DL Intro

Bertelsmann Tech Scholarship
Challenge Course - AI Track

Intro to Deep learning with PyTorch

- ☐ Complete all quizzes, projects
- ☐ complete all lessons
- ☐ participate & class communications - slack

PyTorch - facebook AI Research team
- python first philosophy

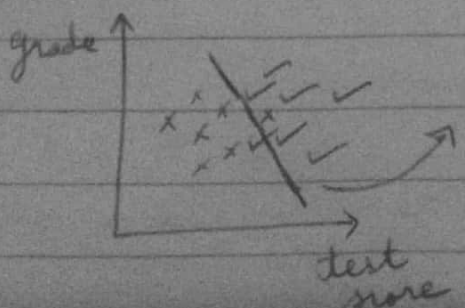
Lesson 3 Intro to Neural Networks

1. Deep learning - deep neural networks
Neural Networks - vaguely mimic the workings of the brain
firing up of neurons - to pass on information

"Neurons that fire together, wire together"

Neural Networks simply draw a classification boundary - either a line or a complex non-linear boundary

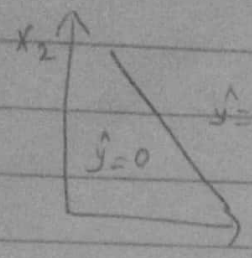
2. Classification problems
task : Accept / Reject a student



model → classifications boundary

How do we find this line?

4. Linear boundaries



classification boundary

$W x_1 + W x_2 + b = 0$

$Wx + b = 0$

$W = (w_1, w_2)$ weights

$x = (x_1, x_2)$ bias

label $y = 0$ or 1

prediction $\hat{y} = \begin{cases} 1 & \text{if } Wx+b \geq 0 \\ 0 & \text{if } Wx+b < 0 \end{cases}$

goal: resemble $\hat{y}$ as close as possible as y

prediction label

how → find weights that get $\hat{y}$ as close as possible to y.

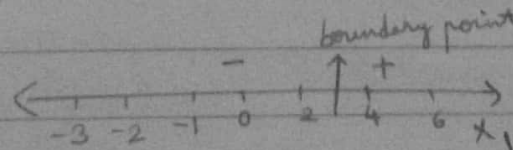
5. Higher Dimensions

linear boundaries

Data	boundary	
1-D	point	$w_1 x_1 + b = 0$
2-D plane	1-D line	$w_1 x_1 + w_2 x_2 + b = 0$
3-D plane	2-D plane	$w_1 x_1 + w_2 x_2 + w_3 x_3 + b = 0$
nD hyperspace	n-1D hyperplane	$w_1 x_1 + w_2 x_2 + \dots w_n x_n + b =$

$\boxed{Wx + b = 0}$

$w_1 x_1 + b = 0 \quad \Rightarrow mx + c = 0$??



if $x \geq 3$ $y = +$

$x < 3$ $y = -$

what is w & b ⇒ $w_1 = 1 \times b = -3$

say $x = 0$ score < 0

$0 + b < 0$

b = negative

Say $x = 2.5$ score < 0

$w_1 x_1 + b < 0$

$w_1 = 0$? No. $w_1 = 1$, $b = -3$

$2.5 + (-3) = -0.5 < 0$

$x = 2.9$ $w_1 x_1 + b = 2.9 - 3 = -0.1 < 0$.

Say $x = 3$ score ≥ 0

$w_1 x_1 + b = 1(3) + (-3) = 0 \Rightarrow 0$ score. ✓

Say $x = 4$ score > 0

$w_1 x_1 + b = 1(4) - 3 = 1$ score > 1.

Quiz. Input feature x weights w bias b dimensions?

$Wx + b = 0$

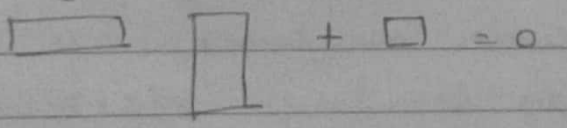
$(1 \times n)(n \times 1) + (1 \times 1) = 0$

$W : (1 \times n)$

$X : (n \times 1)$ n features

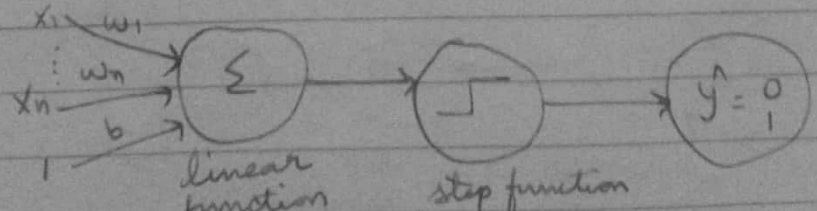
$b : (1 \times 1)$

$(1 \times n)(n \times 1) + (1 \times 1) = 0$



6. Perceptrons

- building blocks of Neural Networks
- draws a one classification boundary $Wx + b = 0$

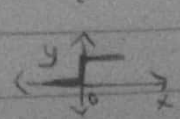


linear function

$\sum_{i=1}^{n} w x_i + b$

step function

$y = \begin{cases} 1 & \text{if } x \geq 0 \\ 0 & \text{otherwise} \end{cases}$



DL Intro

Neural Networks

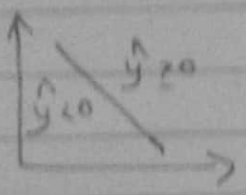
vaguely mimic the functions / workings of brain
Neurons that fire together, wire together.

Linear boundaries

$Wx + b = 0$

$\hat{y} = \begin{cases} 1 & \text{if } Wx+b \geq 0 \\ 0 & \text{if } Wx+b < 0 \end{cases}$

W weights
b bias
x input features



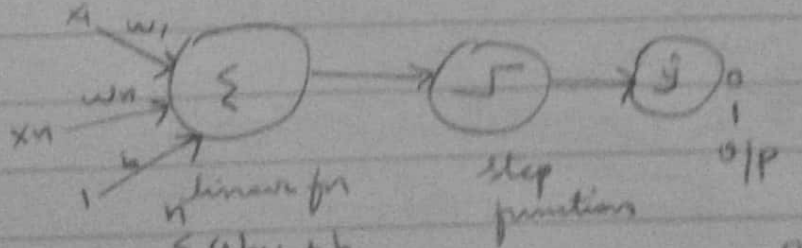
Higher dimensions

Data space	boundary space
1D	point
2D	1-D line
3D	2D plane
nD hyperspace	n-1D hyperplane

for all linear boundaries,
classification boundary $Wx + b = 0$

Perceptron

- building block of Neural Networks
- draws one classification boundary



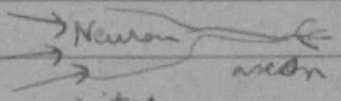
$\sum_{i=1}^{n} w_i x_i + b$

$\sum_{i=1}^{n} w_i x_i + b$

$y = \begin{cases} 0 & \text{otherwise} \\ 1 & \text{if } x \geq 0 \end{cases}$

7. Why 'Neural Networks'?

Perceptrons mimic the neurons in the brain

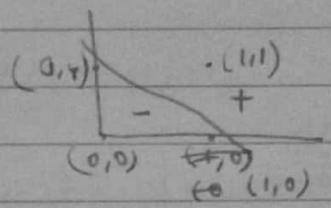


(take o/p of one neuron and pass that as i/p to another Neuron(s) Neural Network.

8. Perceptron as Logical operators

AND

i/p	i/p	o/p
0	0	0
0	1	0
1	0	0
1	1	1



goal $\hat{y} = \begin{cases} 1 & \text{if } w_1x_1 + w_2x_2 + b \geq 0 \\ 0 & \text{if } w_1x_1 + w_2x_2 + b < 0 \end{cases}$

find optimal weights & bias

$w_1 = 1 \quad w_2 = 1 \quad b = -2$

0 0 $\quad 1(0) + 1(0) - 2 = -2 \quad < 0$

1 0 $\quad 1(1) + 1(0) - 2 = 1 - 2 = -1 < 0$

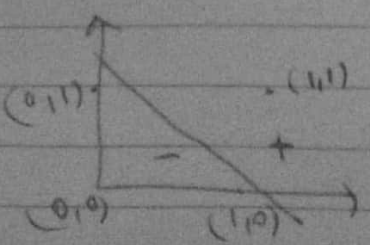
0 1 $\quad 1(0) + 1(1) - 2 = -1 < 0$

1 1 $\quad (1)(1) + (1)(1) - 2 = 1 + 1 - 2 = 0 \leq 0$

$w_1 = 1$

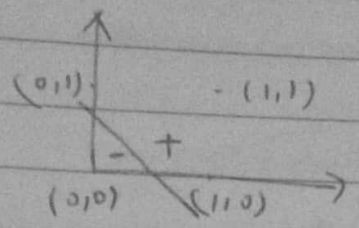
$w_2 = 1$ AND.

$b = -2$



OR

i/p	i/p	o/p
0	0	0
0	1	1
1	0	1
1	1	0



$w_1 x_1 + w_2 x_2 + b = 0$ $\quad b = -1$

$w_1, w_2 = 1$

0 0 $(1)(0) + (1)(0) - 1 = -1 < 0$ ✓

1 0 $(1)(1) + (1)(0) - 1 = 1 - 1 = 0$ ✓

0 1 $\quad = 0$

1 1 $(1)(1) + (1)(1) - 1 = 2 - 1 = 1 > 0$

OR

$w_1 = 1, \quad w_2 = 1, \quad b = -1$

How to convert AND perceptron to OR?

1. decrease the bias → magnitude of bias
2. increase the weights

NOT perceptron

i/p	o/p
0	1
1	0

$w_1 x_1 + b \geq 0$ if $x_1 = 0$

$w_1 x_1 + b < 0$ if $x_1 = 1$

make weight negative

$w_1 = -1 \quad b = +0$

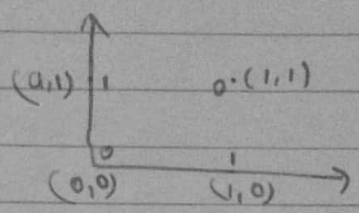
$x_1 = 0 \quad (-1)(0) + 0 = 0 \geq 0$

$x_1 = 1 \quad (-1)(1) + 0 = -1 < 0$

NOT $\quad w_1 = -1 \quad b = 0$

XOR perceptron exclusive OR

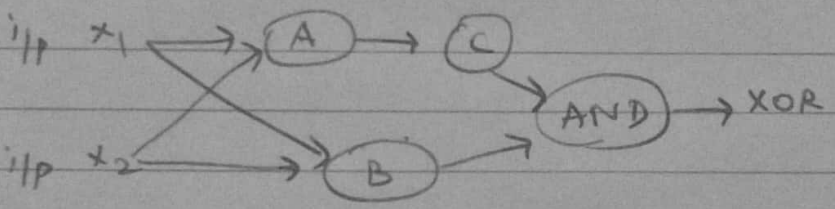
I/P	I/P	O/P
0	0	0
0	1	1
1	0	1
1	1	0



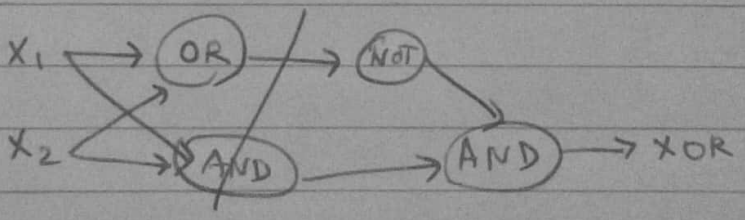
these points can't be seperated by a single line!

Multi layer perceptron using AND, NOT, OR perceptrons to build XOR logic

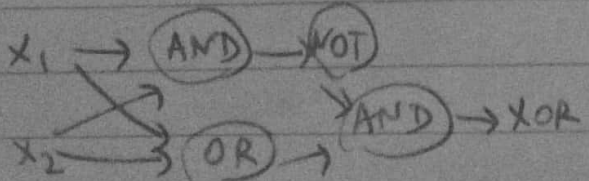
quiz



A, B, C ?



X_1	X_2	OR	NOT	AND_1	AND_2	XOR
0	0	0	1	0	·	0
0	1	1	0	0		1
1	0	1	0	0		1
1	1	1	0	1		0



X_1	X_2	AND	NOT	OR	AND	XOR
0	0	0	1	0	0	0
0	1	0	1	1	1	1
1	0	0	1	1	1	1
1	1	1	0	1	0	0