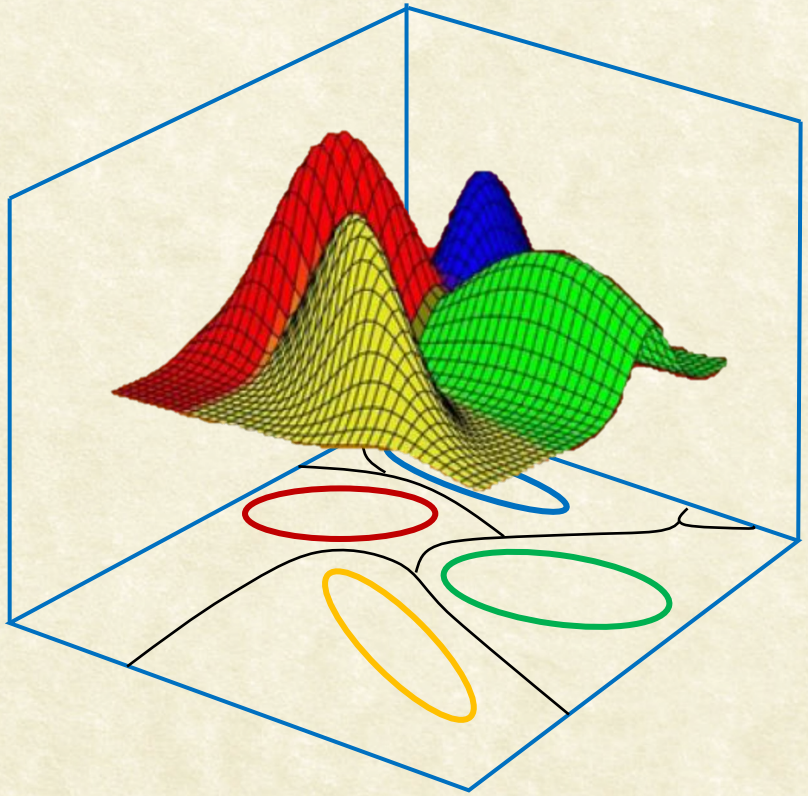
CS7.403: Statistical Methods in AI

Monsoon 2022: Introduction



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About the Course

- Textbooks
  - “Pattern Classification”, by Duda, Hart and Stork
  - “Neural Networks”, by Simon Haykin
  - “Machine Learning - A Probabilistic Perspective”, by Kevin Murphy (free ebook available online)
- Prerequisites
  - Probability and Statistics
    - Probabilities, Distribution functions, Multivariate densities (joint and conditional)
  - Linear Algebra
    - Vectors, Spaces, Subspaces, Matrices, Eigen values and vectors
- Course Webpage
  - https://courses.iiit.ac.in/
  - All details, resources, assignments are posted there

Administrivia

- Lectures: Mon and Thu 2:00 – 3:25pm
- Location: Himalaya 205
- Tutorials: During selected lecture sessions and outside
- Additional help sessions (TA Office hours)
  - Will be scheduled and posted on courses page

Grading

Head	% of Grade
Assignments / Homeworks	25
Project	20
Scheduled Quizzes - 2	20
Mid Term Exam	15
Final Exam	20

- Attendance
- Tutorials (tests)
- Academic Honesty

Class Etiquettes

- Before the Lecture
  - Watch any videos / read any material given for preparation
  - We will start sharp at 2:00pm
    - If you are late, use the back entrance only.
- During the Class
  - Please pay attention in the class
    - Do not use cell phones during class
  - If you have a doubt, ask. Others are likely to have the same doubt.
  - Take notes: Not every topic discussed in the class comes from a textbook

Special Note

- Most classes will be a combination of recorded videos and interaction.
  - Links to videos will be provided before each class
  - We will play the video at 2pm, followed by discussions and exercises in class
- There will be evaluation sessions in specific classes (in https://courses.iiit.ac.in)

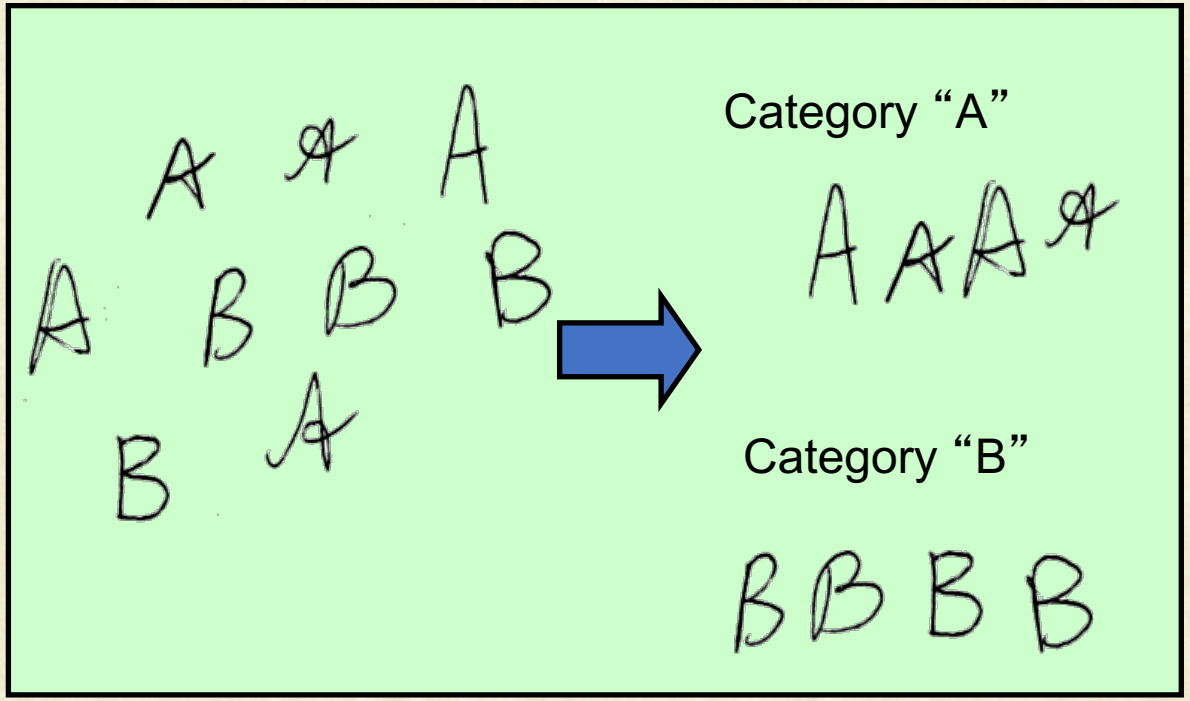
Questions?

Tasks in AI

- Sensing
  - Cameras, Microphones
  - Touch, proximity, GPS, …
- Perception / Recognition
  - Where am I?
  - What do I see /sense?
  - How far is that person?
- Reasoning
  - How did this come about?
  - What is about to happen?
  - What should I do?
- Acting

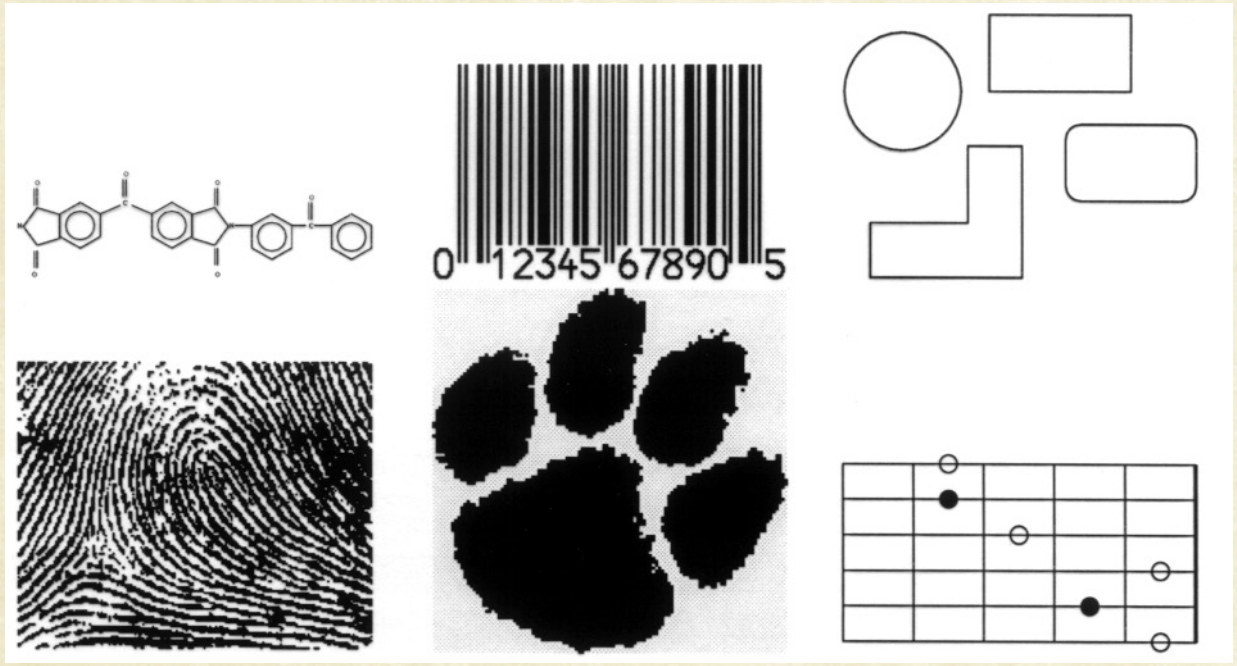
What is Recognition

- Identification of a pattern as a member of a category we already know, or we are familiar with:



What is a Pattern?

- “A pattern is the opposite of a chaos; it is an entity vaguely defined, that could be given a name.” (Watanabe)

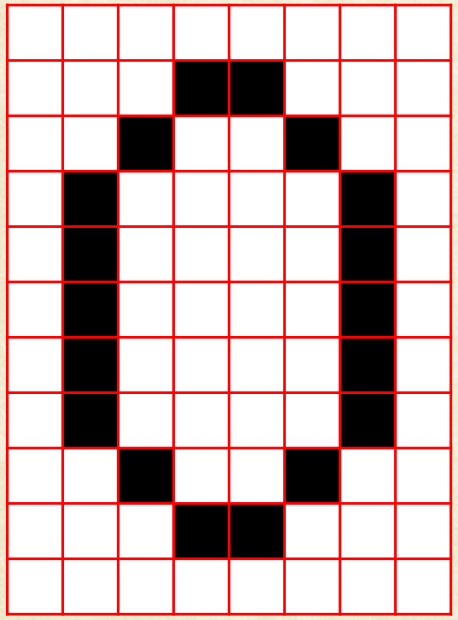


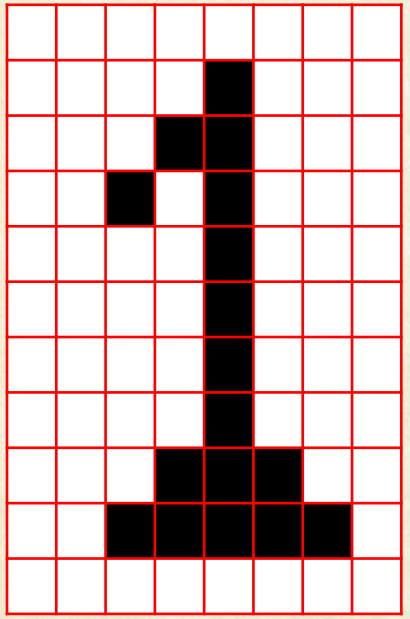
A Pattern Class

- A collection of "similar" (not identical) objects
- A class is defined by class samples
- Inter-class variability
- Intra-class variability

Separating 0s and 1s

- What is the difference between a 0 and a 1?
  - 1: Straight Line: Vertical, Horizontal, Slanted
  - 0: Curvature, Enclosed background
- How do we extract that information?



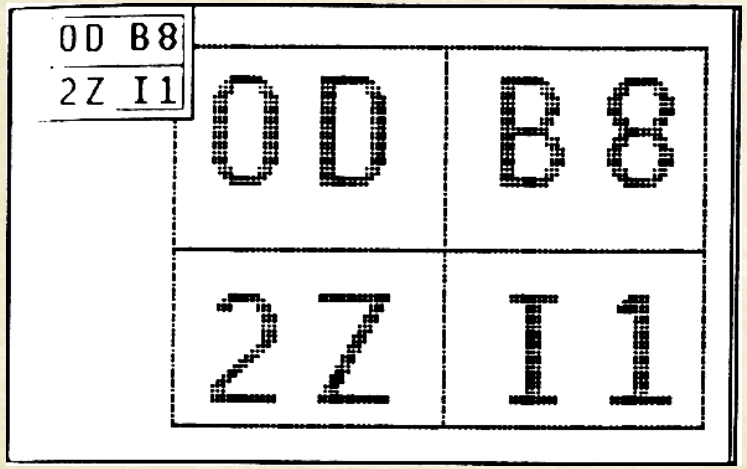


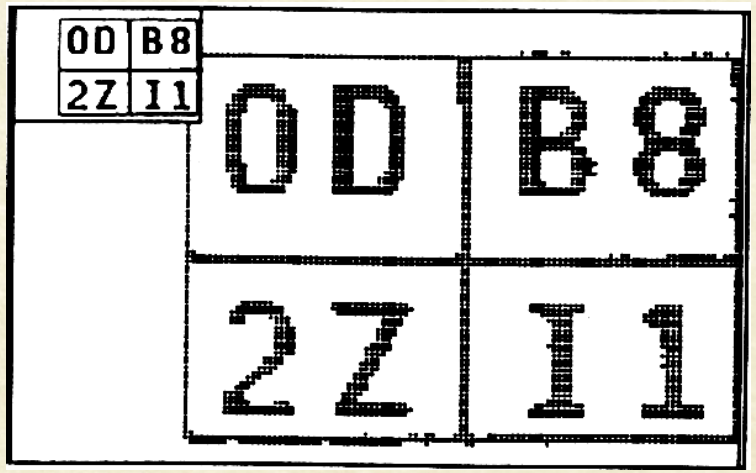
Intra-class and Inter-class Variability

What is a T ?

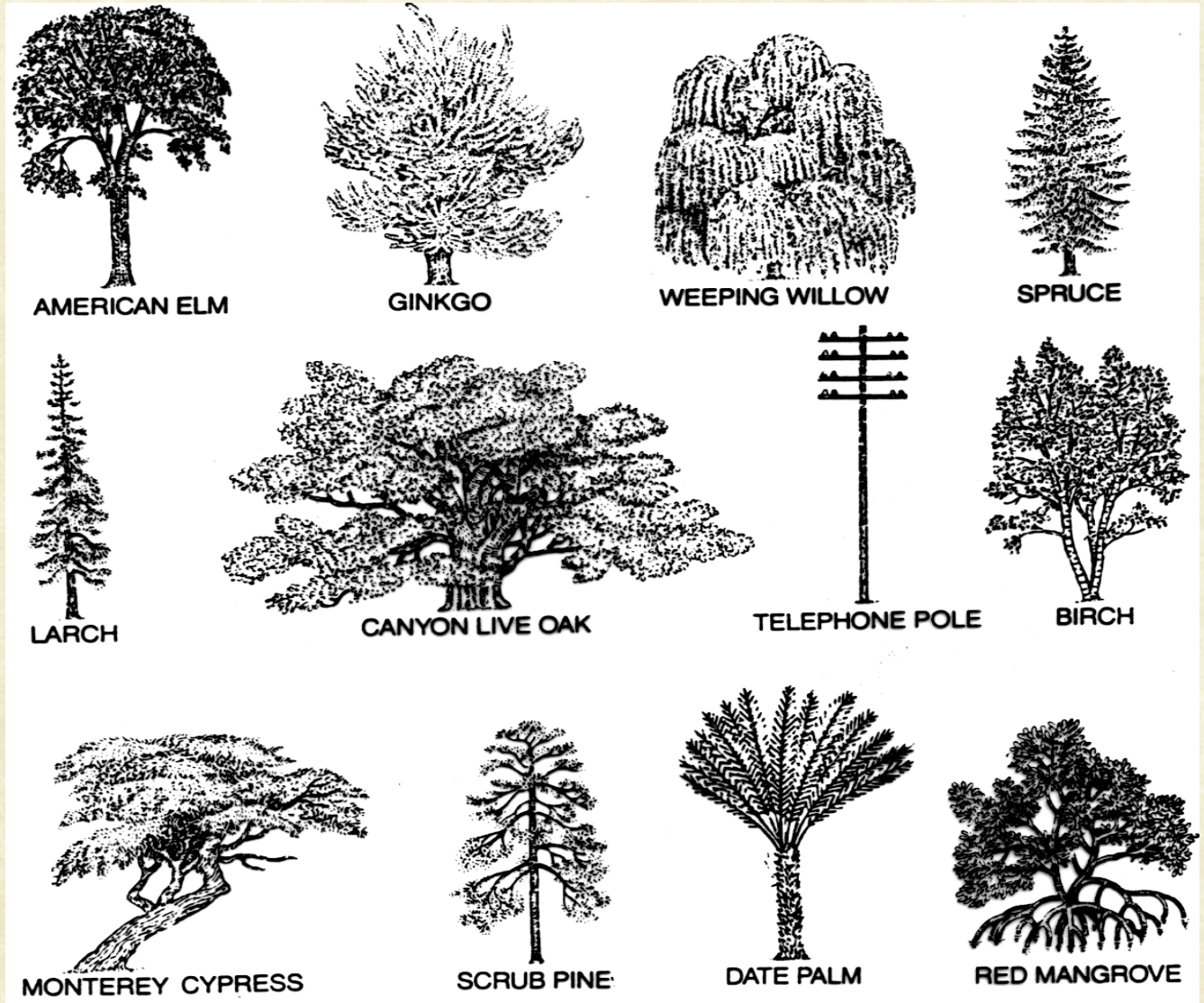
The letter “T” in different typefaces

Other similar characters





What is a Tree?



Pattern Recognition

- Having been shown a few examples (and perhaps a few negative examples) of a pattern class, the system “learns” to tell whether or not a new object belongs in this class (Watanabe)

- Inferring a generality from a few exemplars

- COGNITION = Formation of new classes

  RECOGNITION = known classes

Questions?

AI in Action

X y

Problem	Input	Output
Speech recognition	Speech waveforms	Spoken words, speaker identity
Non-destructive testing	Ultrasound, eddy current, acoustic emission waveforms	Presence/absence of flaw, type of flaw
Detection and diagnosis of disease	EKG, EEG waveforms	Types of cardiac conditions, classes of brain conditions
Natural resource identification	Multispectral images	Terrain forms, vegetation cover
Aerial reconnaissance	Visual, infrared, radar images	Tanks, airfields
Character recognition (page readers, zip code, license plate)	Scanned image	ASCCII character codes

Problem Formulation

$$y = f(X)$$

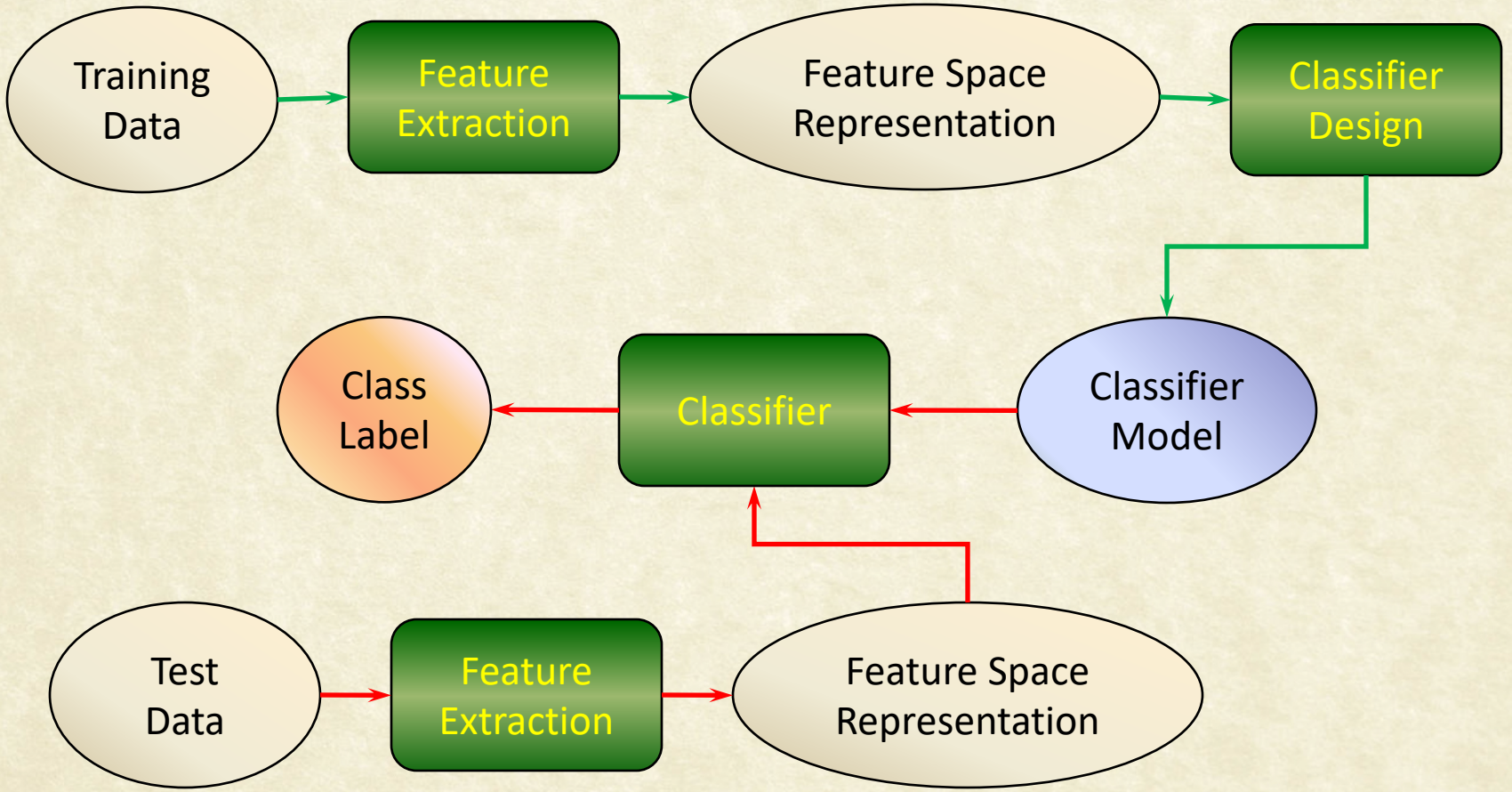
- X: Input. A vector
- y: Output. Class label, predicted value for X
- Problems
  - Classification
  - Regression
  - Time-series prediction
  - Clustering
- How do you formulate problem in this manner?

Pattern Classification

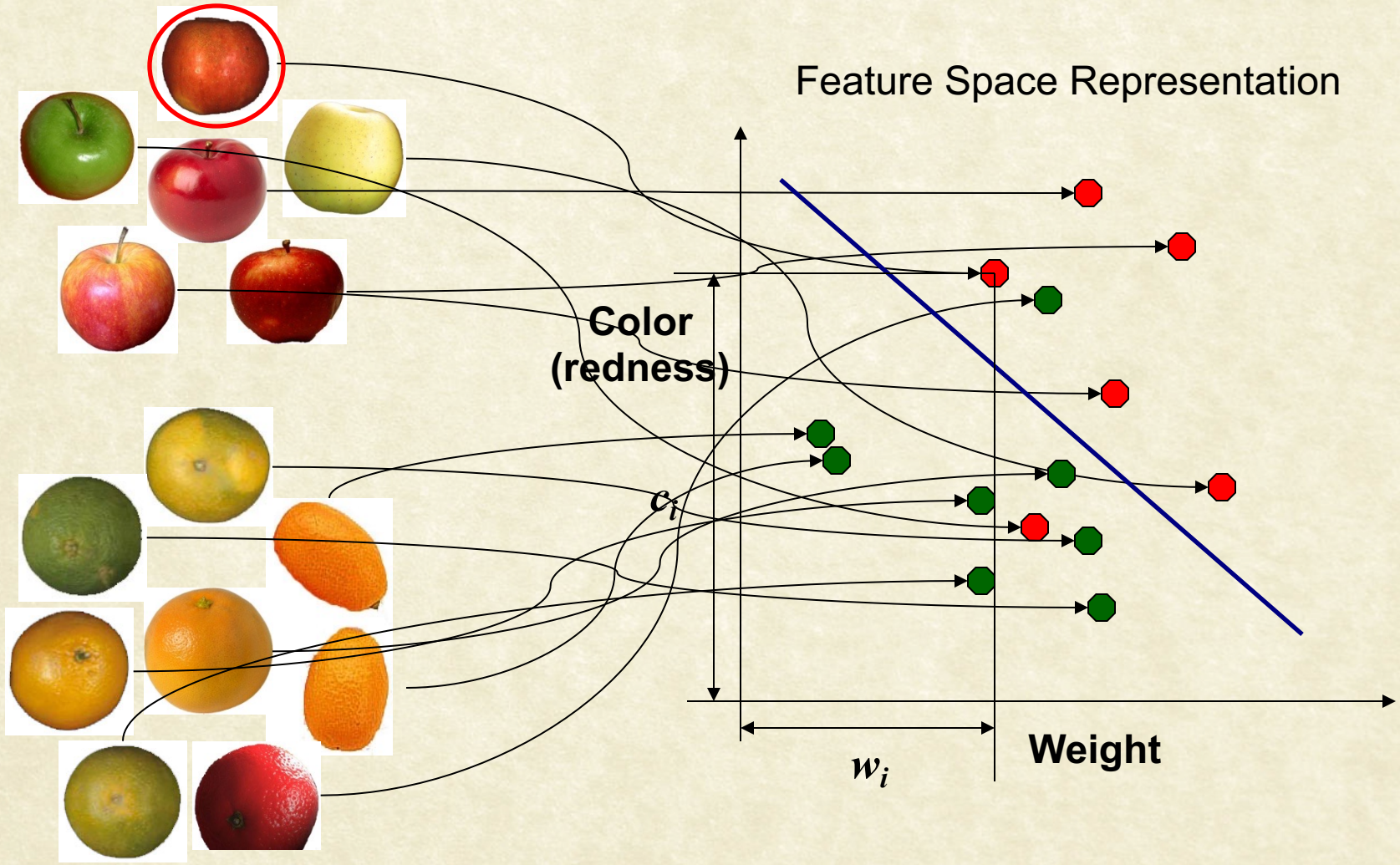
Pattern Classification

- There is too much information in raw data
- Relevant information is hidden
- Feature Extraction: Extract useful information from raw data

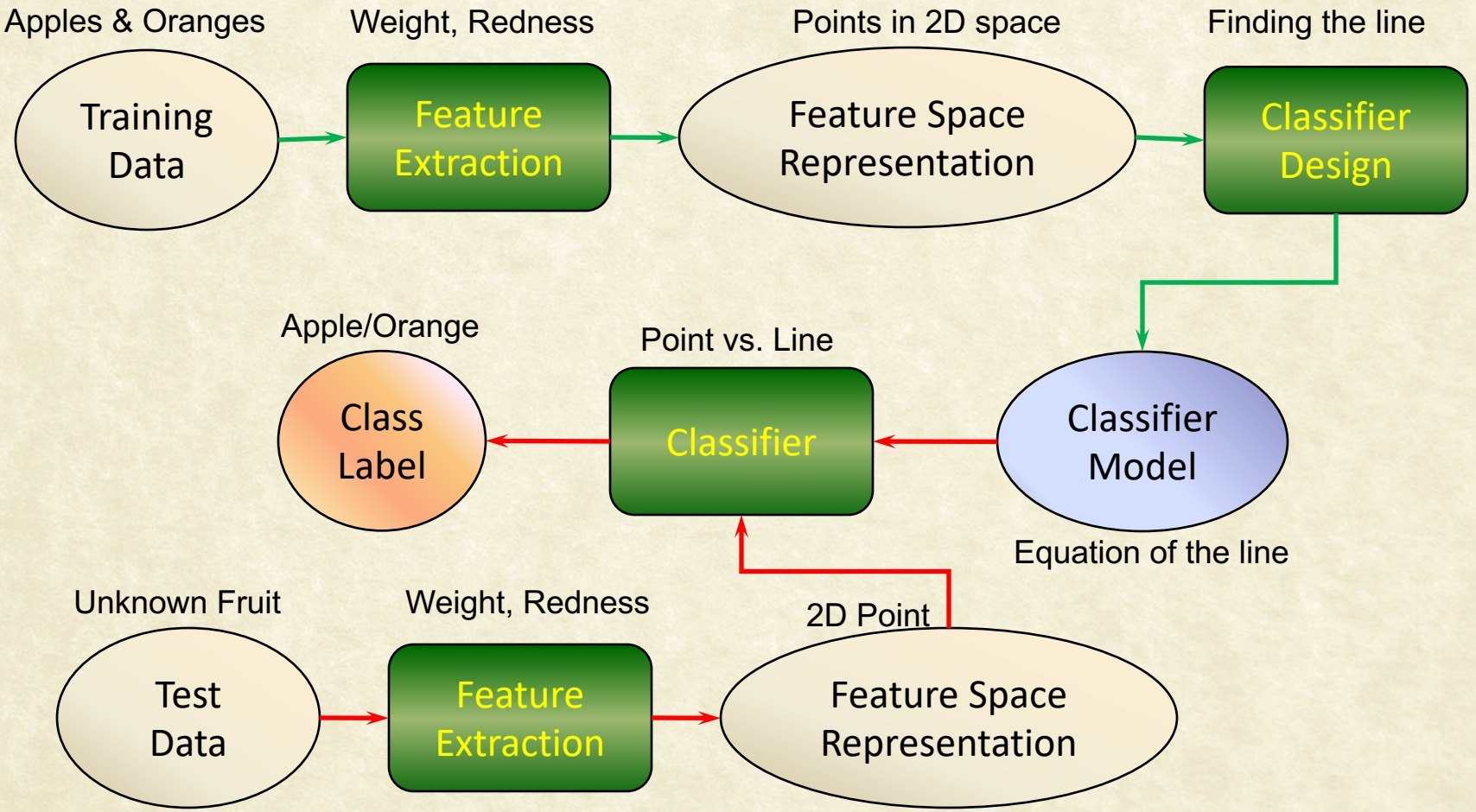
The Pattern Recognition Process



Pattern Representation

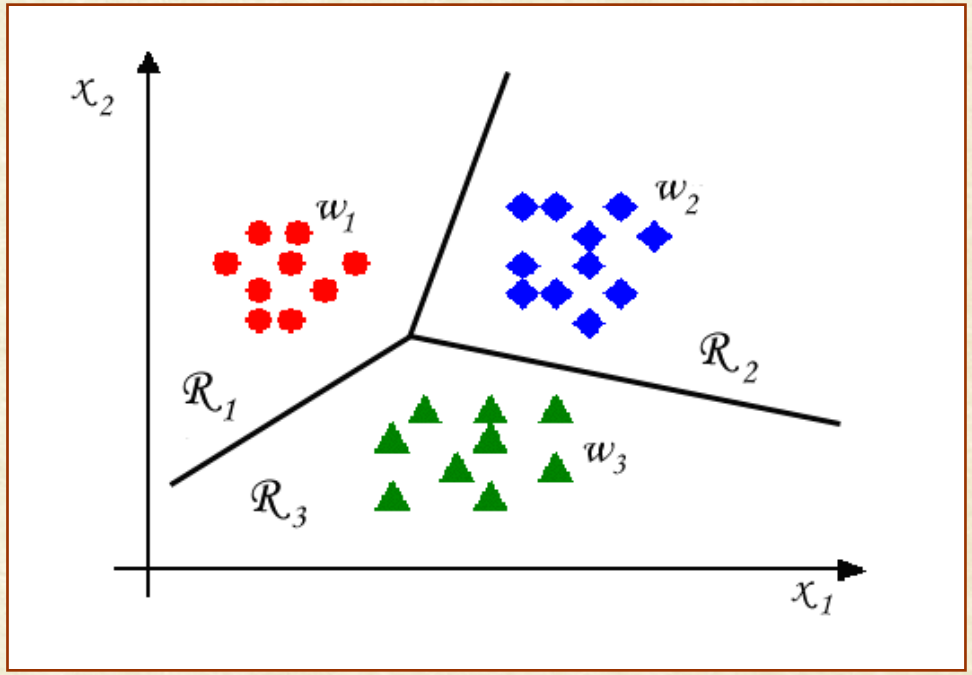


The Pattern Recognition Process



Approaches to Recognition

- Patterns represented in a feature space
  1. Learn a separating boundary between classes
  2. Learn a Statistical model for pattern generation in the feature space



The problem: Given some examples (training samples) from each class, the goal is to construct decision boundaries or a partition of the feature space

Summary

Questions?

- Recognition / Perception is a difficult task
  - Easy for humans
  - Difficult to translate our understanding to code
- Solution: Let the machine learn/generalize from examples
  - How do we represent objects?
  - What features are meaningful?
- How do we distinguish between classes?
  - Find the equation of a separating boundary in the feature space
  - Find a model for each class in the feature space
- Problems in Learning
  - Classification, Regression, Time-series prediction, Clustering