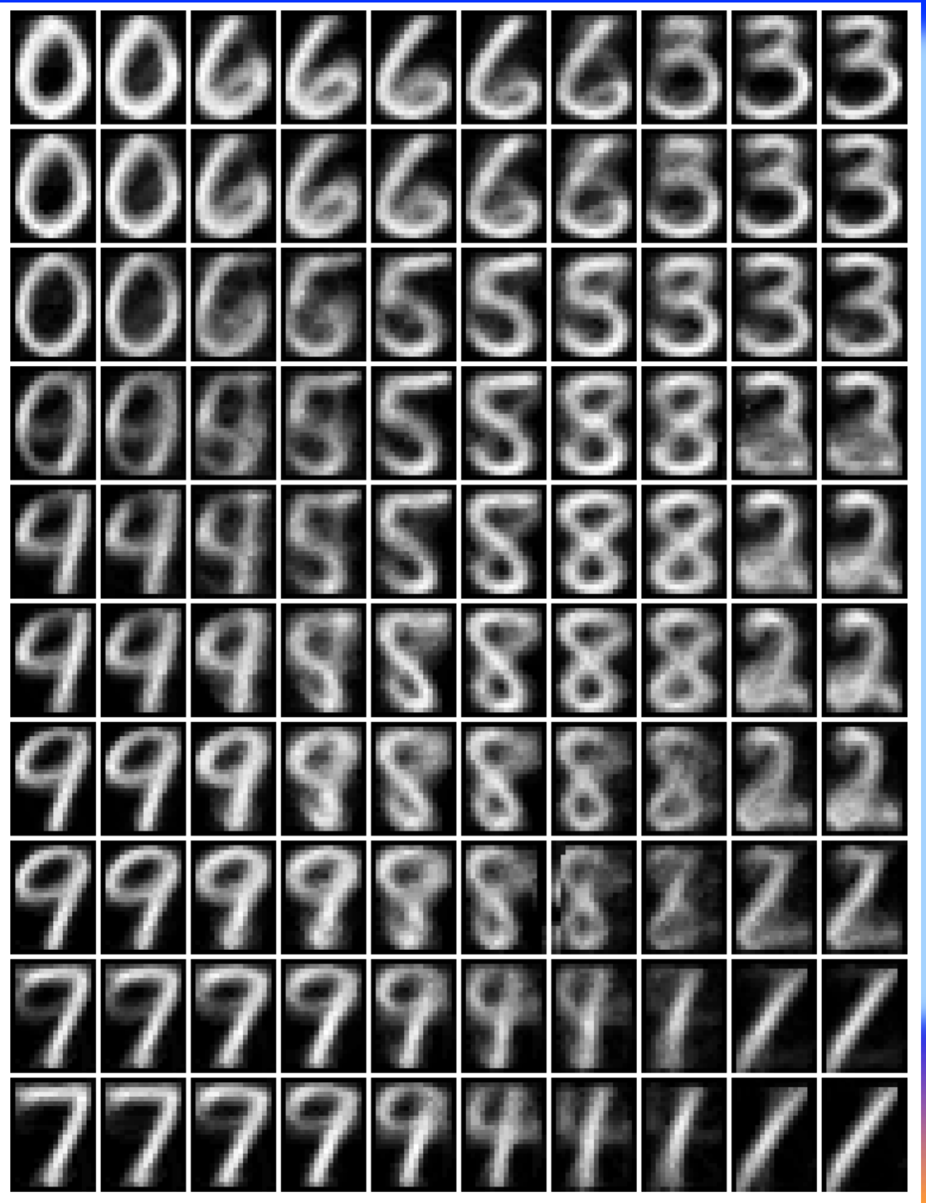
Handwritten Word Recognition

What are these characters?
Are they even characters?



Historical Examples

Handwritten Word Recognition ------------ Buried Explosive Object Detection



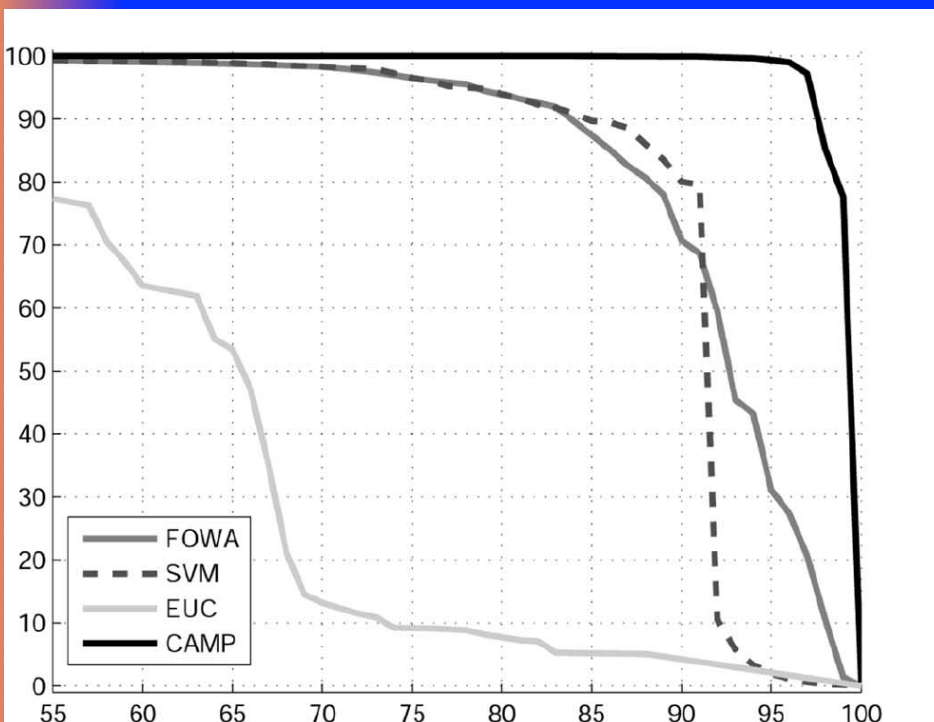
Historical Examples

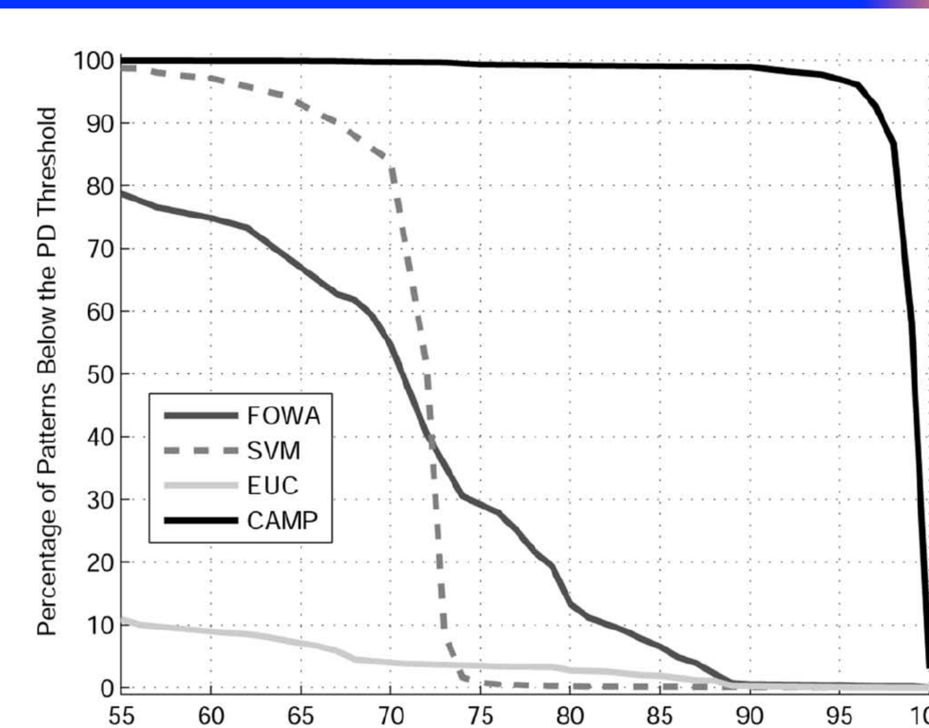
Handwritten Word Recognition ------------ **Buried Explosive Object Detection**

Robustness – Outlier Rejection

Rejection of Outliers as Function of Probability of Detection of Class 1

Rejection of Outliers as Function of Probability of Detection of Class 2

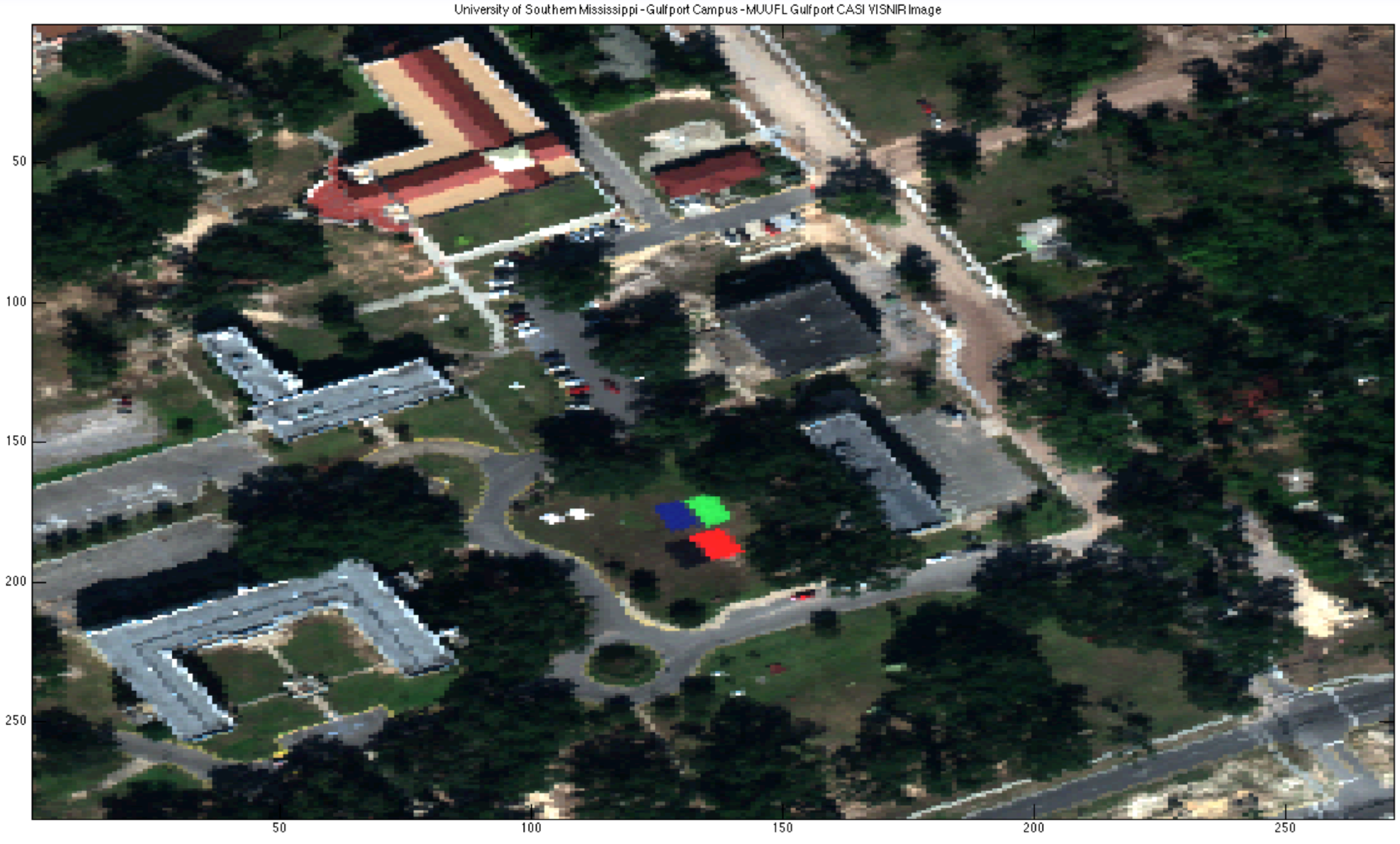




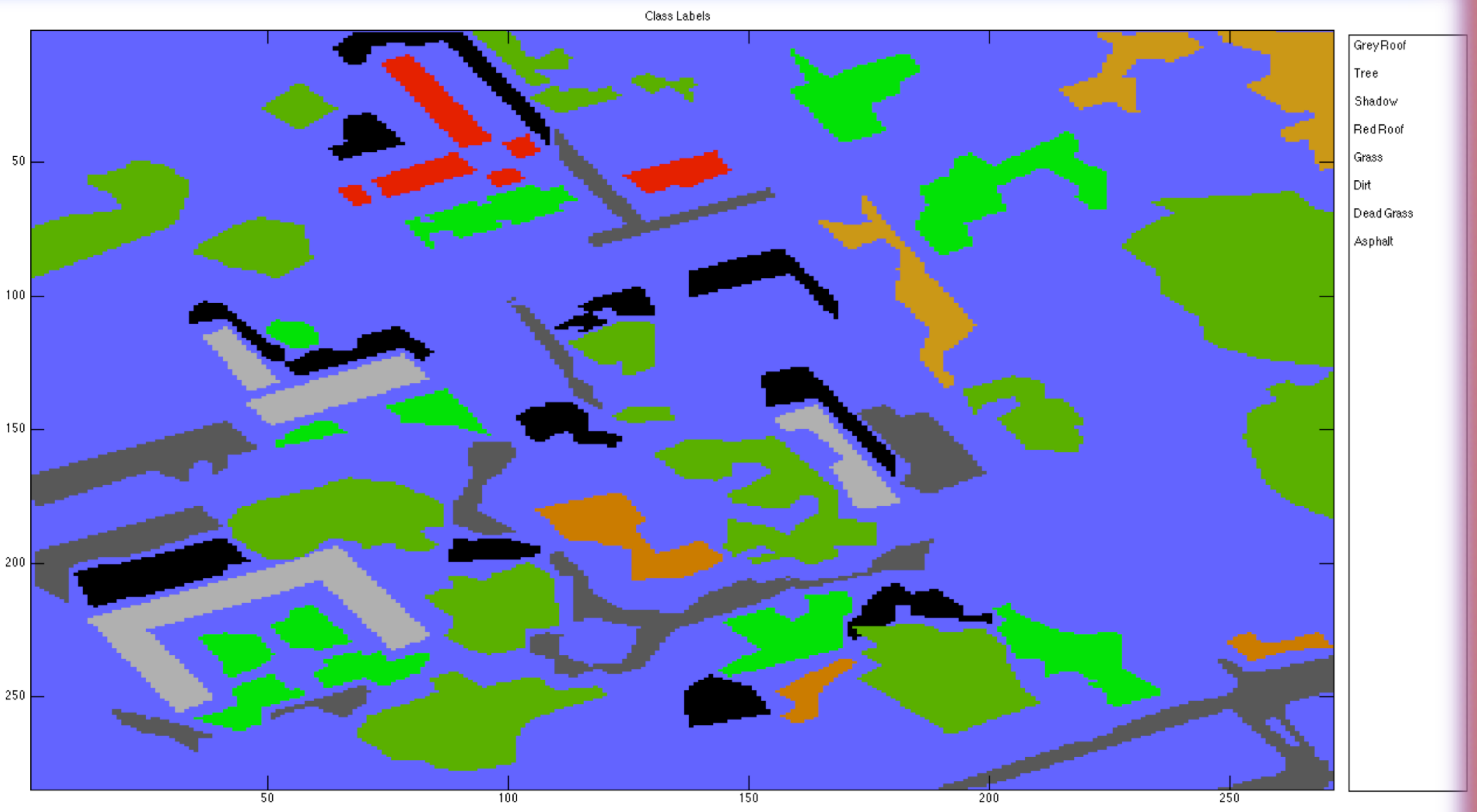
Ambiguity

- Pictures of Oaks

MUFLAG Data –
University of Southern Mississippi Gulfport

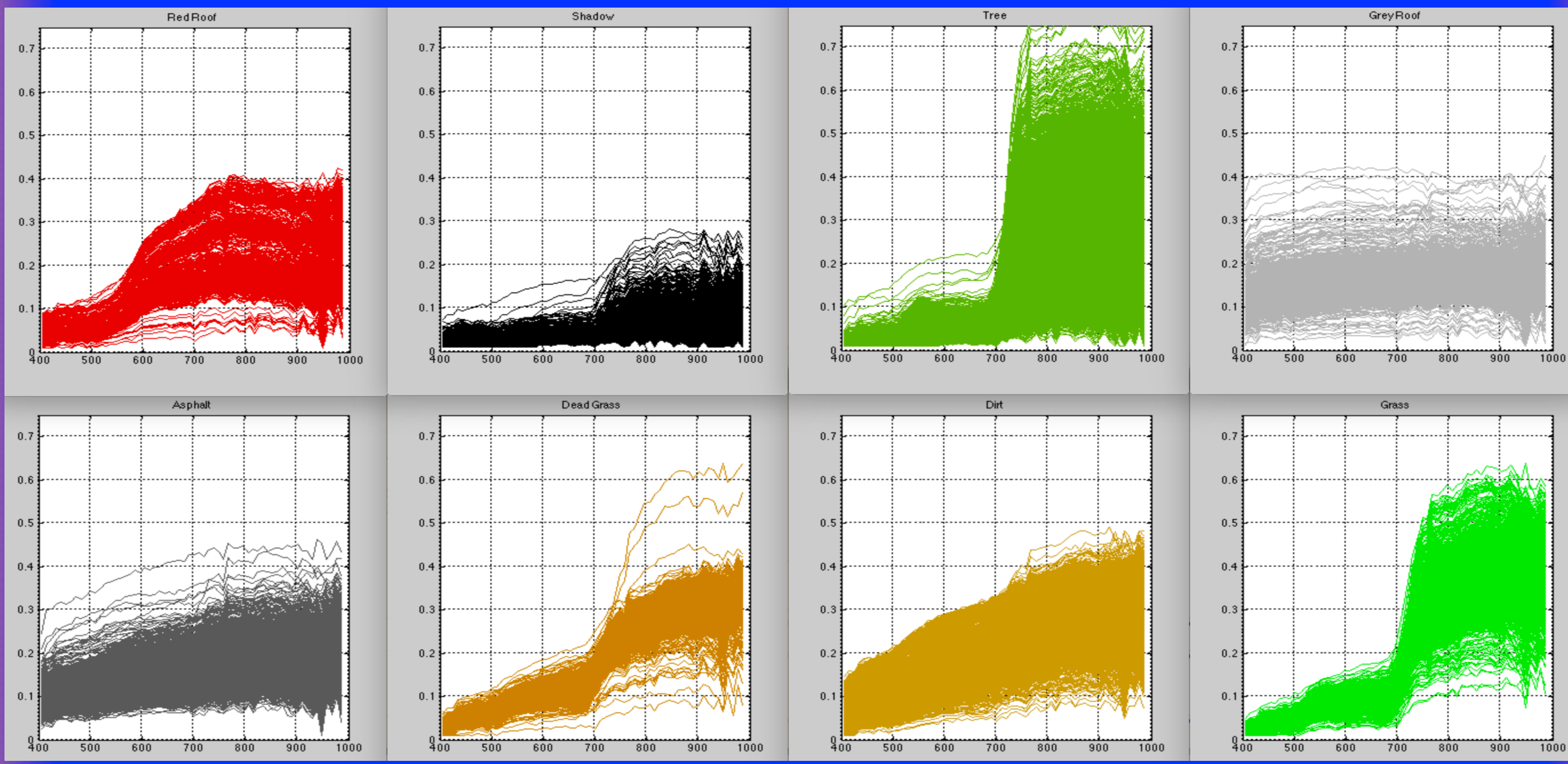


MUFLAG - Classes



Classes

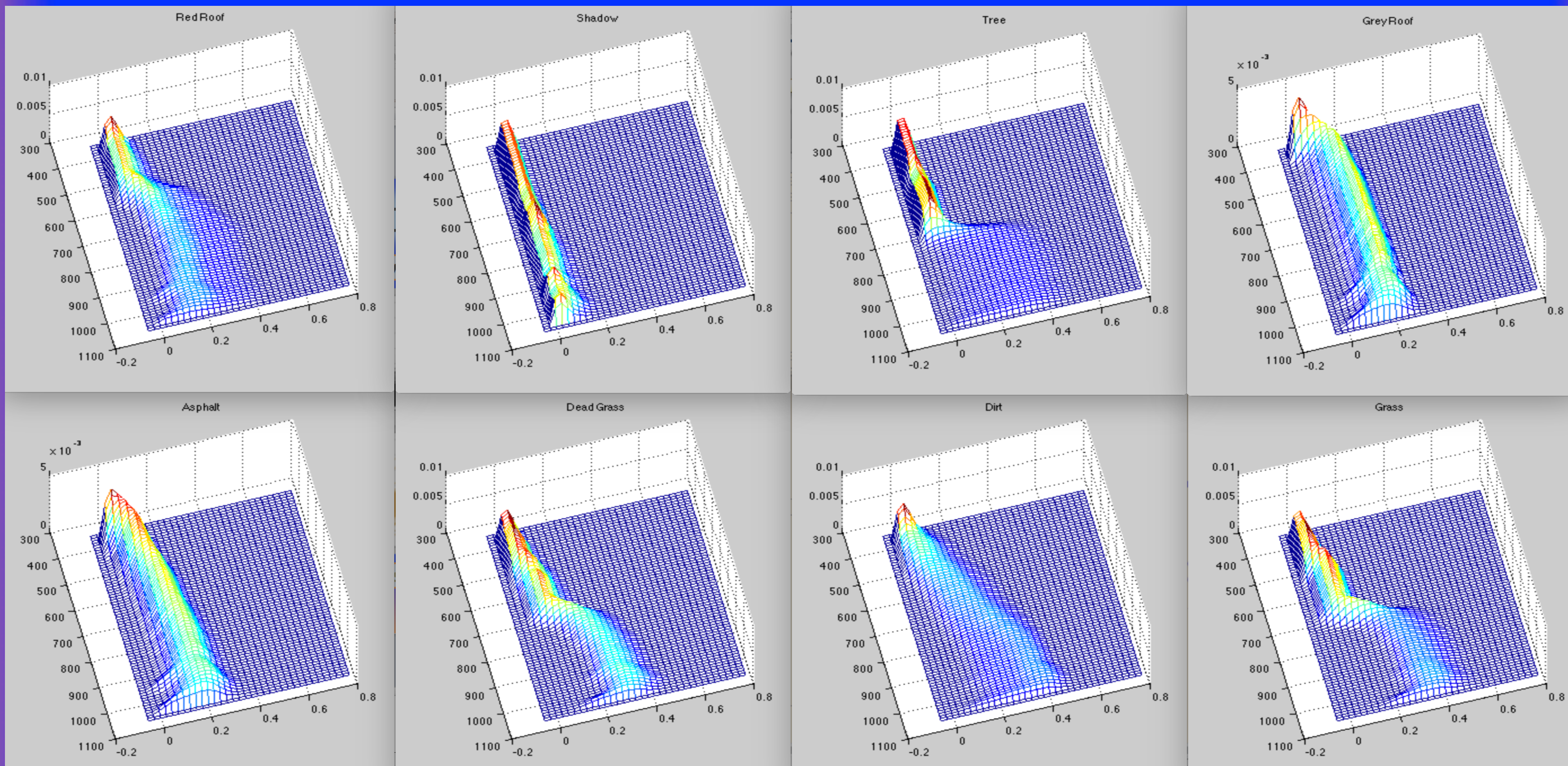
RED ROOF | SHADOW | LIVE OAK | GREY ROOF



ASPHALT | DEAD GRASS | SOIL | LIVE GRASS

Classes as Distributions

RED ROOF | SHADOW | LIVE OAK | GREY ROOF

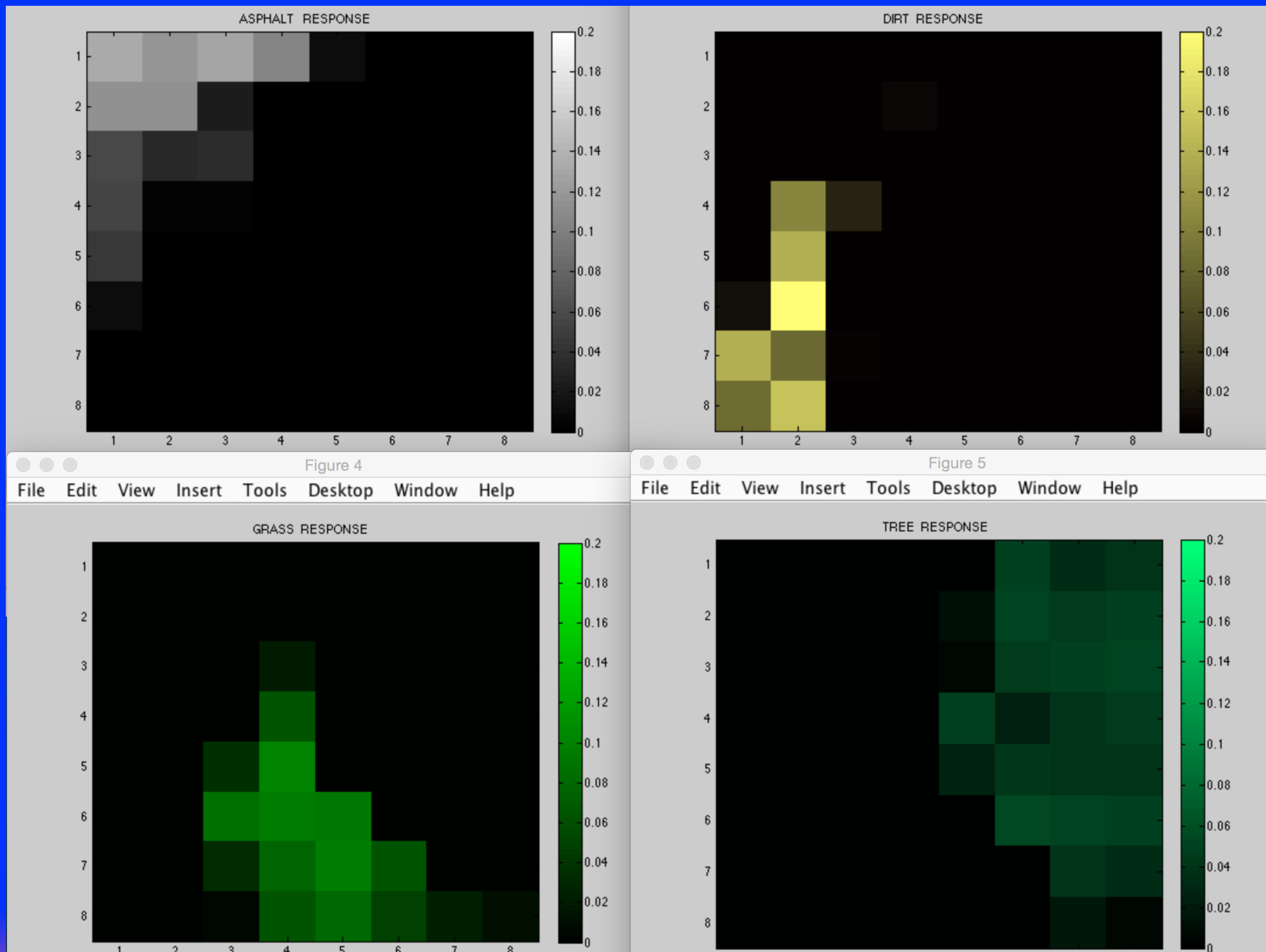


ASPHALT | DEAD GRASS | SOIL | LIVE GRASS

SOM Trained on … ADGRAT

ASPHALT

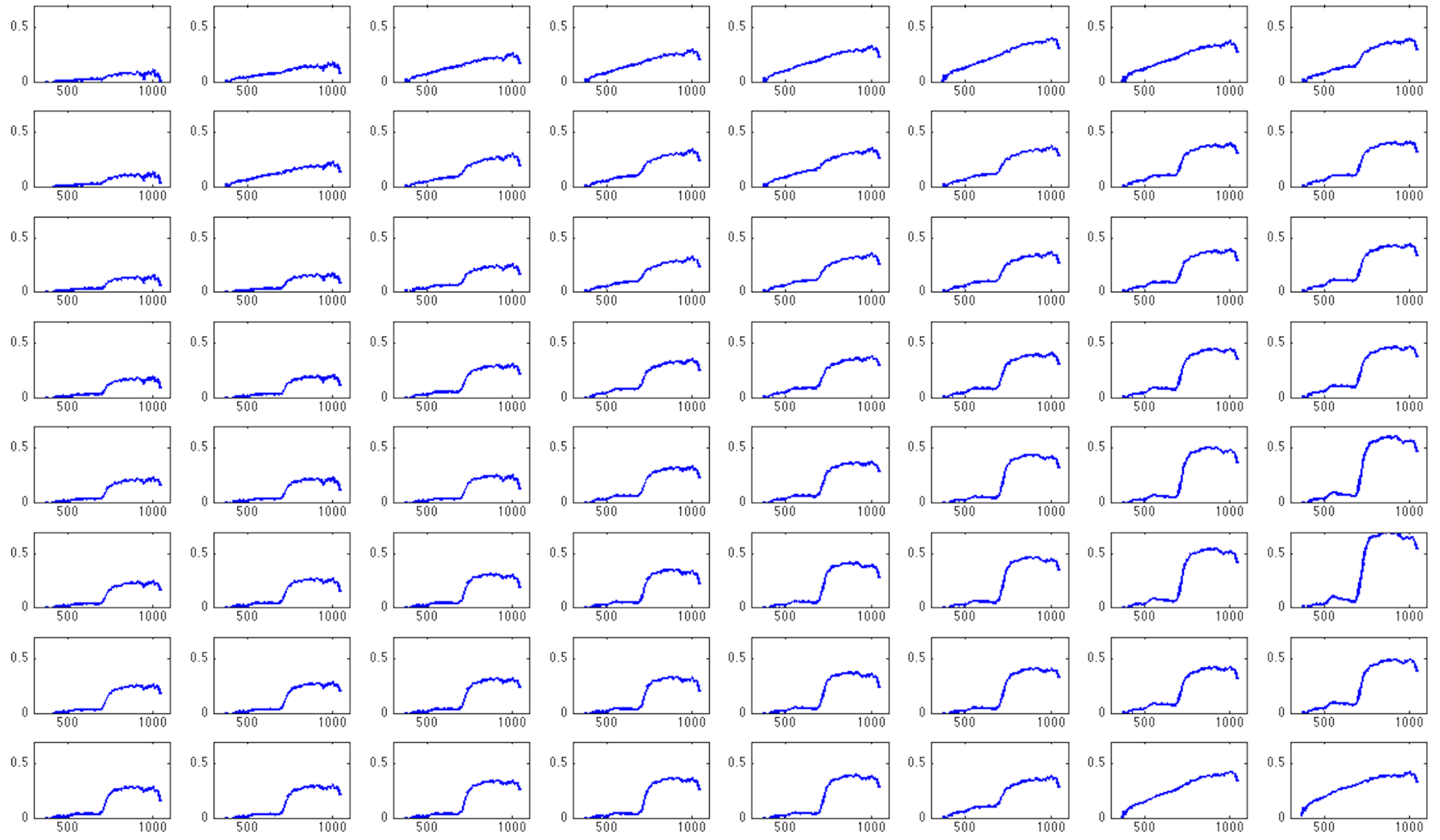
SOIL



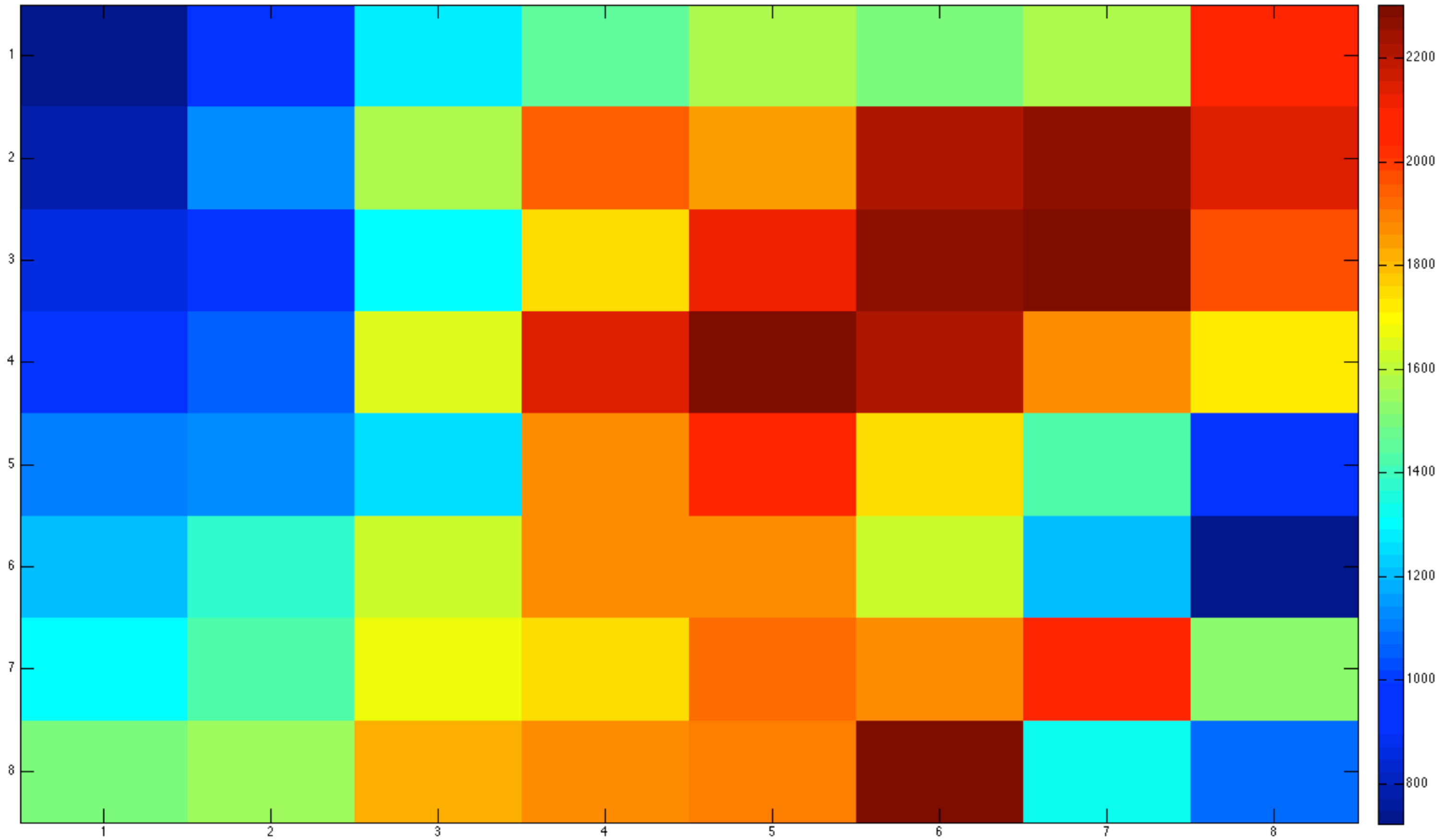
GRASS

TREES

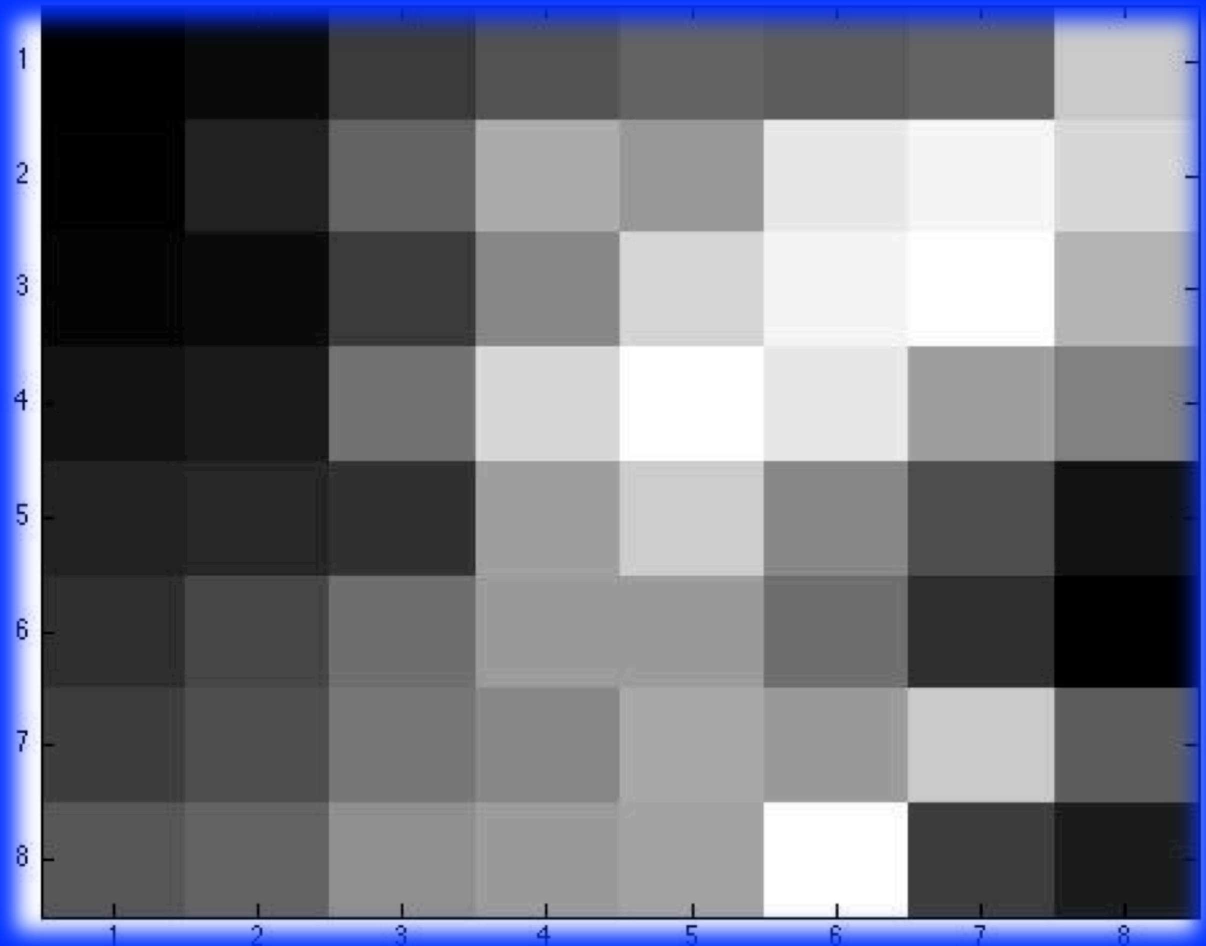
8 x 8 Self Organizing Map



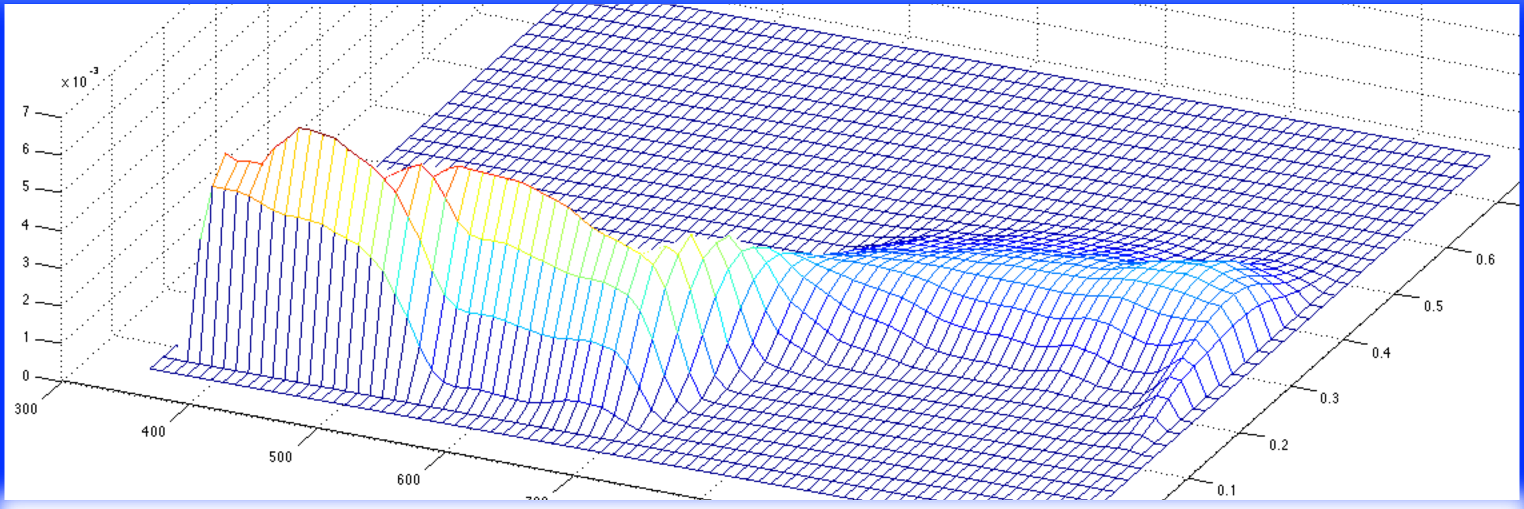
SOM Similiarity to Grass

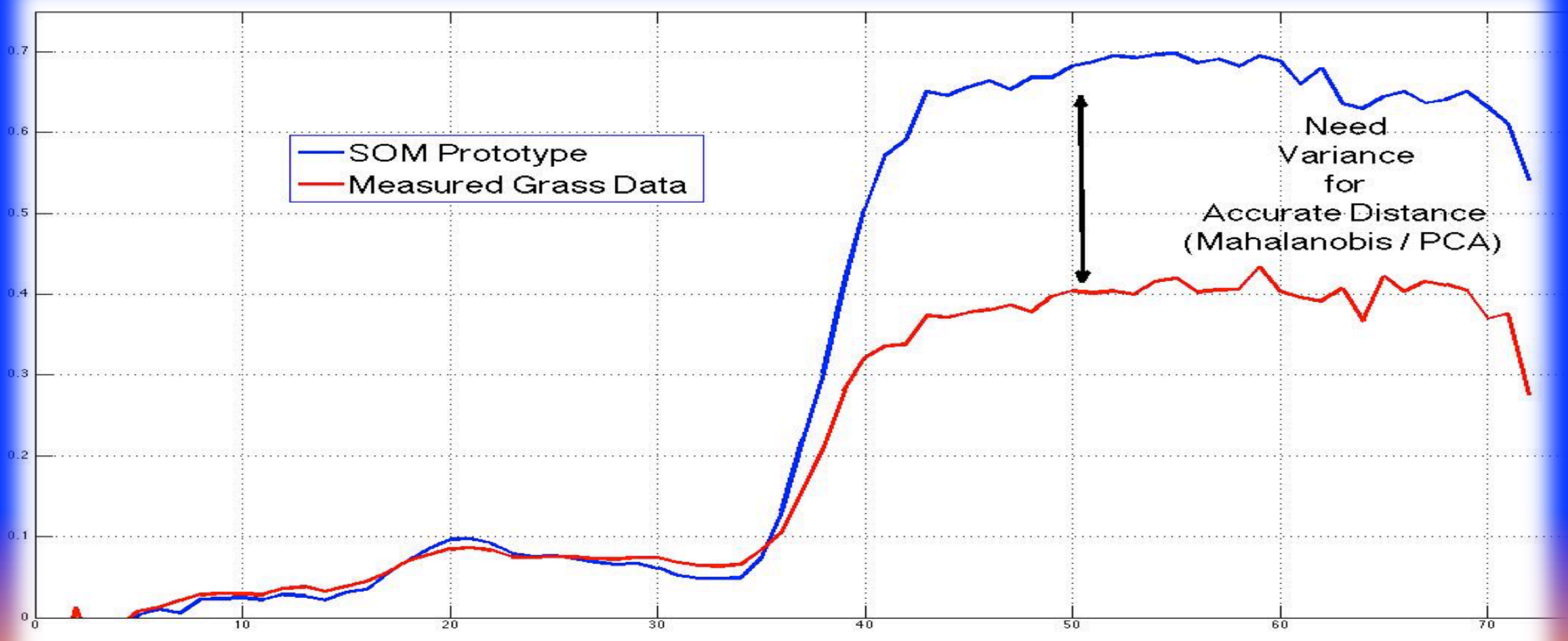


Grass “Hot” Regions

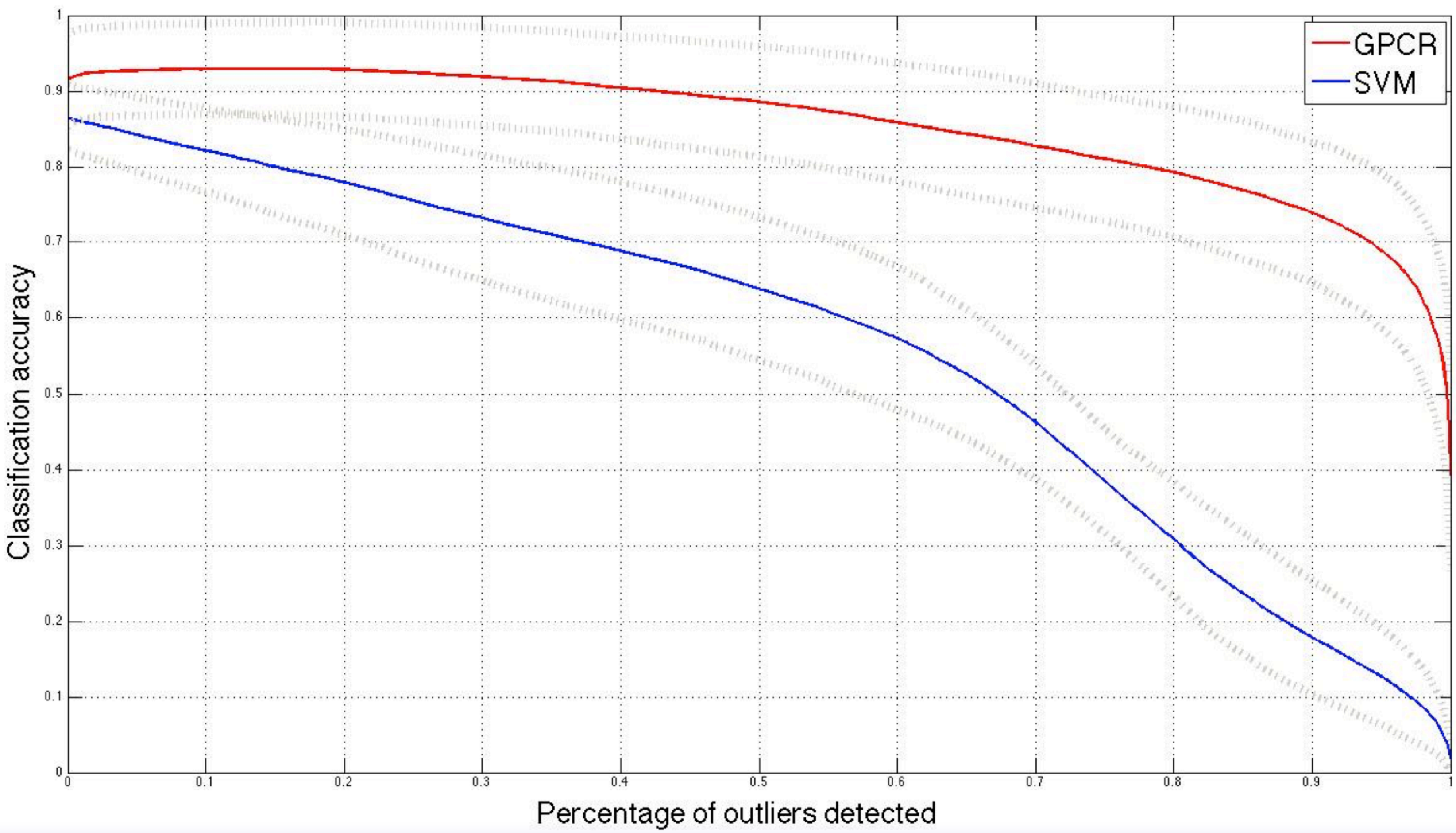


Need for Variance in Similarity i.e.
Mahalanobis or PCA





CAPO on Spectral Data
Spectral Data from UF – NEON Site



Possibilistic
Gaussian Processes

Math Description Later

Possibilistic Gaussian Process
Ordway Swisher Biological Station
NEON – University of Florida
2010 - AVIRIS Data

Oaks vs Pines vs Outlier Vegetation

OSBS Results
100s of runs
Average Area Under Curve (AAUC)

OSBS	**SVM AAUC**	**Gaussian Proc AAUC**
With Outliers	**78**	**88**
No Outliers	**96**	**100**

Panama Ground Measurement Results Made by Stephanie Bohlman et al. ASD Field Spec 4 (UF CISE Instrument)

Panama	SVM AAUC	Gaussian Proc AAUC
With Outliers	93.8	96.0
No Outliers	99.6	99.9

Recommended Future Work

- **Algorithm Development Environment (ADE)**
  – Well Defined Problems, Standardized Evaluation
  – HyspIRI, NEON
  – Vegetation
    - PRAM Classification & Regression (Chemistry)
  – System Level Processing
    - Principle of Least Commitment (David Marr, 1982)
  – Time Series
  – Multiple Information Sources

Hosted Widely Available ADE

- Alg Dev Tools
- Fast Computing
- More Data
  - NEON (NSF)
  - HyspIRI (NASA)