Machine Learning Applications in Land Cover Mapping

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Outline

- Introduction
- Brief recap of Remote Sensing
- Classification
- Traditional Land Cover Classification Techniques
- Machine Learning Techniques
- Feature Selection
- Ensemble Classification
- Summary
- Land Cover Classification Schemes

Introduction

- Land Cover
- Land Cover Mapping
- Importance of accurate land cover mapping
- Satellite Imagery as a Source of land cover information

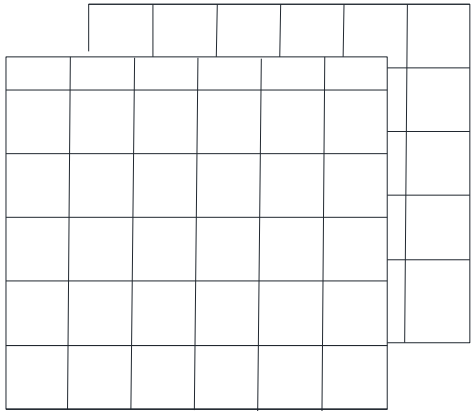
Recap on Satellite Remote Sensing

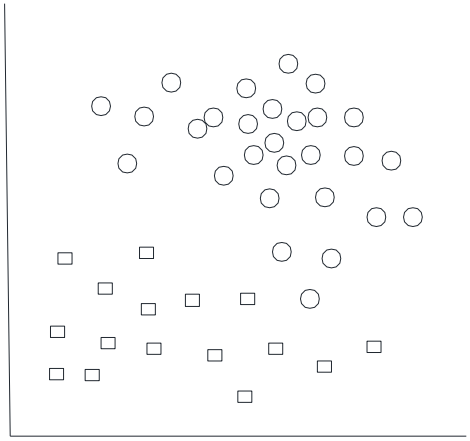
- Resolutions
  - Temporal
  - Spatial
  - Radiometric
  - Spectral

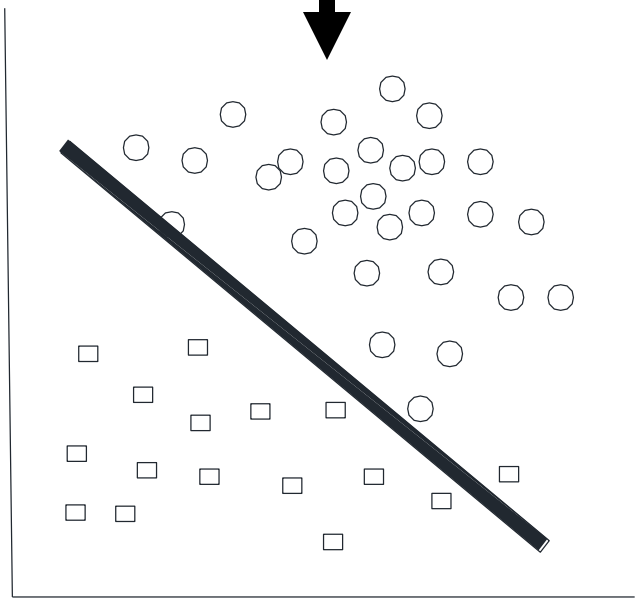
Classification

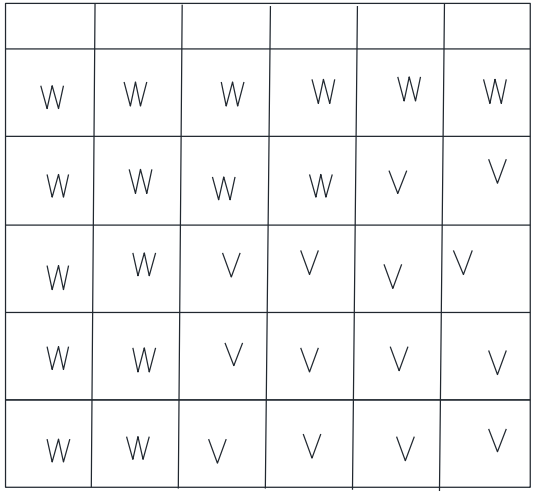
- Unsupervised Classifiers
  - Clustering Algorithms
  - Define different clusters in feature space
  - Then assign classes to the identified clusters

Unsupervised Classification





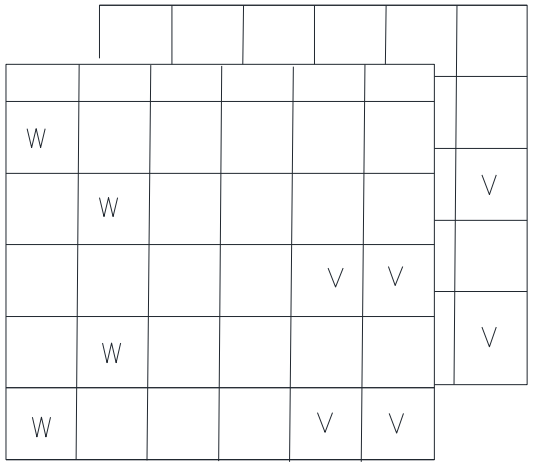


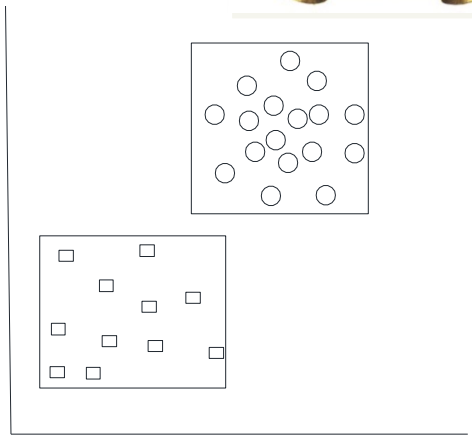


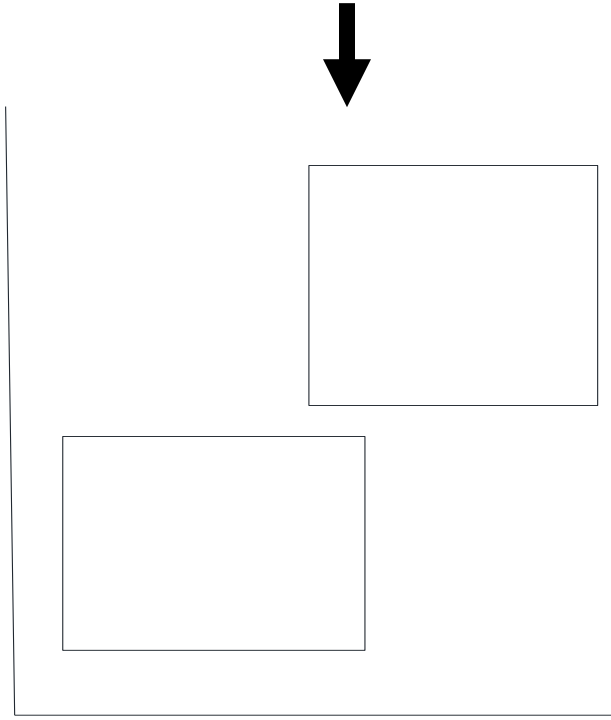
Supervised Classification

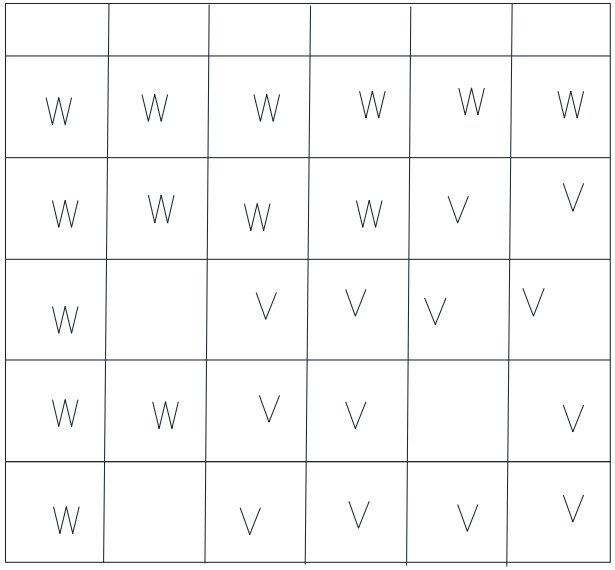
- Supervised
  - Need training data
  - Training data is used to define
    - Decision rules
    - Decision boundaries

Supervised Classification

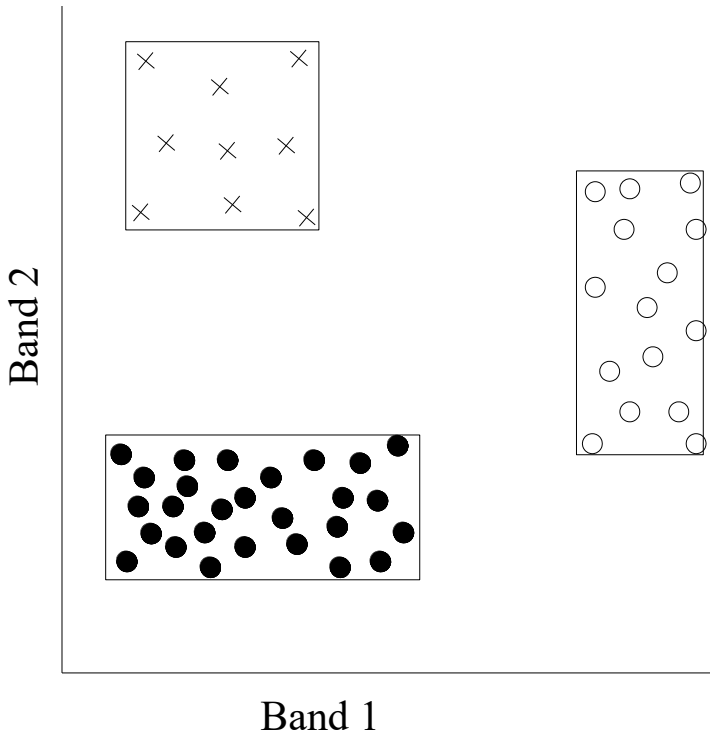


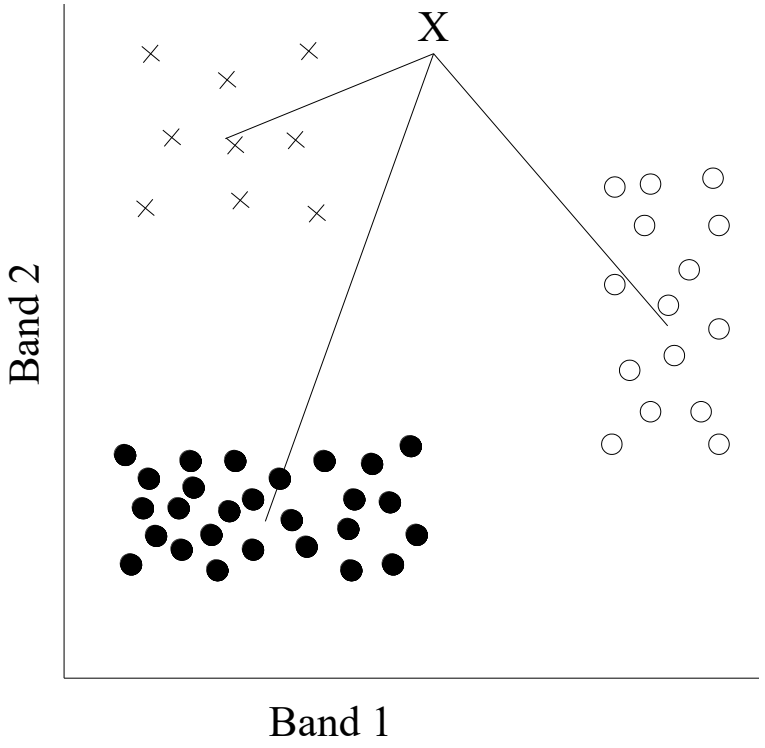




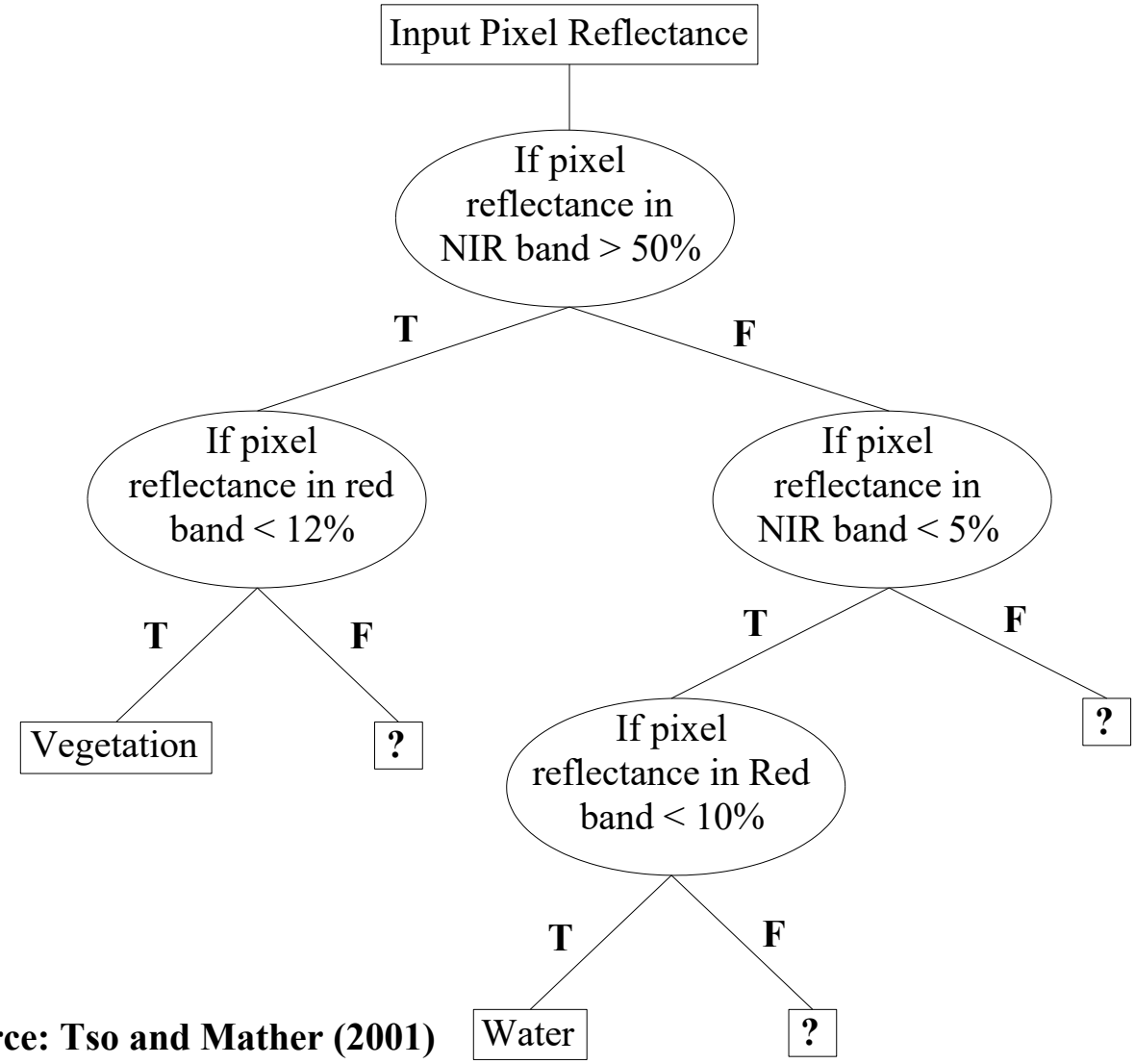


Traditional Classifiers



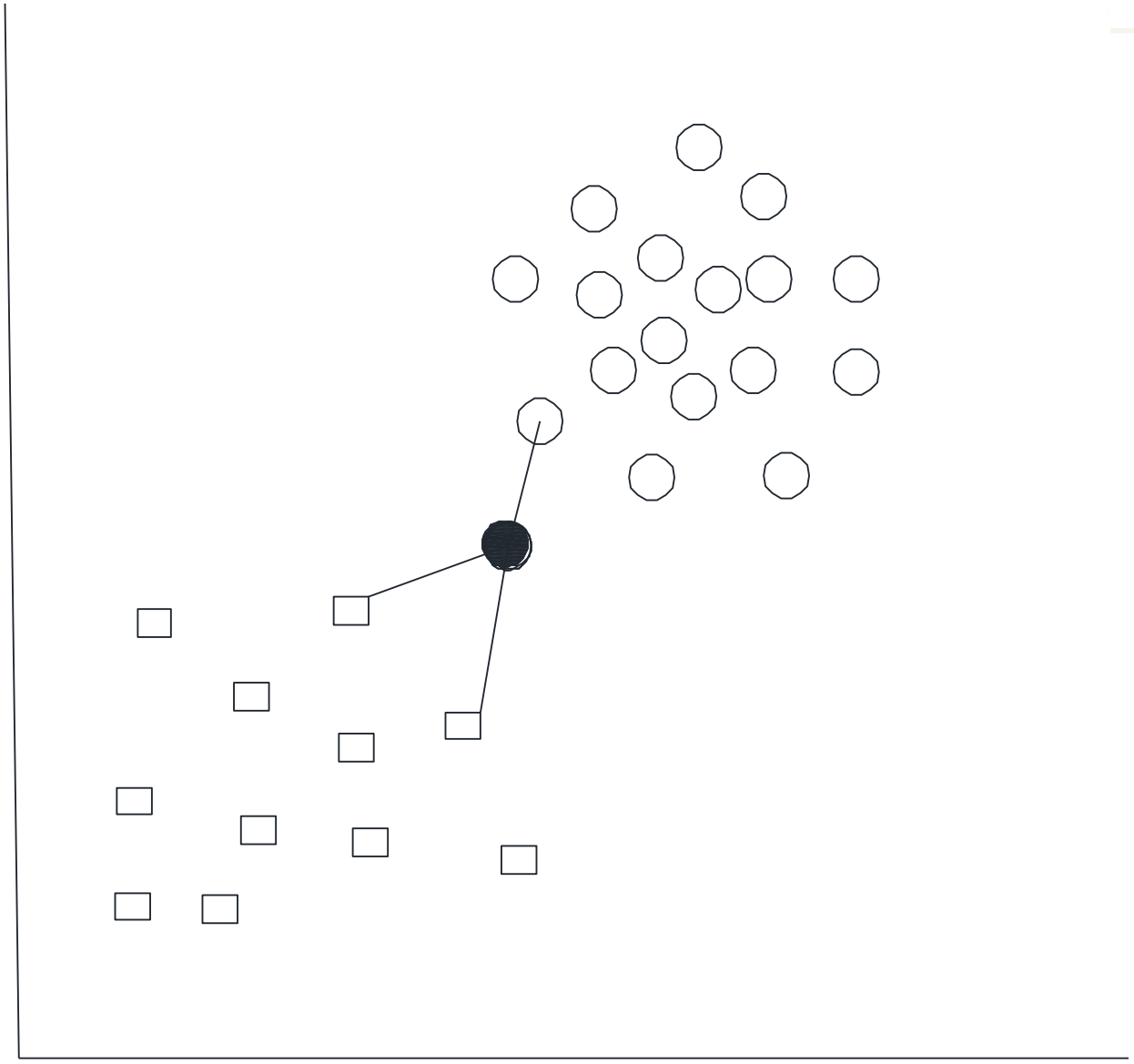


Examples of ML Techniques

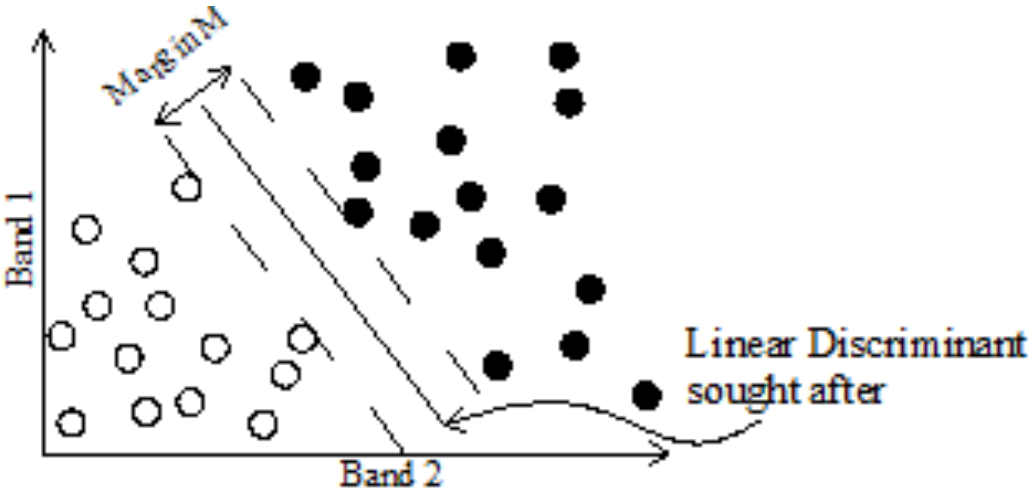


Source: Tso and Mather (2001)

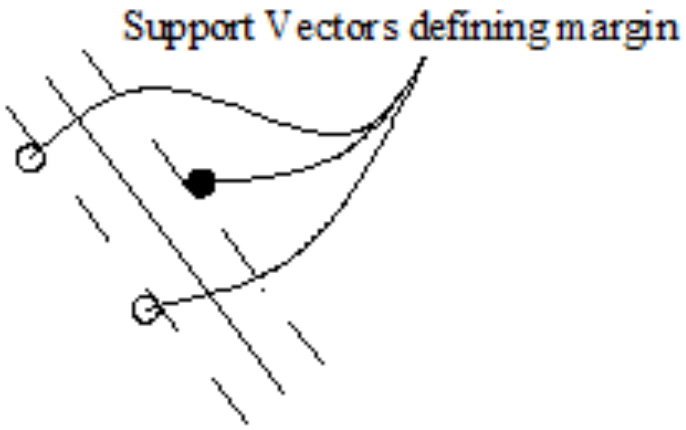
KNN



Support Vector Machines



a) Illustration of linear discriminant and margin



b) Illustration of Support Vectors

a) Scatter plot of linearly inseparable dataset in feature space

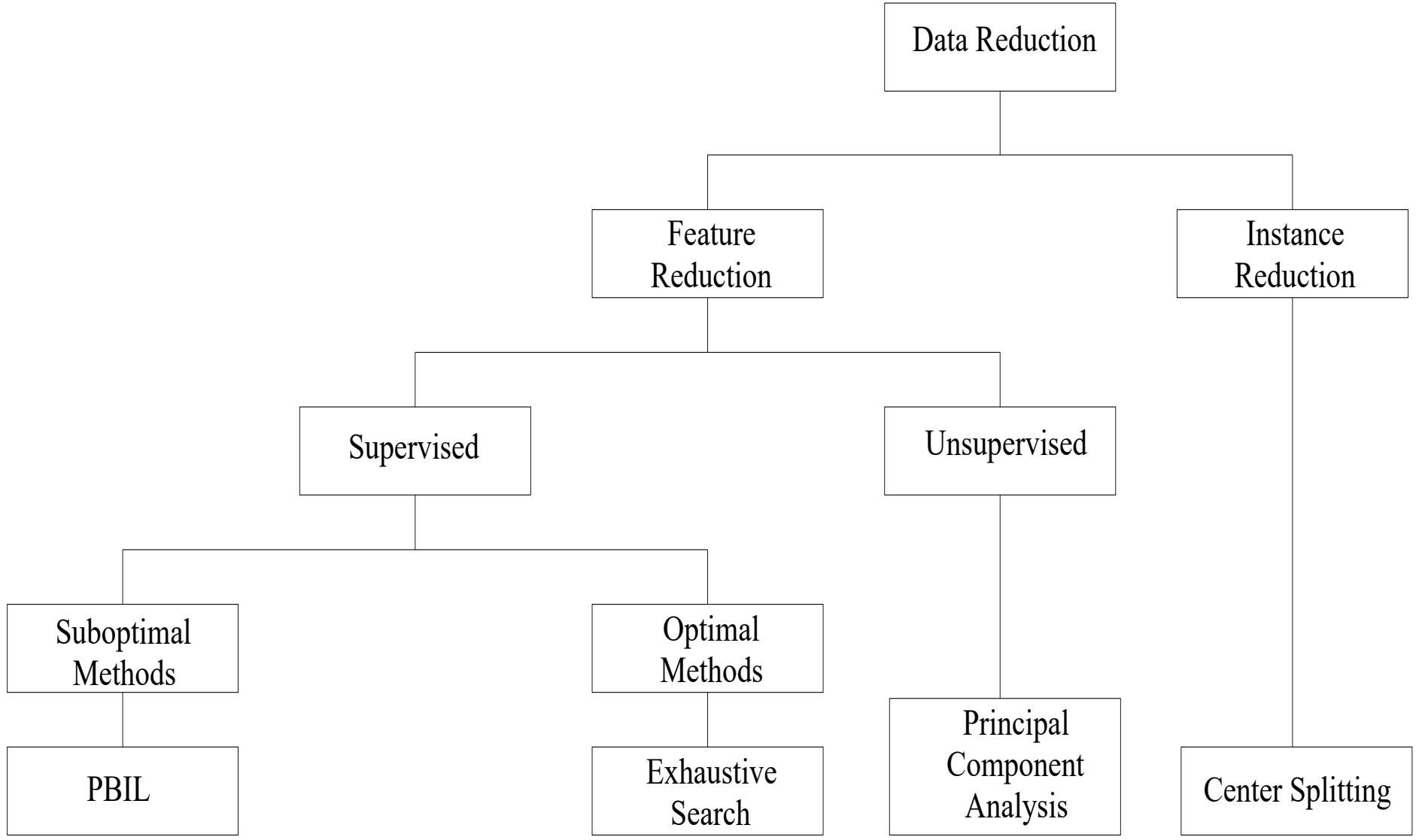
b) In high dimension, the dataset is linearly separable hence a linear discriminant can be fitted to define the decision boundary

c) Performing classification in this higher dimension feature space is equivalent to performing a nonlinear classification in the previous feature space

Multiclass Classification

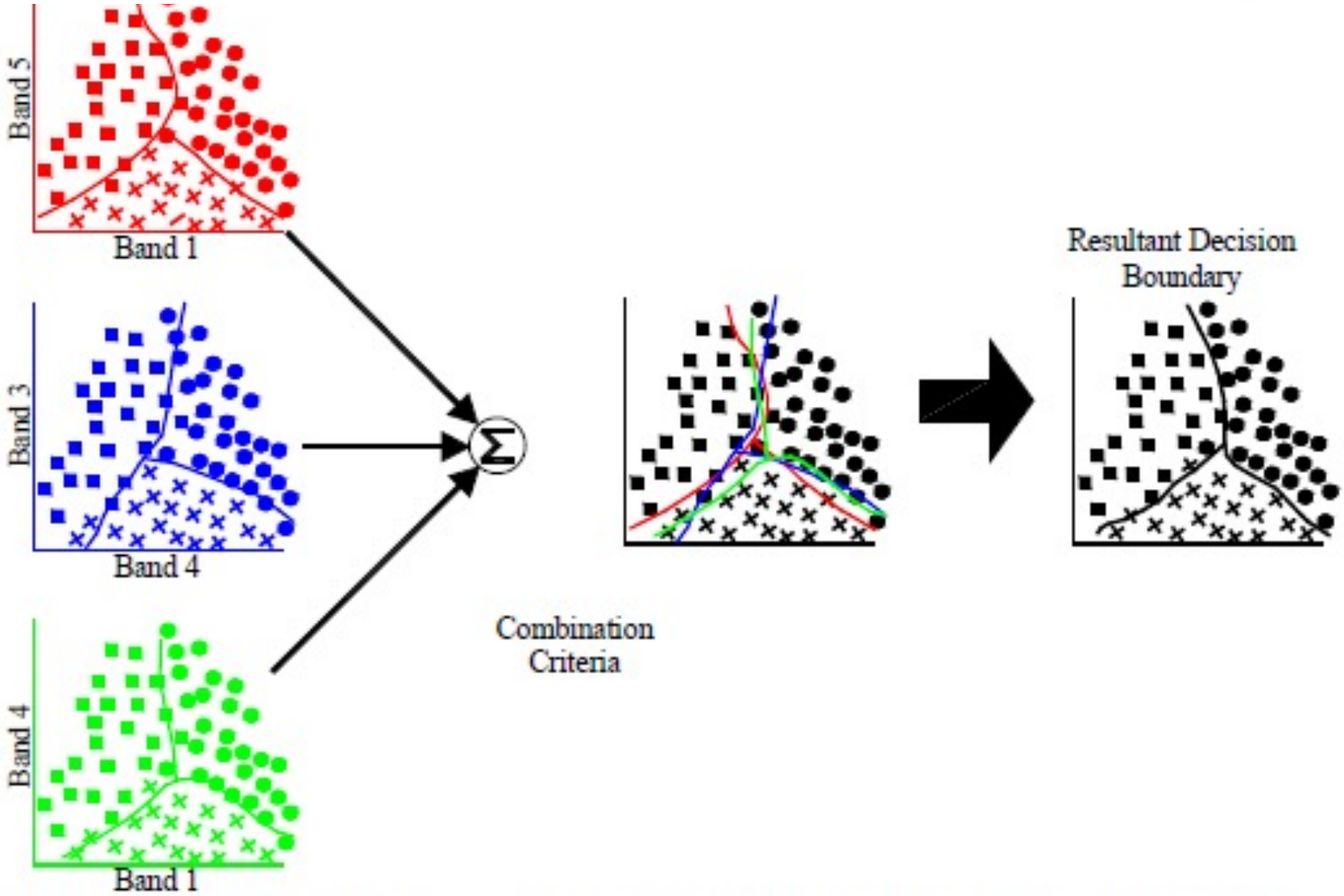
- One against All
- One against One

Feature Reduction



Ensemble Classification

- In ML ensemble classification goes by several names:
  - multiple classifier systems, committee of classifiers, mixture of experts and ensemble based systems
- Aim is to combine the outputs of several classifiers in order to derive an accurate classification


Band 5
Band 1
Band 3
Band 4
Band 4
Band 1
Σ
Combination
Criteria
Resultant Decision
Boundary

Ensemble Classification

- Pillars of Ensemble classification
  - Diversity
  - Combination of the outputs
- Diversity in ensemble systems can be achieved through using different:
  - training datasets
  - classifiers
  - features
  - training parameters

Combination of Outputs

- Some of the methods include
  - majority voting
  - Weighted majority voting or
- More sophisticated methods like
  - Consensus Theory
  - Stacking

Take Home Exercise

- For a given location of interest:
  - Identify at least 5 classes of interest
  - Select training data for the identified classes
  - Apply at least three classification algorithms
  - Calculate the classification accuracy for the classified images
  - These three (Or more) classifiers will now form your ensemble
  - Carry out a majority vote for the classified images
  - Calculate the classification accuracy for your ensemble
  - How does the classification accuracy of the ensemble compare with the individual classifiers

Ensemble Feature Selection

- Indian Pines Hyperspectral Dataset
- https://purr.purdue.edu/publications/1947/1
- Used SVM
- Diversity was enforced through using different band combinations
- Selection of features
  - Exhaustive search
  - Random Feature selection
- Two ensemble FS techniques were used
  - Majority Voting
  - Cross Validation Majority

Ens.	1	2	3	4
BC 1	0.6209	0.6214	0.4591	0.6176
BC 2	0.6134	0.6323	0.4737	0.6531
BC 3	0.6112	0.6264	0.3383	0.6084
BC 4	0.6232	0.6418	0.3937	0.6605
BC 5	0.6128	0.6317	0.4141	0.6276
BC 6	0.6149	0.6323	0.4687	0.6314
BC 7	0.6125	0.6281	0.4885	0.5803
BC 8	0.6190	0.6242	0.5288	0.6425
BC 9	0.6202	0.6168	0.4067	0.6151
BC 10	0.6338	0.6435	0.3593	0.5989
MV	**0.6212**	**0.6314**	**0.4707**	**0.6482**
SB	**0.6338**	**0.6418**	**0.5288**	**0.6605**

Classification Summary

- Supervised Vs Unsupervised
- Parametric Vs Nonparametric
- Hard Vs Soft
- Per pixel Vs OBIA

Land Cover Classification Schemes

- Provides a reference system for land surfaces
- Standardization and harmonization of classifications enables us to combine existing heterogeneous land cover datasets to support global land cover data analysis
- Standardization helps compare different regions

LCCS

- A classification describes the systematic framework with the names of the classes and the criteria used to distinguish them, and the relation between classes

- necessarily involves definition of class boundaries that should be clear, precise, possibly quantitative, and based upon objective criteria

Land cover classification systems by scale

- National scale
  - For many years, agencies at various governmental levels and institutions have been collecting land cover data, but most of them have worked independently and without coordination. The land cover classification systems at a national scale always refer to smaller scales than those generally used for large-scale topographic mapping (the study of source materials, map design and production at 1:5000–1:10,000 scales).
- Regional scale
  - Land cover classification at a regional scale, between 1:250,000 and 1:100,000, always used the second and third-generation sensors for remote sensing that encompasses Landsat TM, SPOTHRV/XS, IRS-1C/LISS, Landsat ETM+, and MODIS, etc. CORINE, AFRICOVER and the Asian Association on Remote Sensing (AARS) projects have been realized at this scale
- Global scale
  - The land cover classification system at a global scale refers to scales smaller than 1:250,000, which always uses the NOAA Advanced Very High Resolution Radiometer (AVHRR) satellites.

Example 1: National Land Cover Classification Schemes

Classification Systems	Organization	Nation	Year
National Land Survey Classification System	Land and Resources Ministry of China	China	1984; 2007
National Land Cover Data Classification System	United States Geological Survey	United States	1992; 2001; 2006; 2
National Institute of Statistics, Geography and Informatics	nstitute of Gegography of the National University of Mexico	Mexico	1993; 2000
National Institute of Statistics, Geography and Informatics	National Land Cover Database	SouthAfrican	1996
US National Vegetation Classification Standard	Federal Geographic Data Committee	United States	1997
National Forest Inventory Land Cover Classification Scheme	Candadian Forest Inventory Committee	Canada	1999
Anderson Classifiaction system –		USA	
National biomass study(NBS) Land cover Classification scheme	National forestry authority	Uganda	1990-2009

Example 2: Regional Land Cover Classification Schemes

Classificaiton Systems	Organizations	Years	Continent	Members
CORINE/LandCover90	COordination of INformation on the Environment	1990	Europe	27 countries of the European Union (EEA and EU member countries)
CORINE/LandCover 2000	Image and Corine Land Cover 2000	2000		
CORINE/LandCover2006		2006		
AFRICOVER Land Cover Classificaiton System	Food and Agriculture Organisation of the United Nations	1995–2002	Africa	12 African countries
AARS Land Cover Classification	The Land Cover Working Group of the Asian Association on Remote Sensing	1999	Asia	49 members from 29 coutries/regions
North American Land Change Monitoring System Legend	The North American Land Change Monitoring System	2005	North American	Canada, Mexico and the United States

Example 3: Global Land Cover Classification Schemes

Classficiation Systems	Organizations	Years
USGS Land Use/Land Cover Classification Systems (National)	United States Geological Survey	1972/1976
EarthSat GeoCover Land Cover Legend	US Earth Satellite Corporation (EarthSat)	1990
UNEP/FAO Land Cover Legend	The United Nations Environmental Programme/Food and Agriculture Organization of the United Nations	1993
Land Cover Classification System	The United Nations Environmental Programme/Food and Agriculture Organization of the United Nations	1996
International Geosphere-Biosphere Programme-Data and Information System	United States Geological Survey/Joint Research Centre-Space Application Institute	1996
GOFC/GOLD Land and Forest Cover Classification System	Committee Earth Observation Satellites	1998
UMD Global Land Cover Classification	University of Marland Department of Geography	1998

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