AI Course Notes

Finley Holt

2025-12-24

Table of contents

1 Lecture 1: Overview

For questions about course content, email learnAI@ll.mit.edu

1.1 Introduction to Machine Learning

Artificial Intelligence — machines or computers that mimic human intelligence through behaviors which are typically associated with cognitive functions such as learning and problem solving.

- Narrow AI replicate human intelligence on specific tasks or in a limited environment
- Machine learning is a family of algorithms that perform tasks without needing the algorithm to be explicitly programmed by a human. Instead, the decisions of the algorithm are governed by rules that are data driven
- Three main types: supervised, unsupervised, reinforcement

1.2 Supervised Machine Learning

Good for when you have large amounts of labeled data that precisely represents what you want to learn.

- **Classification** — find a decision boundary in order to predict discrete class labels
- **Regression** — find a "best fit" function in order to predict continuous values

1.3 Building a Machine Learning Pipeline

Machine learning is a tool.

Gathering and Preparing Your Data:

- What problem am I trying to solve?
- Is ML even the right tool?
- What data do I need?
- Do I have access to it?

1) Extract features
2) Convert to numeric values
3) Normalize

- Data Split
  - Split data into 3 sets: *Training: data used to train the model
    - Validation: data used to iteratively evalutate and improve the model
    - Testing: data used to evaluate the final model (hold out – never use to train!)
- Selecting a model is an art and a science
  - Choose a model type
    - Nearest neighbor
    - Decision tree
    - Support vector machine (SVM)
    - Random forest
    - Neural network
    - …
  - Choose model parameters
    - Initial weights, hyperparameters
    - Size, depth, # neurons, # neighbors, …
    - Learning rate, loss function, …
    - …
  - Model Validation
    - Validation is used to iteratively evaluate the performance of a trained machine learning model when applied to "new" data.
    - There are lots of evaluation metrics.
    - Training and validation errors can point to whether or model is under-fitting, has an appropriate fit, or is over-fitting.

2 Lecture 2: Data Requirements and Conditioning

2.1 Key Questions

- When organizing data, what is the most effective format and why?
- How do missing data affect downstream processing and results?
- How may unbalanced data cause unintended bias?
- What is the value of outliers in a dataset?

2.2 Data Requirements and Data Conditioning

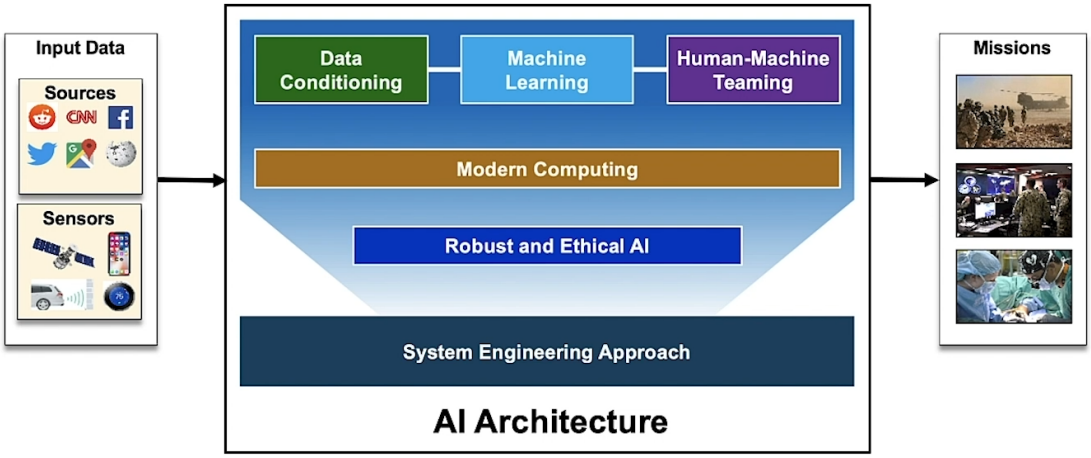

Figure 1: AI System Architecture

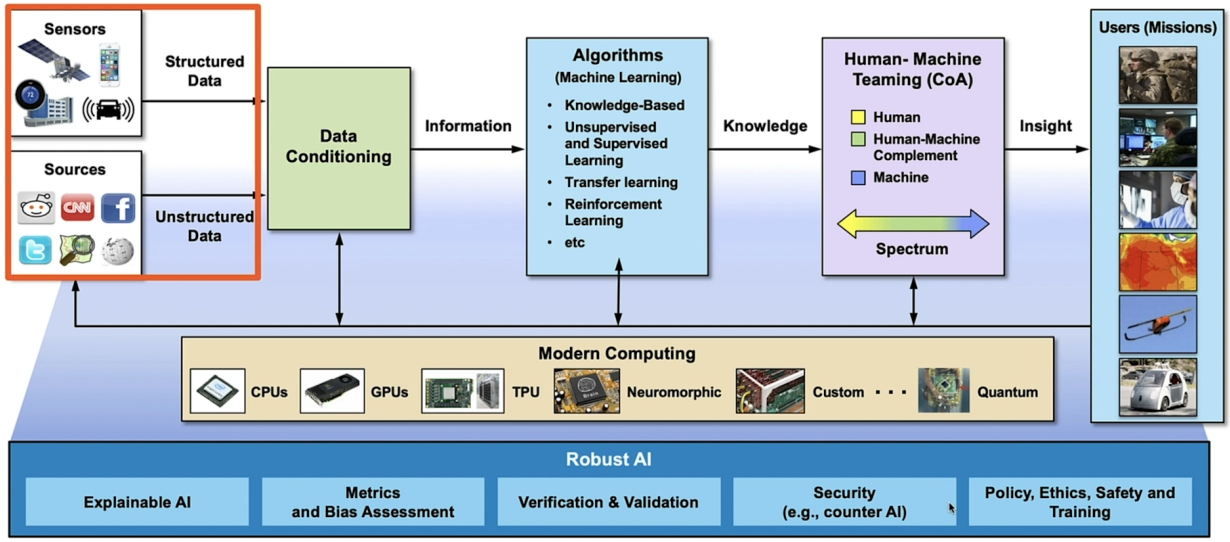

Figure 2: AI Canonical Architecture

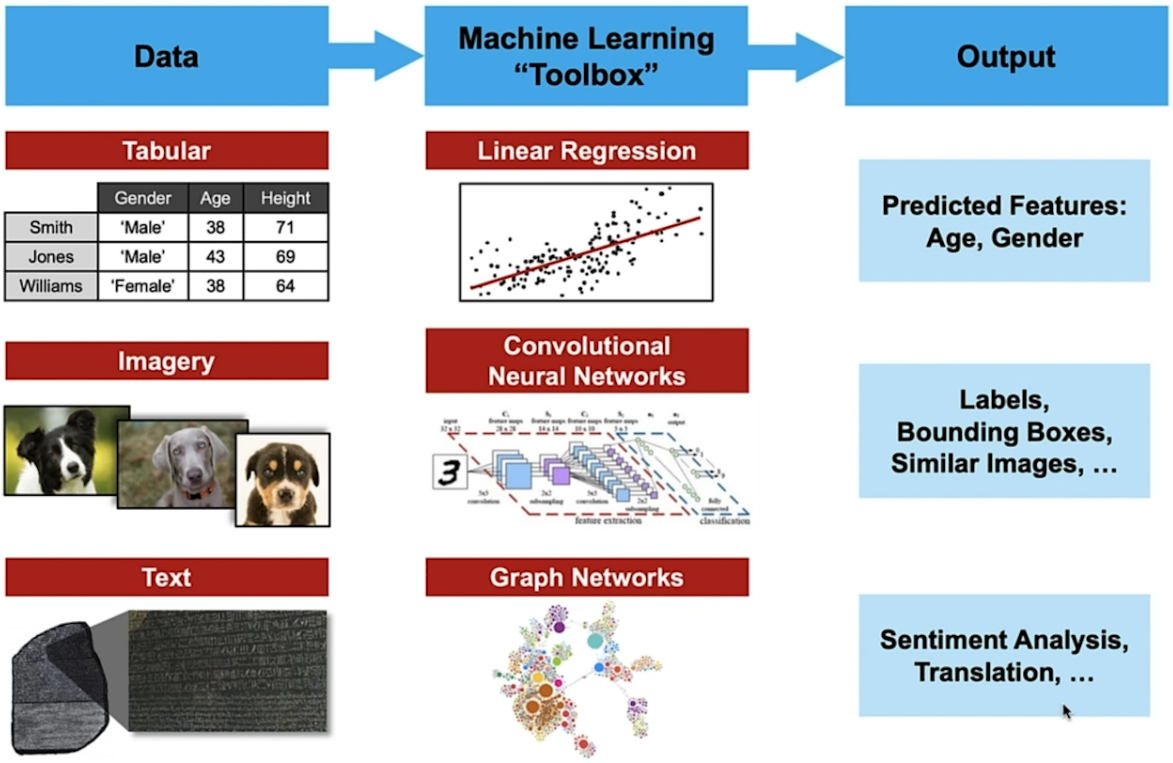

Figure 3: Data Requirements for Machine Learning

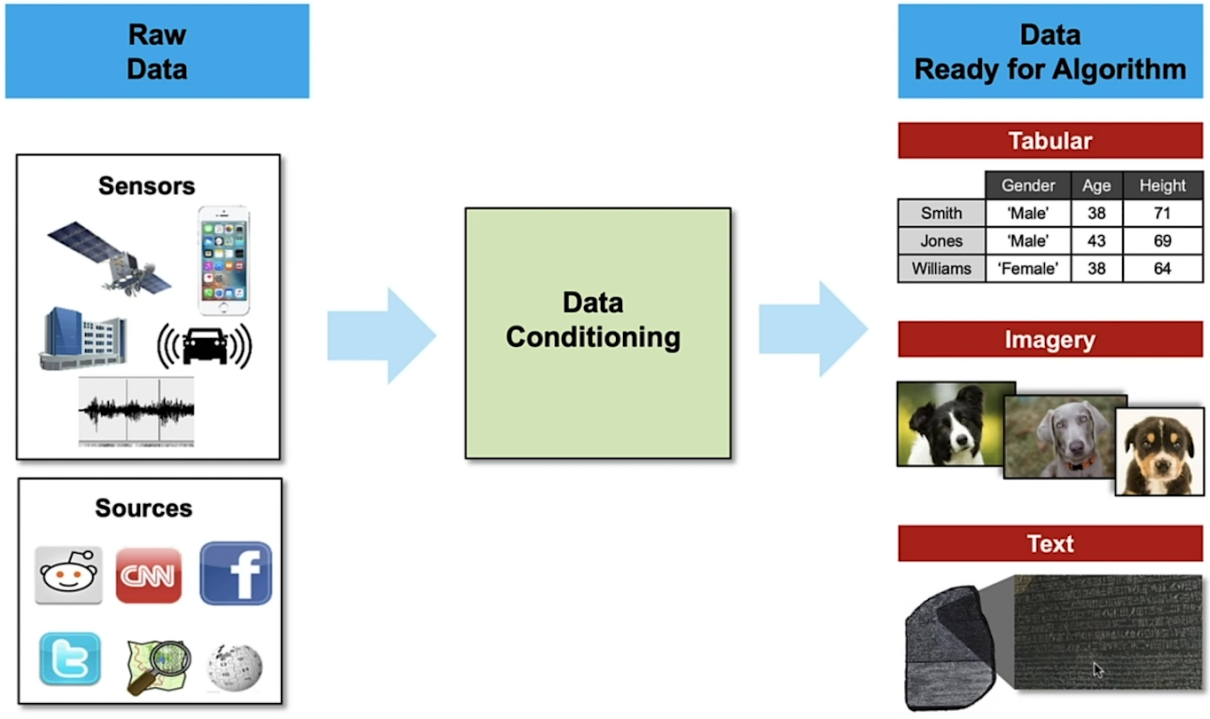

Figure 4: From Raw to Ready

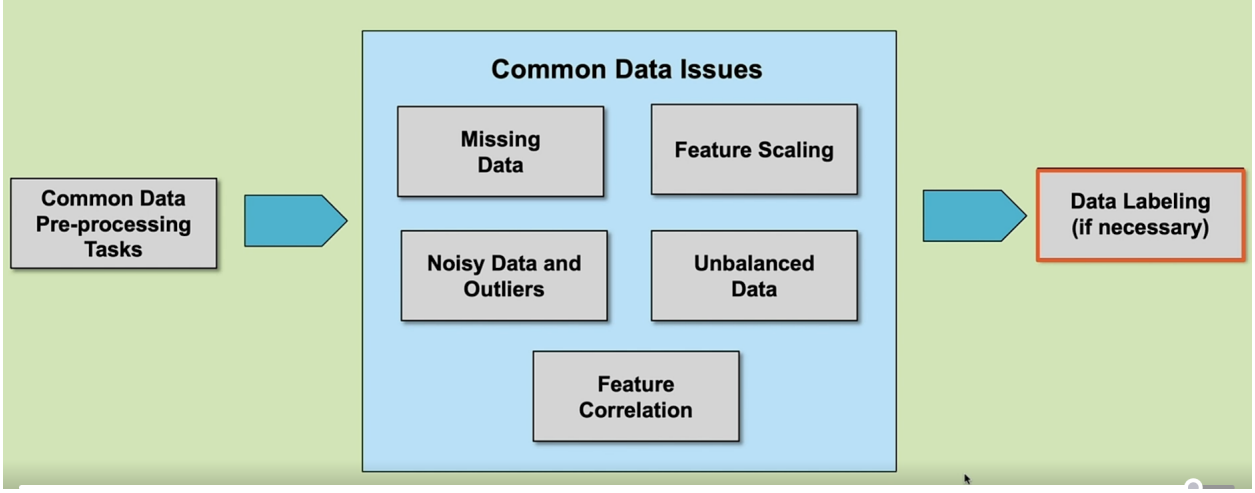

Figure 5: Data Conditioning Pipeline

3 Lecture 3: Introduction to Deep Learning

4 Lecture 4: Introduction to Computer Vision

5 Lecture 5: Introduction to Natural Language Processing

6 Lecture 6: Introduction to Robust and Safe AI

7 Lecture 7: Introduction to Advanced Computing and Hardware

8 Lecture 8: Human and Machine Teaming

9 Lecture 9: System Level Approach to AI