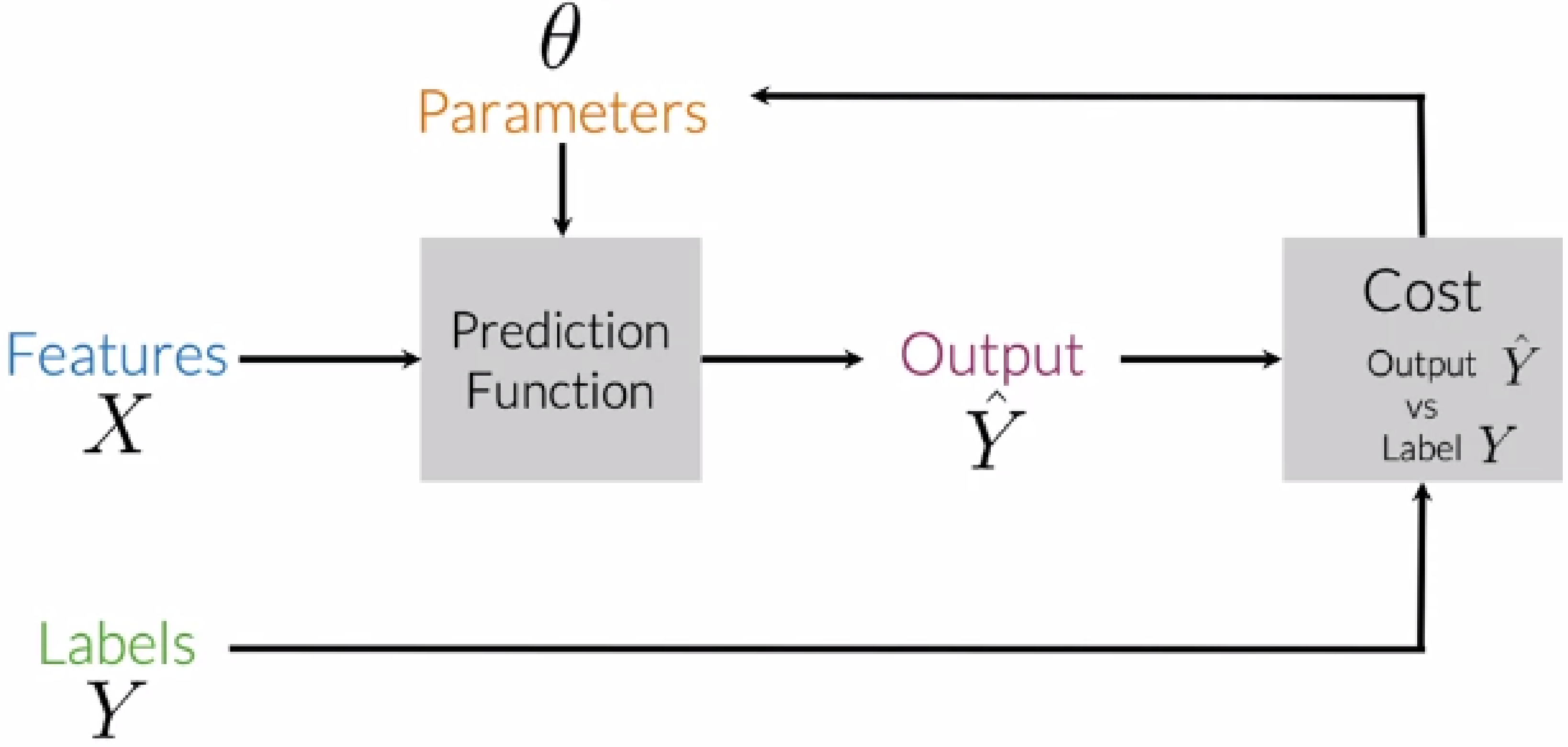
Supervised ML (training)



Sentiment analysis

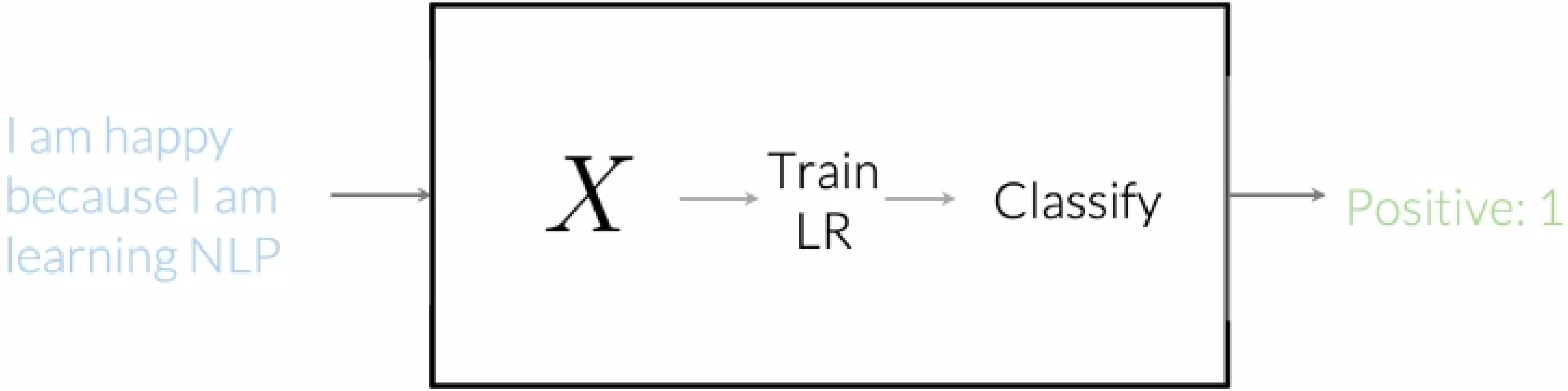
Tweet: I am happy because I am learning NLP

Positive: 1

Negative: 0

Logistic regression

Sentiment analysis



Vocabulary

Tweets:

[tweet_1, tweet_2, ..., tweet_m] →

I am happy because I am learning NLP
...
...
...
I hated the movie

$V =$

[I, am, happy, because, learning, NLP, ... hated, the, movie]

Feature extraction

I am happy because I am learning NLP

[I ,	am,	happy,	because,	learning,	NLP,	...	hated,	the,	movie]
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
[1,	1,	1,	1,	1,	1,	...	0,	0,	0]

A lot of zeros! That's a sparse representation.

Problems with sparse representations

I am happy because I am learning NLP

All zeros!

$$[1,1,1,1,1,1,\ldots,0,\ldots,0,0,0]$$

$1 \longleftrightarrow |V|$

Problems with sparse representations

I am happy because I am learning NLP

All zeros!

$$[1,1,1,1,1,1,\overbrace{\ldots,0,\ldots,0,0,0}^{\text{All zeros!}}]$$

$1 \longleftrightarrow |V|$

$$[\theta_0, \theta_1, \theta_2, \ldots, \theta_n]$$

$$n = |V|$$

Problems with sparse representations

I am happy because I am learning NLP

$$\underbrace{[1,1,1,1,1,1,\ldots,0,\ldots,0,0,0]}_{1 \longleftrightarrow |V|}$$

All zeros!

$$[\theta_0, \theta_1, \theta_2, \ldots, \theta_n] \rightarrow$$

$$n = |V|$$

1. Large training time
2. Large prediction time

Positive and negative counts

Corpus

I am happy because I am learning NLP
I am happy
I am sad, I am not learning NLP
I am sad

Positive and negative counts

Corpus

I am happy because I am learning NLP
I am happy
I am sad, I am not learning NLP
I am sad

Vocabulary
I
am
happy
because
learning
NLP
sad
not

Positive and negative counts

Positive tweets	Negative tweets
I am happy because I am learning NLP	I am sad, I am not learning NLP
I am happy	I am sad

Positive and negative counts

Positive tweets

I am happy because I am learning NLP

I am happy

Vocabulary
I
am
happy
because
learning
NLP
sad
not

Positive and negative counts

Positive tweets

I am happy because I am learning NLP

I am happy

Vocabulary	PosFreq (1)
I	3
am	3
happy	2
because	1
learning	1
NLP	1
sad	0
not	0

Positive and negative counts

Vocabulary	NegFreq (0)
I	3
am	3
happy	0
because	0
learning	1
NLP	1
sad	2
not	1

Negative tweets

I am sad, I am not learning NLP

I am sad

Word frequency in classes

Vocabulary	PosFreq (1)	NegFreq (0)
I	3	3
am	3	3
happy	2	0
because	1	0
learning	1	1
NLP	1	1
sad	0	1
not	0	1

Word frequency in classes

Vocabulary	PosFreq (1)	NegFreq (0)
I	3	3
am	3	3
happy	2	0
because	1	0
learning	1	1
NLP	1	1
sad	0	1
not	0	1

freqs: dictionary mapping from (word, class) to frequency

Word frequency in classes

Vocabulary	PosFreq (1)	NegFreq (0)
I	3	3
am	3	3
happy	2	0
because	1	0
learning	1	1
NLP	1	1
sad	0	2
not	0	1

freqs: dictionary mapping from (word, class) to frequency

Feature extraction

freqs: dictionary mapping from (word, class) to frequency

Feature extraction

freqs: dictionary mapping from (word, class) to frequency

$$X_m = [\qquad\qquad\qquad\qquad\qquad\qquad\qquad]$$

Features of tweet m

Feature extraction

freqs: dictionary mapping from (word, class) to frequency

$$\underbrace{X_m}_{\text{Features of tweet m}} = [\underbrace{1}_{\text{Bias}}, \qquad\qquad\qquad\qquad]$$

Feature extraction

freqs: dictionary mapping from (word, class) to frequency

$$X_m = [1, \sum_w freqs(w, 1), \qquad\qquad\qquad]$$

Features of tweet m

Bias

Sum Pos. Frequencies

Feature extraction

freqs: dictionary mapping from (word, class) to frequency

$$X_m = [1, \sum_w freqs(w, 1), \sum_w freqs(w, 0)]$$

Features of tweet m

Bias

Sum Pos. Frequencies

Sum Neg. Frequencies

Feature extraction

I am sad, I am not learning NLP

Feature extraction

Vocabulary	PosFreq (1)
I	3
am	3
happy	2
because	1
learning	1
NLP	1
sad	0
not	0

I am sad, I am not learning NLP

Feature extraction

Vocabulary	PosFreq (1)
I	3
am	3
happy	2
because	1
learning	1
NLP	1
sad	0
not	0

I am sad, I am not learning NLP

$$X_m = [1, \sum_w freqs(w,1), \sum_w freqs(w,0)]$$

Feature extraction

Vocabulary	PosFreq (1)
I	3
am	3
happy	2
because	1
learning	1
NLP	1
sad	0
not	0

I am sad, I am not learning NLP

$$X_m = [1, \sum_w freqs(w, 1), \sum_w freqs(w, 0)]$$

Feature extraction

Vocabulary	PosFreq (1)
I	3
am	3
happy	2
because	1
learning	1
NLP	1
sad	0
not	0

I am sad, I am not learning NLP

$$X_m = [1, \sum_w freqs(w,1), \sum_w freqs(w,0)]$$

$$\sum_w freqs(w,1) \rightarrow \boxed{8}$$

Feature extraction

Vocabulary	NegFreq (0)
I	3
am	3
happy	0
because	0
learning	1
NLP	1
sad	2
not	1

I am sad, I am not learning NLP

$$X_m = [1, \sum_w freqs(w,1), \sum_w freqs(w,0)]$$

Feature extraction

Vocabulary	NegFreq (0)
I	3
am	3
happy	0
because	0
learning	1
NLP	1
sad	2
not	1

I am sad, I am not learning NLP

$$X_m = [1, \sum_w freqs(w,1), \underbrace{\sum_w freqs(w,0)}_{\boxed{11}}]$$

Feature extraction

I am sad, I am not learning NLP

$$X_m = [1, \sum_w freqs(w,1), \sum_w freqs(w,0)]$$

Feature extraction

I am sad, I am not learning NLP

$$X_m = [1, \sum_w freqs(w,1), \sum_w freqs(w,0)]$$

$$\downarrow$$

$$X_m = [1, 8, 11]$$

Preprocessing: stop words and punctuation

@YMourri and @AndrewYNg are
tuning a GREAT AI model at
https://deeplearning.ai!!!

Preprocessing: stop words and punctuation

@YMourri and @AndrewYNg are tuning a GREAT AI model at https://deeplearning.ai!!!

Stop words
and
is
are
at
has
for
a

Punctuation
,
.
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!
“
‘

Preprocessing: stop words and punctuation

@YMourri ~~and~~ @AndrewYNg ~~are~~ tuning ~~a~~ GREAT AI model ~~at~~ https://deeplearning.ai!!!

Stop words
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Preprocessing: stop words and punctuation

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Stop words
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Preprocessing: stop words and punctuation

@YMourri @AndrewYNg tuning
GREAT AI model
https://deeplearning.ai~~!!!~~

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Preprocessing: stop words and punctuation

@YMourri @AndrewYNg tuning GREAT AI model https://deeplearning.ai~~!!!~~

@YMourri @AndrewYNg tuning GREAT AI model https://deeplearning.ai

Stop words
and
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for
of

Punctuation
,
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:
!
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Preprocessing: Handles and URLs

@YMourri @AndrewYNg tuning GREAT AI model
https://deeplearning.ai

Preprocessing: Handles and URLs

~~@YMourri @AndrewYNg~~ tuning GREAT AI model
~~https://deeplearning.ai~~

Preprocessing: Handles and URLs

~~@YMourri @AndrewYNg~~ tuning GREAT AI model ~~https://deeplearning.ai~~

tuning GREAT AI model

Preprocessing: Stemming and lowercasing

tuning GREAT AI model

Preprocessing: Stemming and lowercasing

tuning GREAT AI model

tun

Preprocessing: Stemming and lowercasing

tuning GREAT AI model

tun → tune

tun → tuned

tun → tuning

Preprocessing: Stemming and lowercasing

tuning GREAT AI model

tun → tune, tuned, tuning

GREAT

Great

great

Preprocessing: Stemming and lowercasing

tuning GREAT AI model

tun → tune, tuned, tuning

GREAT, Great, great → great

Preprocessing: Stemming and lowercasing

tuning GREAT AI model

tun → tune, tuned, tuning

GREAT, Great, great → great

Preprocessed tweet:

[tun, great, ai, model]

General overview

I am Happy Because i am learning NLP @deeplearning

$\downarrow$ Preprocessing

[happy, learn, nlp]

General overview

I am Happy Because i am learning NLP @deeplearning

Preprocessing

[happy, learn, nlp]

Feature Extraction

[1, 4, 2]

General overview

I am Happy Because i am learning NLP @deeplearning

↓ Preprocessing

[happy, learn, nlp]

↓ Feature Extraction

Bias ← [1, 4, 2]

General overview

I am Happy Because i am learning NLP @deeplearning

↓ Preprocessing

[happy, learn, nlp]

↓ Feature Extraction

Bias ← [1, 4, 2]

↓

Sum positive frequencies

General overview

I am Happy Because i am learning NLP @deeplearning

↓ Preprocessing

[happy, learn, nlp]

↓ Feature Extraction

Bias ← [1, 4, 2] → Sum negative frequencies

↓

Sum positive frequencies

General overview

I am Happy Because i am learning NLP @deeplearning

I am sad not learning NLP

...

I am sad :(

General overview

I am Happy Because i am learning NLP @deeplearning

I am sad not learning NLP →

...

I am sad :(

[happy, learn, nlp]

[sad, not, learn, nlp]

...

[sad]

General overview

I am Happy Because i am learning NLP @deeplearning

I am sad not learning NLP → [happy, learn, nlp] → [[1, 40, 20],

[sad, not, learn, nlp]   [1, 20, 50],

...   ...

I am sad :([sad]   [1, 5, 35]]

Tweets	Preprocessed	Features
I am Happy Because i am learning NLP @deeplearning	[happy, learn, nlp]	[[1, 40, 20],
I am sad not learning NLP	[sad, not, learn, nlp]	[1, 20, 50],
...	...	...
I am sad :(	[sad]	[1, 5, 35]]

General overview

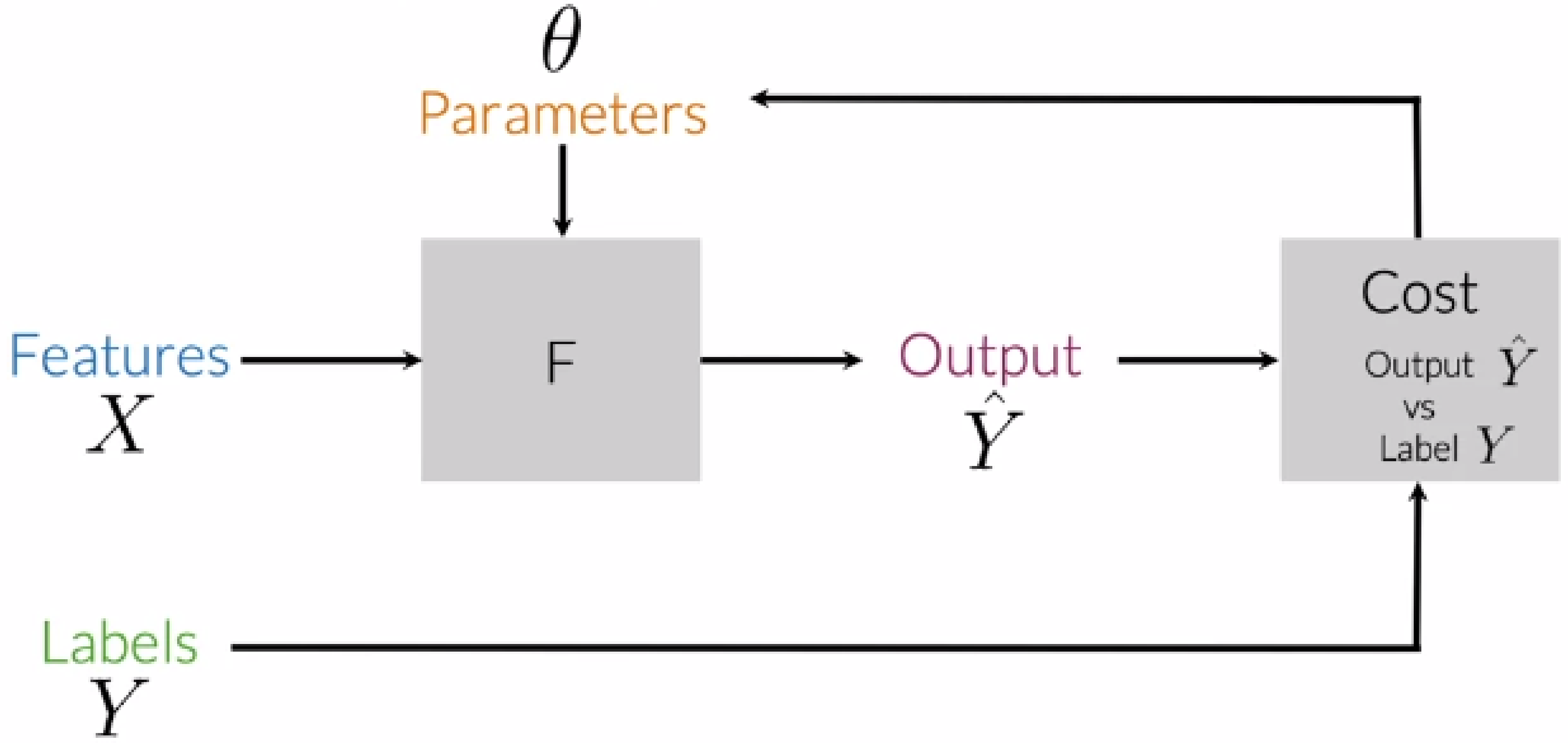
$$\begin{bmatrix} 1 & X_1^{(1)} & X_2^{(1)} \\ 1 & X_1^{(2)} & X_2^{(2)} \\ \vdots & \vdots & \vdots \\ 1 & X_1^{(m)} & X_2^{(m)} \end{bmatrix} \longleftrightarrow$$

[[1, 40, 20],
[1, 20, 50],
...
[1, 5, 35]]

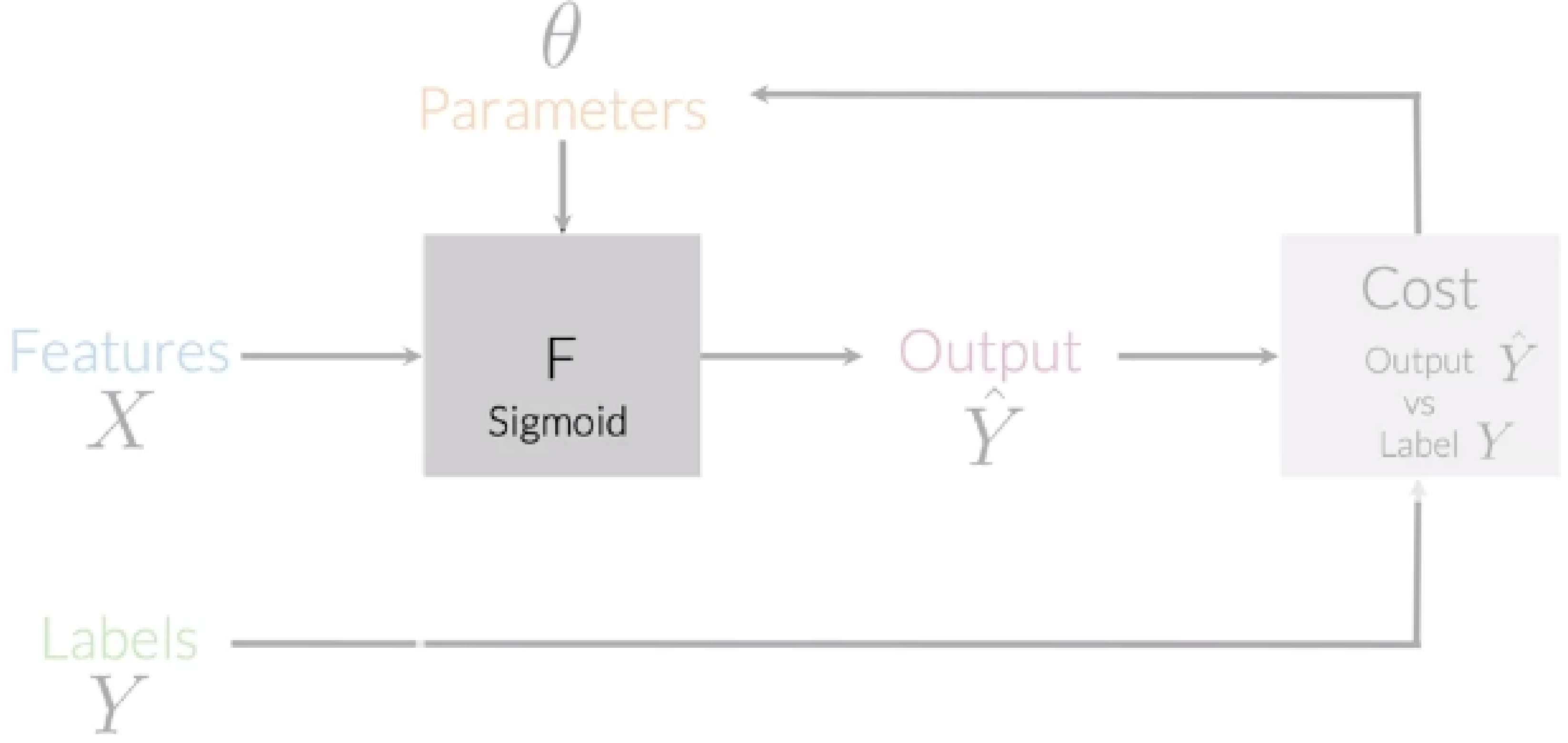
General Implementation

```
freqs = build_freqs(tweets,labels) #Build frequencies dictionary

X = np.zeros((m,3)) #Initialize matrix X

for i in range(m): #For every tweet

        p_tweet = process_tweet(tweets[i]) #Process tweet

    X[i,:] = extract_features(p_tweet,freqs) #Extract Features
```

Overview of logistic regression



Overview of logistic regression



Overview of logistic regression

$$h(x^{(i)}, \theta) = \frac{1}{1 + e^{-\theta^T x^{(i)}}}$$

Overview of logistic regression

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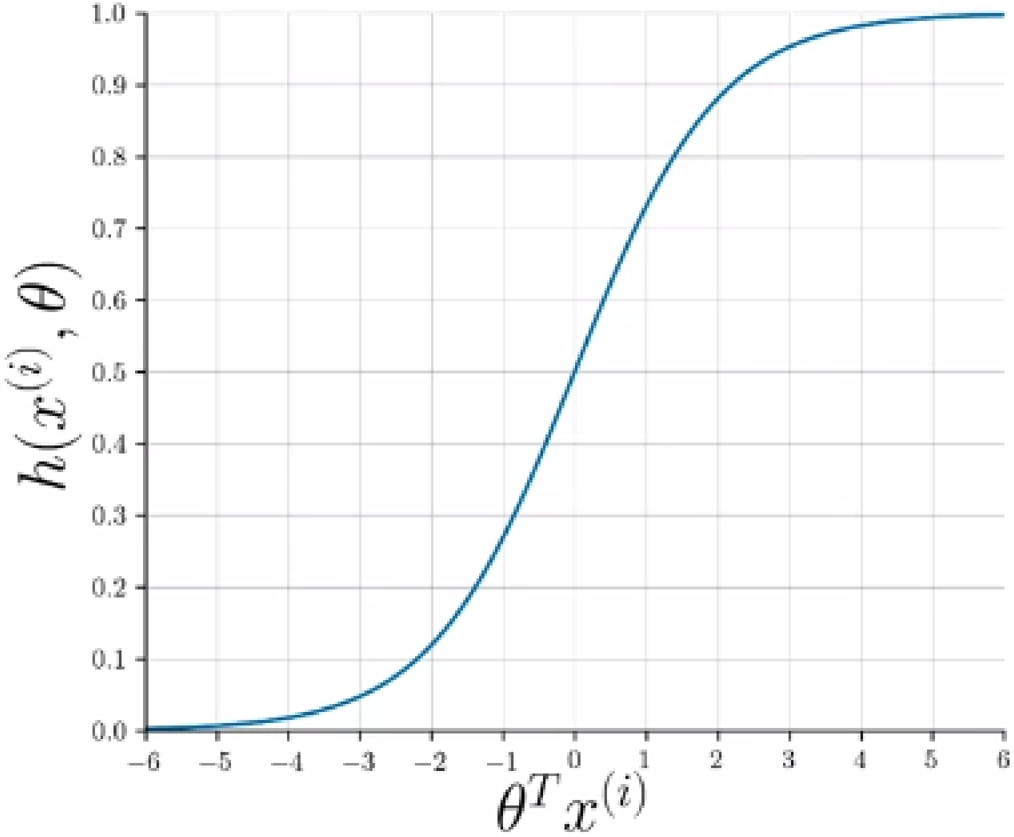
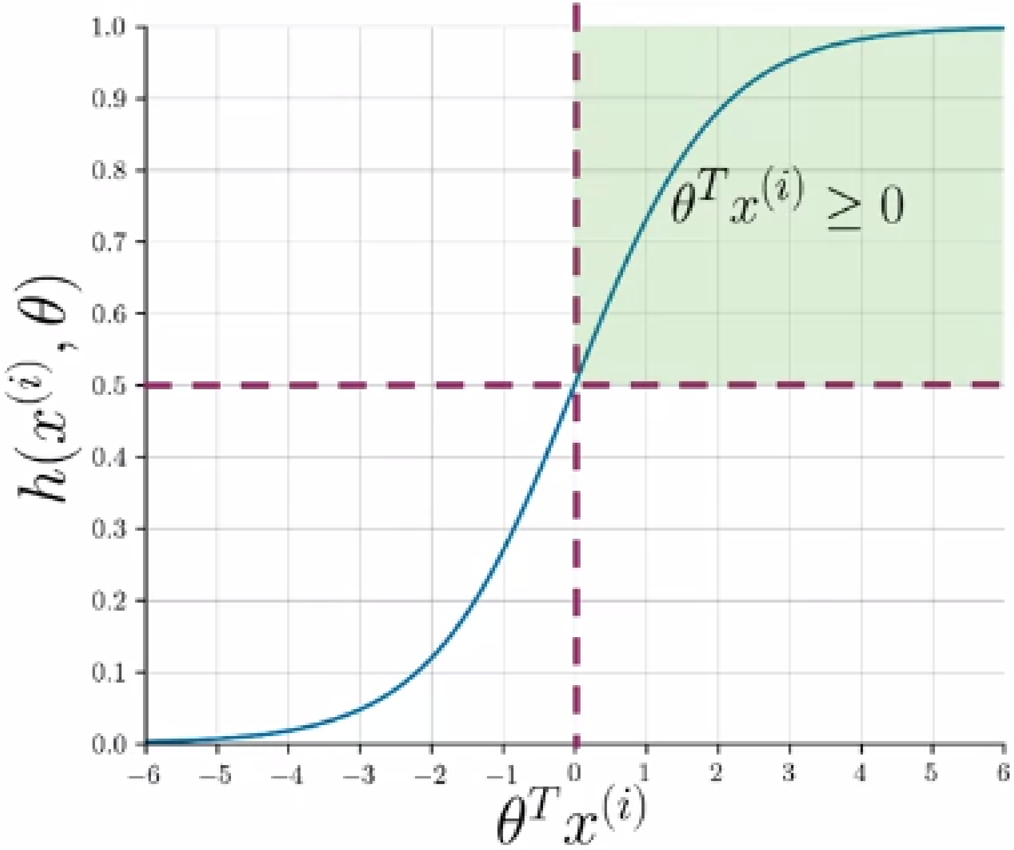


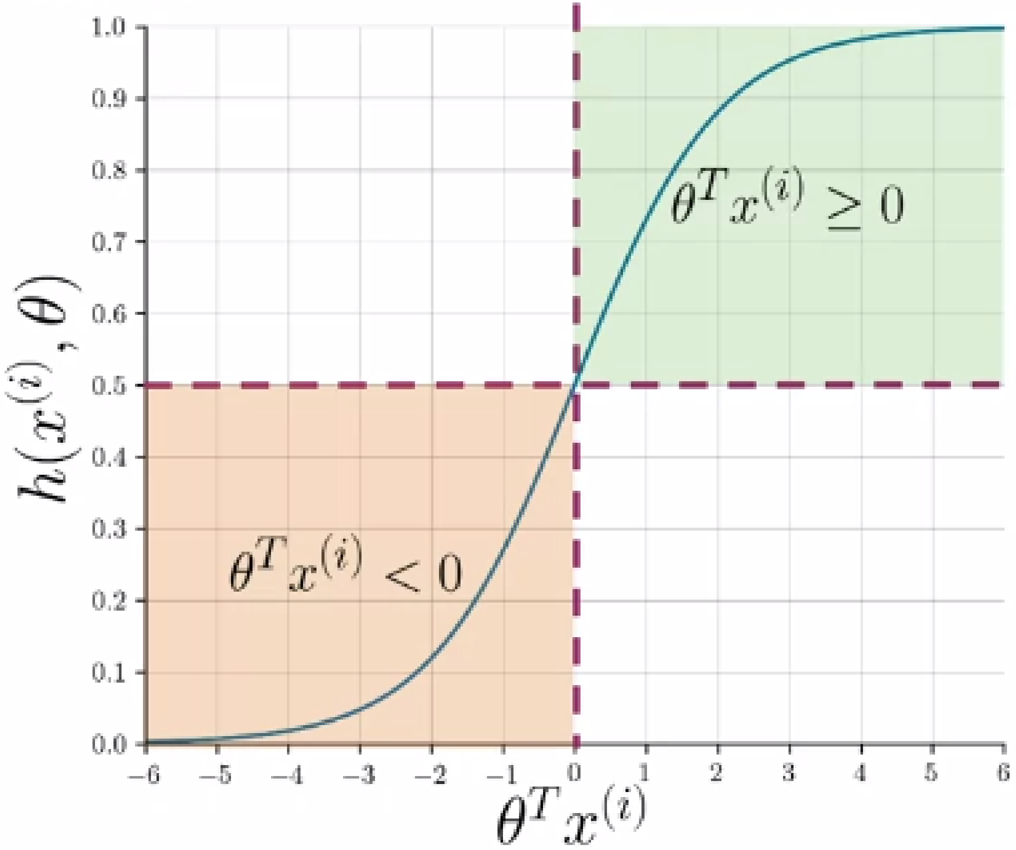
Overview of logistic regression

$$h(x^{(i)}, \theta) = \frac{1}{1 + e^{-\theta^T x^{(i)}}}$$



Overview of logistic regression

$$h(x^{(i)}, \theta) = \frac{1}{1 + e^{-\theta^T x^{(i)}}}$$



Overview of logistic regression

@YMourri and
@AndrewYNg are tuning a
GREAT AI model

Overview of logistic regression

@YMourri and
@AndrewYNg are tuning a
GREAT AI model

↓

[tun, ai, great, model]

Overview of logistic regression

@YMourri and
@AndrewYNg are tuning a
GREAT AI model

$\downarrow$

[tun, ai, great, model]

$\downarrow$

$$x^{(i)} = \begin{bmatrix} 1 \\ 3476 \\ 245 \end{bmatrix}$$

Overview of logistic regression

@YMourri and
@AndrewYNg are tuning a
GREAT AI model

$\downarrow$

[tun, ai, great, model]

$\downarrow$

$$x^{(i)} = \begin{bmatrix} 1 \\ 3476 \\ 245 \end{bmatrix} \quad \theta = \begin{bmatrix} 0.00003 \\ 0.00150 \\ -0.00120 \end{bmatrix}$$

Overview of logistic regression

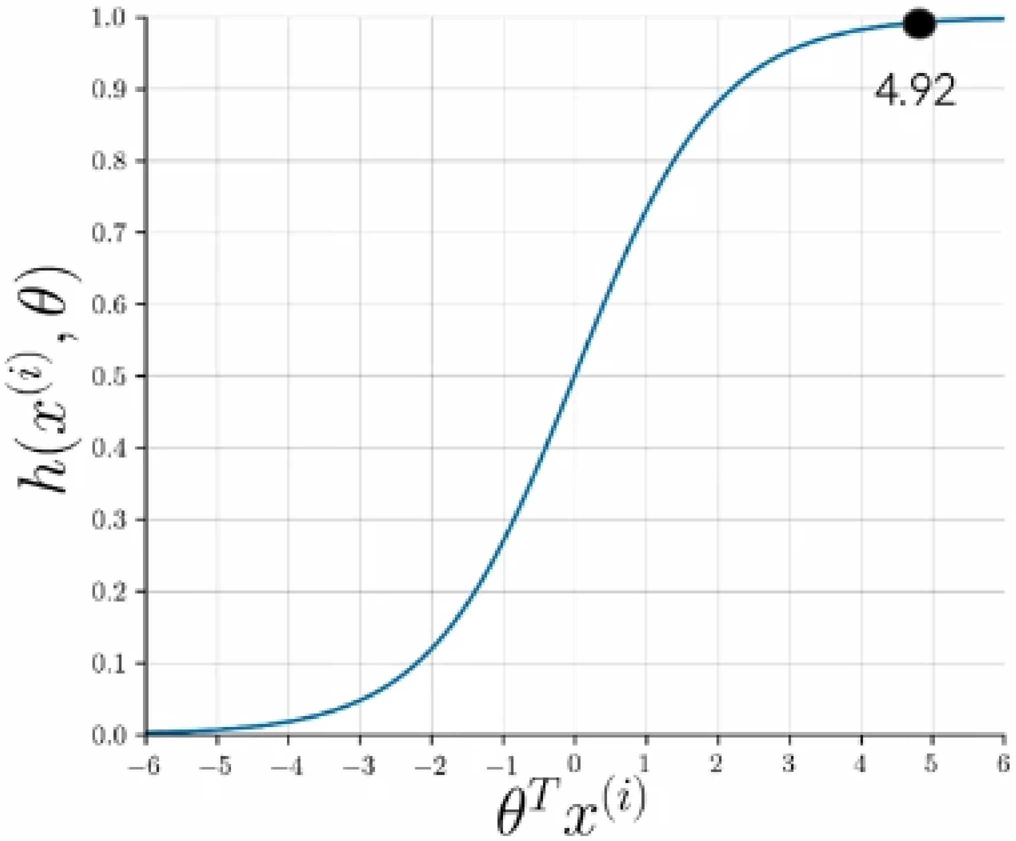
@YMourri and @AndrewYNg are tuning a GREAT AI model

↓

[tun, ai, great, model]

↓

$$x^{(i)} = \begin{bmatrix} 1 \\ 3476 \\ 245 \end{bmatrix} \quad \theta = \begin{bmatrix} 0.00003 \\ 0.00150 \\ -0.00120 \end{bmatrix}$$



Overview of logistic regression

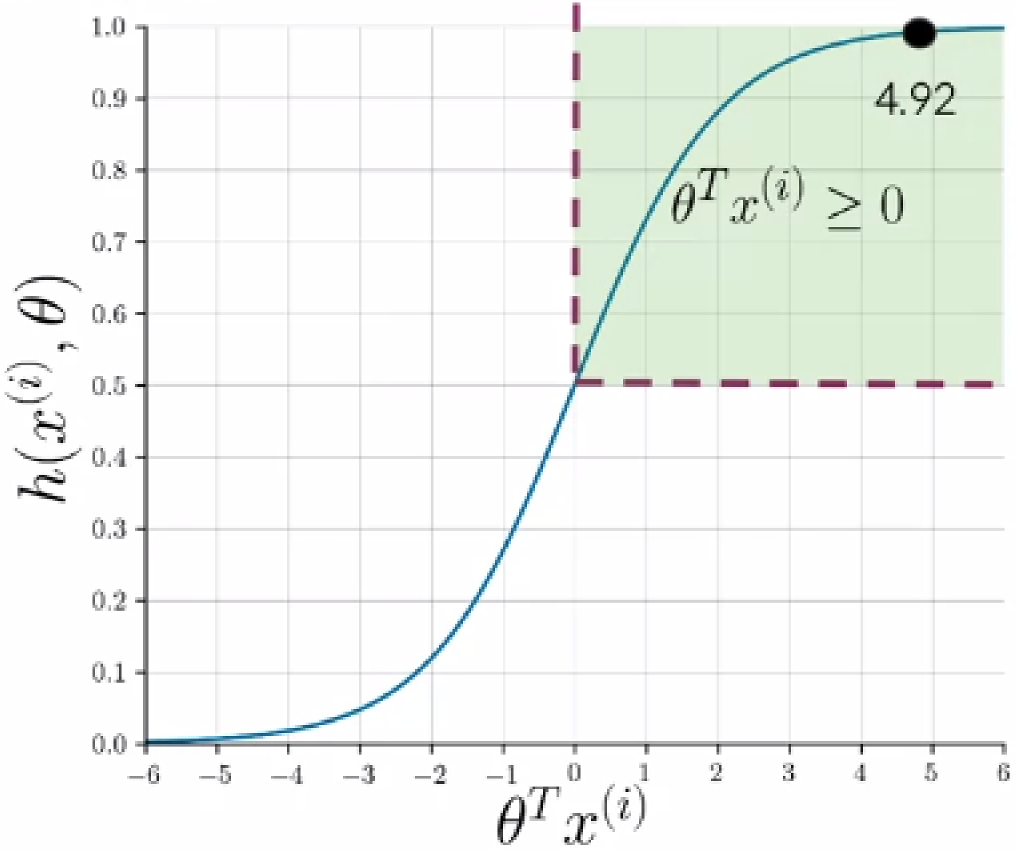
@YMourri and @AndrewYNg are tuning a GREAT AI model

↓

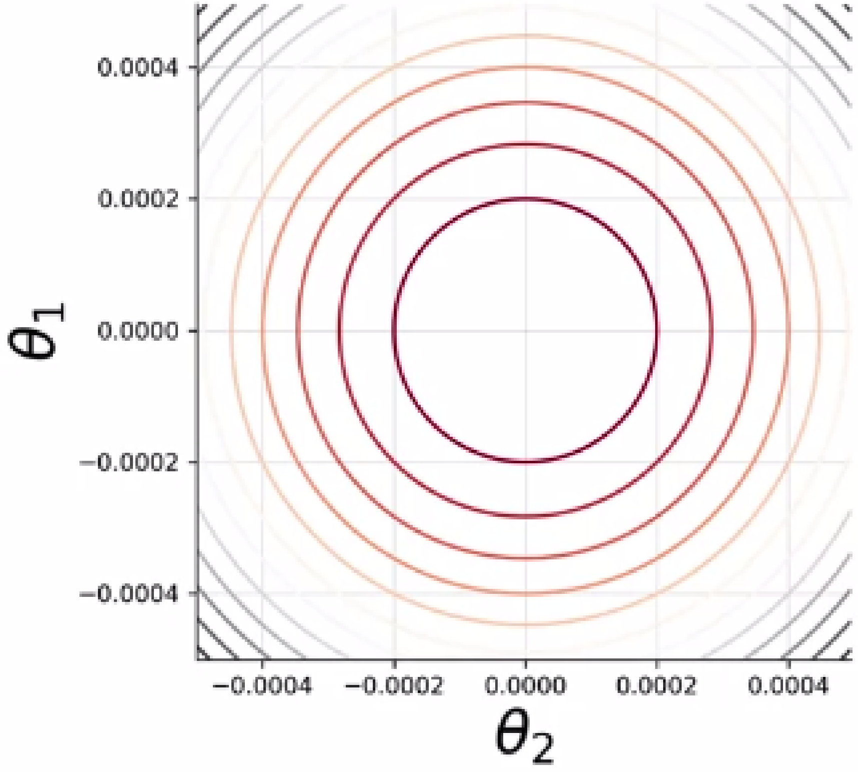
[tun, ai, great, model]

↓

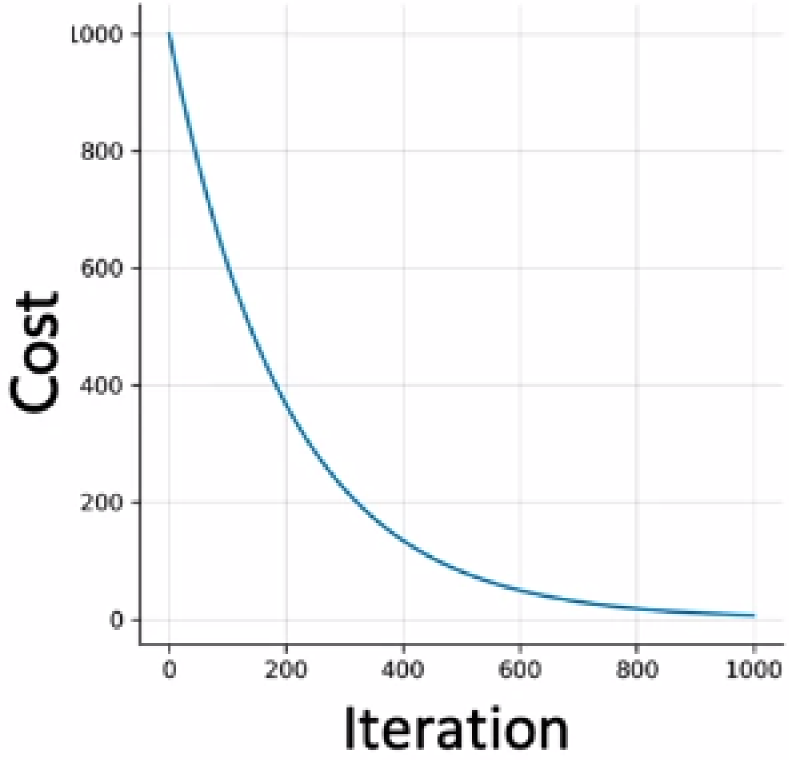
$$x^{(i)} = \begin{bmatrix} 1 \\ 3476 \\ 245 \end{bmatrix} \quad \theta = \begin{bmatrix} 0.00003 \\ 0.00150 \\ -0.00120 \end{bmatrix}$$



Training LR

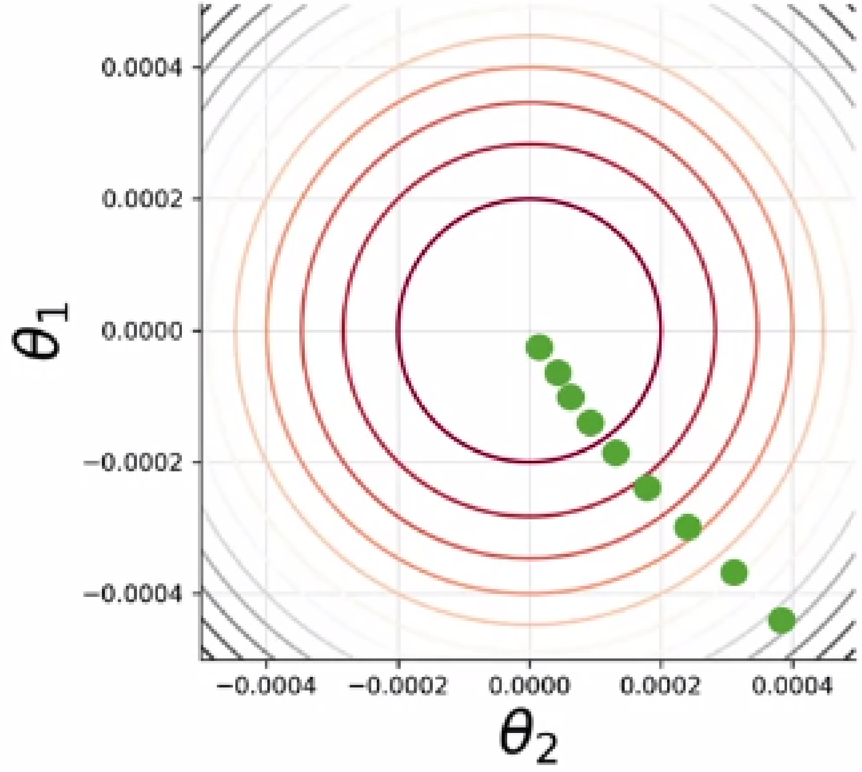


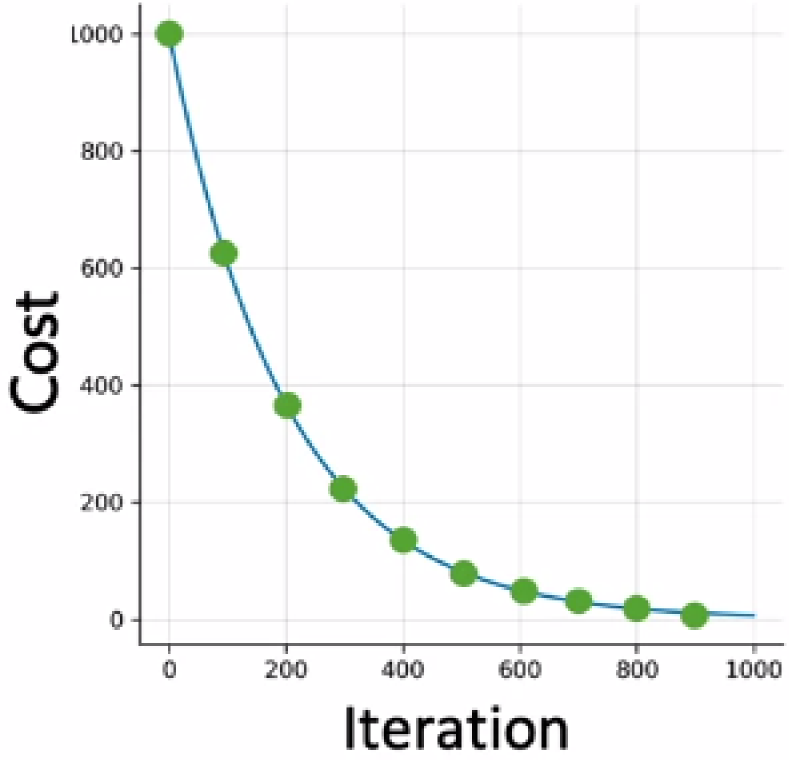
0.0004
0.0002
0.0000
−0.0002
−0.0004
θ_1
−0.0004
−0.0002
0.0000
0.0002
0.0004
θ_2



1000
800
600
400
200
0
Cost
0
200
400
600
800
1000
Iteration

Training LR


0.0004
0.0002
0.0000
−0.0002
−0.0004
θ_1
−0.0004
−0.0002
0.0000
0.0002
0.0004
θ_2


1000
800
600
400
200
0
Cost
0
200
400
600
800
1000
Iteration

Training LR

$\boxed{\theta}$

Initialize parameters

Training LR

$$\theta$$

$$\downarrow$$

$$h = h(X, \theta)$$

Initialize parameters

$\downarrow$

Classify/predict

Training LR

$$\theta$$

$$\downarrow$$

$$h = h(X, \theta)$$

$$\downarrow$$

$$\nabla = \frac{1}{m} X^T (h - y)$$

Initialize parameters

$\downarrow$

Classify/predict

$\downarrow$

Get gradient

Training LR

$$\theta$$

$$\downarrow$$

$$h = h(X, \theta)$$

$$\downarrow$$

$$\nabla = \frac{1}{m} X^T (h - y)$$

$$\downarrow$$

$$\theta = \theta - \alpha \nabla$$

Initialize parameters

↓

Classify/predict

↓

Get gradient

↓

Update

Training LR

$$\theta$$

$$h = h(X, \theta)$$

$$\nabla = \frac{1}{m} X^T (h - y)$$

$$\theta = \theta - \alpha \nabla$$

$$J(\theta)$$

Initialize parameters

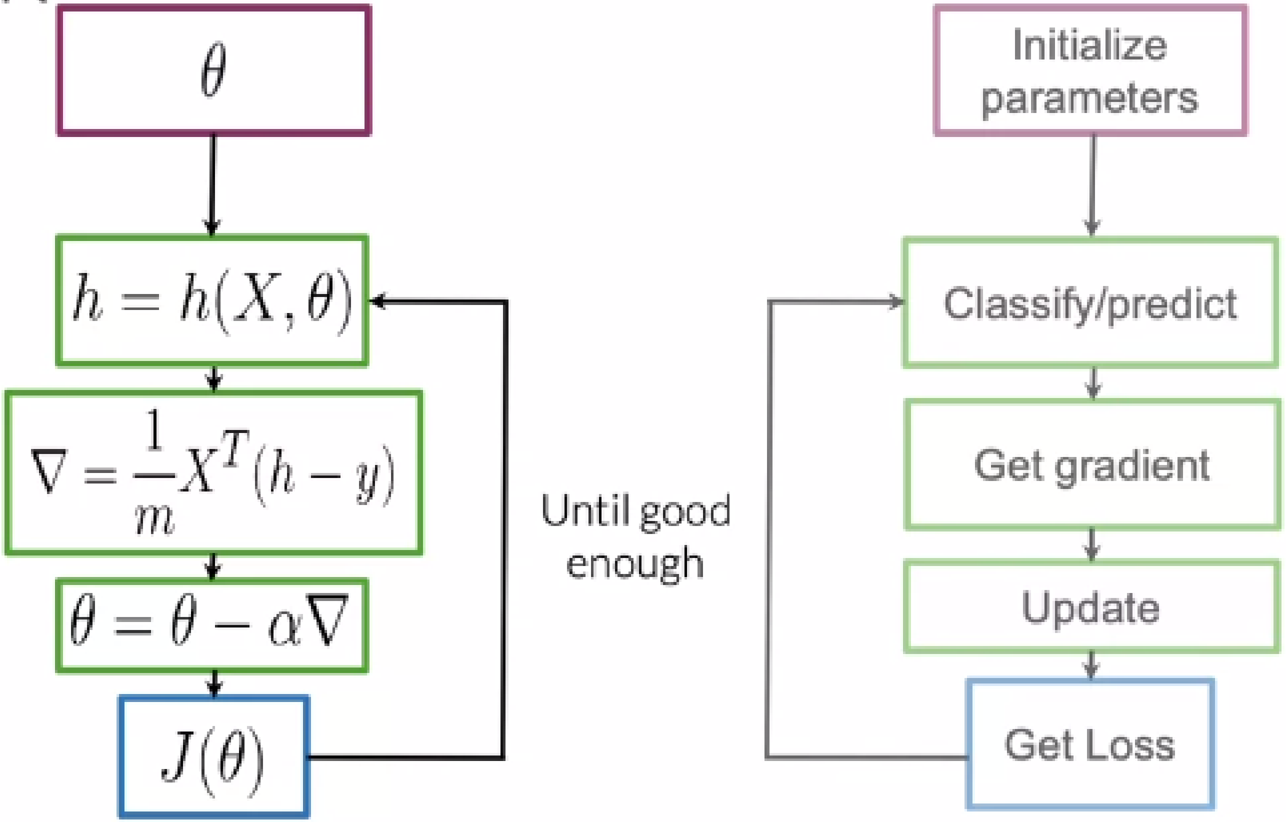
Classify/predict

Get gradient

Update

Get Loss

Training LR



θ
$h = h(X, \theta)$
$\nabla = \frac{1}{m} X^T (h - y)$
$\theta = \theta - \alpha \nabla$
$J(\theta)$
Until good enough
Initialize parameters
Classify/predict
Get gradient
Update
Get Loss

Testing logistic regression

- X_{val} Y_{val} θ

Testing logistic regression

- $X_{val}\ Y_{val}\ \theta$

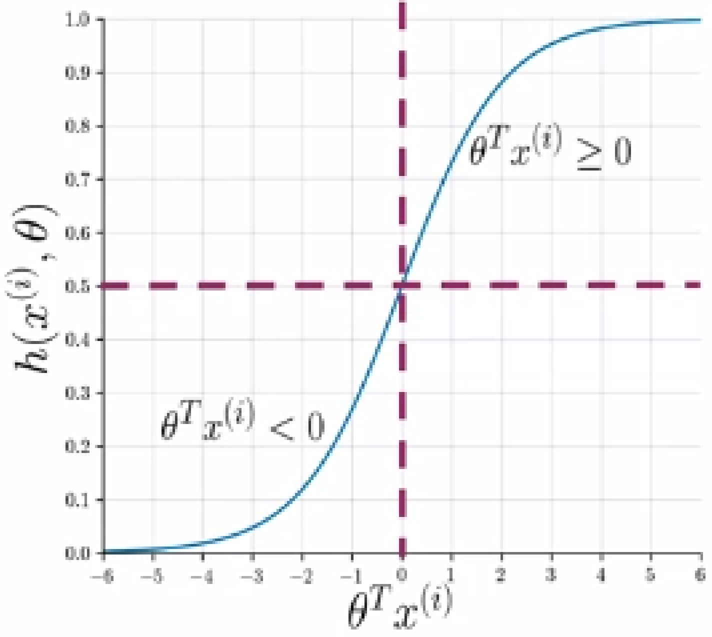
$$h(X_{val}, \theta)$$

Testing logistic regression

- $X_{val}\ Y_{val}\ \theta$

$$h(X_{val}, \theta)$$

$$pred = h(X_{val}, \theta) \geq 0.5$$



Testing logistic regression

- $X_{val}\ Y_{val}\ \theta$

$$h(X_{val}\cdot\theta)$$

$$pred = h(X_{val}\cdot\theta) \geq 0.5 \quad \begin{bmatrix} 0.3 \\ 0.8 \\ 0.5 \\ \vdots \\ h_m \end{bmatrix}$$

Testing logistic regression

- $X_{val}\ Y_{val}\ \theta$

$$h(X_{val}\cdot\theta)$$

$$pred = h(X_{val}\cdot\theta) \geq 0.5 \qquad \begin{bmatrix} 0.3 \\ 0.8 \\ 0.5 \\ \vdots \\ h_m \end{bmatrix} \geq 0.5$$

Testing logistic regression

- $X_{val}\ Y_{val}\ \theta$

$$h(X_{val}, \theta)$$

$$pred = h(X_{val}, \theta) \geq 0.5$$

$$\begin{bmatrix} 0.3 \\ 0.8 \\ 0.5 \\ \vdots \\ h_m \end{bmatrix} \geq 0.5 = \begin{bmatrix} 0.3 \geq 0.5 \\ 0.8 \geq 0.5 \\ 0.5 \geq 0.5 \\ \vdots \\ pred_m \geq 0.5 \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \\ 1 \\ \vdots \\ pred_m \end{bmatrix}$$

Testing logistic regression

- $X_{val} \quad Y_{val} \quad \theta$

$$h(X_{val}, \theta)$$

$$pred = h(X_{val}, \theta) \geq 0.5$$

$$\sum_{i=1}^{m} \frac{(pred^{(i)} == y_{val}^{(i)})}{m}$$

Testing logistic regression

- $X_{val}\ Y_{val}\ \theta$

$$h(X_{val}, \theta)$$

$$pred = h(X_{val}, \theta) \geq 0.5$$

$$\sum_{i=1}^{m} \frac{(pred^{(i)} == y_{val}^{(i)})}{m}$$

$$\begin{bmatrix} 0 \\ 1 \\ 1 \\ \vdots \\ pred_m \end{bmatrix} == \begin{bmatrix} 0 \\ 0 \\ 1 \\ \vdots \\ Y_{val_m} \end{bmatrix}$$

$$\begin{bmatrix} 1 \\ 0 \\ 1 \\ \vdots \\ pred_m == Y_{val_m} \end{bmatrix}$$

Testing logistic regression

- $X_{val}\ Y_{val}\ \theta$

$$h(X_{val}, \theta)$$

$$pred = h(X_{val}, \theta) \geq 0.5$$

$$\sum_{i=1}^{m} \frac{(pred^{(i)} == y_{val}^{(i)})}{m}$$

Testing logistic regression

$$Y_{val} = \begin{bmatrix} 0 \\ 1 \\ 1 \\ 0 \\ 1 \end{bmatrix} \quad pred = \begin{bmatrix} 0 \\ 1 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$

Testing logistic regression

$$Y_{val} = \begin{bmatrix} 0 \\ 1 \\ 1 \\ 0 \\ 1 \end{bmatrix} \quad pred = \begin{bmatrix} 0 \\ 1 \\ 0 \\ 0 \\ 1 \end{bmatrix} \quad (Y_{val} == pred) = \begin{bmatrix} 1 \\ 1 \\ 0 \\ 1 \\ 1 \end{bmatrix}$$

Testing logistic regression

$$Y_{val} = \begin{bmatrix} 0 \\ 1 \\ \underline{1} \\ 0 \\ 1 \end{bmatrix} \quad pred = \begin{bmatrix} 0 \\ 1 \\ \underline{0} \\ 0 \\ 1 \end{bmatrix} \quad (Y_{val} == pred) = \begin{bmatrix} 1 \\ 1 \\ \underline{0} \\ 1 \\ 1 \end{bmatrix}$$

$$\boxed{\text{accuracy} = \frac{4}{5} = 0.8}$$

Cost function for logistic regression

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}\left[y^{(i)}\log h(x^{(i)},\theta) + (1-y^{(i)})\log(1-h(x^{(i)},\theta))\right]$$

Cost function for logistic regression

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}[y^{(i)}\log h(x^{(i)},\theta) + (1-y^{(i)})\log(1-h(x^{(i)},\theta))]$$

Cost function for logistic regression

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Cost function for logistic regression

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Cost function for logistic regression

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}\left[\boxed{y^{(i)} \log h(x^{(i)},\theta)} + \boxed{(1-y^{(i)}) \log(1-h(x^{(i)},\theta))}\right]$$

$y^{(i)}$	$h(x^{(i)},\theta)$

Cost function for logistic regression

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}\left[\boxed{y^{(i)} \log h(x^{(i)},\theta)} + \boxed{(1-y^{(i)}) \log(1-h(x^{(i)},\theta))}\right]$$

$y^{(i)}$	$h(x^{(i)},\theta)$	
0	any	0

Cost function for logistic regression

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}\left[\boxed{y^{(i)}\log h(x^{(i)},\theta)} + \boxed{(1-y^{(i)})\log(1-h(x^{(i)},\theta))}\right]$$

$y^{(i)}$	$h(x^{(i)},\theta)$	
0	any	0
1	0.99	~0

Cost function for logistic regression

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}\left[\boxed{y^{(i)} \log h(x^{(i)}, \theta)} + \boxed{(1 - y^{(i)}) \log(1 - h(x^{(i)}, \theta))}\right]$$

$y^{(i)}$	$h(x^{(i)}, \theta)$	
0	any	0
1	0.99	~0
1	~0	-inf

Cost function for logistic regression

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}\left[\boxed{y^{(i)} \log h(x^{(i)},\theta)} + \boxed{(1-y^{(i)}) \log(1-h(x^{(i)},\theta))}\right]$$

$y^{(i)}$	$h(x^{(i)},\theta)$

Cost function for logistic regression

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}\left[\boxed{y^{(i)}\log h(x^{(i)},\theta)} + \boxed{(1-y^{(i)})\log(1-h(x^{(i)},\theta))}\right]$$

$y^{(i)}$	$h(x^{(i)},\theta)$	
1	any	0

Cost function for logistic regression

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}\left[\boxed{y^{(i)} \log h(x^{(i)}, \theta)} + \boxed{(1 - y^{(i)}) \log(1 - h(x^{(i)}, \theta))}\right]$$

$y^{(i)}$	$h(x^{(i)}, \theta)$	
1	any	0
0	0.01	~0

Cost function for logistic regression

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}\left[\boxed{y^{(i)}\log h(x^{(i)},\theta)} + \boxed{(1-y^{(i)})\log(1-h(x^{(i)},\theta))}\right]$$

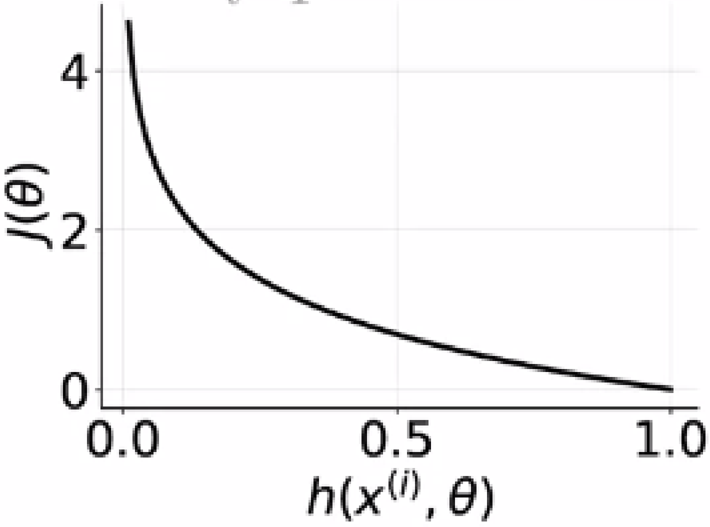
$y^{(i)}$	$h(x^{(i)},\theta)$	
1	any	0
0	0.01	~0
0	~1	-Inf

Cost function for logistic regression

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}\left[\boxed{y^{(i)} \log h(x^{(i)}, \theta)} + \boxed{(1 - y^{(i)}) \log(1 - h(x^{(i)}, \theta))}\right]$$

Cost function for logistic regression

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}[y^{(i)} \boxed{\log h(x^{(i)}, \theta)} + (1 - y^{(i)}) \log(1 - h(x^{(i)}, \theta))]$$



Cost function for logistic regression

$$J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}\left[y^{(i)}\log h(x^{(i)},\theta) + (1-y^{(i)})\boxed{\log(1-h(x^{(i)},\theta))}\right]$$