CMSC 471

Machine Learning

What is AI?

- Building Intelligent Agents

What is AI?

- Building Intelligent Agents
- Agents that can:
  - Perceive
  - Reason
  - Act
  - (Autonomous)

Let’s try to build an Intelligent Agent

Bill applies for a credit card

Agent has to approve or reject Bill’s request

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Does this task require “Intelligence”?

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Does this task require “Intelligence”?

How can we automate this decision?

What does any agent need to make an Intelligent Decision?

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Answer : Information

Building an Automated Intelligent Agent (AI)

Step 1: **Gather Information**

In **AI terms**, this is like the agent “perceiving” its environment and ”remembering”
In **ML terms**, this step is called **data collection.**

Building an Automated Intelligent Agent (AI)

Step 1: **Gather Information**

What do information do we need to review Bill's request?

- Information about Bill:
  - Age, Zipcode, Income, Credit Score etc.
- Information about past customers:
  - What is the minimum age for approval?
  - What is the minimum income for approval?
  - …

Building an Automated Intelligent Agent (AI)

Step 1 Part 2: **Data Preparation**

We have the data now. **Can we process it?**

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Probably not straight away.
Represent the data in a way that is processable.

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Step 1 Part 2: Data Preparation

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Represent the data in a way that is processable.

We worked on this before.
Environment States helped us fit any event into our problem paradigm. Think Graph Search Space, CSN, FOL etc.

For **ML**, data is typically represented as **feature vectors**.
Also called **attribute set**.

Building an Automated Intelligent Agent (AI)

Step 1 Part 2: Data Preparation

What do we need for reviewing credit card request?

- Age
- Income
- Credit Score
- Zipcode

Age	Income	Credit Score	Zipcode

Building an Automated Intelligent Agent (AI)

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Feature Vector

Typical Representations: Tables, Arrays, Matrices etc.

Labeled vs Unlabeled data

Label/ Class known to us

Labeled Data

Age	Income	Credit Score	Zipcode	Review Decision

Unlabeled Data

Age	Income	Credit Score	Zipcode

Labeled vs Unlabeled data

Label/ Class known to us

Labeled Data

Age	Income	Credit Score	Zipcode	Review Decision

- Easier to work with
- Not always feasible to have
- Used for **Supervised Learning**

Unlabeled Data

Age	Income	Credit Score	Zipcode

- Harder to work with; but we have models specifically targeting unlabeled data
- Usually this is what we will have
- Used for **Unsupervised Learning**

Going back to our AI

- We have all the data we could possibly need
- We will consider the easier use case:
  - Everything is labeled!
- But now what?

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We need to **understand** and **reason** over the data

ML approach is **Data Modeling**

Building an Automated Intelligent Agent (AI)

Step 2 : Data Modelling

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We have label/output (Y)

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But if we can learn f, given any X we will be able to predict Y

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This is what ML models do

Building an Automated Intelligent Agent (AI)

Step 2 : Data Modelling

We think that:

Review Decision = f (Age, Income, Credit Score, Zipcode, etc.)

We know this

We must learn this

Given enough data, we can **train** an ML model to learn **f**

Building an Automated Intelligent Agent (AI)

Step 3 : Act

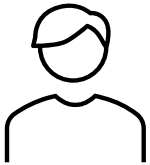
We know f and we know $Y = f(X)$

We have a new use case, X_{new}

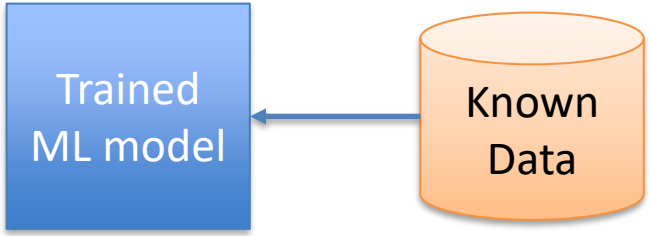
Can we decide Y_{new}?

This is **Class Prediction**

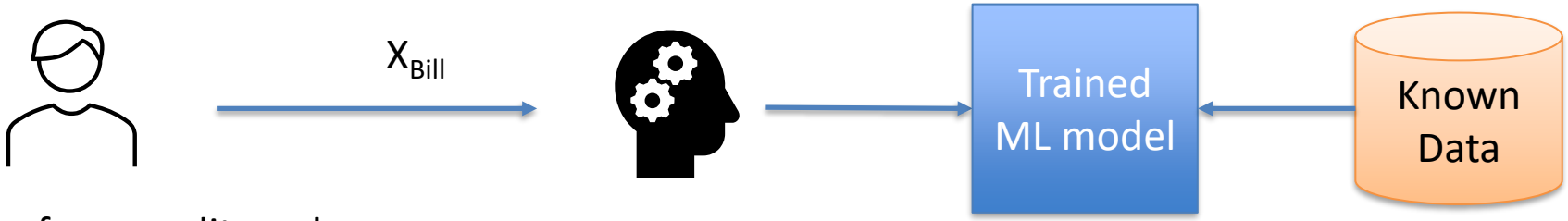
Building an Automated Intelligent Agent (AI)



Bill applies for a credit card

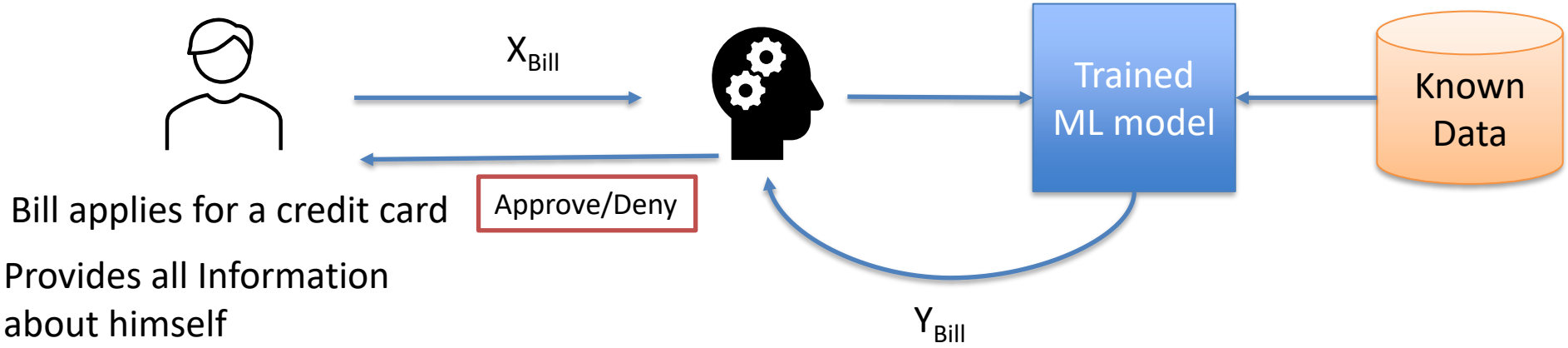


Building an Automated Intelligent Agent (AI)



Bill applies for a credit card
Provides all Information about himself

Building an Automated Intelligent Agent (AI)



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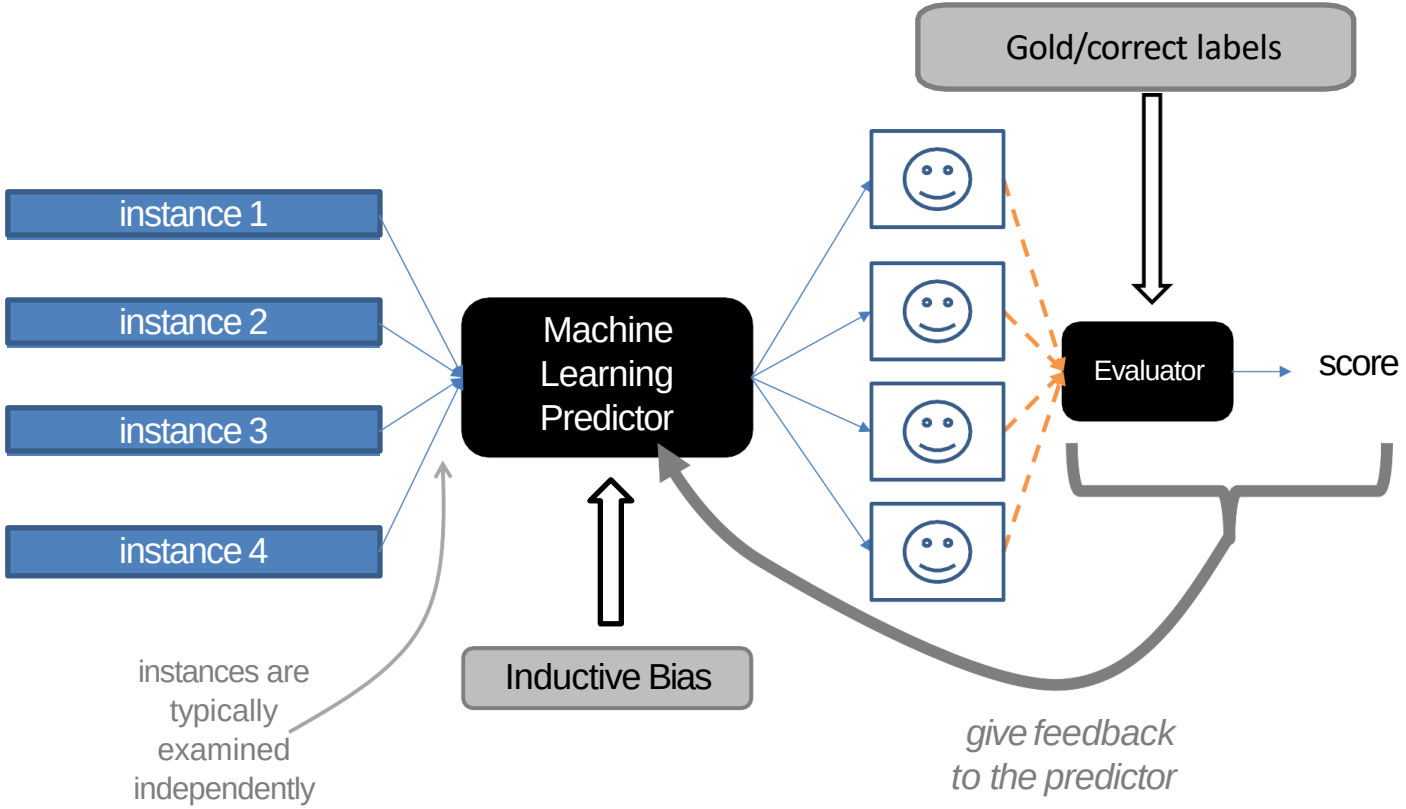
Machine Learning Framework: Learning

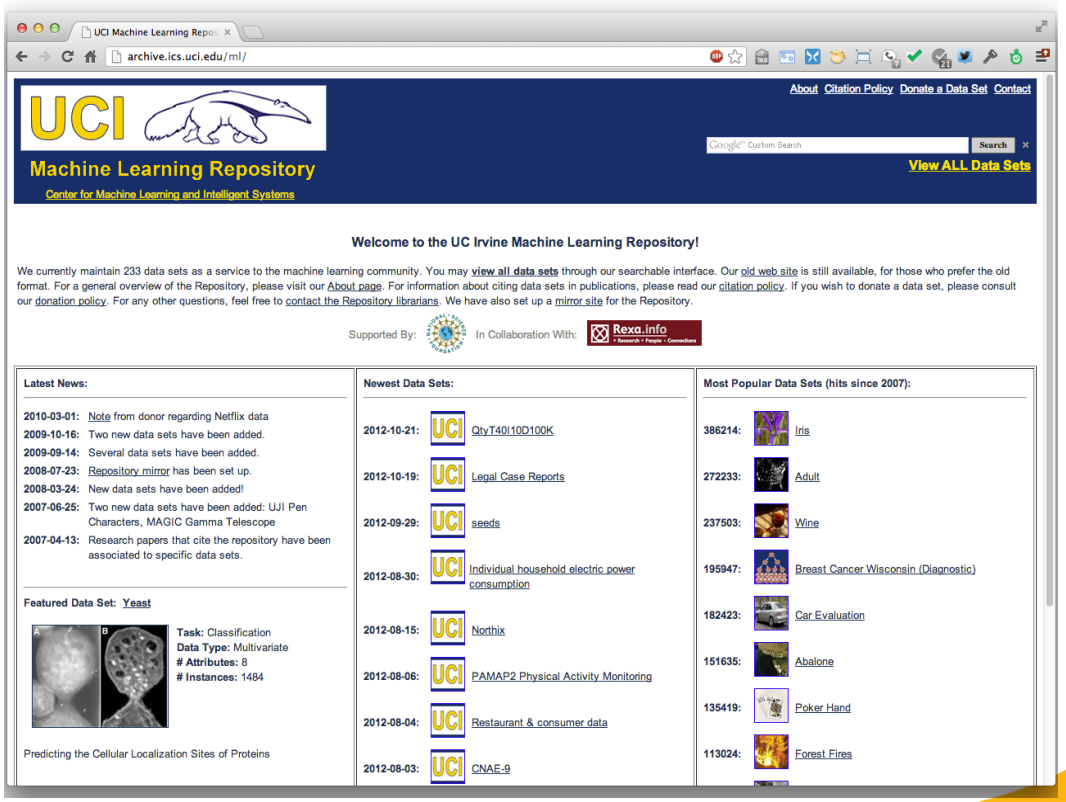


What will we learn in ML?

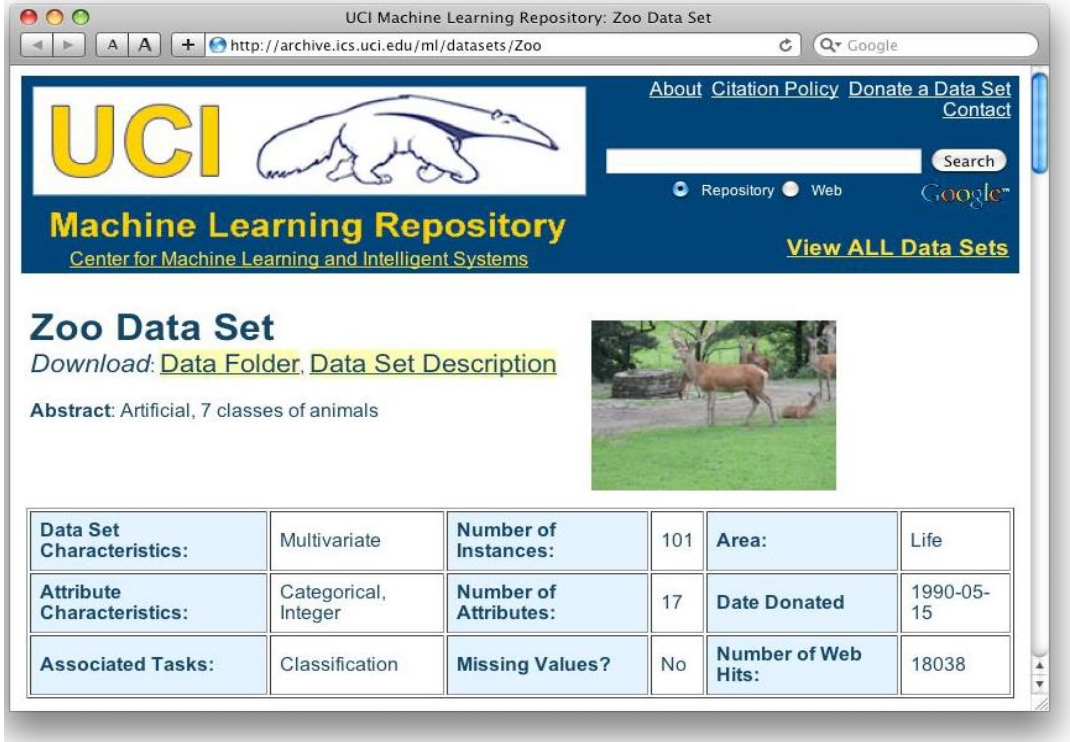
- Building Machine Learning Framework:
  - **Preparing** Data for ML
  - **Training** a model
  - **Evaluating** Model Performance
- Different types of ML models

First thing's First: Get the Data!

http://archive.ics.uci.edu/ml



Zoo Data Set



Data Set Characteristics:	Multivariate	**Number of Instances:**	101	**Area:**	Life
Attribute Characteristics:	Categorical, Integer	**Number of Attributes:**	17	**Date Donated**	1990-05-15
Associated Tasks:	Classification	**Missing Values?**	No	**Number of Web Hits:**	18038

http://archive.ics.uci.edu/ml/datasets/Zoo

Zoo data

Feature/ Attributes

animal name: string
hair: Boolean
feathers: Boolean
eggs: Boolean
milk: Boolean
airborne: Boolean
aquatic: Boolean
predator: Boolean
toothed: Boolean
backbone: Boolean
breathes: Boolean
venomous: Boolean
fins: Boolean
legs: {0,2,4,5,6,8}
tail: Boolean
domestic: Boolean
catsize: Boolean

Label/ Output

type: {mammal, fish, bird, shellfish, insect, reptile, amphibian}

101 examples

aardvark,1,0,0,1,0,0,1,1,1,1,0,0,4,0,0,1,mammal
antelope,1,0,0,1,0,0,0,1,1,1,0,0,4,1,0,1,mammal
bass,0,0,1,0,0,1,1,1,1,0,0,1,0,1,0,0,fish
bear,1,0,0,1,0,0,1,1,1,1,0,0,4,0,0,1,mammal
boar,1,0,0,1,0,0,1,1,1,1,0,0,4,1,0,1,mammal
buffalo,1,0,0,1,0,0,0,1,1,1,0,0,4,1,0,1,mammal
calf,1,0,0,1,0,0,0,1,1,1,0,0,4,1,1,1,mammal
carp,0,0,1,0,0,1,0,1,1,0,0,1,0,1,1,0,fish
catfish,0,0,1,0,0,1,1,1,1,0,0,1,0,1,0,0,fish
cavy,1,0,0,1,0,0,0,1,1,1,0,0,4,0,1,0,mammal
cheetah,1,0,0,1,0,0,1,1,1,1,0,0,4,1,0,1,mammal
chicken,0,1,1,0,1,0,0,0,1,1,0,0,2,1,1,0,bird
chub,0,0,1,0,0,1,1,1,1,0,0,1,0,1,0,0,fish
clam,0,0,1,0,0,0,1,0,0,0,0,0,0,0,0,0,shellfish
crab,0,0,1,0,0,1,1,0,0,0,0,0,4,0,0,0,shellfish
…

Data Preprocessing

- Feature functions help extract useful features (characteristics) of the data

- They turn *data* into *numbers*

Data Preprocessing

- Feature functions help extract useful features (characteristics) of the data
- They turn *data* into *numbers*
  - Features that are not 0 are said to have fired
  - Often binary-valued (0 or 1), but can be real-valued

Data Preprocessing

Type = shellfish

Type_mammal	Type_fish	Type_bird	Type_shellfish	Type_insect	Type_reptile	Type_amphibian
0	0	0	1	0	0	0

Types of ML task

Output \ Data	Labeled	Unlabeled
Discrete	✓ classification or categorization	✓ clustering
Continuous	✓ regression	dimensionality reduction

Choosing an ML model: Depends on your task

- Classification:
  - Decision Trees
  - Naïve Bayes
  - Logistic Regression etc.
- Regression:
  - Random Forest
  - Linear Regression etc.
- Clustering:
  - K-Means Clustering
  - Mean-Shift Clustering
  - DBSCAN etc.

Evaluation: How Well Are We Doing?

Classification

- Precision, Recall, F1
- Accuracy
- Log-loss
- ROC-AUC
- …

Regression

- (Root) Mean Square Error
- Mean Absolute Error
- …

Clustering

- Mutual Information
- V-score
- …

Evaluation methodology (1)

Standard methodology:

1. Collect large set of examples with correct classifications (aka ground truth data)
2. Randomly divide collection into two disjoint sets: ***training*** and ***test*** *(e.g., via a 90-10% split)*
3. Apply learning algorithm to **training** set giving hypothesis H
4. Measure performance of H on the held-out **test** set