CS 5806 Machine Learning II

Lecture 1 - Course Introduction
August 21st, 2023
Hoda Eldardiry

Outline

- Introduction to Machine Learning

- Course Logistics

Instructor

- Hoda Eldardiry
- 15+ years of experience in ML
- https://people.cs.vt.edu/hdardiry/

Teaching Assistants

Vasanth Reddy Baddam

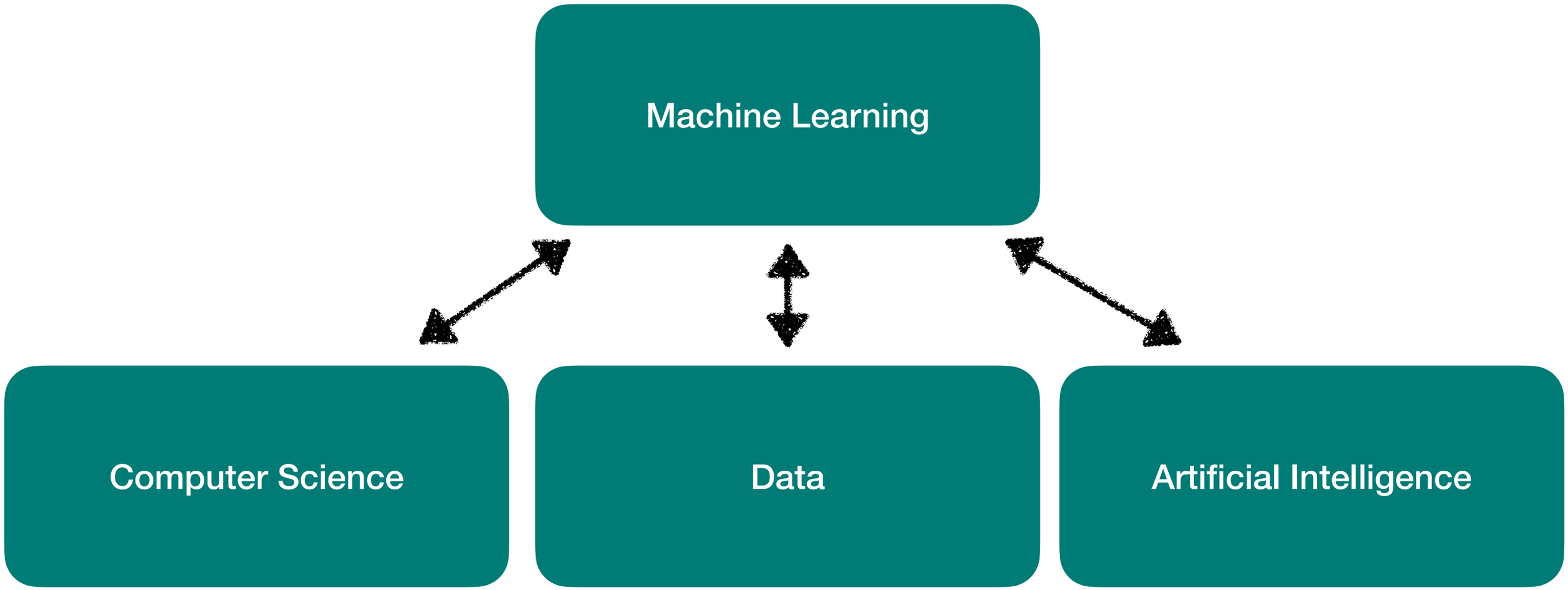
Jiaying Gong

What is Machine Learning?

- **What is Machine Learning?**

- **What are some applications of Machine Learning?**

Connection & Comparison



Computer Science & Machine Learning

- Traditional computer science
  - Program computer for every task

- New paradigm
  - Provide examples to machine
  - Machine learns to accomplish a task based on the examples

- Machine learning*
  - Gives computers the ability to learn without being explicitly programmed

* Definition by Arthur Samuel (1959)

Data & Machine Learning

- Machine Learning is the study of algorithms that
  - Learn from large quantities of data
  - Identify patterns
  - Make predictions on new instances

Artificial Intelligence & Machine Learning

- AI goal - develop intelligent machines

- Subgoals to achieve human intelligence
  - Perception
  - Reasoning
  - Control / Motion / Manipulation
  - Planning
  - Communication
  - Creativity
  - **Learning**

LEARNING to do what …?

Learning to ..	AI/ML Field
Recognize spoken words	Speech Recognition
Drive an autonomous vehicle	Robotics
Play games	Games / Reasoning
Recognize images	Computer Vision

From data to knowledge

DATA

- **Data exists in many domains:**
  Computer Science
  Social Science
  Economics
  Medicine
  Bioinformatics

- **Example datasets:**
  WWW
  Social networks
  Biological networks
  Communication networks
  Transportation networks
  Energy grids
  Knowledge graphs
  Social media
  Finance data
  Citation data
  Marketing data
  Molecular structures

KNOWLEDGE

- Useful insights can be derived from data

- Complex data characteristics pose challenges for effective learning:
  — Multimodal
  — Multi-relational
  — Dynamic
  — Large
  — Noise

ML big picture

- Learning paradigms - data? form of prediction?
- Problem formulation - structure of output prediction?
- Theoretical foundations - what principles guide learning?
- Facets of building ML systems - how to build systems?
- Big ideas in ML - ideas driving development in ML?
- Applications of ML - key challenges?

Learning paradigms

- **What data is available and when? What form of prediction?**

Technique	Brief description
Supervised learning	Learn from data and labeled examples
Unsupervised learning	Learn from data
Semisupervised learning	Learn from labeled examples and data
Reinforcement learning	Learn from trial and error
Active learning	Learn which examples to learn from
Ensemble learning	Learn from multiple models
Online learning	Learn in real-time - dynamically adapt to new data
Recommender systems	Predict user rating or preference of items - learn from user info, item info, similar users
Feature learning	Learn features from data - features are then used to learn from data
Hyperparameter optimization	Tuning - choosing optimal parameters that control the learning process

Problem formulation

Structure of output prediction	Problem formulation
Boolean	Binary Classification
Categorical	Multi-class Classification
Ordinal	Ordinal Classification
Real	Regression
Ordering	Ranking
Multiple discrete	Structured Prediction
Multiple continuous	E.g. dynamical systems
Both discrete & continuous	E.g. mixed graphical models

Theoretical foundations

- What principles guide learning?
    - Probabilistic
    - Information theoretic
    - Evolutionary search
    - ML as optimization

Facets of building ML systems

- How to build systems that are ***robust, efficient, adaptive, effective***?

  - Data preparation
  - Model selection
  - Training (optimization / search)
  - Hyperparameter tuning on validation data
  - (Blind) Assessment on test data

Big ideas in ML

- What are the **ideas** driving **development** of the field?
  - Inductive bias
  - Generalization / overfitting
  - Bias-variance decomposition
  - Generative vs. discriminative
  - Deep nets, graphical models
  - PAC learning
  - Distant rewards

Applications of ML

- Key challenges..

  - **Natural Language Processing (NLP)**
    – Machine translation, question answering, dialog systems

  - **Speech recognition**
    – Siri, Cortana

  - **Computer Vision**
    – Image and video analysis

  - **Robotic Control**
    – Autonomous vehicles

  - **Intelligent assistants**
    – Activity recognition, recommender systems

  - **Computational finance**
    — Stock trading, portfolio optimization

Course Logistics

- Please review our canvas site

  - Syllabus
    - Prerequisites
    - Course Schedule (2 Midterms)
    - Project: post your topic of interest on our teaming googlesheet

  - Discussions
    - Join our “Introduction” discussion
    - Post a response! Tell us about you!
    - Read posts to learn about your peers
    - Leave a response for your peers
    - Find mutual interest to team up on the final project