# CS540 Introduction to Artificial Intelligence

## Lecture 1

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Based on lecture slides by Jerry Zhu, Yingyu Liang, and Charles Dyer

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# Socrative

## Admin

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log in WU489

- Download the Socrative App or go to the Socrative website.
- Use Room CS540C log in with wisc ID.
- Choose "$C$" for the first question $Q1$.

# Logistics, Grading

## Admin

- Everything is on the course website.
- Talk about these and answer questions at the end of the lecture.

# What is AI

## Motivation

# Is This Face Real

## Quiz

- Which face is real?
- $A$ : Left
- $B$ :
- $C$ :
- $D$ :
- $E$ : Right
- (Do not choose $B, C, D$.)

# Is This Face Real

## Quiz

- How is the real face different from the fake one?
- Short answer.
- (Write something random if you do not know: Do not leave it blank.)

# Socrative

## Admin

- Submit a regrade request if you missed any questions or selected the incorrect answer by mistake.

# Generative Adversarial Network

## Motivation

- Generative Adversarial Network (GAN):

1. Generative part: input random noise and output fake images.
2. Discriminative part: input real and fake images and output labels real or fake.
3. The two parts compete with each other.

# Supervised Learning Example 1

## Motivation

| Data | images of cats and dogs |
|---|---|
| Features (Input) | height, length, eye color, ... |
| Labels (Output) | cat or dog |

| Data | images of 1000 object classes |
|---|---|
| Features (Input) | pixel information ... |
| Labels (Output) | turtle or rifle |

# Supervised Learning Example 2

## Motivation

| Data | handwritten characters |
|---|---|
| Features (Input) | pixel intensity, stroke, ... |
| Labels (Output) | $\delta$ or $\sigma$, $\varphi$ or $\psi$ |

| Data | voice recording |
|---|---|
| Features (Input) | signal, sound (phoneme), ... |
| Labels (Output) | recognize speech or wreck a nice beach |

# Supervised Learning Example 3

## Motivation

P2

| Data | medical records |
|---|---|
| Features (Input) | scan, blood, and test results, ... |
| Labels (Output) | cancer or no cancer |

| Data | patient information |
|---|---|
| Features (Input) | age, pre-existing conditions, ... |
| Labels (Output) | cancer or no cancer |

# Supervised Learning Example 4

## Motivation

P3

| Data | emails |
|---|---|
| Features (Input) | word count, capitalization, ... |
| Labels (Output) | spam or ham |

| Data | comments |
|---|---|
| Features (Input) | word count, capitalization, ... |
| Labels (Output) | offensive or not |

# Supervised Learning Example 5

## Motivation

| Data | face images |
|---|---|
| Features (Input) | edges, corners, ... |
| Labels (Output) | face or non-face |

| Data | self-driving car data |
|---|---|
| Features (Input) | color, distance (depth), movement, ... |
| Labels (Output) | road or car or pedestrian |

# Supervised Learning Example 6

## Motivation

| Data | book or movie reviews |
|---|---|
| Features (Input) | word count, capitalization, ... |
| Labels (Output) | positive or negative |

| Data | financial transactions |
|---|---|
| Features (Input) | amount, frequency, ... |
| Labels (Output) | fraud or not |

# Supervised Learning Example 7

## Motivation

| Data | painting |
|---|---|
| Features (Input) | appearance, price, ... |
| Labels (Output) | art or garbage |

| Data | essay |
|---|---|
| Features (Input) | length, key words, ... |
| Labels (Output) | A+ or $F$ |

# Supervised Learning

## Motivation

- Supervised learning:

| Data | Features | Labels | - |
|---|---|---|---|
| Sample | $\{(x_{i1}, \ldots, x_{im})\}_{i=1}^{n}$ | $\{y_i\}_{i=1}^{n}$ | find "best" $\hat{f}$ |
| - | observable | known | - |
| New | $(x'_1, \ldots, x'_m)$ | $y'$ | guess $\hat{y} = \hat{f}(x')$ |
| - | observable | unknown | - |

$x_{ij}$ → jth feature
↳ ith data point instance.

want $y_i \approx \hat{f}(x_i)$

$y_i$ → label of instance i

# Training and Test Sets

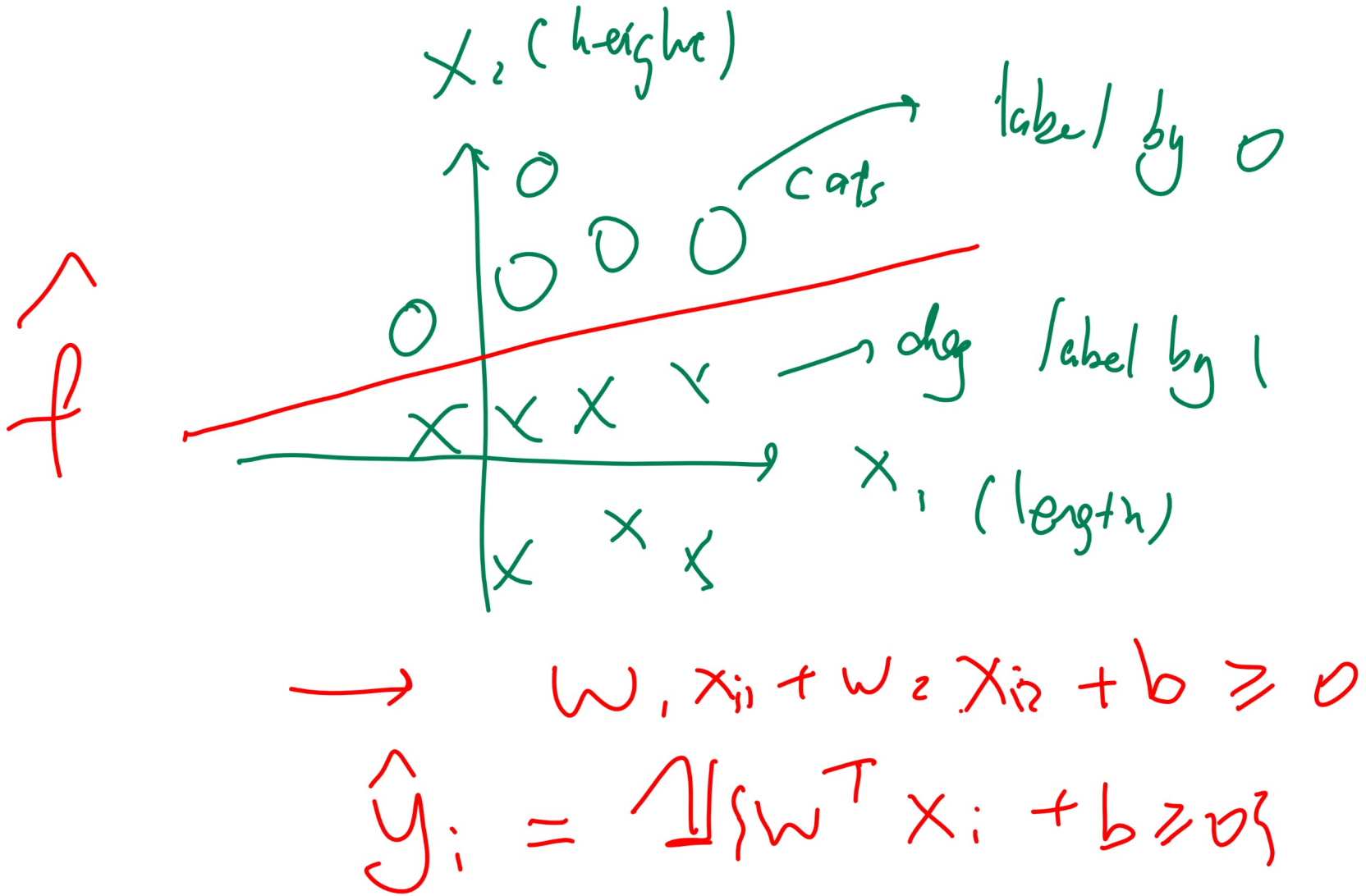
## Motivation

- Supervised learning:

| Data | Features | Labels | - |
|---|---|---|---|
| Training | $\{(x_{i1}, ..., x_{im})\}_{i=1}^{n'}$ | $\{y_i\}_{i=1}^{n'}$ | find "good" $\hat{f}$ |
| - | observable | known | - |
| Validation | $\{(x_{i1}, ..., x_{im})\}_{i=n'}^{n}$ | $\{y_i\}_{i=n'}^{n}$ | find "best" $\hat{f}$ |
| - | observable | known | - |
| Test | $(x'_1, ..., x'_m)$ | $y'$ | guess $\hat{y} = \hat{f}(x')$ |
| - | observable | unknown | - |

# Simple 2D Example Diagram

## Motivation



# Linear Classifier

## Motivation

linear threshold unit.
&
LTU perceptron

- One possible guess is in the form of a linear classifier.

$$\hat{y} = \mathbb{1}_{\{w_1 x_1 + w_2 x_2 + \ldots + w_m x_m + b \geqslant 0\}}$$
$$= \mathbb{1}_{\{w^T x + b \geqslant 0\}} = \begin{cases} 1 & \text{if } w^T x + b \geqslant 0 \\ 0 & \text{ow.} \end{cases}$$

- The $\mathbb{1}$ (open number 1) is the indicator function.

$$\mathbb{1}_E = \begin{cases} 1 & \text{if } E \text{ is true} \\ 0 & \text{if } E \text{ is false} \end{cases}$$

# Brute Force LTU Learning

## Motivation

# Perceptron Algorithm

## Description

- Initialize random weights.
- Evaluate the activation function at one instance $x_i$ to get $\hat{y}_i$.
- If the prediction $\hat{y}_i$ is 0 and actual $y_i$ is 1, increase the weights by $x_i$.
- If the prediction $\hat{y}_i$ is 1 and actual $y_i$ is 0, decrease the weights by $x_i$.
- Repeat for all data points and until convergent.

# Perceptron Algorithm Diagram

## Description

# Perceptron Algorithm

## Definition

learning rate: how much to move.

current prediction

true label

- Update weights using the following rule.

$$w = w - \alpha (a_i - y_i) x_i$$

$$b = b - \alpha (a_i - y_i)$$

$$a_i = \mathbb{1}_{\{w^T x_i + b \geq 0\}}$$

activation → prediction based on current line / hyperplane.

# Perceptron Algorithm

## Quiz

- Let the learning rate be $\alpha = 0.2$. Currently $w = \begin{bmatrix} 0.2 & 0.7 & 0.9 \end{bmatrix}^T$, $b = -0.7$, and $x_i = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix}^T$ and $y_i = 0$. What is the updated weights $\begin{bmatrix} w \\ b \end{bmatrix}$?

$$w = w - \alpha (a_i - y_i) x_i = \begin{pmatrix} 0.2 \\ 0.7 \\ 0.9 \end{pmatrix} - 0.2(1 - 0)\begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} \Rightarrow \begin{pmatrix} 0.2 \\ 0.7 \\ 0.7 \end{pmatrix}$$

$$a_i = \mathbb{1}\{w^T x_i + b\} = \mathbb{1}\{\begin{pmatrix} 0.2 & 0.7 & 0.9 \end{pmatrix}\begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} - 0.7 \geq 0\}$$

# Perceptron Algorithm, Answer

Quiz

$= \mathbb{1}\{0.9 - 0.7 \geq 0\}$

$= \mathbb{1}\{0.2 \geq 0\} = 1$

# Perceptron Algorithm, Another One

## Quiz

- Let the learning rate be $\alpha = 0.1$. Currently $w = \begin{bmatrix} 0.2 \\ -0.3 \end{bmatrix}$, $b = 0.4$, and $x_i = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ and $y_i = 1$. What is the updated weights $\begin{bmatrix} w \\ b \end{bmatrix}$?
- $A: \begin{bmatrix} 0.2 \\ -0.3 \\ 0.4 \end{bmatrix}$, $B: \begin{bmatrix} 0.2 \\ -0.2 \\ 0.5 \end{bmatrix}$, $C: \begin{bmatrix} 0.2 \\ -0.4 \\ 0.3 \end{bmatrix}$
- $D: \begin{bmatrix} 0.2 \\ -0.2 \\ 0.3 \end{bmatrix}$, $E: \begin{bmatrix} 0.2 \\ -0.4 \\ 0.5 \end{bmatrix}$

Q6

$b = b - \alpha(a_i - y_i)$

$w = w - \alpha(a_i - y_i)x_i$

$a_i = \mathbb{1}_{\{w^T x_i + b \geq 0\}}$

$a_i = \mathbb{1}_{\{[0.2 \ -0.3]\begin{bmatrix} 0 \\ 1 \end{bmatrix} + 0.4 \geq 0\}}$

$= \mathbb{1}_{\{0.1 \geq 0\}} = 1$

# Perceptron Algorithm, Another One, Answer

## Quiz

# Perceptron Algorithm, Another One Too

## Quiz

- Let the learning rate be $\alpha = 0.1$. Currently $w = \begin{bmatrix} 0.2 \\ -0.3 \end{bmatrix}$, $b = 0.4$, and $x_i = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ and $y_i = 0$. What is the updated weights $\begin{bmatrix} w \\ b \end{bmatrix}$?
- $A: \begin{bmatrix} 0.2 \\ -0.3 \\ 0.4 \end{bmatrix}, B: \begin{bmatrix} 0.2 \\ -0.2 \\ 0.5 \end{bmatrix}, C: \begin{bmatrix} 0.2 \\ -0.4 \\ 0.3 \end{bmatrix}$
- $D: \begin{bmatrix} 0.2 \\ -0.2 \\ 0.3 \end{bmatrix}, E: \begin{bmatrix} 0.2 \\ -0.4 \\ 0.5 \end{bmatrix}$

15% · max{exam, quiz + math + dis} + 15% · exam final.

# Perceptron Algorithm, Another One Too, Answer

## Quiz