

Lecture 9: Unsupervised Learning and Clustering

INFO 1998: Introduction to Machine Learning



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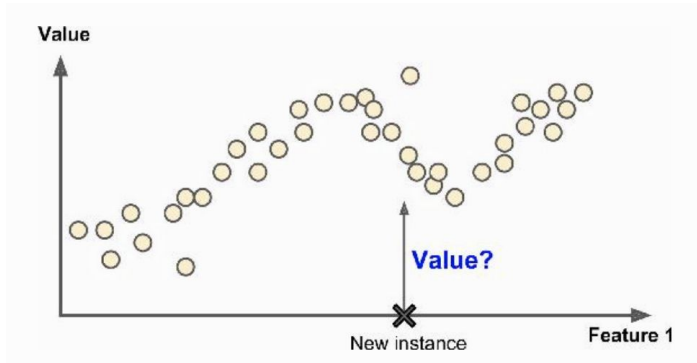
Announcements

- Final project due April 24!

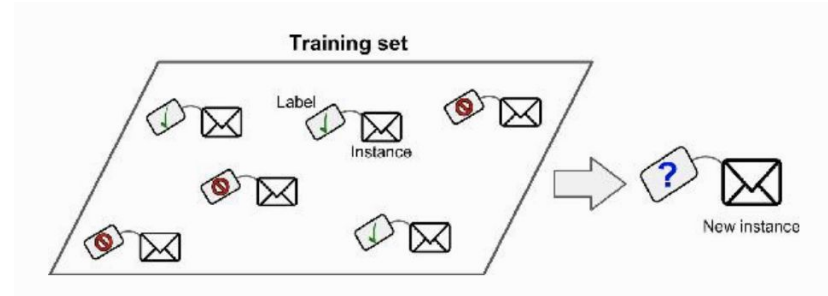


Recap: Supervised Learning

- The training data you feed into your algorithm includes **desired solutions**
- Two types you've seen so far: **regressors and classifiers**
- In both cases, there are definitive “answers” to learn from



Example 1: Regressor
Predicts value



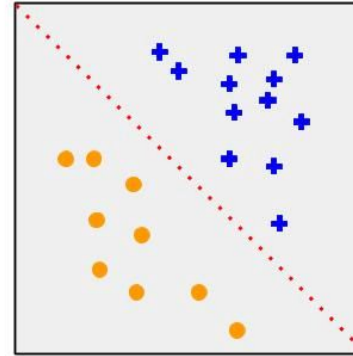
Example 2: Classifier
Predicts label



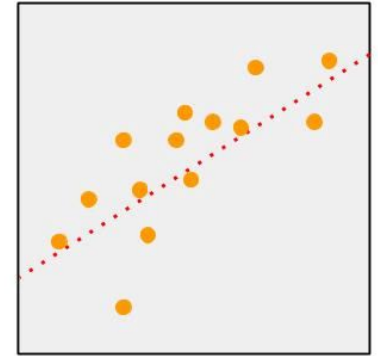
Recap: Supervised Learning

Supervised learning algorithms we have covered so far:

- k-Nearest Neighbors
- Linear Regression
- Logistic Regression
- Perceptron / SVM
- Decision Trees / Random Forest



Classification



Regression

Which of these are classifiers? Which are regressors?

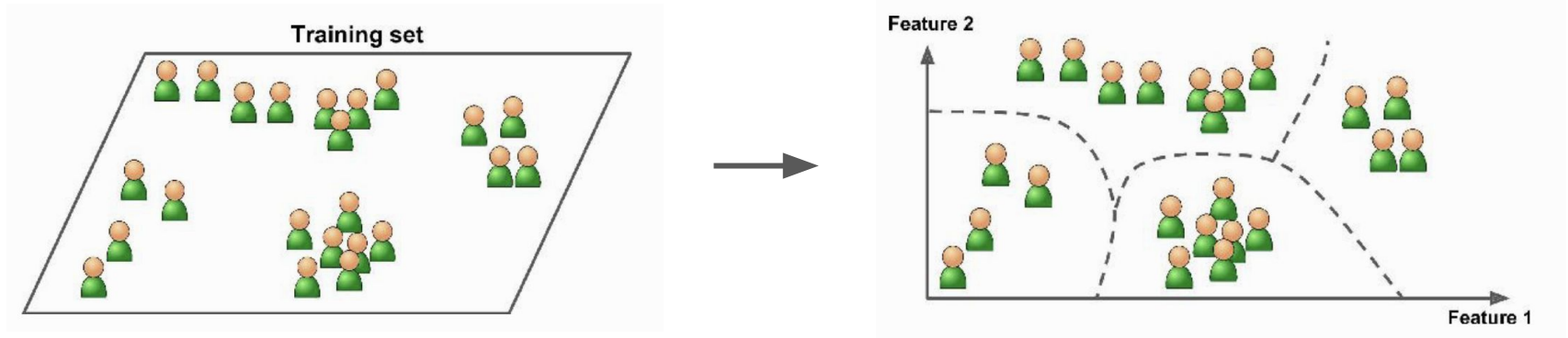


What are some **limitations** of supervised learning?



Today: Unsupervised Learning

- In unsupervised learning, the training data is **unlabeled**
- Algorithm tries to learn by itself



An Example: Clustering



Unsupervised Learning

Some types of unsupervised learning problems:

1

Clustering

k-Means, Hierarchical Cluster Analysis (HCA), Gaussian Mixture Models (GMMs), etc.

2

Dimensionality Reduction

Principal Component Analysis (PCA), Locally Linear Embedding (LLE)

3

Association Rule Learning

Apriori, Eclat, Market Basket Analysis

...

More



Unsupervised Learning

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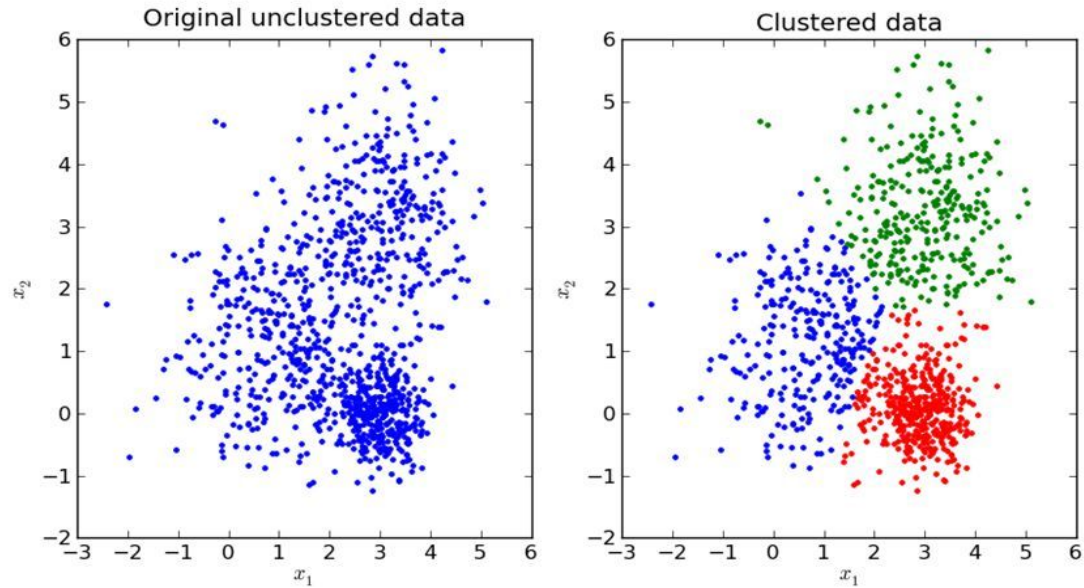


Cluster Analysis

- **Loose definition:** Clusters have objects which are “similar in some way” (and “dissimilar to objects in other clusters)
- Clusters are **latent variables (variables that are unknown)**
- Understanding clusters can:
 - Yield underlying trends in data
 - Supply useful parameters for predictive analysis
 - Helpful exercise, take any arbitrary supervised task, pretend it's unsupervised and work backwards. We can then see based on clustering what features/latent variables cause the trends or classifications



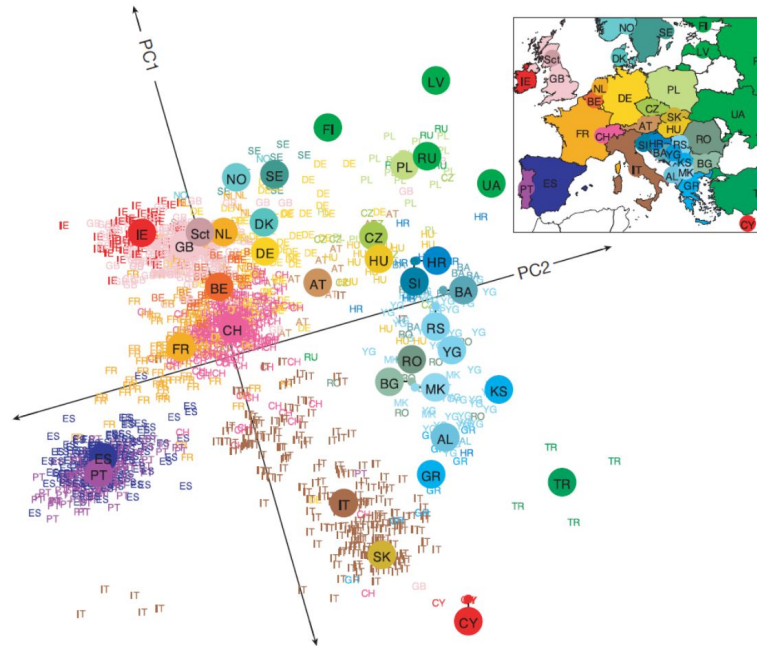
Cluster Analysis



Clustering Application

Finding Population Structure in Genetic Data

From 1,387
European
samples



Clustering Application

Recommender Systems

Intuition: People who are “similar”, will like the same things



A Bunch of Cool Logos



Running Example: Recommender Systems

Use 1: Collaborative Filtering

- “People similar to you also liked X”
- Use other’s rating to suggest content

Pros

If cluster behavior is clear,
can yield good insights

Cons

Computationally expensive

Can lead to dominance of certain
groups in predictions



Running Example: Recommend MOVIES

	Amy	Jef	Mike	Chris	Ken
The Piano	—	—	+		+
Pulp Fiction	—	+	+	—	+
Clueless	+		—	+	—
Cliffhanger	—	—	+	—	+
Fargo	—	+	+	—	+



Running Example: Recommender Systems

Use 2: Content filtering

- “Content similar to what YOU are viewing”
- Use user’s watch history to suggest content

Pros

Recommendations made by learner are intuitive

Scalable

Cons

Limited to existing data about content

Difficult to suggest for new users



Another Example: Cambridge Analytica

- Uses Facebook profiles to build psychological profiles, then use traits for target advertising
- Ex. has personality test measuring openness, conscientiousness, extroversion, agreeableness and neuroticism -> different types of ads



Cambridge
Analytica



How do we actually perform this
“cluster analysis”?



Defining 'Similarity'

- Remember from K Nearest Neighbors Discussion
- How do we calculate proximity of different data points?
- Euclidean distance:

$$E(x, y) = \sqrt{\sum_{i=0}^n (x_i - y_i)^2}$$

- Other distance measures:
 - Squared euclidean distance, manhattan distance



Popular Clustering Algorithms

Hierarchical
Cluster Analysis
(HCA)

k-Means
Clustering

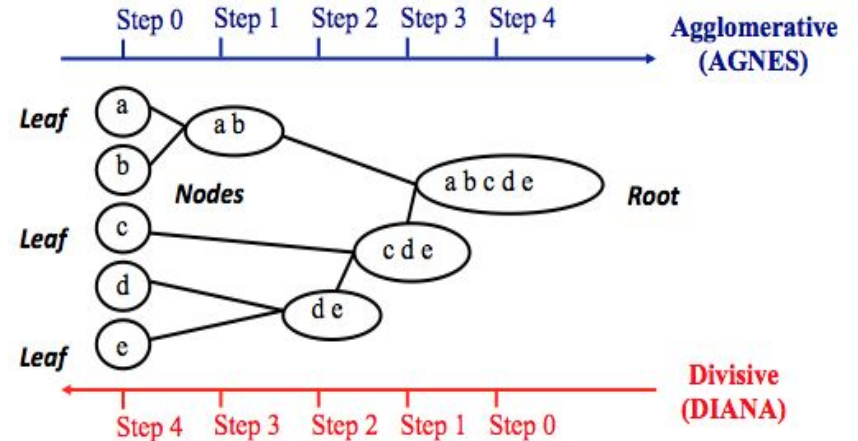
Gaussian
Mixture Models
(GMMs)



Algorithm 1: Hierarchical Clustering

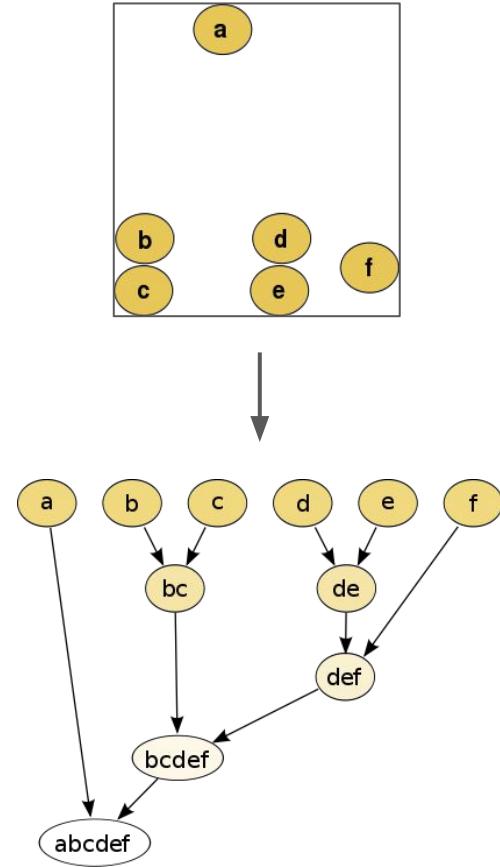
Two types:

- Agglomerative Clustering
 - Creates a tree of **increasingly large** clusters
(*Bottom-up*)
- Divisive Hierarchical Clustering
 - Creates a tree of **increasingly small** clusters
(*Top-down*)



Agglomerative Clustering Algorithm

- Steps:
 - Start with each point in its own cluster
 - Unite adjacent clusters together
 - Repeat
- Creates a tree of **increasingly large** clusters

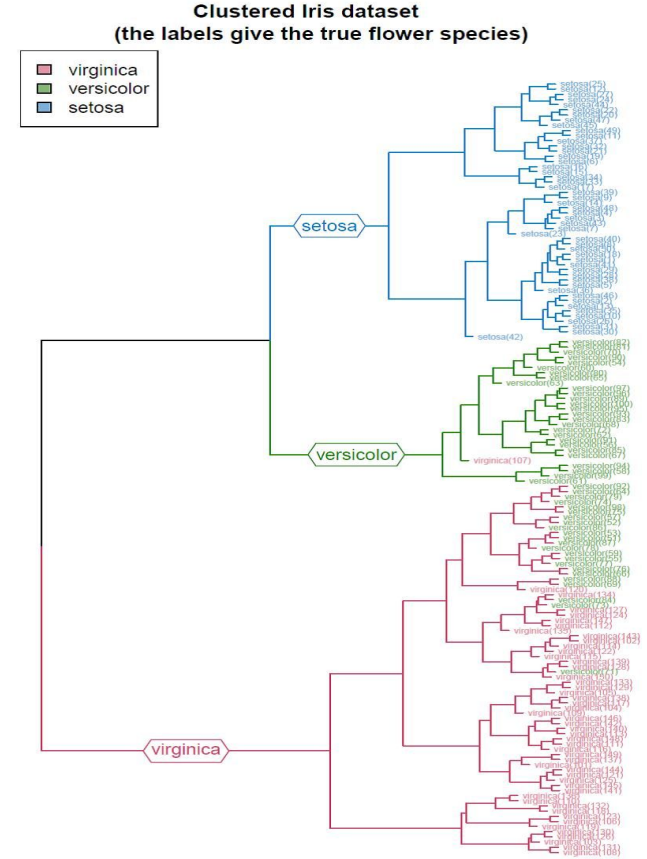


Agglomerative Clustering Algorithm

How do we visualize clustering?

Using **dendrograms**

- Each width represents distance between clusters before joining
- Useful for estimating how many clusters you have



The iris dataset that we all love

Demo 1



Popular Clustering Algorithms

Hierarchical
Cluster Analysis
(HCA)

k-Means
Clustering

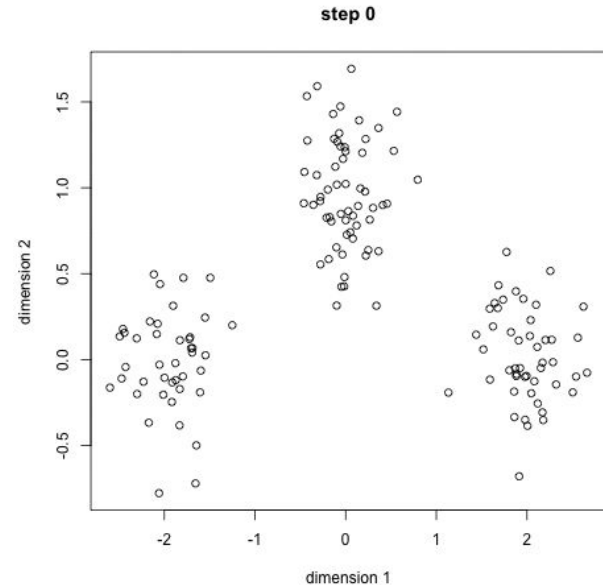
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Algorithm 2: k-Means Clustering

Input parameter: k

- Starts with k random centroids
- Cluster points by calculating distance for each point from centroids
- Take average of clustered points
- Use as new centroids
- Repeat until convergence



Interactive Demo: <https://www.naftaliharris.com/blog/visualizing-k-means-clustering/>



Algorithm 2: k-Means Clustering

- A **greedy** algorithm
- Disadvantages:
 - Initial means are randomly selected which can cause suboptimal partitions
Possible Solution: Try a number of different starting points
 - Depends on the value of k



Demo 2



Popular Clustering Algorithms

Hierarchical
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k-Means
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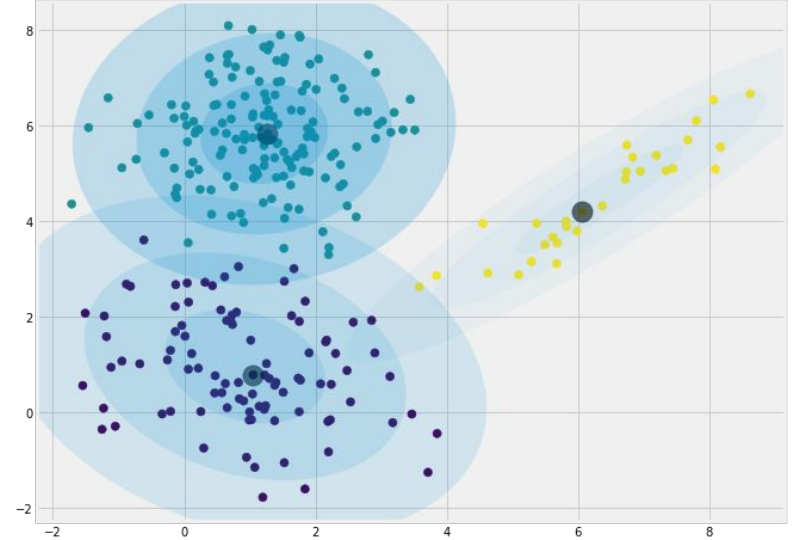
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Algorithm 3: Gaussian Mixture Models

Input parameter: k

- Starts with k Gaussian distributions
- Train on data to find the appropriate means and covariances for each cluster
- Compute probability of each test point lying inside each distribution and predict the one with the highest probability.



Demo 3



Coming Up

- **Assignment 9:**
 - Due next Wednesday, Nov 15th, 11:59PM
- **Last Lecture:**
 - Real-world applications of ML
- **Final Project:**
 - Due Nov 29th, 11:59PM



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