CSCE 636: Deep Learning

Introduction

About the instructor and course

- Associate Professor of Computer Science and Engineering, TAMU
- Research interests: machine learning, deep learning, applications to biology and neuroscience
- Office: HRBB 410C
- Office hours: MW 10:00 am - 11:00 am
- Email: sji@tamu.edu
- Telephone: (979) 458-1547
- Meeting time and location:
  MWF 11:30 am - 12:20 pm,
  Zachry Engineering Ed. Complex 244

Course Description and Prerequisites

- An introduction to the field of deep learning, including basic machine learning, supervised learning, logistic regression, loss functions, neural networks, optimization, error back-propagation, regularization and generalization, convolutional neural networks, recurrent neural networks, generative and adversarial models, applications to natural language processing and computer vision.
- Prerequisites include **basic machine learning** (e.g., supervised learning, linear regression, logistic regression, support vector machines), **linear algebra** (e.g., singular value decomposition), **multivariate calculus, access to GPU, proficiency in Python programming**

Textbook and Resource Material

- Main text:
  Charu C. Aggarwal: Neural Networks and Deep Learning, Springer, September 2018
  https://www.amazon.com/dp/3319944622
  http://www.charuaggarwal.net/neural.htm
  https://rd.springer.com/book/10.1007/978-3-319-94463-0
- Additional materials:

1. YS Abu-Mostafa, M Magdon-Ismail, HT Lin: Learning from Data, only Chapters 3 and 7
   http://amlbook.com/
   https://www.amazon.com/Learning-Data-Yaser-S-Abu-Mostafa/dp/1600490069
2. Aston Zhang, Zack C. Lipton, Mu Li, Alex J. Smola
   Dive into Deep Learning
   https://www.d2l.ai/

Grading Policies

- Homework (4): 40%: There will be four homework assignments containing both written and programming components.
- Exam (2): 35%: There will be two exams covering the foundations of neural networks and deep learning. Exam 1 will be 15% and final exam will be 20%.
  Final exam schedule: Wednesday, December 11, 2019, 10:30 a.m. – 12:30 p.m.
- Project (1): 25%: There will be one semester-long, team project. Students are required to form teams of 2-3 students and carry out a project related to deep learning and applications to computer vision or natural language processing. Example projects include (1) implementation and comparison of several existing methods on benchmark data sets and gain some insights, (2) extension of existing methods by incorporating more functions and features, (3) improvements to current models and algorithms with experimental evaluation. The minimal requirement is that each project must have an experimental section with results.

More on project

- Most deep learning code requires GPU, thus students are required to have access to GPU.
- Project milestones are as follows:
- Project proposal: Each team is required to discuss their project proposal with the instructor and submit a one-page proposal.
- Mid-term report: Each team is required to submit a mid-term report of 3 pages to report the results of project. Preliminary experimental results and plan for the remaining parts of the project are required.
- Final report and presentation: At the end of semester, each team will be asked to submit a report (minimum of 6 pages excluding references) and do a presentation on their research project. The presentation should be done by all team members and the contributions of each team member should be made clear in both presentation and in report.
- Example projects from Stanford Deep Learning classes can be found at:

  http://cs231n.stanford.edu/project.html

Late Policies

- For homework assignment, 25% is deducted for each late day for up to three days (including weekends) after which submissions are not accepted. Late project reports will not be accepted.
- Student rule 7 on attendance:

https://student-rules.tamu.edu/rule07/

Grading continued

- Final letter grades will be based on absolute percentage as follows*:*

  A = 90-100

  B = 80-89

  C = 70-79

  D = 60-69

  F = <60

The university states that an **<u>Incomplete</u>** can only be given when the student has completed the course with the exception of a major quiz, final exam, or single major assignment. Instructors should only give this grade when the deficiency is due to an approved university excused absence (see Student Rule 10.6).

Academic integrity

- All homework assignments are individual and collaboration among students is strictly prohibited.
- Project reports should be treated as scientific publications, and all rules governing paper-writing apply.
- Plagiarism: copy of one complete sentence, including copy from yourself

Class topics (subject to change)

Week	Topic	Required Reading
1	Introduction to machine learning	Chapter 1
2	Introduction to deep learning	Chapter 1
3	Loss functions and shallow models	Chapter 2
4	Loss functions and shallow models	Chapter 2, Project proposal due
5	Training and optimization	Chapter 3
6	Training and optimization	Chapter 3
7	Regularization and generalization	Chapter 4, Exam 1
8	Regularization and generalization	Chapter 4, Project mid-term report due
9	Convolutional neural networks	Chapter 8
10	Convolutional neural networks	Chapter 8
11	Recurrent neural networks	Chapter 7
12	Advanced topics	Chapter 10
13	Project presentation	
14	Project presentation	Project final report due

eCampus/Blackboard

- Syllabus is available on eCampus
- Slides, notes etc., will be on eCapmus
- HW on eCampus, email reminders
- Check eCampus regularly
- No hardcopy handouts for this class

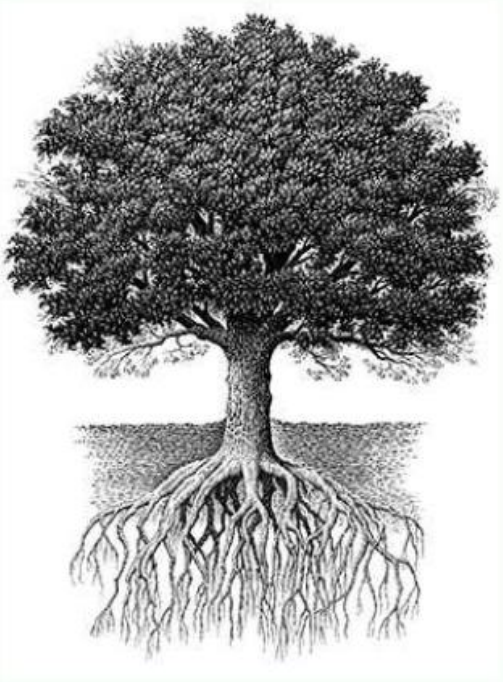
Human versus machine intelligence

- 213621.36521*142513.54/1254.3215

Let's *Define* a Tree?

A brown *trunk* moving upwards and *branching* with *leaves* ...

Defining is Hard; Recognizing is Easy



Hard to give a complete mathematical definition of a tree.

Even a 3 year old can tell a tree from a non-tree.

The 3 year old has learned from data.

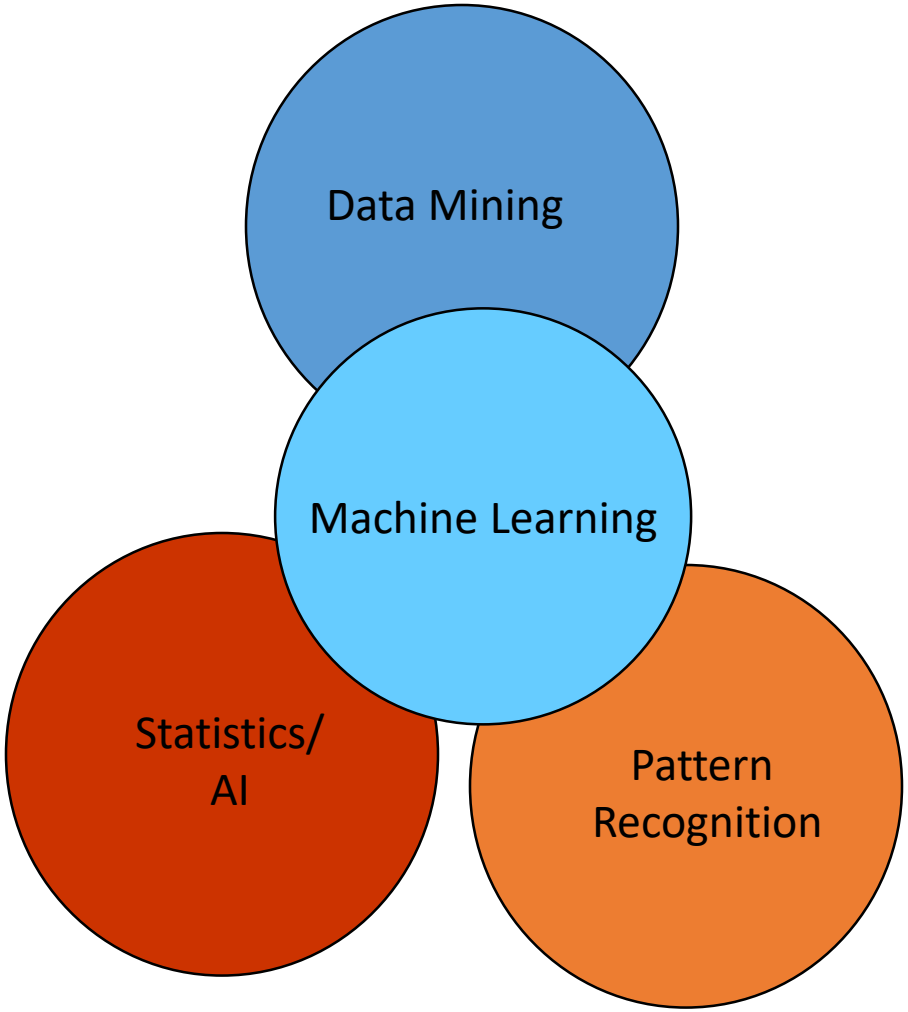
What is Machine Learning?

- The goal of the field of machine learning is to build computer systems that learn from experience and that are capable to adapt to their environments.
- Learning techniques and methods developed in this field have been successfully applied to a variety of applications, including text classification, gene/protein function prediction, financial forecasting, credit card fraud detection, collaborative filtering, digit/face recognition.

Machine Learning Applications

- Computer vision, natural language processing, search engines, medical diagnosis, bioinformatics, detecting credit card fraud, stock market analysis, speech and handwriting recognition, software engineering, robot locomotion.

Related Fields



Machine Learning Tasks

- Supervised learning: (x, y)
  - Classification
  - Regression
- Unsupervised learning
  - Clustering
  - Density estimation
  - Visualization (dimensionality reduction)
- Semi-supervised learning
- …

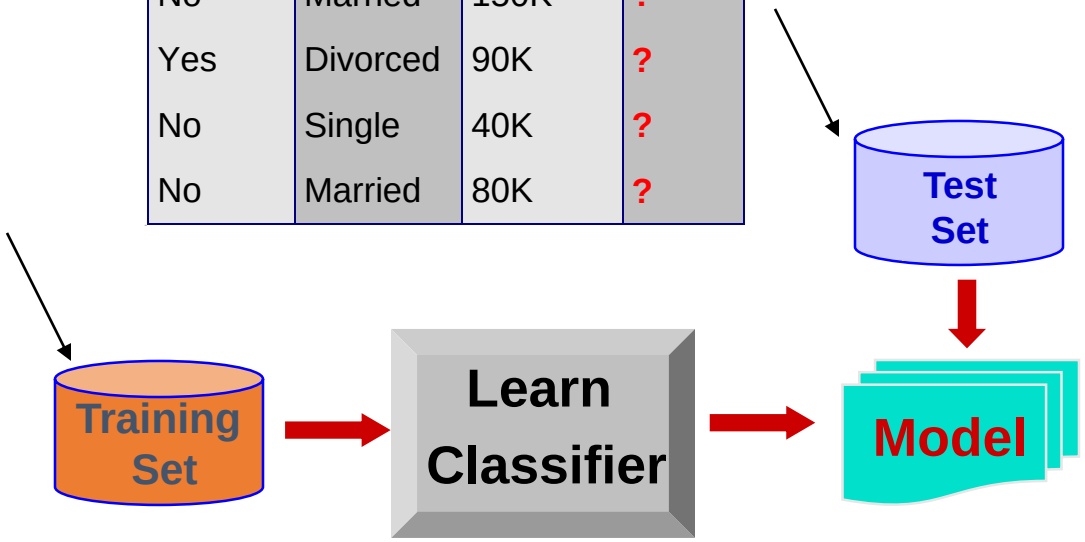
Classification: Definition

- Given a collection of records (*training set*)
  - Each record contains a set of *attributes*, one of the attributes is the *class*.
- Find a *model* for class attribute as a function of the values of other attributes.
- Goal: previously unseen records should be assigned a class as accurately as possible.
  - A *test set* is used to determine the accuracy of the model. Usually, the given data set is divided into training and test sets, with training set used to build the model and test set used to validate it.

Classification Example

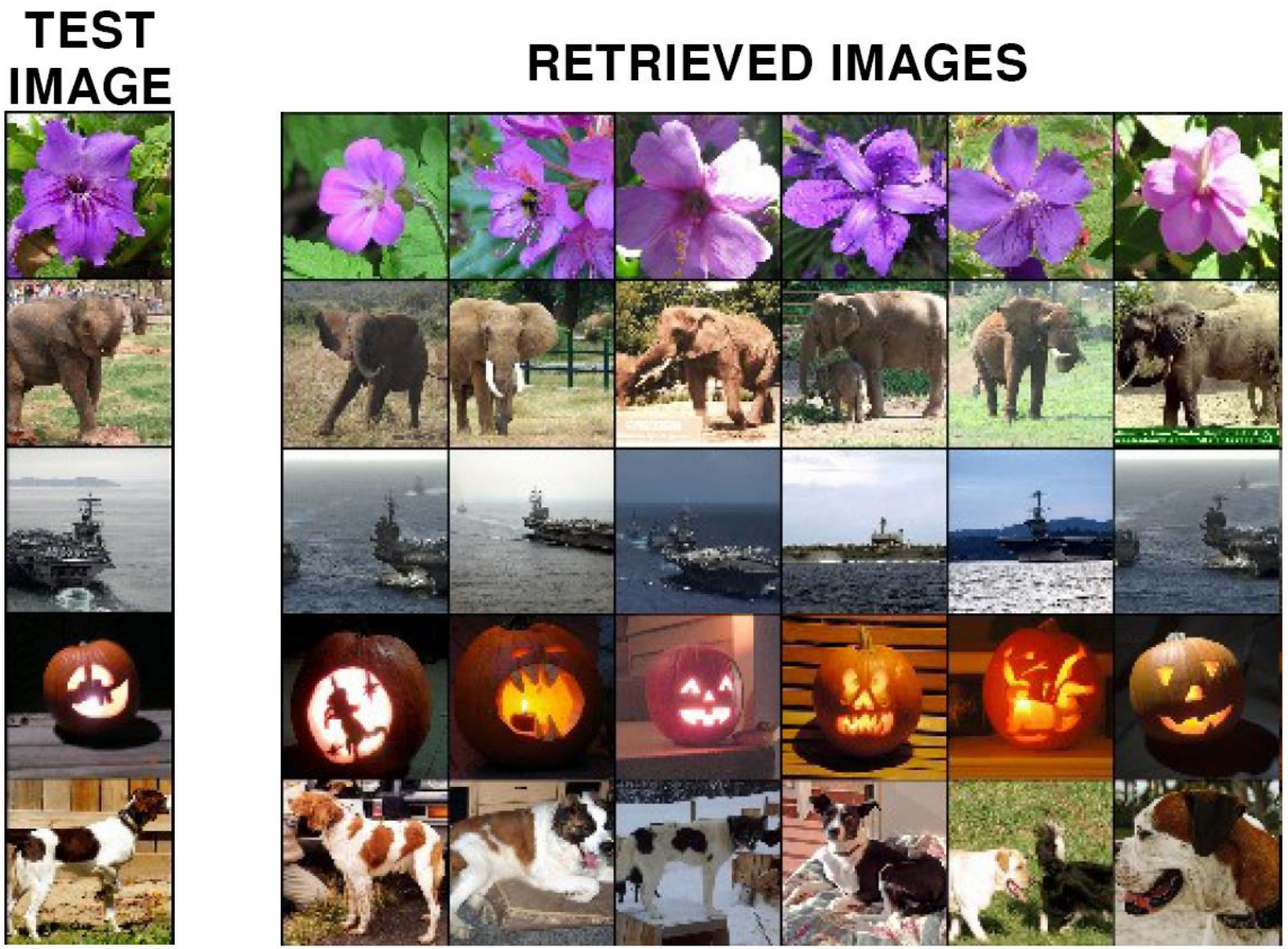
Tid	Refund (categorical)	Marital Status (categorical)	Taxable Income (continuous)	Cheat (class)
1	Yes	Single	125K	No
2	No	Married	100K	No
3	No	Single	70K	No
4	Yes	Married	120K	No
5	No	Divorced	95K	Yes
6	No	Married	60K	No
7	Yes	Divorced	220K	No
8	No	Single	85K	Yes
9	No	Married	75K	No
10	No	Single	90K	Yes

Refund	Marital Status	Taxable Income	Cheat
No	Single	75K	?
Yes	Married	50K	?
No	Married	150K	?
Yes	Divorced	90K	?
No	Single	40K	?
No	Married	80K	?

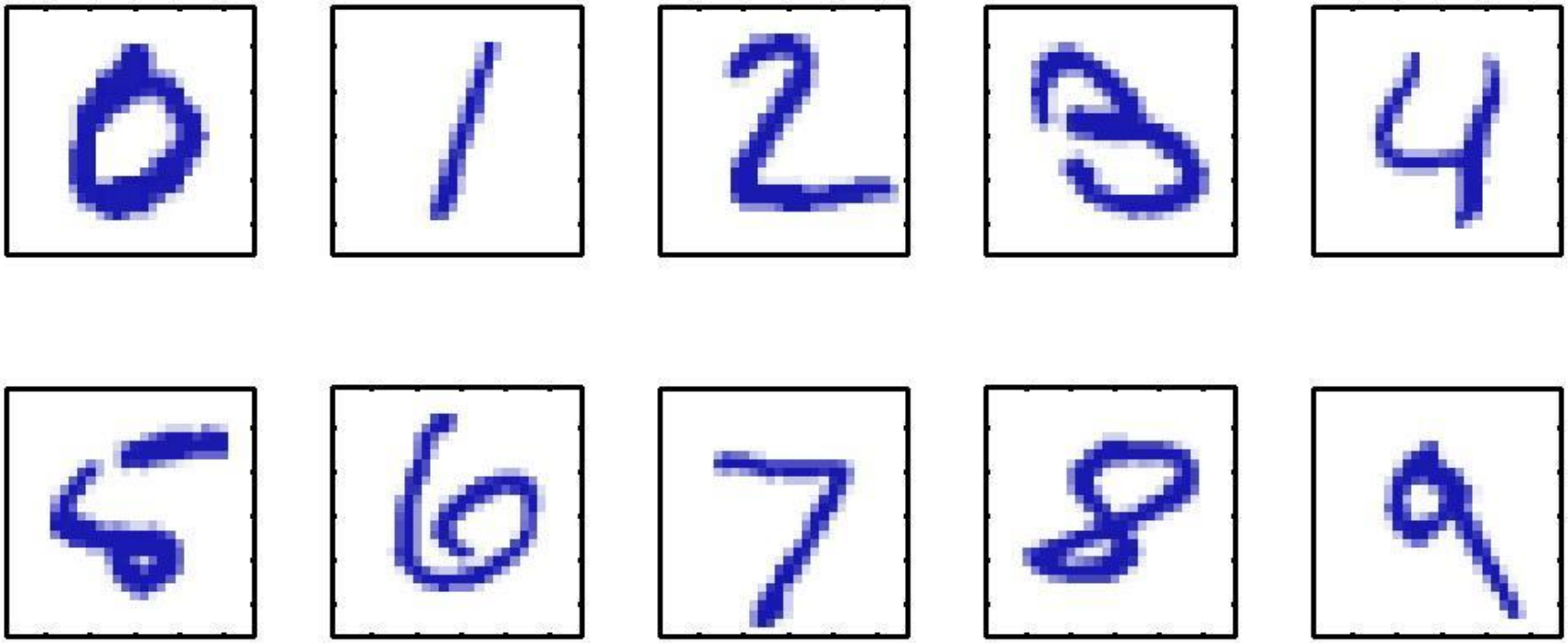


Face/pedestrian detection

Image retrieval

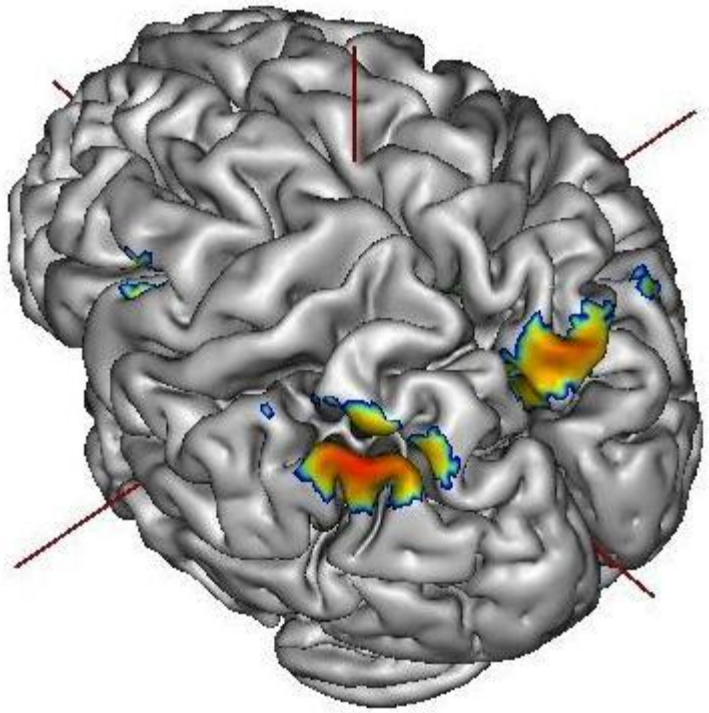


Handwritten Digit Recognition



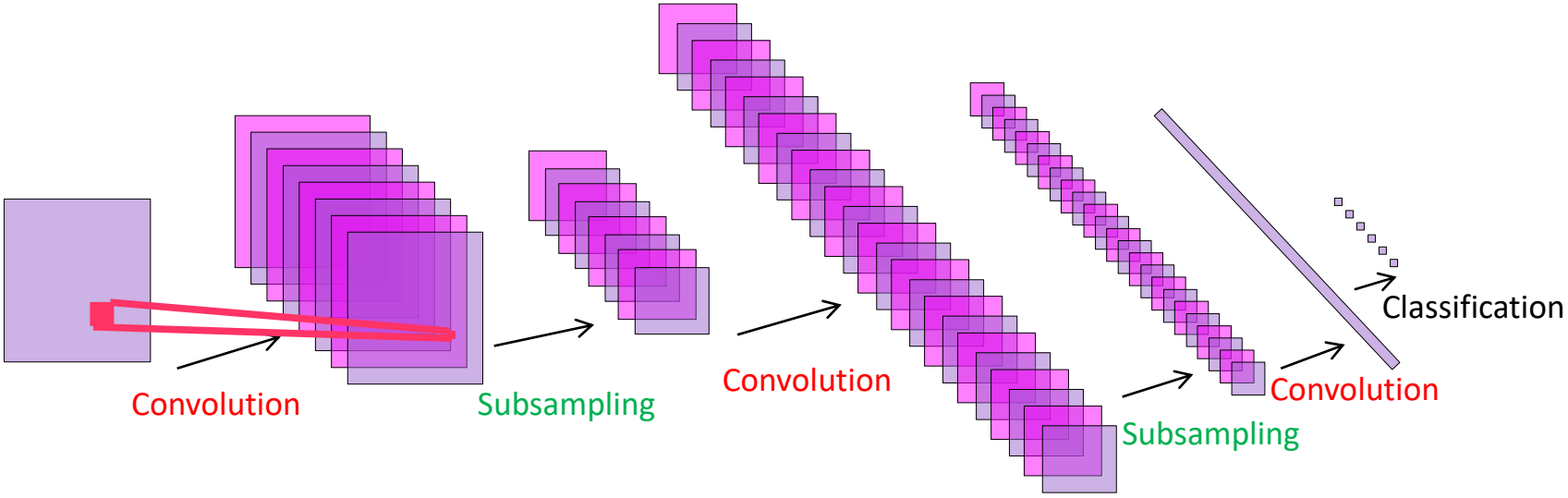
Medical informatics

- Alzheimer's Disease Detection
  - Goal: To predict class (AD or normal) of a sample (person), based on neuroimaging data such as MRI and PET



Reduced gray matter volume (colored areas) detected by MRI voxel-based morphometry in AD patients compared to normal healthy controls.

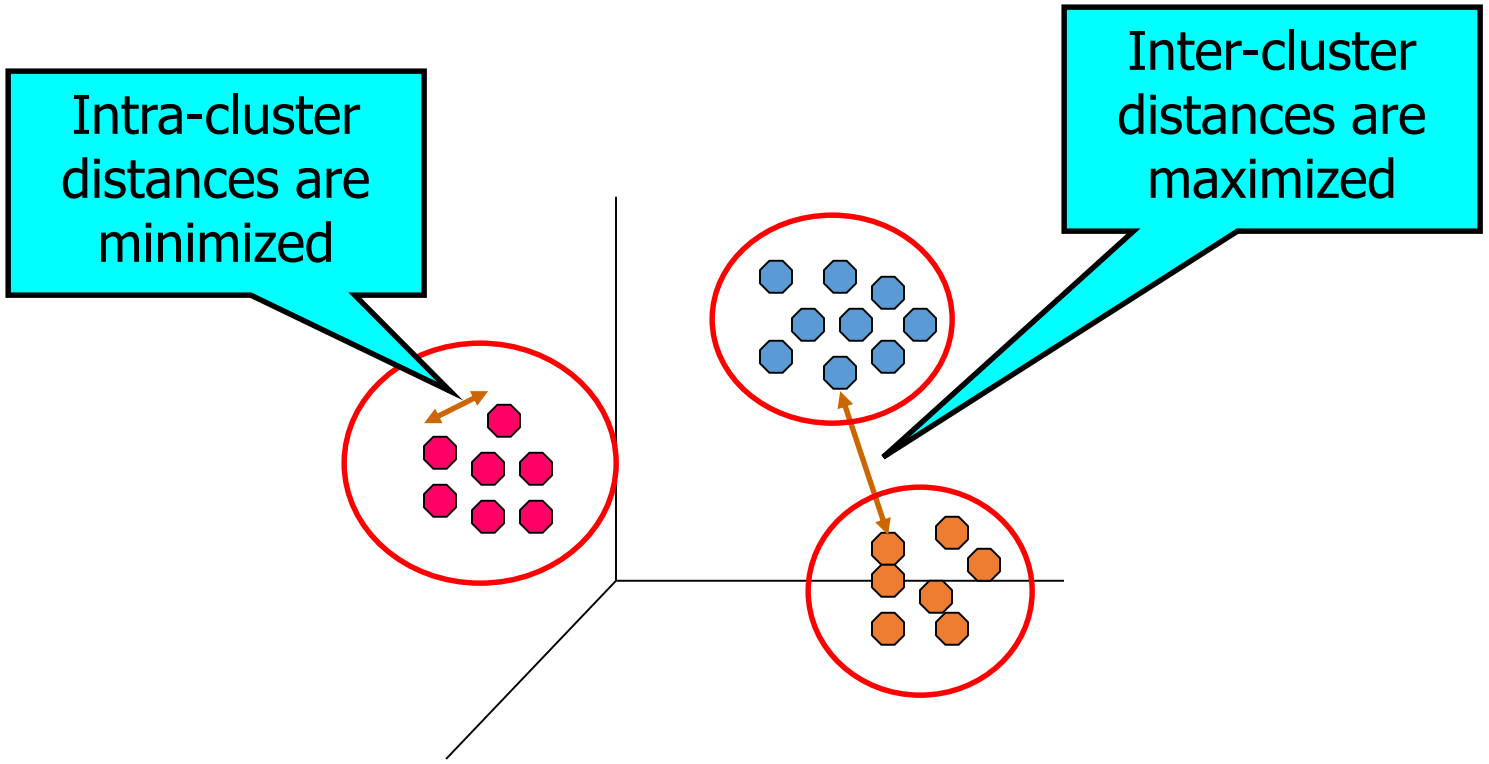
Deep learning



Clustering Definition

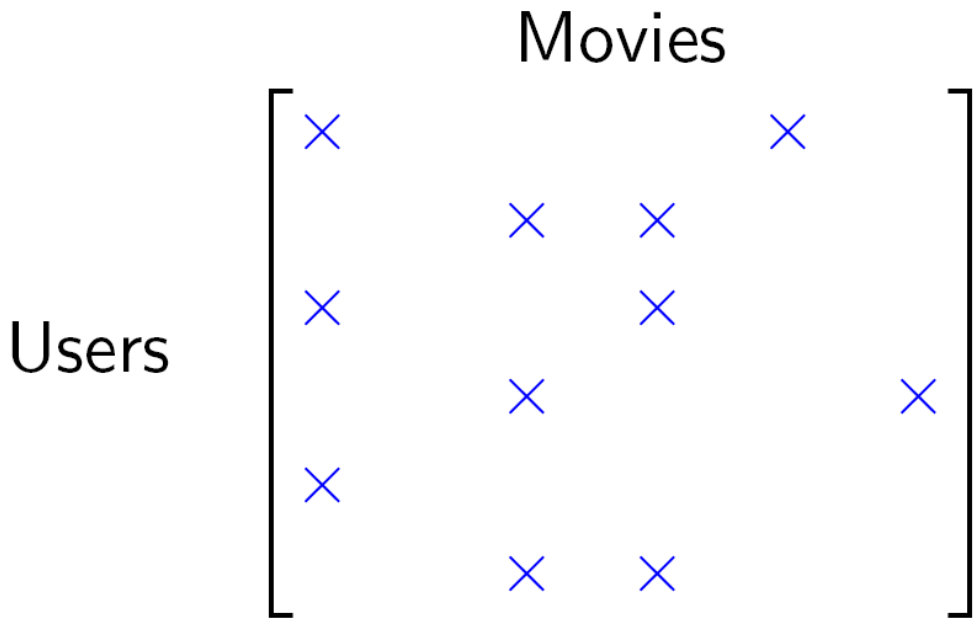
- Given a set of data points, each having a set of attributes, and a similarity measure among them, find clusters such that
  - Data points in one cluster are more similar to one another.
  - Data points in separate clusters are less similar to one another.
- Similarity Measures:
  - Euclidean Distance if attributes are continuous.
  - Other Problem-specific Measures.

Illustrating Clustering



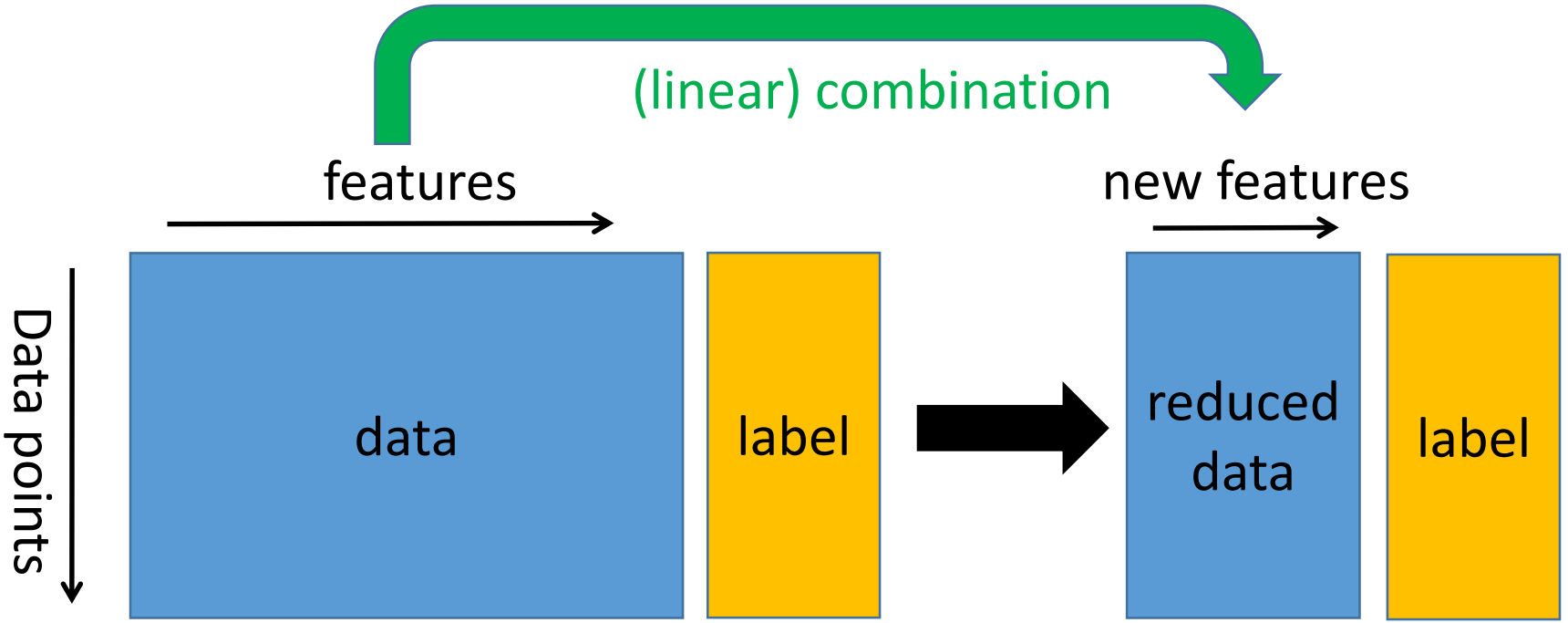
Collaborative Filtering

- Netflix database
  - About a million users
  - About 25,000 movies
- People rate movies
- Sparsely sampled entries



What is Dimensionality Reduction

- Dimensionality reduction extracts a small number of features by removing irrelevant, redundant, and noisy information
- Different from feature selection



Dimensionality Reduction Algorithms

- Supervised:
  - Linear discriminant analysis (LDA)
  - Canonical correlation analysis (CCA)
  - Partial least squares (PLS)
- Unsupervised:
  - Principal component analysis (PCA)