



भारतीय प्रौद्योगिकी संस्थान हैदराबाद  
Indian Institute of Technology Hyderabad

# AI5001: Introduction to Modern AI

## Fall 2019

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# Outline

1. Motivating Examples
2. Introduction to Artificial Intelligence
3. Introduction to Modern AI
4. Introduction to Machine Learning

# Introduction to Artificial Intelligence

What are intelligent systems?

- ▶ Accept a stimulus
- ▶ Represent the stimulus
- ▶ Cognitive process acts on the stimulus - may create internal representations
- ▶ Take action

# Motivation

A few *automation problems* to ponder over . . .

# Motivation

How to *classify* email as genuine or spam <sup>1</sup>?



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<sup>1</sup><http://www.pcworld.com/article/3072435/data-center-cloud/5-ways-to-stop-spam-from-invading-your-email.html>

# Motivation

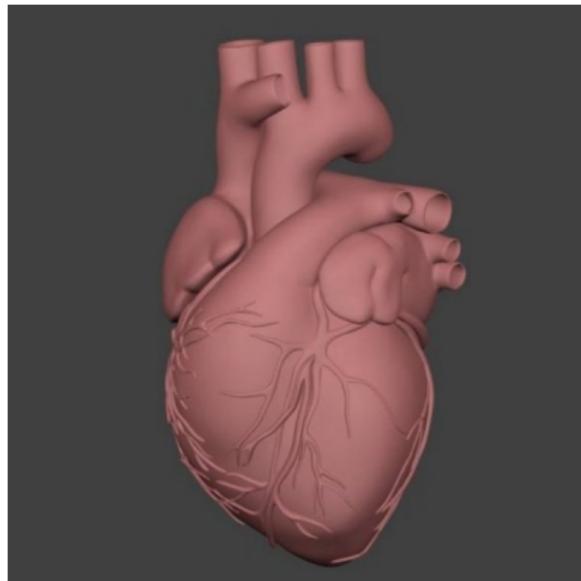
How to *classify* handwritten digits <sup>2</sup>?



<sup>2</sup><http://yann.lecun.com/exdb/mnist/>

# Motivation

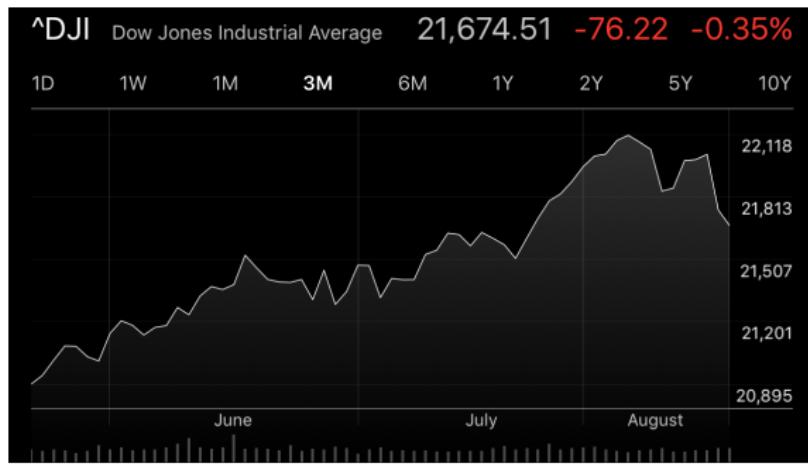
How to *predict* chances of a second heart attack <sup>3</sup>?



<sup>3</sup><https://free3d.com/3d-model/human-heart-2-79840.html>

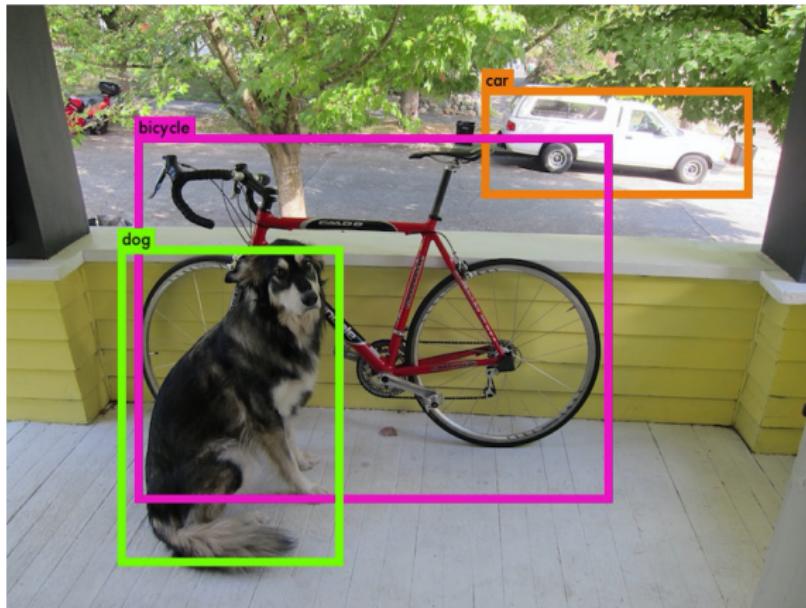
# Motivation

How to *predict* stock prices?



# Motivation

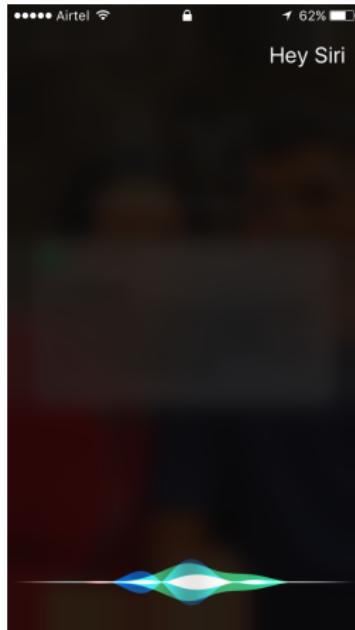
How to *detect* objects in a scene <sup>4</sup>?



<sup>4</sup><https://pjreddie.com/darknet/yolov1/>

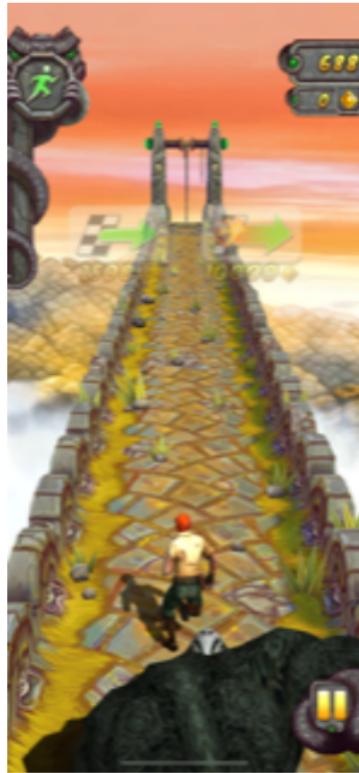
# Motivation

How to *recognize* voice?



# Motivation

How to *play*?



# Introduction to Artificial Intelligence

How to choose an action?

- ▶ **Rational behavior - winning strategy, maximize achievement, guarantee fairness**
- ▶ Rational inference
- ▶ Probabilistic inference
- ▶ Learning

# Intelligent Agents

- ▶ Agent is anything:
  - ▶ that perceives the *environment* through *sensors*
  - ▶ acts upon the *environment* through *actuators*
- ▶ Examples: humans, robots
- ▶ A **rational agent** is one that does the *right thing*
- ▶ What is the *right thing*?
  - ▶ look at the *consequences*
  - ▶ has *desirable* consequences
  - ▶ desirability captured by a **performance measure**

# What is Rationality?

Rationality depends on four things:

- ▶ Performance measure for success
- ▶ Agent's prior knowledge of the environment
- ▶ Actions that the agent can perform
- ▶ Agent's percept sequence to date

Definition: *For each possible percept sequence, a rational sequence should select an action that is expected to maximize its performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has.*

## Example: Automated Taxi

- ▶ Agent: Taxi driver
- ▶ Performance measure: Safety, speed, legal, comfort, profits
- ▶ Environment: Roads, other traffic, pedestrians, customers
- ▶ Actuators: Steering, accelerator, brake, signal, horn, display
- ▶ Sensors: Cameras, sonar, speedometer, GPS, accelerometer

**PEAS** description

# Agent Types

- ▶ Simple reflex agents: actions based on *current percept*
- ▶ Model-based reflex agents: based on agent's *model of the world*
- ▶ **Goal-based agents:** *goal information* drives actions
- ▶ Utility-based agents: actions driven by *utility function*

# Environment Types

- ▶ Fully observable vs partially observable
- ▶ Single agent vs multiagent
- ▶ Deterministic vs stochastic
- ▶ Episodic vs sequential
- ▶ Static vs dynamic
- ▶ Discrete vs continuous
- ▶ Known vs unknown

# Good Old Fashioned AI (GOFAI)

- ▶ Search
- ▶ Game Theory
- ▶ Probabilistic Reasoning
- ▶ **Learning**

# Introduction to Machine Learning

## What is Machine Learning?

- ▶ Learning from data: a method of teaching machines to improve predictions from data
- ▶ Can be thought of as a method for computers to recognize patterns
- ▶ A natural outgrowth of the intersection of computer science and statistics

“A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P if its performance at tasks in T, as measured by P, improves with experience E.”<sup>5</sup>

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<sup>5</sup> “The Discipline of Machine Learning”, T. M. Mitchell, CMU

# Introduction to Machine Learning

Machine learning algorithms are broadly classified into:

- ▶ **Supervised Learning:** Learning from *labeled data*
- ▶ **Unsupervised Learning:** Learning from *unlabeled data*
- ▶ **Reinforcement Learning:** Learning to achieve a *goal* in the presence of *feedback/reward*

# Supervised Learning

Input	Label
	Cat
	Dog
	Fish
	Bird
	?

# Supervised Learning

**Problem Statement:** Given a set of examples

$\{(x_1, y_1), (x_2, y_2), \dots, (x_N, y_N)\}$  where  $x_i \in \mathbb{R}^m$ ,  $y_i \in \mathbb{R}$  (or  $\mathbb{G}$ ) find a function  $f : \mathbb{R}^m \rightarrow \mathbb{R}$  (or  $\mathbb{G}$ ) that “best” estimates  $y_i$  from  $x_i$ ; i.e.,  $\hat{y}_i = f(x_i)$

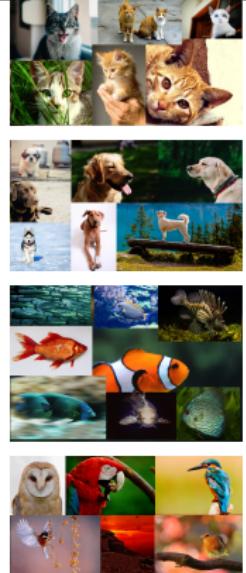
- ▶ In ML parlance,  $x_i$  is called a *feature vector* and  $y_i$  is called a *label*
- ▶ If  $y_i \in \mathbb{R}$ , the problem is termed *regression*
- ▶ If  $y_i \in \mathbb{G}$ , where  $\mathbb{G}$  is a finite set, the problem is termed *classification*

# Supervised Learning

A *fundamental problem* in supervised learning is the choice of  $f()$

- ▶ The notion of “best” estimates is with respect to the choice of fidelity measure used to compare  $\hat{y}_i$  and  $y_i$
- ▶ The set  $\{(x_1, y_1), (x_2, y_2), \dots, (x_N, y_N)\}$  is called a *training set*
- ▶ Importantly, the *utility* of a function  $f()$  is determined by its performance on *unseen*  $x$
- ▶ A set of *unseen*  $x$  called a *validation/test* set is employed to determine utility

# Unsupervised Learning

Input	Clusters
	

# Unsupervised Learning

**Problem Statement:** Given a set of examples  $\{x_1, x_2, \dots, x_N\}$  where  $x_i \in \mathbb{R}^m$ , what can be *inferred* from it?

Can

- ▶ pattern(s) be found or can the data be clustered?
- ▶ the data be statistically modeled?
- ▶ sparse representations be found?

# Reinforcement Learning

- ▶ Learning to achieve a *goal* in the presence of *feedback/reward*
- ▶ Different from supervised and unsupervised learning
- ▶ Mimics human/animal learning - closest to our definition of rational behaviour
- ▶ Exploration and exploitation

# Reinforcement Learning

Elements of RL:

- ▶ Agent
- ▶ Environment
- ▶ Policy
- ▶ Reward
- ▶ Value function
- ▶ Environment model

# Let's play tic-tac-toe