CS 106A, Lecture 26
A Gentle Intro. to Machine Learning

suggested reading:

none!

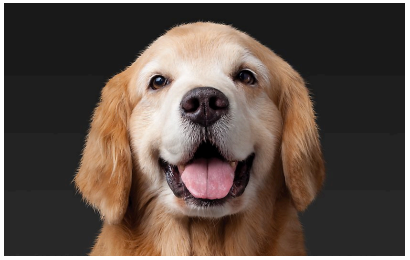
Plan for today

- What is machine learning?
- Why is it useful?
- Supervised Learning
  - Demo: k-Nearest-Neighbor
- What else can machine learning do?

Animal Classification Ex.

- We have a picture and we want to know if it's a cat or not.

true



false

true

false

Animal Classification Ex.

Here's one way you might code this…

```
private void isCat(GImage animal) {
      int[][] pixels = animal.getPixelArray();
      if (containsTwoEyes(pixels)){
            if (hasWhiskers(pixels)){
                  if (hasPointyEars(pixels)){
                        return true;
                  }
            }
      }
      return false;
}
```

Some tricky cases

Pros/Cons

- Pros
  - Matches our human intuition about what a cat is
  - Easy to understand the code
- Cons
  - Requires us to explicitly enumerate every feature that's important, and know how important it is
  - Need to write code to detect eyes, and whiskers, and the pointiness of ears
  - Will never improve… cannot learn from its mistakes

What is Machine Learning?

- "The field of study that gives computers the ability to learn without being explicitly programmed" - Arthur Samuel, 1959
- How can a computer do this?

Data.

Animal Classif.: Take 2

- Here's a sketch of how we can approach this problem in the machine learning paradigm:

- Input to the algorithm: MANY cats and MANY not-cats
- For each image provided to the algorithm:
  - Predict whether image is cat or not-cat
    - If correct, great, proceed to the next image
    - If incorrect, **update** the algorithm to do better next time

cat

cat

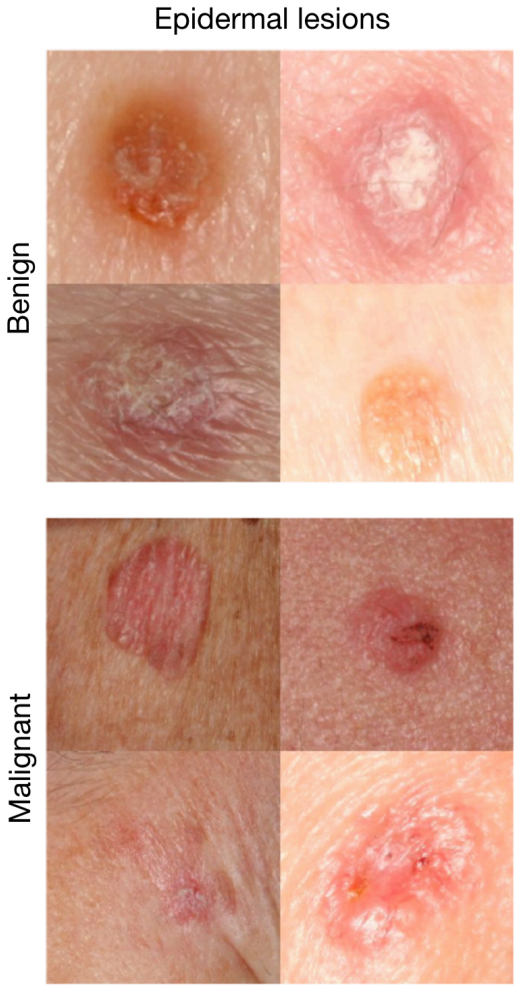
...

not cat

Pros/Cons

- Pros
  - Doesn't require us to explicitly tell the algorithm what's important to distinguish between cats and not-cats
  - Not specific to the cat problem: we could show it images of **anything** and **train** it to learn the difference
  - Gets better the more data we give it
- Cons
  - Sometimes hard to know why the algorithm makes the predictions it does
  - Requires us to specify an **update** mechanism: how is the algorithm supposed to improve itself?
  - Might require a lot of data to perform well

Where is this useful?



Esteva et al., Nature 2017.

- Skin cancer classification
  - Is a given lesion **benign** or **malignant**?
- A machine learning algorithm has been shown to perform **as well** as dermatologists.
- There are other tasks where machine learning algorithms perform **better** than skilled humans.

Digit Classification

- Task:
  - Given a picture of a **handwritten digit** from 0-9, predict which integer it is

Digit Classification

- Task:
  - Given a picture of a **handwritten digit** from 0-9, predict which integer it is


→ 3


→ 4

"label"


→ 2


→ 9

Train Data / Test Data

The algorithm gets **training data** that it can use to make predictions.

We use **test data** to evaluate how well it performs.

k-Nearest Neighbors

- Idea: when given a **test** image, look through all the **training** images to find the **"closest"** image.
- Under the assumption that "close" images share the same label, return the label of that closest training image.
  - What does it mean for an image to be "close" to another image?

k-Nearest Neighbors

- Idea: when given a **test** image, look through all the **training** images to find the **k** **"closest"** images.
- Under the assumption that "close" images share the same label, return the **most common** label of the **k closest images**.

k-Nearest Neighbors

Given a test image **T** and a set of training images **S**:

C = **k** closest images to **T**

For each training image **I** in **S**:

    distance = distance(**I, T**)

    if distance < distance between **I** and the images in **C**:

        add **I** to **C**

return most common label in **C**

k-Nearest Neighbors

TRAIN

TEST

K=3

k-Nearest Neighbors

TRAIN

TEST

K=3

k-Nearest Neighbors

Given a test image **T** and a set of training images **S**:

C = **k** closest images to **T**

For each training image **I** in **S**:

    distance = distance(**I, T**)

    if distance < distance between **I** and the images in **C**:

        add **I** to **C**

return most common label in **C**

k-Nearest Neighbors demo!

nothing to see here, carry on ☺

What else can ML do?

- Supervised Learning
  - Classification, like the cat or skin cancer or digits examples
  - **Regression**

Regression Example

- **House price prediction**

Training Data

Square Footage	House Price
1,000	150,000
1,256	175,000
5,897	2,000,000
4,300	1,300,000
2,400	750,000
2,600	690,000
3,000	1,000,000

Test Time

"My house has 1,800 square feet. How much should I expect it to sell for?"

What else can ML do?

- Supervised Learning
  - Classification
  - Regression
- **Unsupervised Learning**
  - Finding **structure** in unlabeled data

Netflix Prize Example

- Netflix Prize

What else can ML do?

- Supervised Learning
  - Classification
  - Regression
- Unsupervised Learning
- **Reinforcement Learning**

What remains really hard?

- Human-like dialog
- Common-sense reasoning about the world
- **Strong** generalization
- Learning to learn
- … and much else ☺