

Machine Learning

Let's have some fun

Overview

- Price of a house
- Spam !!!
- Recommendation
- Apply to a university
- Ninjas
- Apples and Oranges
- Pizza Parlour

Overview

- **Price of a house**
 - **Spam !!!**
 - **Recommendation**
 - **Apply to a university**
-

- Ninjas
- Apples and Oranges
- Pizza Parlour

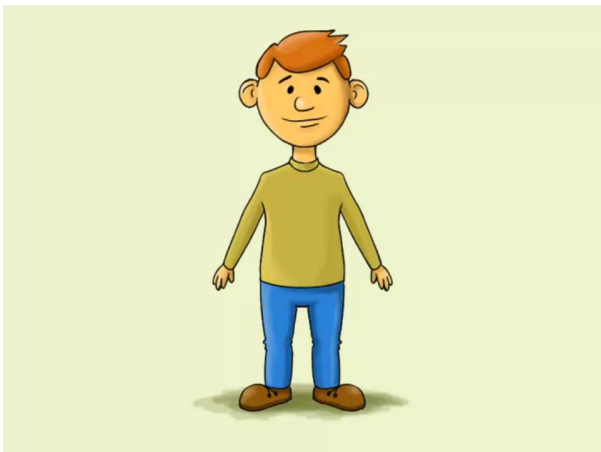
What is Machine Learning?

Learn from experience



What is Machine Learning?

Learn from experience

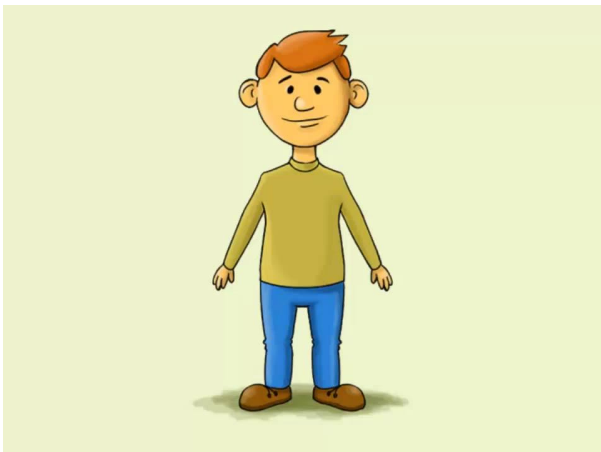


Follow Instructions

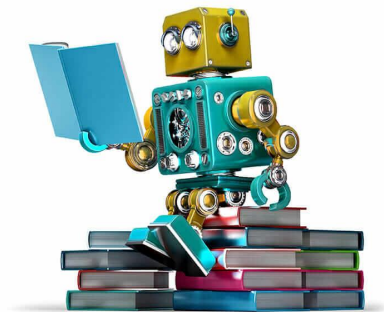


What is Machine Learning?

Learn from experience



Learn from Data



Follow Instructions



Learning

- ❑ Memorization (Declarative)
 - ❑ Accumulation of facts
 - ❑ Limitations
 - ❑ Time to memorize
 - ❑ Space to store the information
- ❑ Generalization (Imperative)
 - ❑ Deduce information from the old facts
 - ❑ Limitations
 - ❑ Accuracy of the deduction
 - ❑ Assumes Past \rightarrow Future

Price of a house



Price : \$70,000

Price of a house



Price : \$70,000



Price: \$160,000

Price of a house



Price : \$70,000

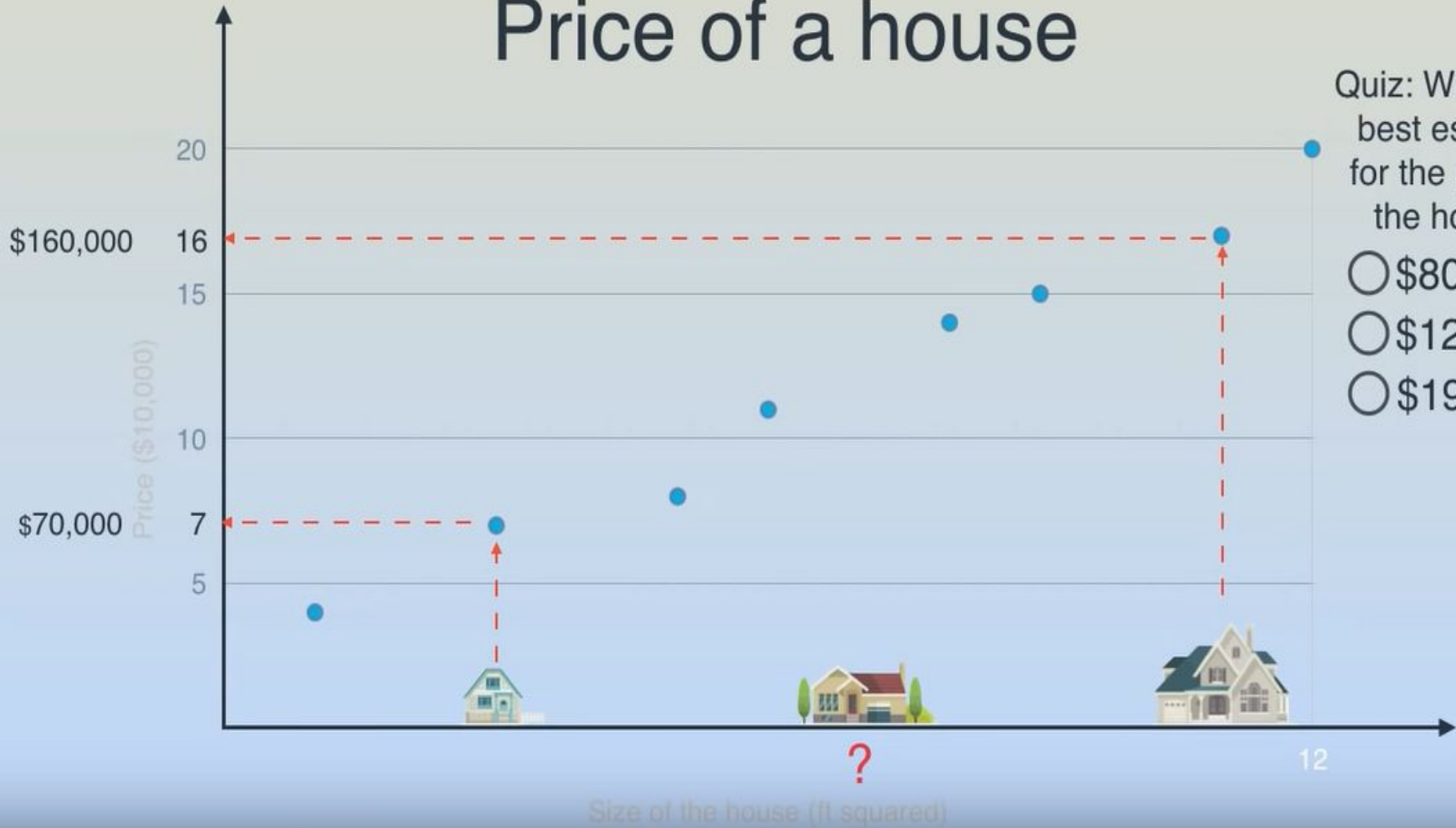


???



Price: \$160,000

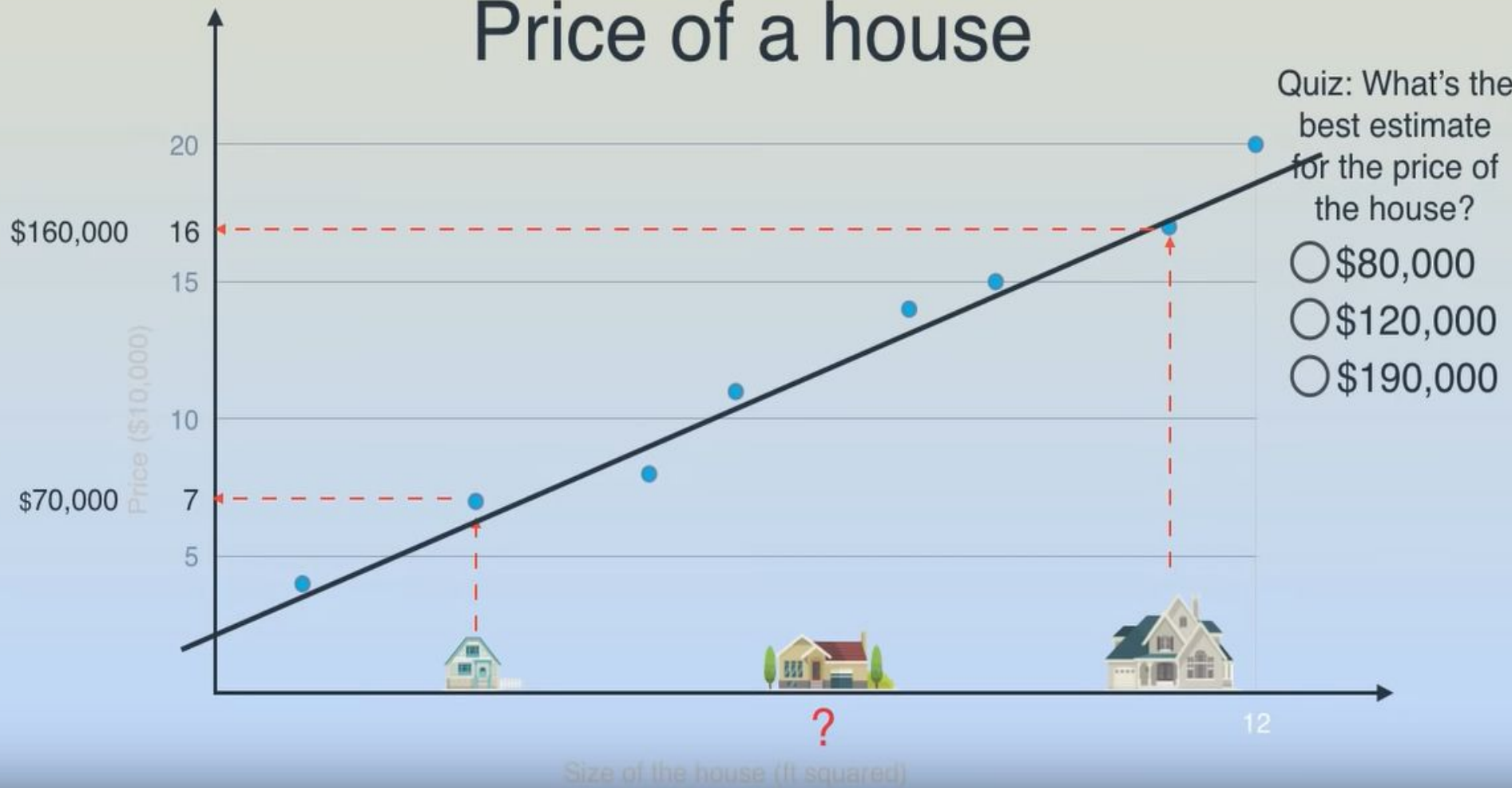
Price of a house



Quiz: What's the best estimate for the price of the house?

- ☐ \$80,000
- ☐ \$120,000
- ☐ \$190,000

Price of a house



Price of a house



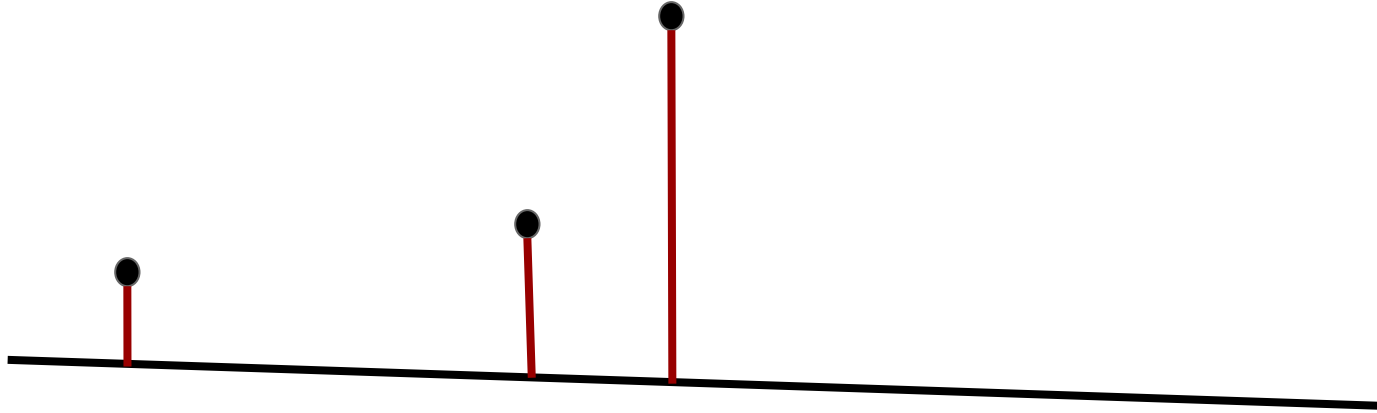
Linear Regression

- How can we learn to predict the **prices of houses of other sizes** in the city, as a **function of their living area**?
- Example of supervised learning problem.
- When the target variable we are trying to predict is continuous, **regression** problem.

Linear Regression



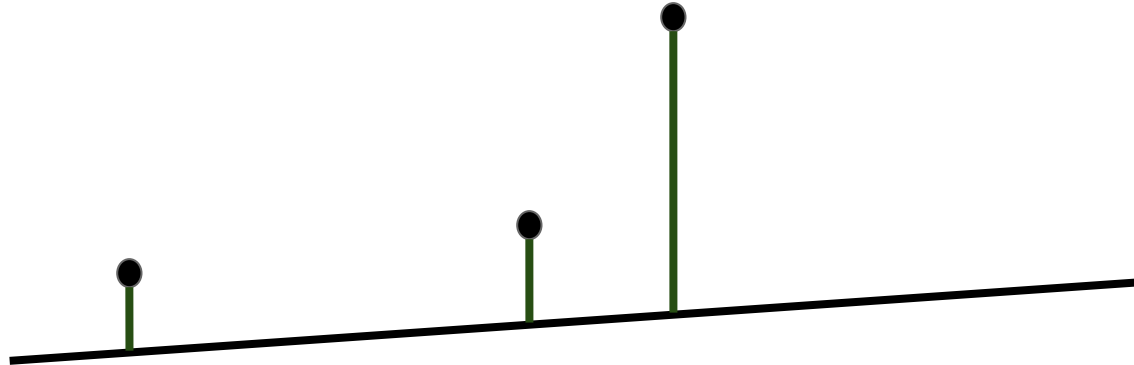
Linear Regression



Error :



Linear Regression

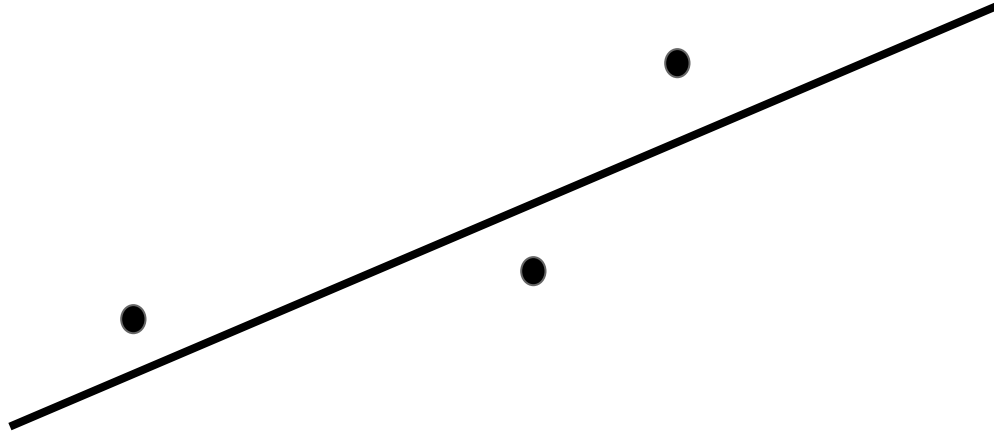


Error :



Linear Regression

Finally:



- Gradient Descent
- Method of least square : Add the sum of squares of error at individual point.

Gradient descent

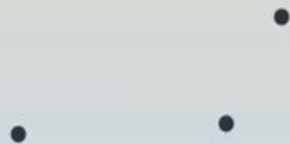


Mount Errorest



Gradient descent

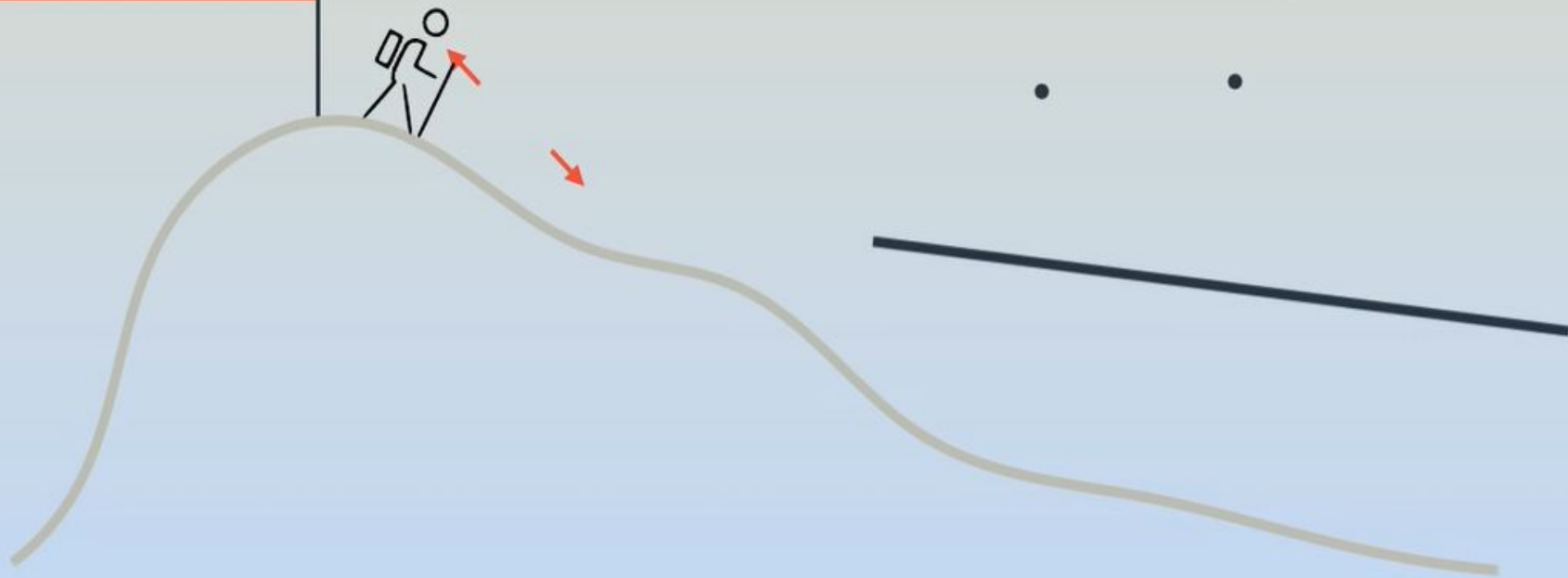
Mount Errorest



Gradient descent

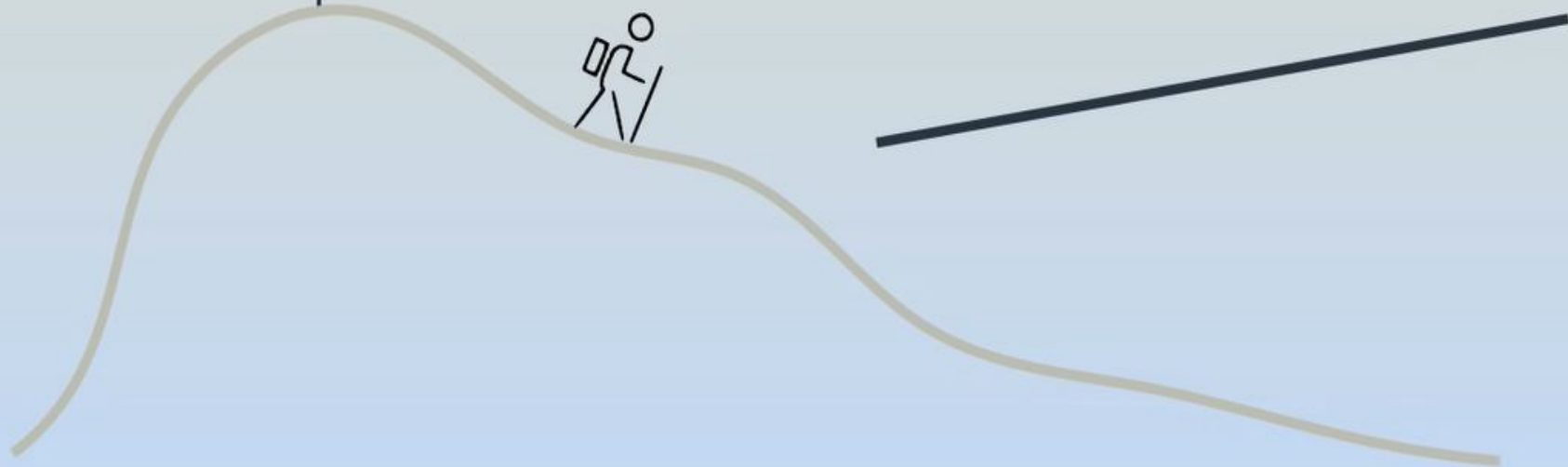


Mount Errorest



Gradient descent

Mount Errorest



Gradient descent

Mount Errorest



Linear and Polynomial Regression



Detecting Spam e-mails



Detecting Spam e-mails

Spam



Non-spam



Detecting Spam e-mails



“Cheap”

Spam



Non-spam



Detecting Spam e-mails



“Cheap”

Spam



Non-spam



Detecting Spam e-mails



“Cheap”

Spam

Non-spam



Detecting Spam e-mails



“Cheap”

Spam

Non-spam

Quiz: If an e-mail contains the word “cheap”, what is the probability of it being spam?



Detecting Spam e-mails



“Cheap”

Spam



Non-spam



Quiz: If an e-mail contains the word “cheap”, what is the probability of it being spam?

- ☐ 40%
- ☐ 60%
- ☐ 80%

Detecting Spam e-mails



“Cheap”

Spam



80%

Non-spam



20%

Quiz: If an e-mail contains the word “cheap”, what is the probability of it being spam?

- ☐ 40%
- ☐ 60%
- ☒ 80%

Conclusion:

If the e-mail contains the word “cheap”,
The probability of it being spam is 80%

Detecting Spam e-mails



“Cheap” → 80%



Spelling mistake → 70%



Missing title → 95%



etc...

Quiz: If an e-mail contains the word “cheap”, what is the probability of it being spam?



40%



60%



80%

Conclusion:

If the e-mail contains the word “cheap”,
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Naive Bayes Algorithm



“Cheap” → 80%



Spelling mistake → 70%



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etc...

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40%



60%









80%

Conclusion:







If the e-mail contains the word “cheap”,
The probability of it being spam is 80%

Recommending Apps







Gender	Age	App
F	15	
F	25	
M	32	
F	40	
M	12	
M	14	

Recommending Apps



Gender	Age	App
F	15	
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Recommending Apps

Gender	Age	App
F	15	
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M	14	

Quiz: Between Gender and Age, which one seems more decisive for predicting what app will the users download?

- ☐ Gender
- ☐ Age

Recommending Apps

Gender	Age	App
F	15	
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- ☐ Gender
- ☐ Age

Recommending Apps







Gender	Age	App
F	15	
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☐ Gender




☐ Age

Recommending Apps

Gender	Age	App
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Recommending Apps

Gender	Age	App
F	25	
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F	40	









Recommending Apps

Gender	Age	App
F	25	
M	32	
F	40	



Decision Tree

Gender	Age	App
F	15	
F	25	
M	32	
F	40	
M	12	
M	14	



Acceptance at a University



Test



Grades


Acceptance at a University





Test



Grades

Student 1
Test: 9/10 
Grades: 8/10

Student 2
Test: 3/10 
Grades: 4/10

Student 3
Test: 7/10 
Grades: 6/10

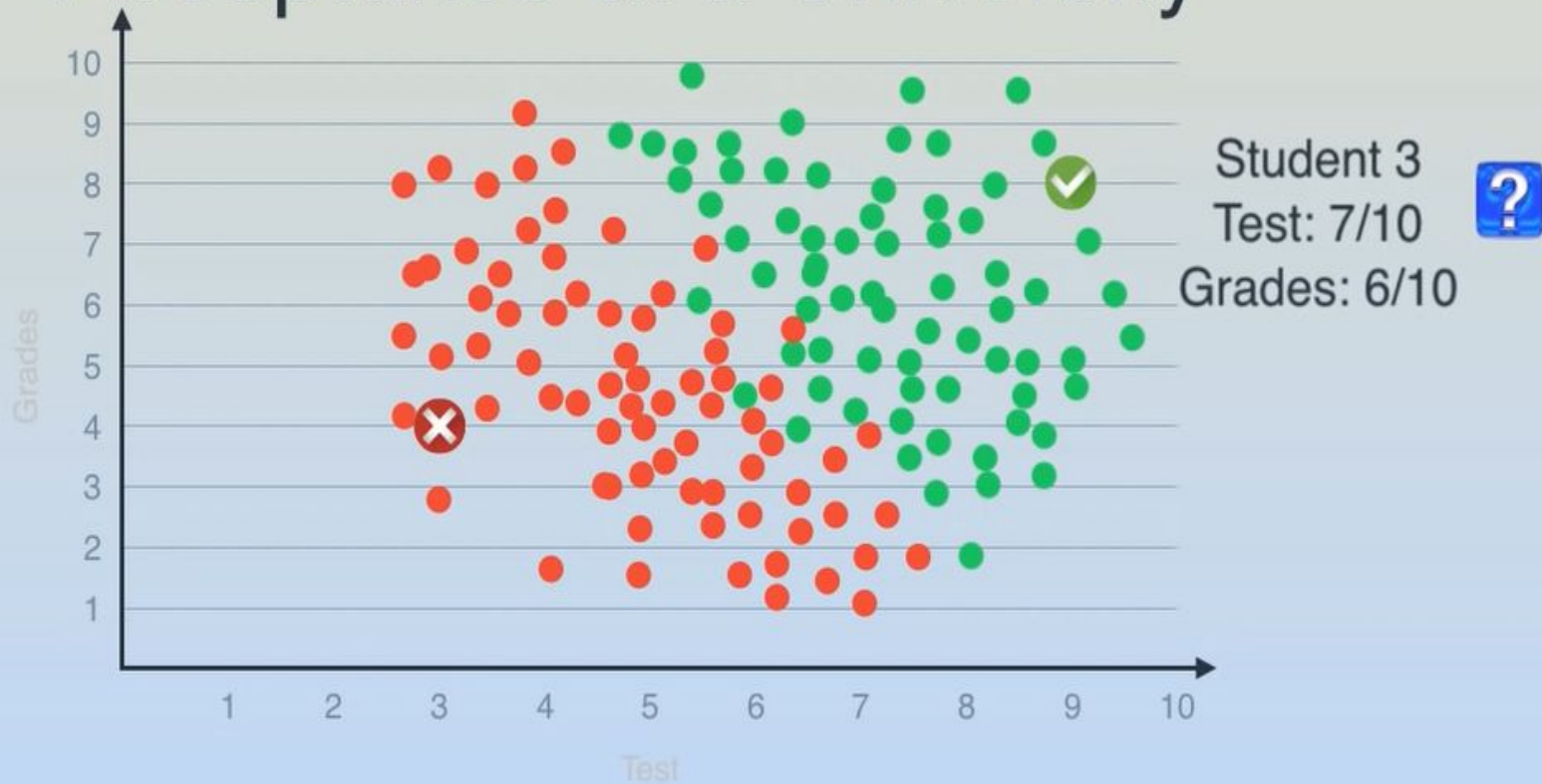
Acceptance at a University



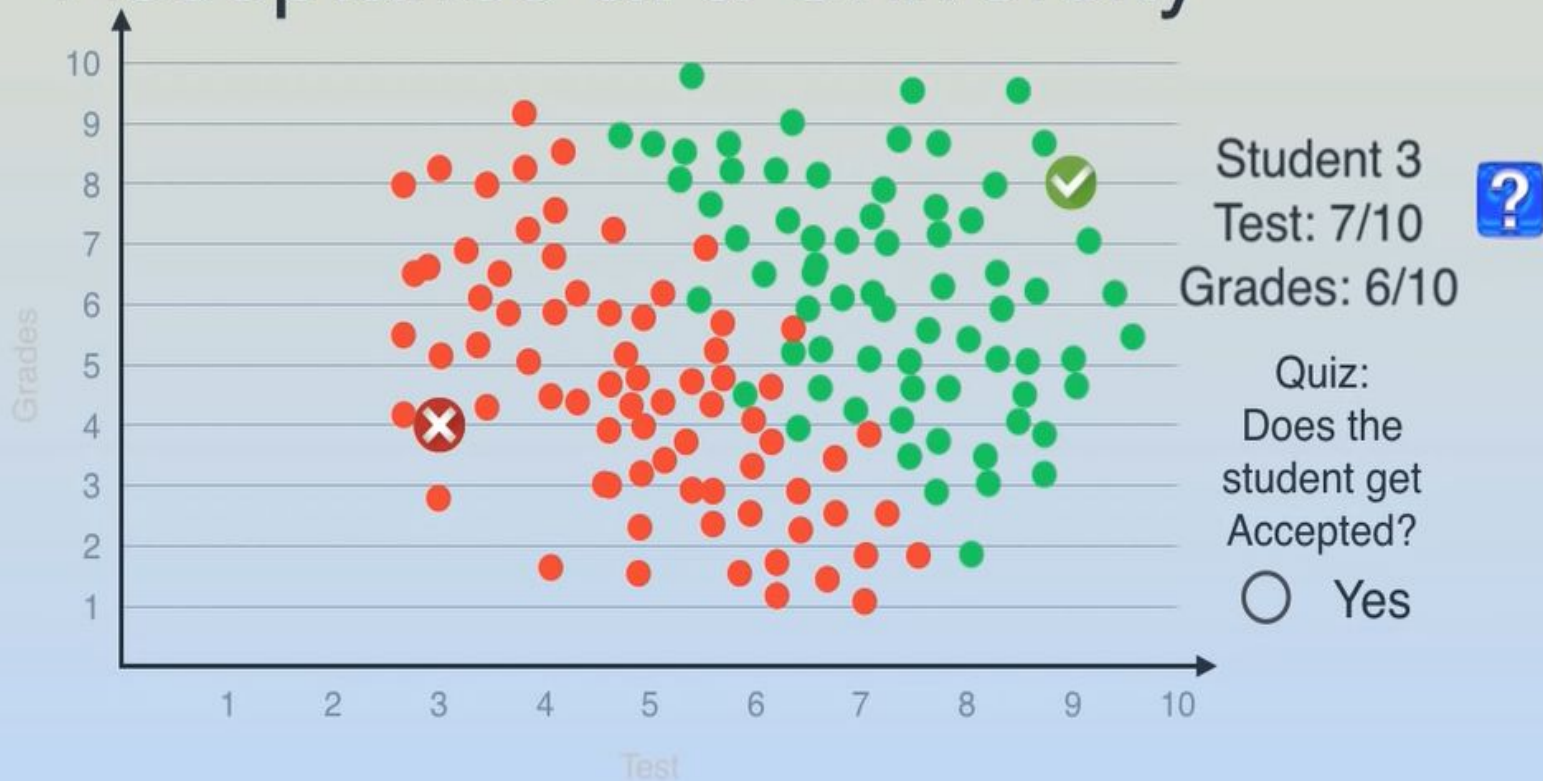
Acceptance at a University



Acceptance at a University



Acceptance at a University



Acceptance at a University



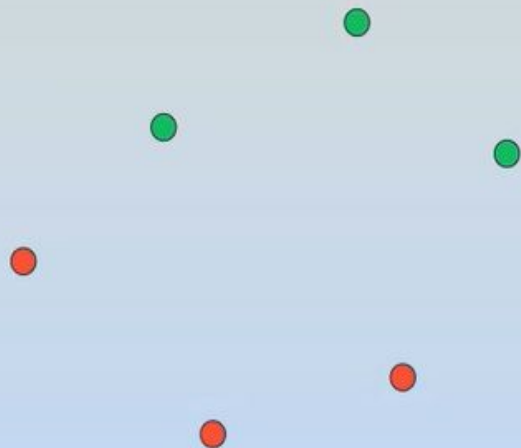
Acceptance at a University



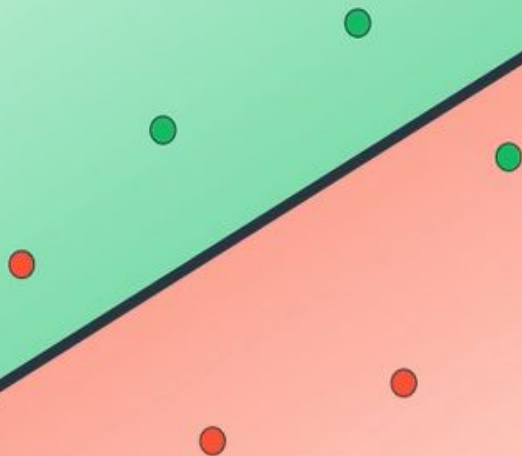
Logistic Regression



Logistic Regression



Logistic Regression



Logistic Regression

Errors: 2



Logistic Regression

Errors: 2



Gradient descent

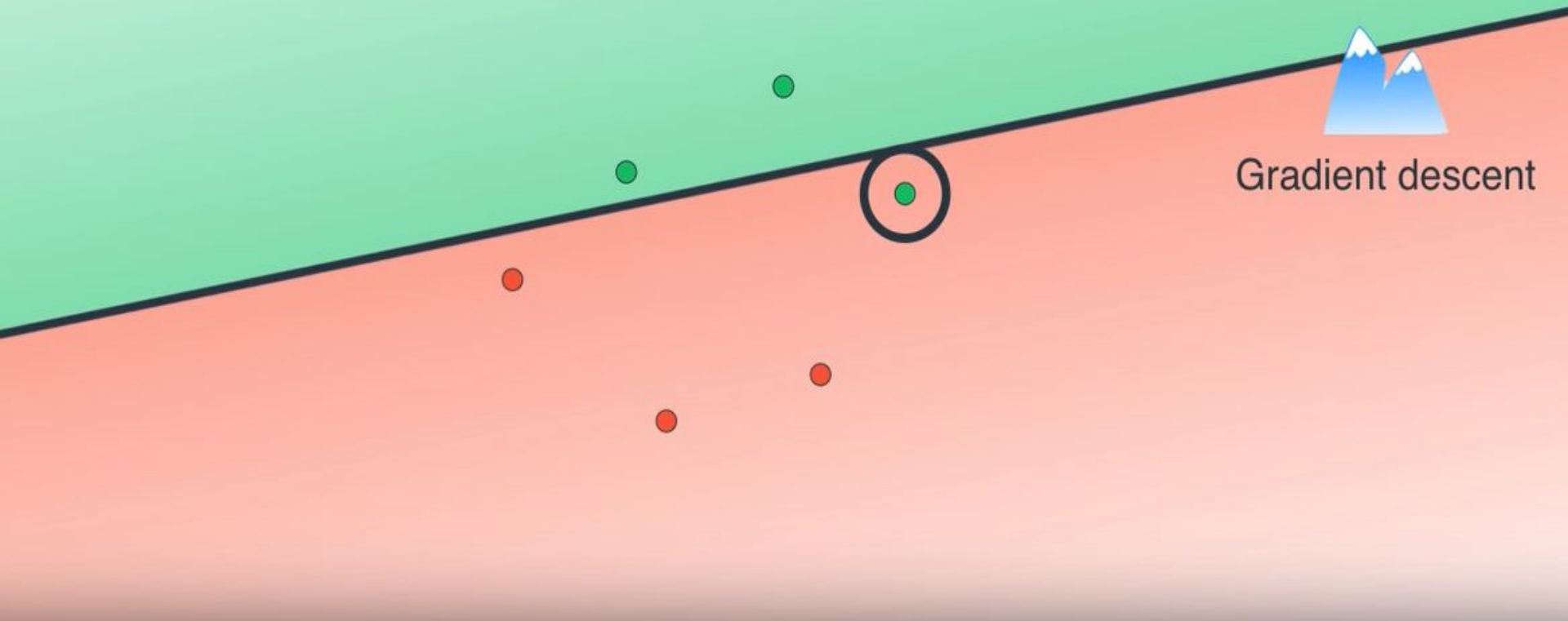


Logistic Regression

Errors: 1



Gradient descent

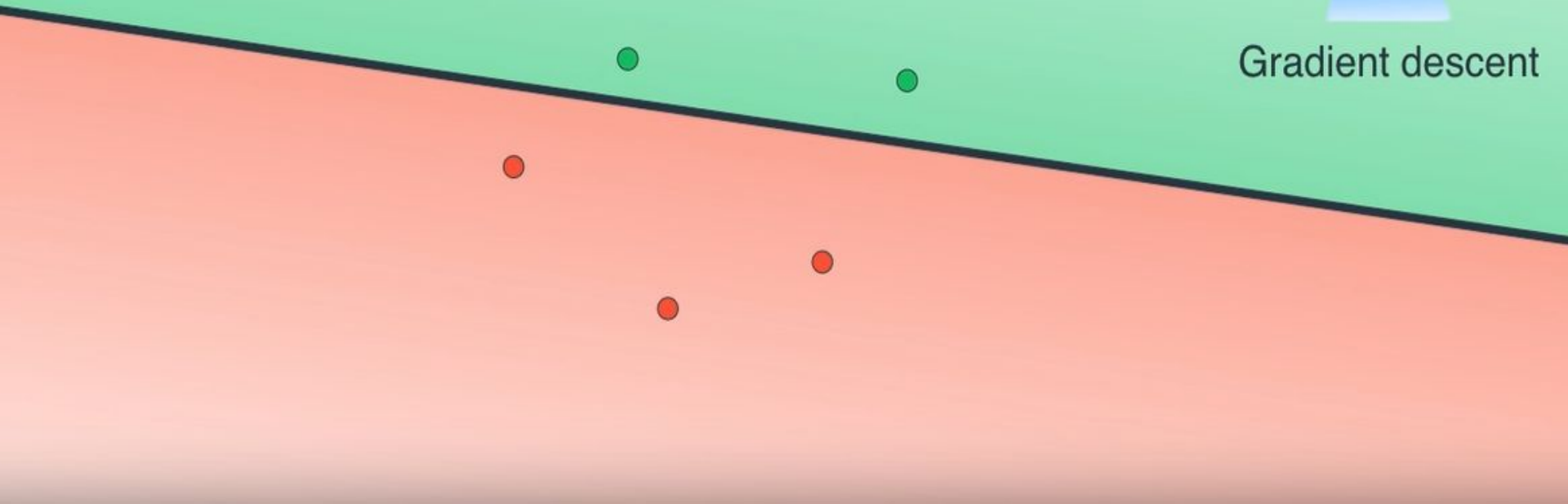


Logistic Regression

Errors: 0



Gradient descent

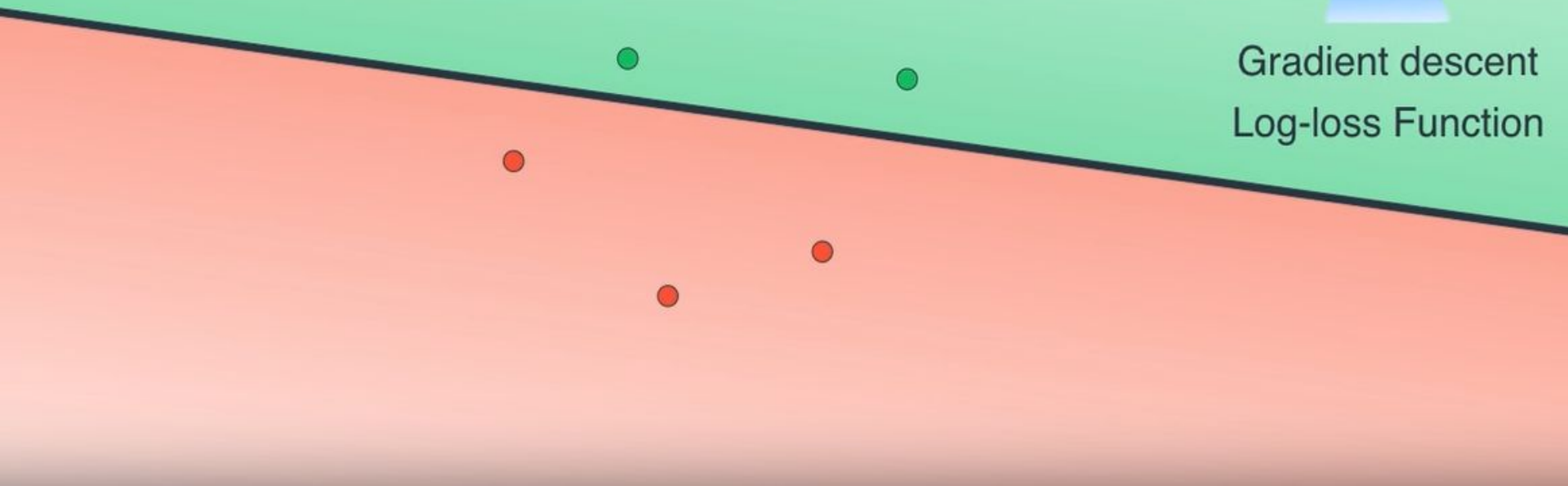


Logistic Regression

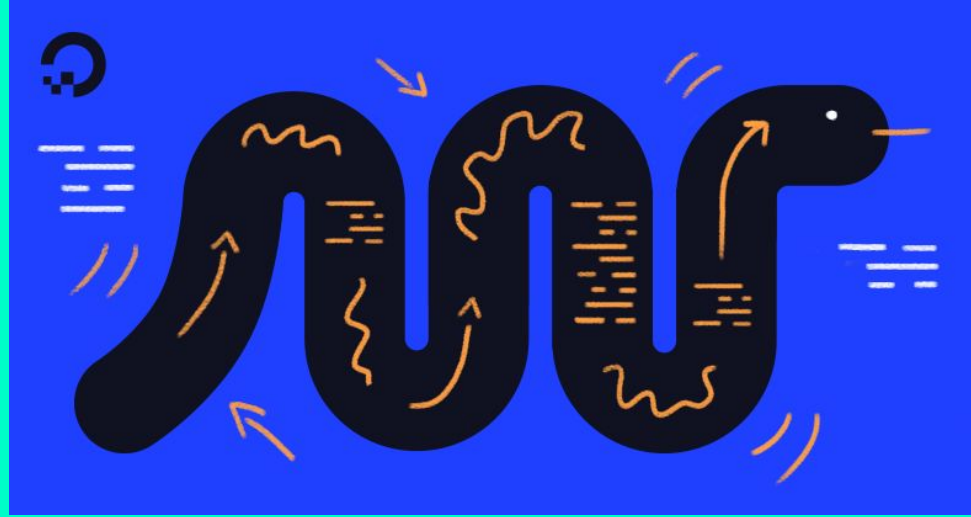
~~Errors:~~ 0



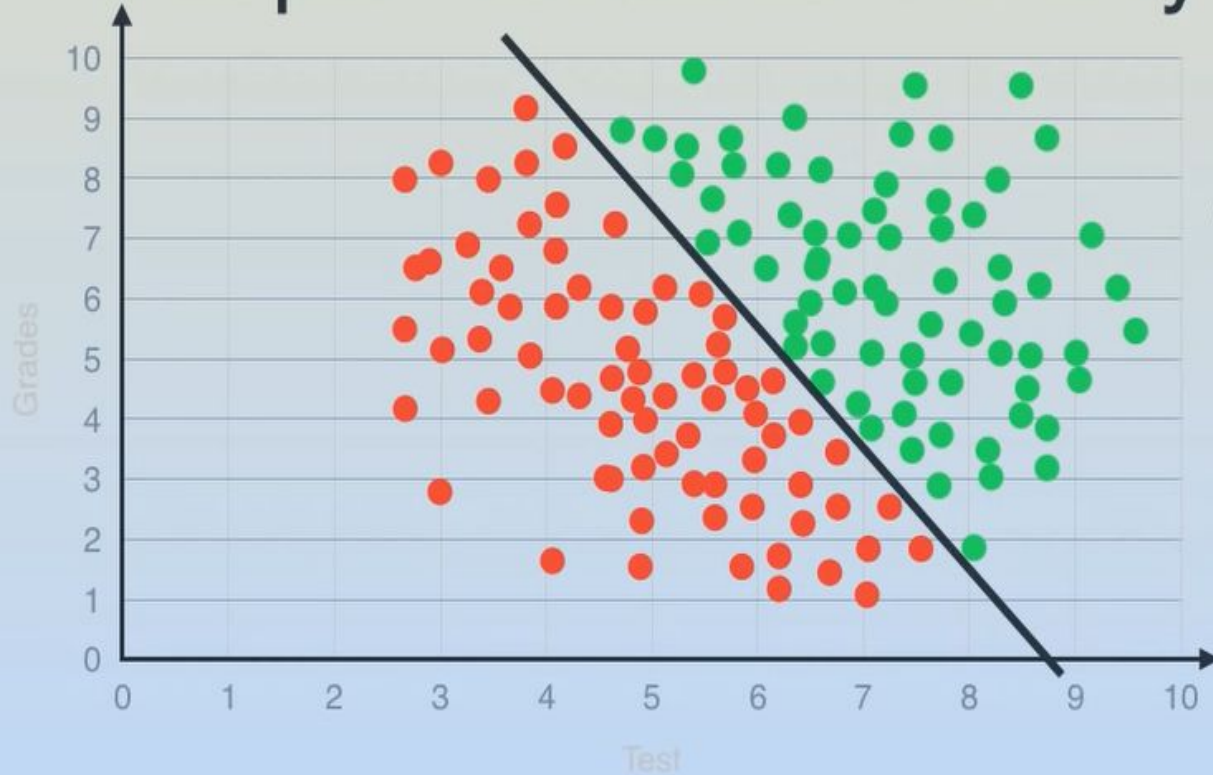
Gradient descent
Log-loss Function



**ML without
coding ???**



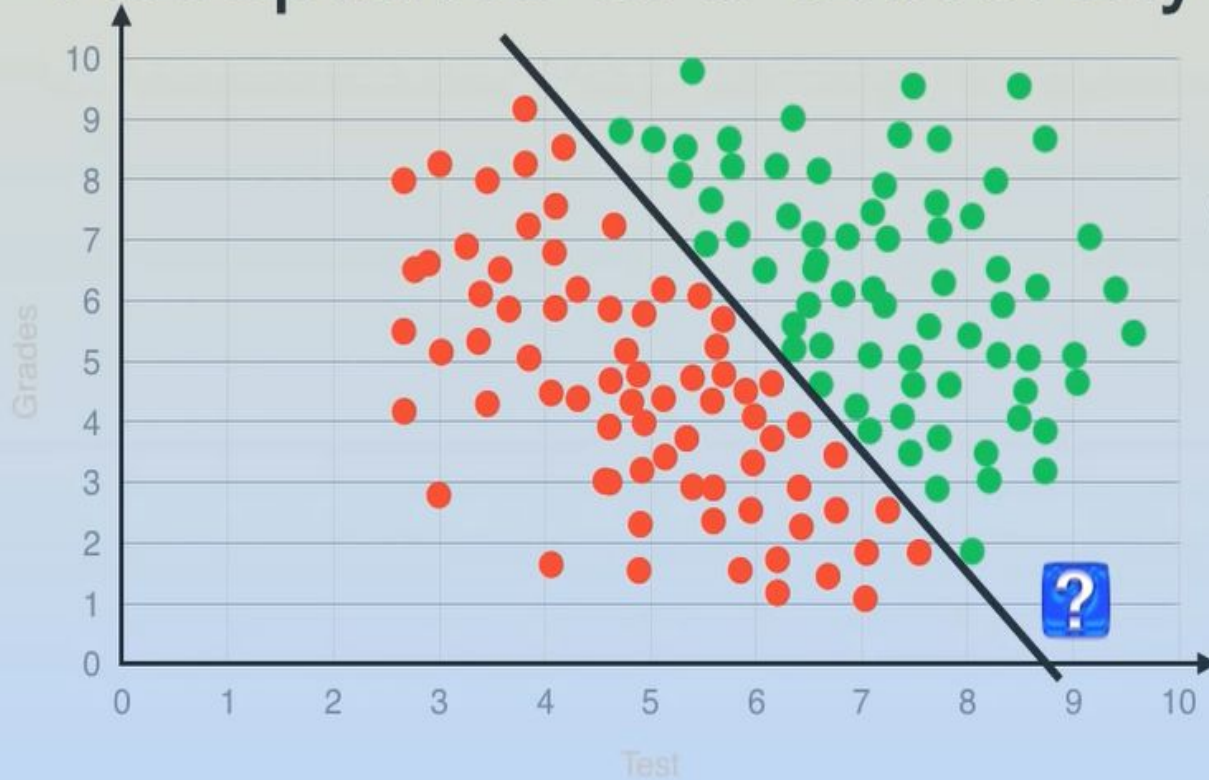
Acceptance at a University



Student 4
Test: 9/10
Grades: 1/10

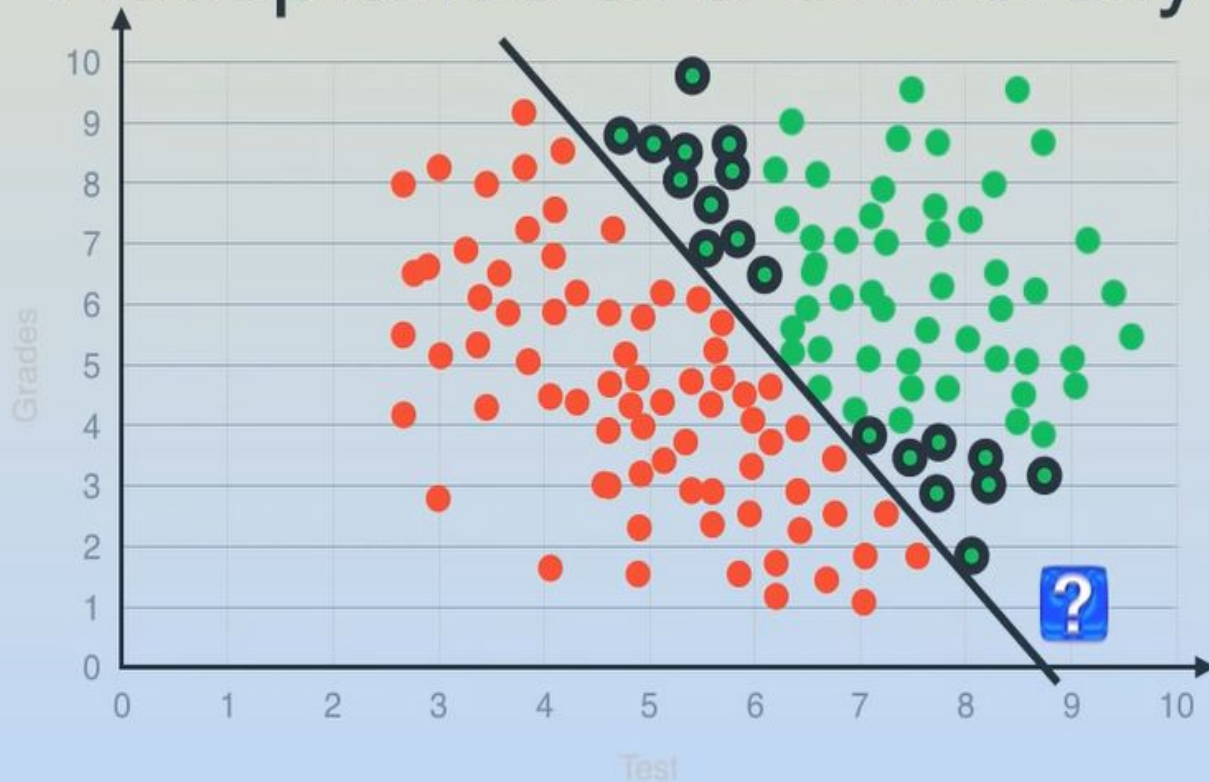


Acceptance at a University



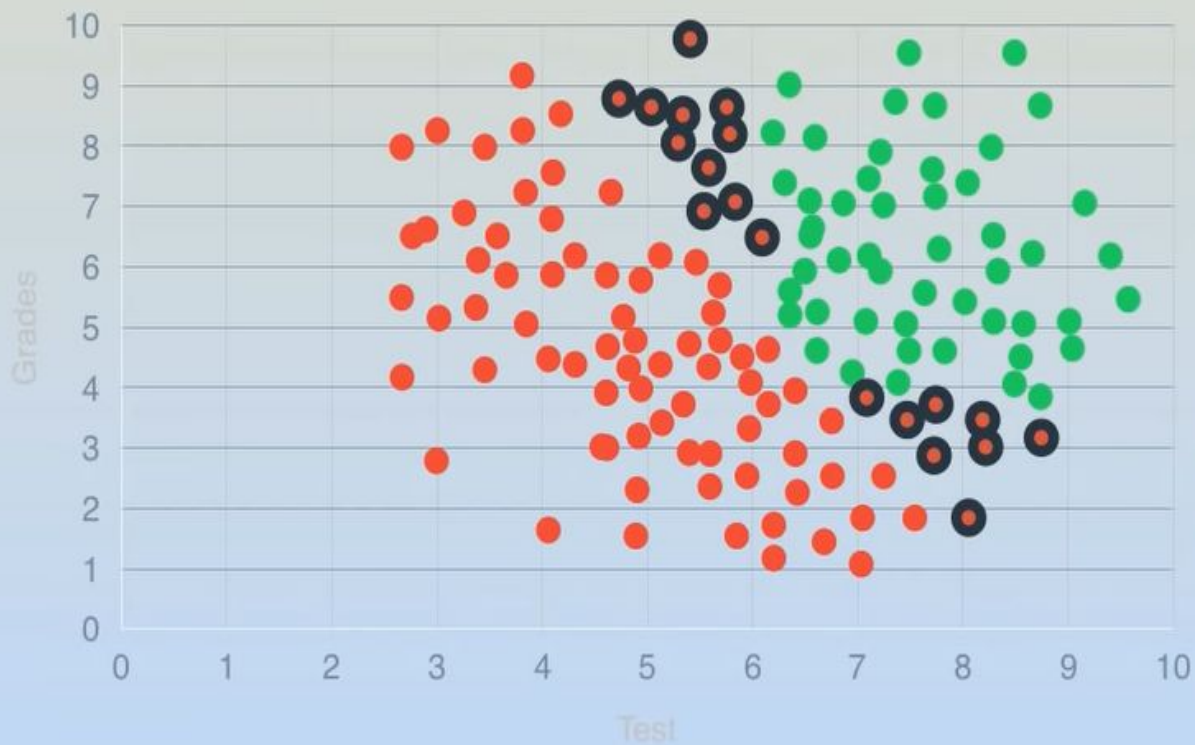
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Acceptance at a University

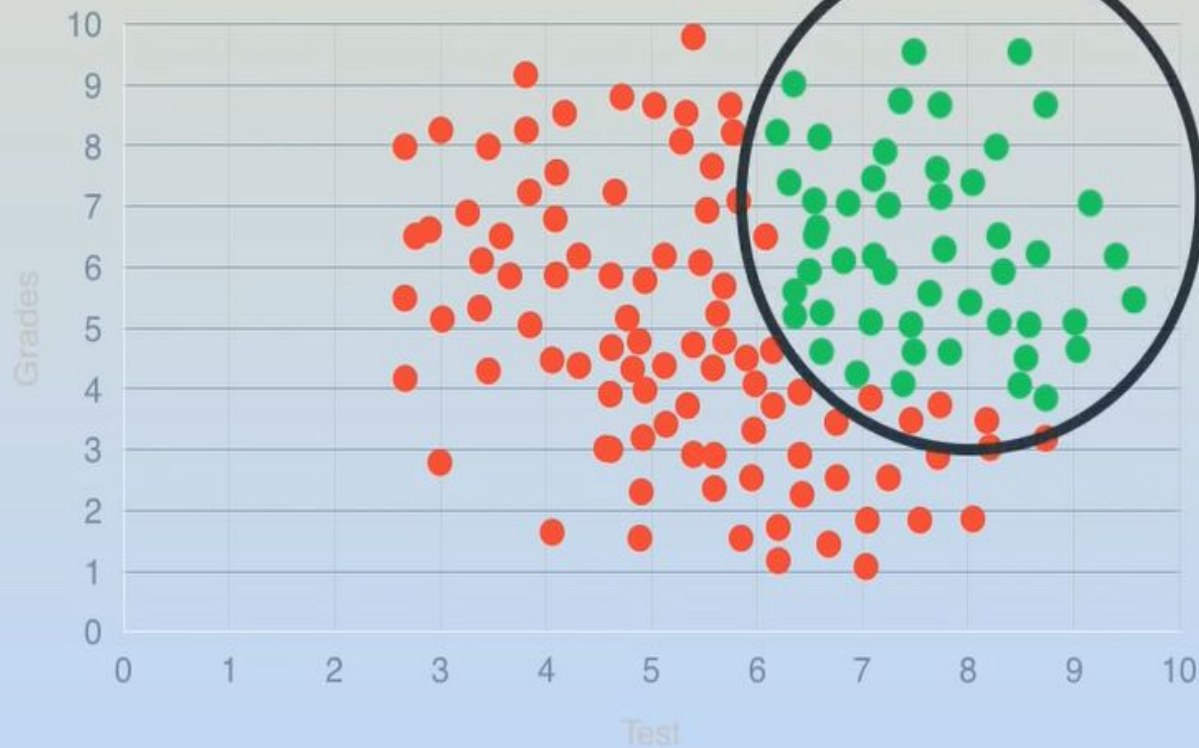


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Acceptance at a University



Acceptance at a University

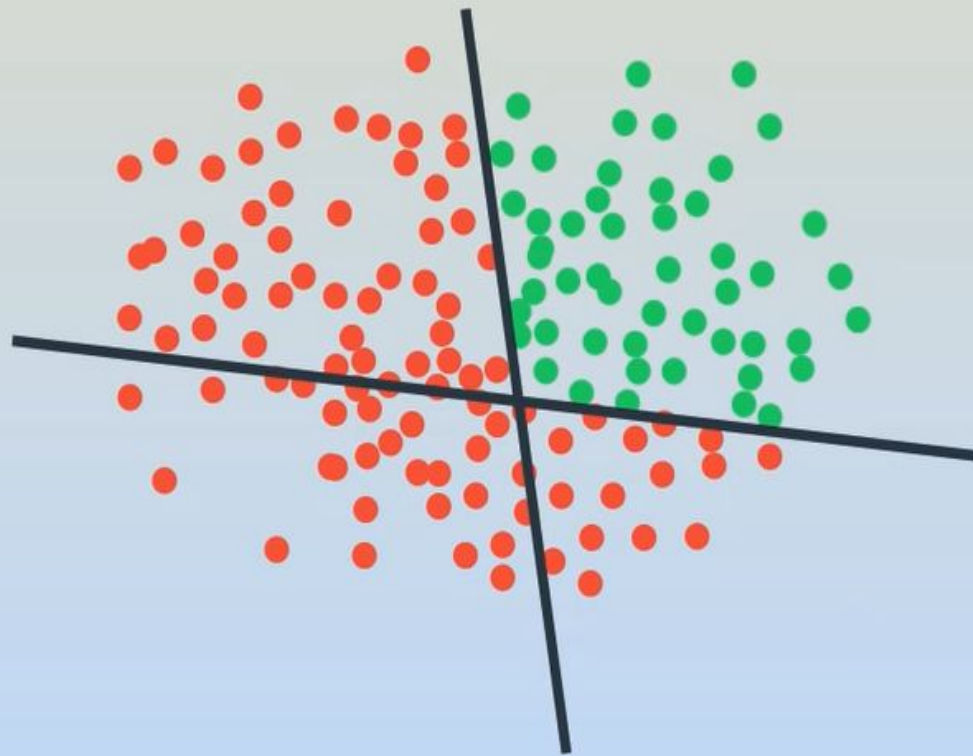


Acceptance at a University

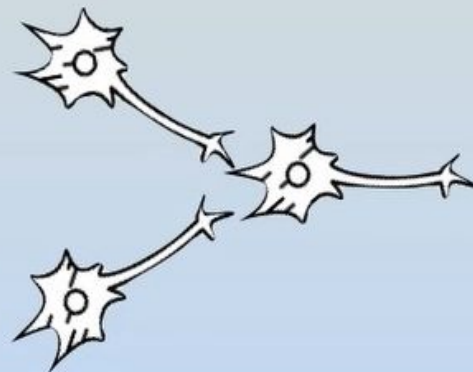
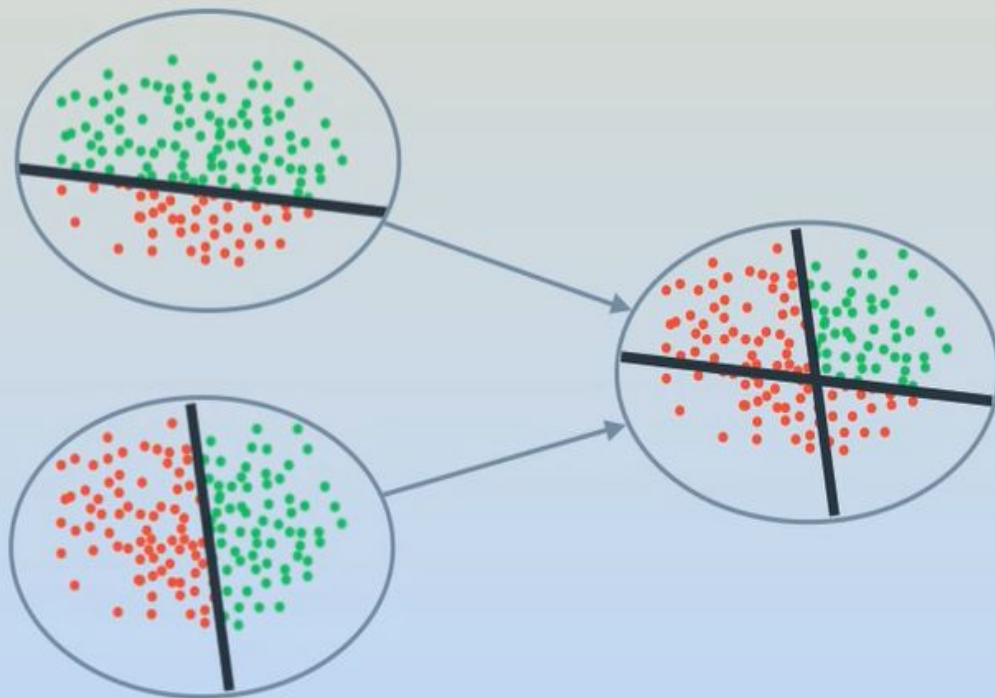


Gradient descent

Neural Network



Neural Network



Logistic Regression & Neural Networks

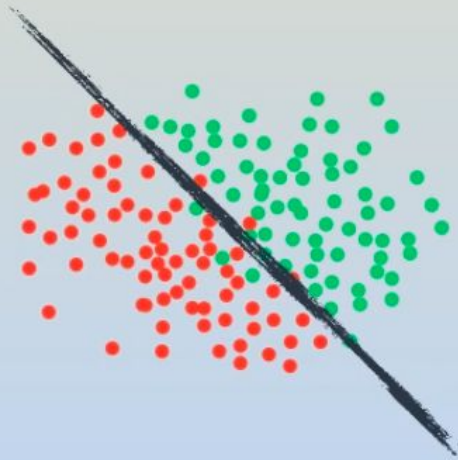


Logistic Regression

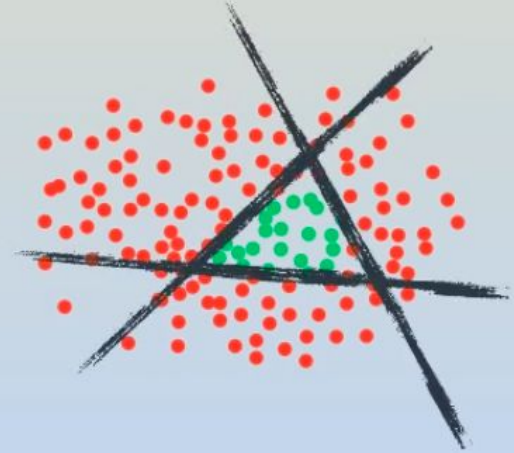
Logistic Regression & Neural Networks



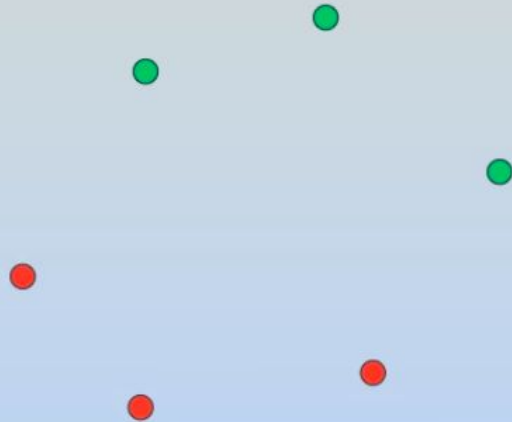
Logistic Regression



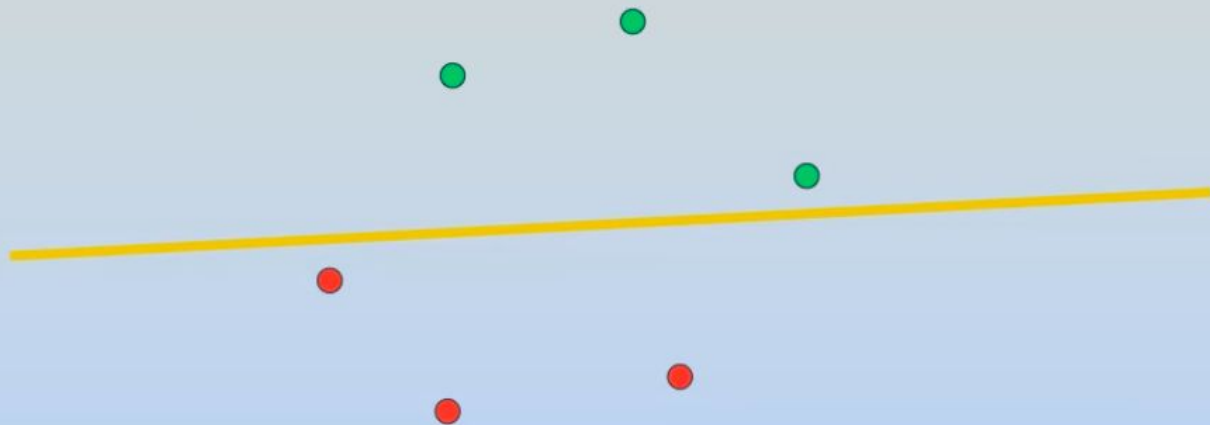
Neural Network



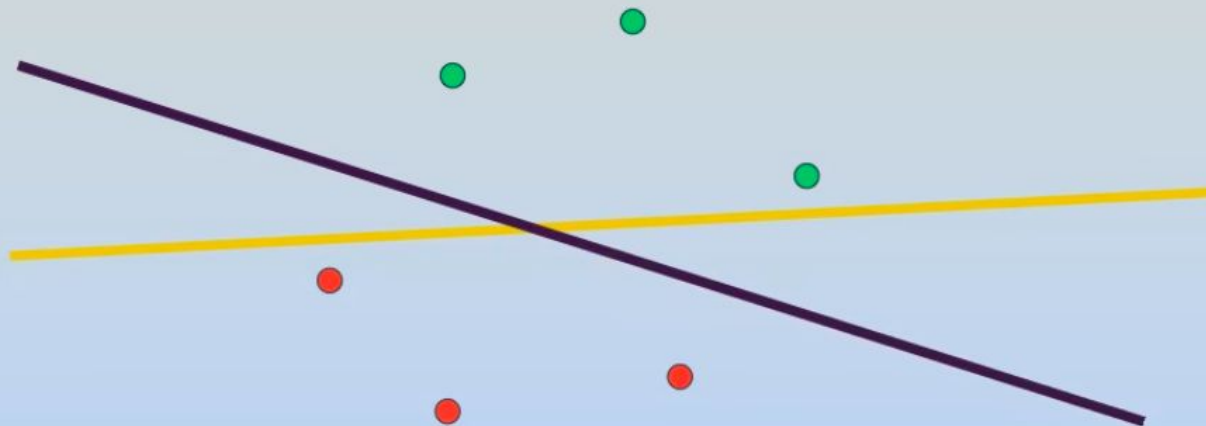
Cutting data with style



Cutting data with style

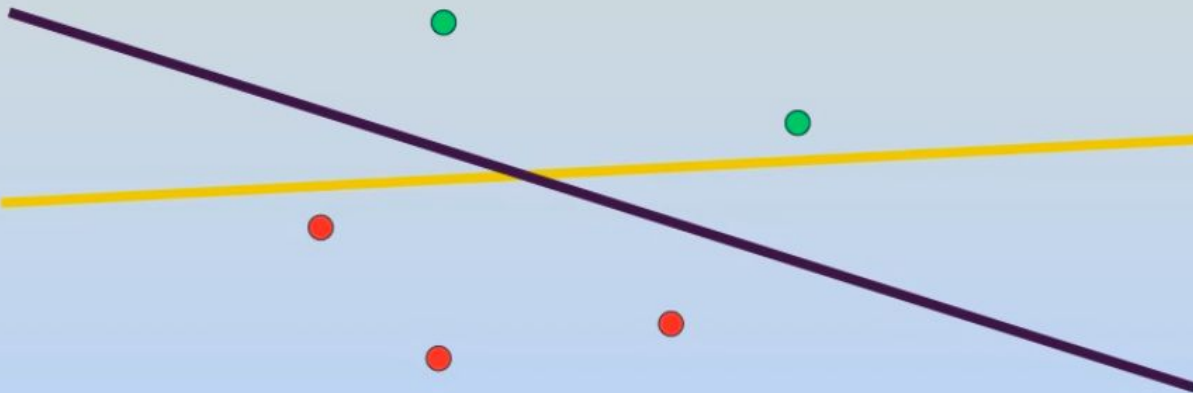


Cutting data with style



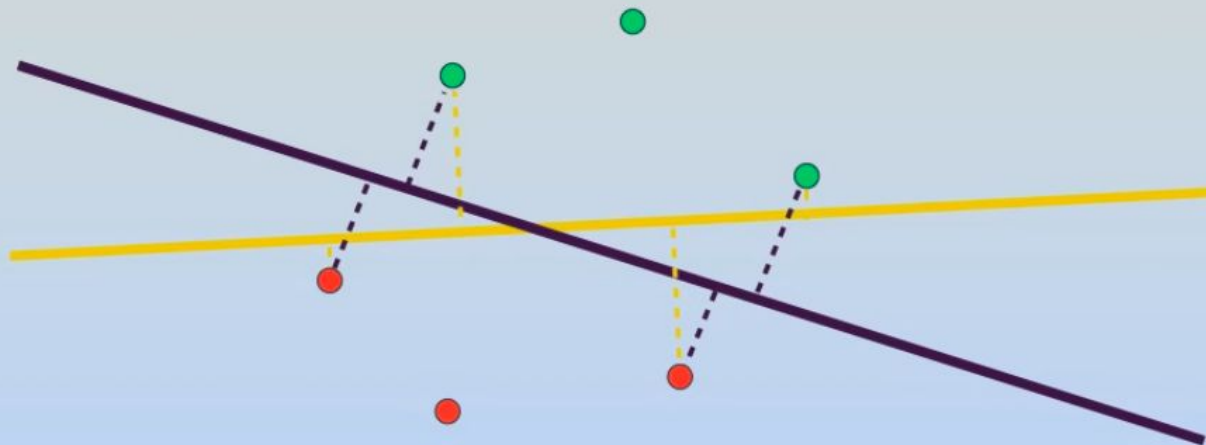
Cutting data with style

Quiz:
Which one is a
better line?



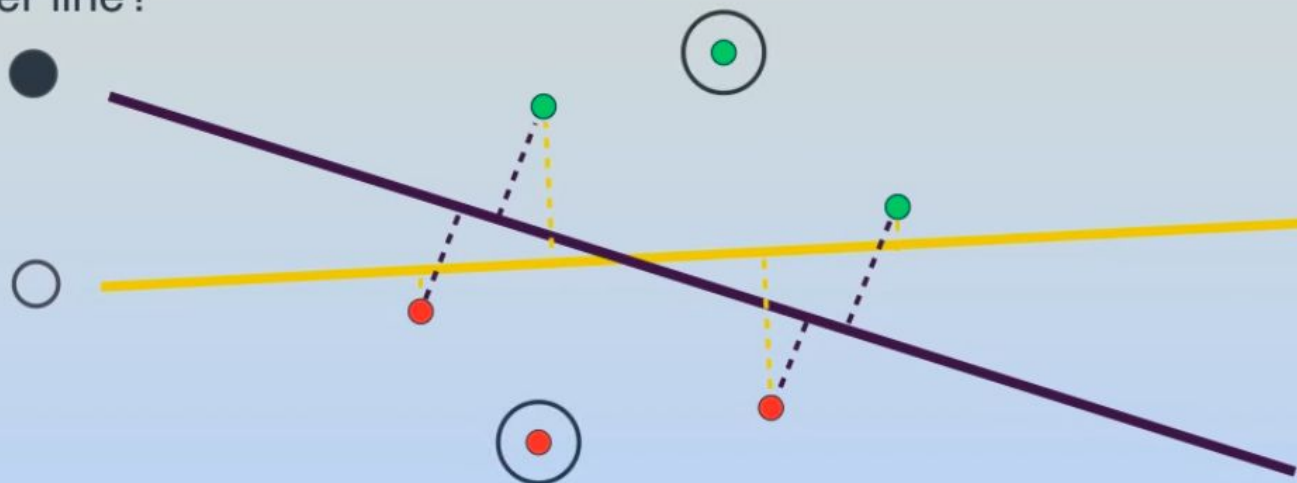
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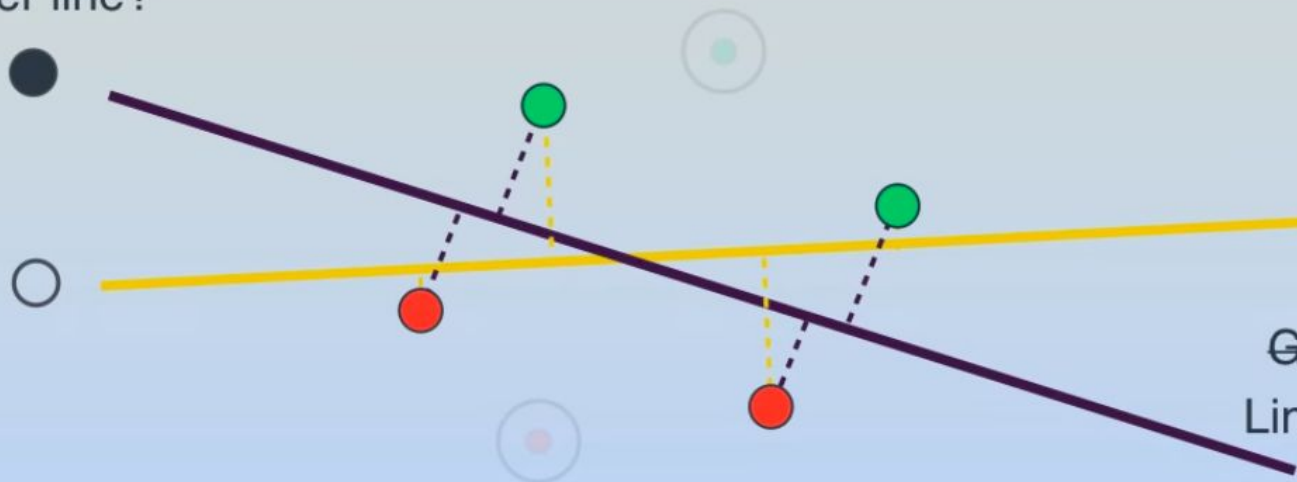
Cutting data with style

Quiz:
Which one is a
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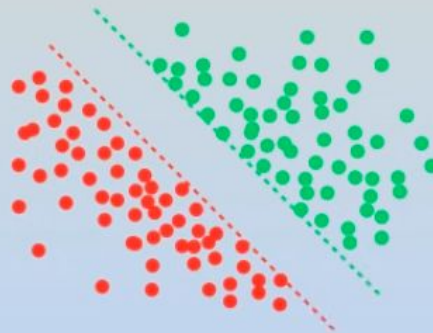
Support Vector Machine

Quiz:
Which one is a
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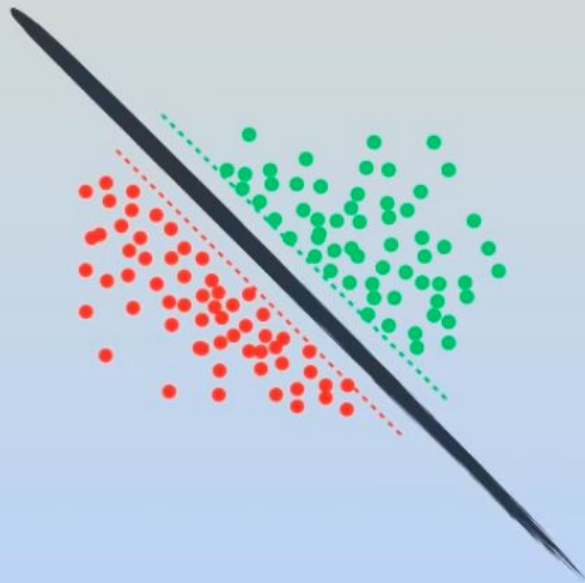


Gradient-descent
Linear Optimization

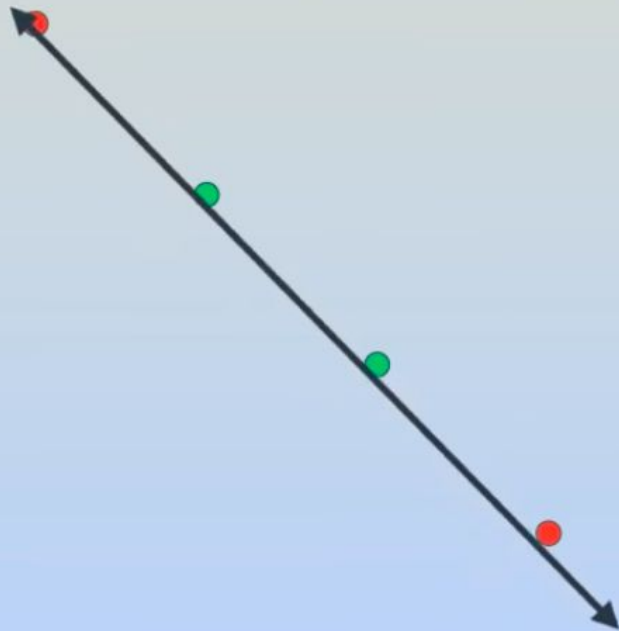
Support Vector Machines

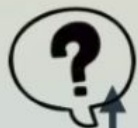


Support Vector Machines



When a line is not enough...

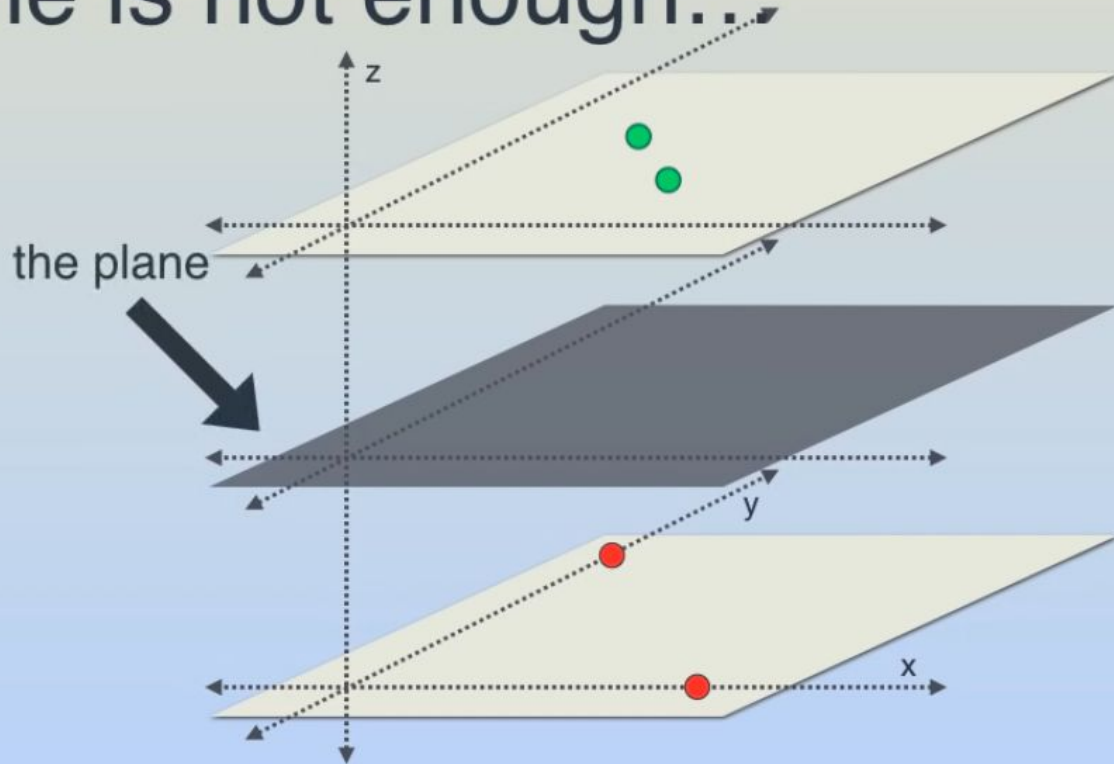
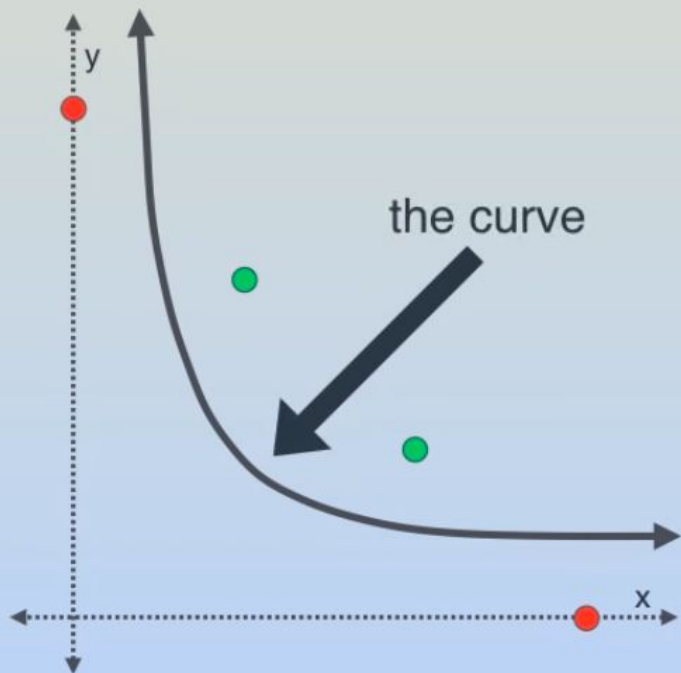




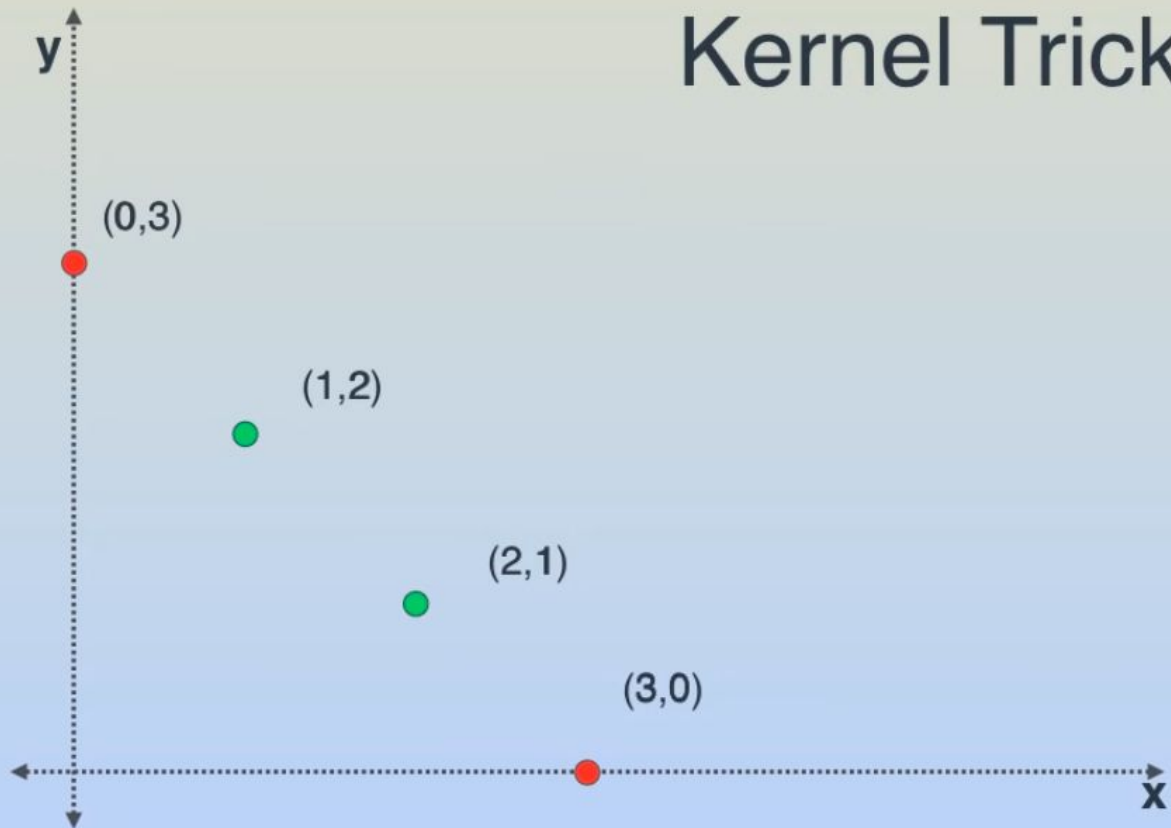
When a line is not enough...



When a line is not enough...



Kernel Trick



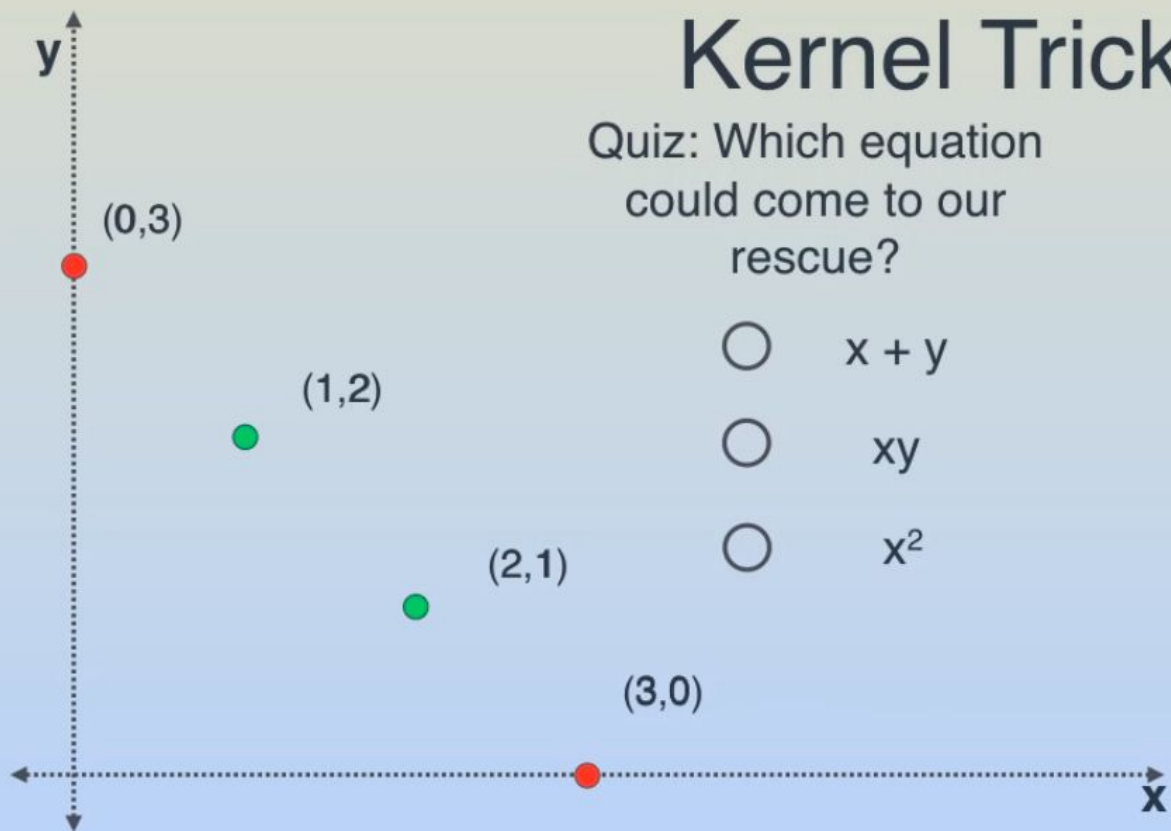
Kernel Trick

Quiz: Which equation
could come to our
rescue?

☐ $x + y$

☐ xy

☐ x^2



Kernel Trick

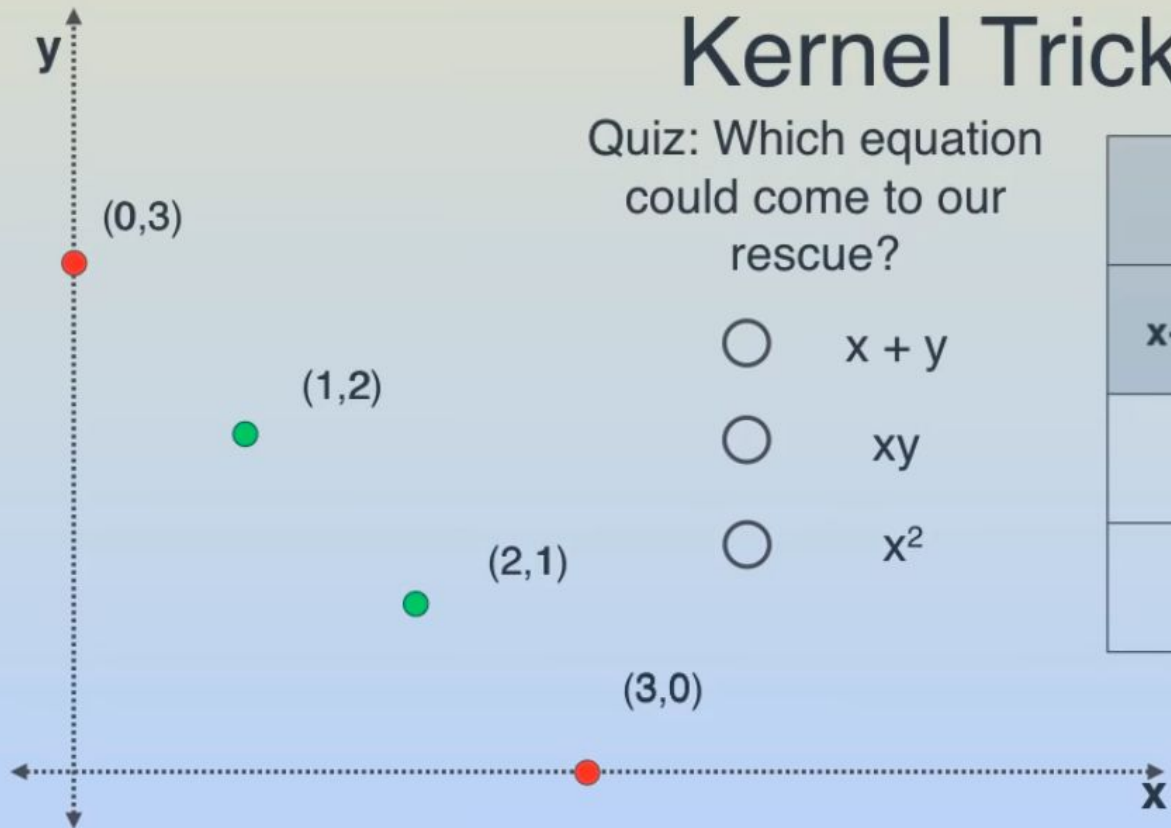
Quiz: Which equation
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☐ x^2

	(0,3)	(1,2)	(2,1)	(3,0)
$x+y$	3	3	3	3



Kernel Trick

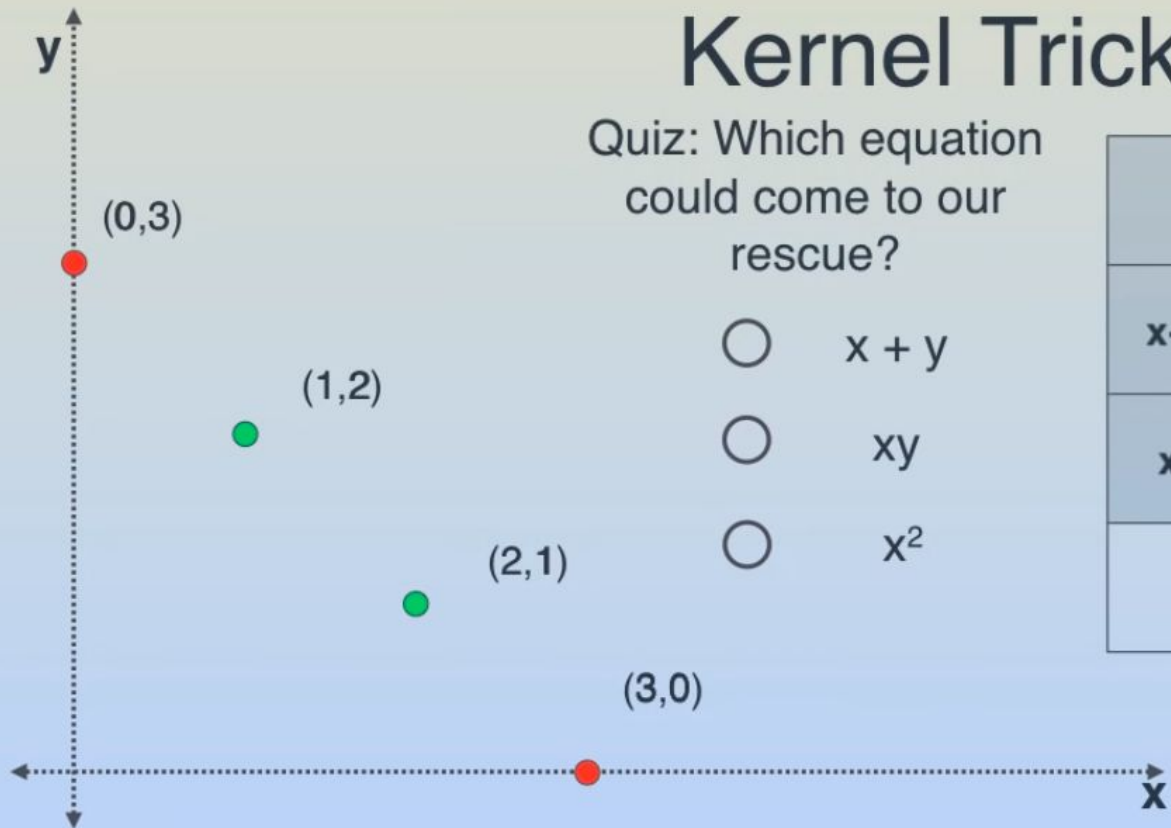
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	(0,3)	(1,2)	(2,1)	(3,0)
$x+y$	3	3	3	3
xy	0	2	2	0



Kernel Trick

Quiz: Which equation could come to our rescue?

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	(0,3)	(1,2)	(2,1)	(3,0)
$x+y$	3	3	3	3
xy	0	2	2	0
x^2	0	1	4	9



Kernel Trick

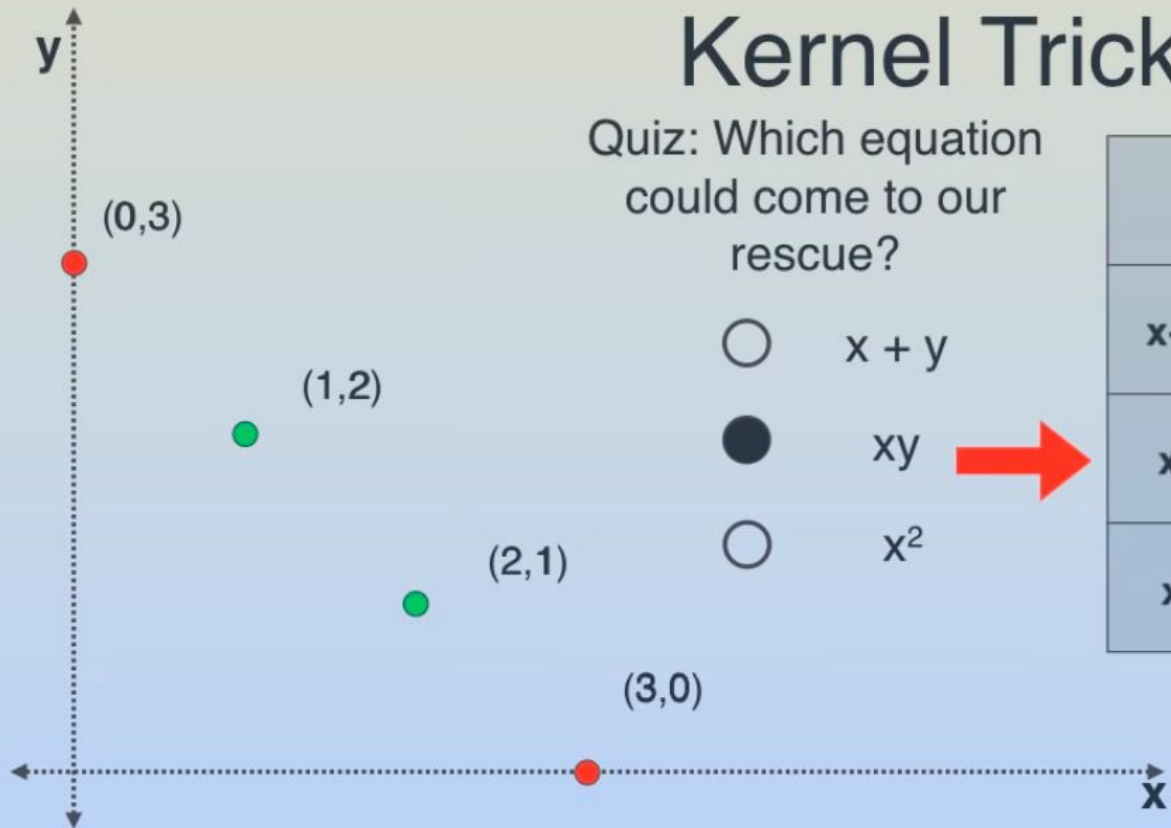
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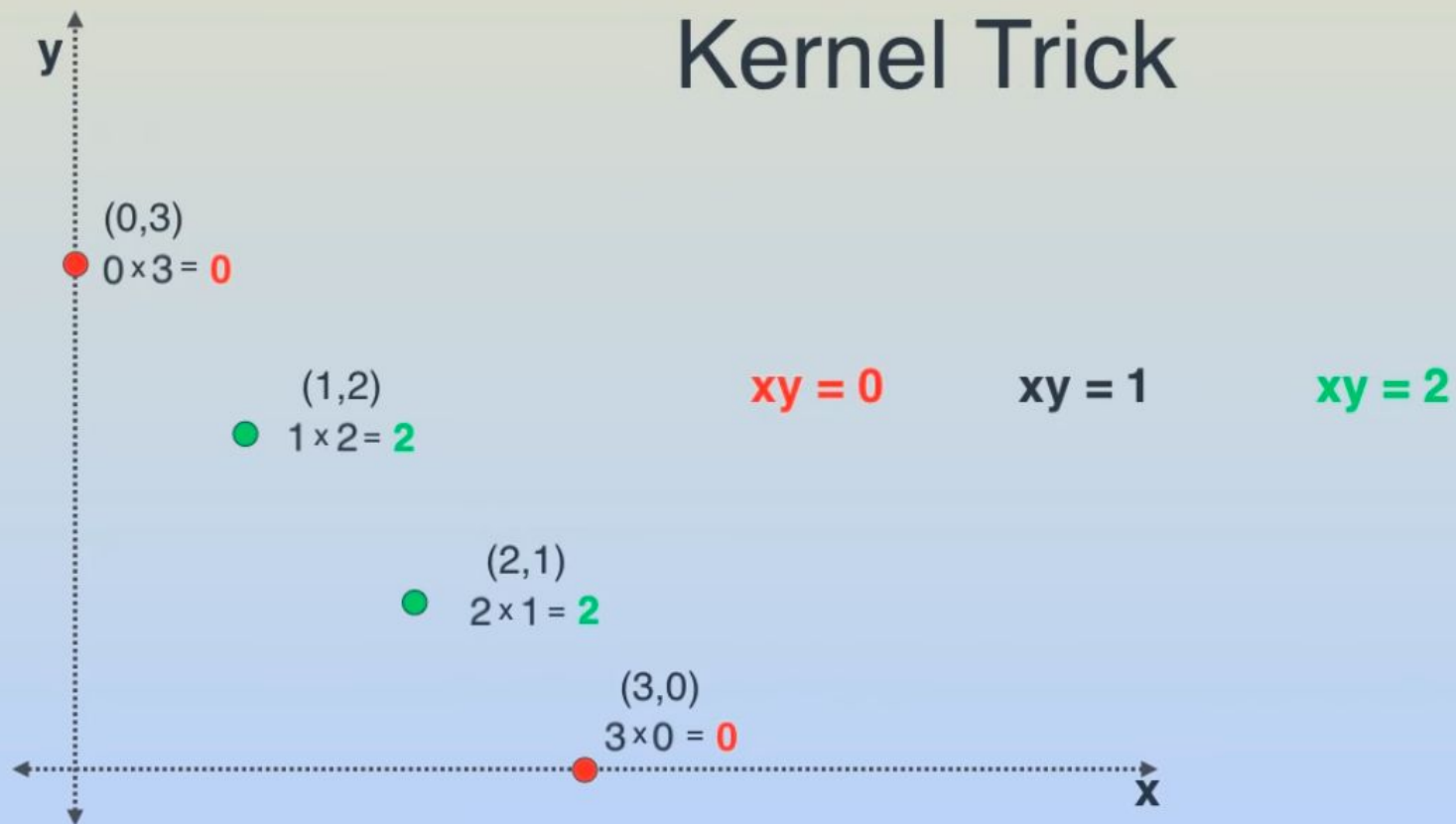
☒ xy 

☐ x^2

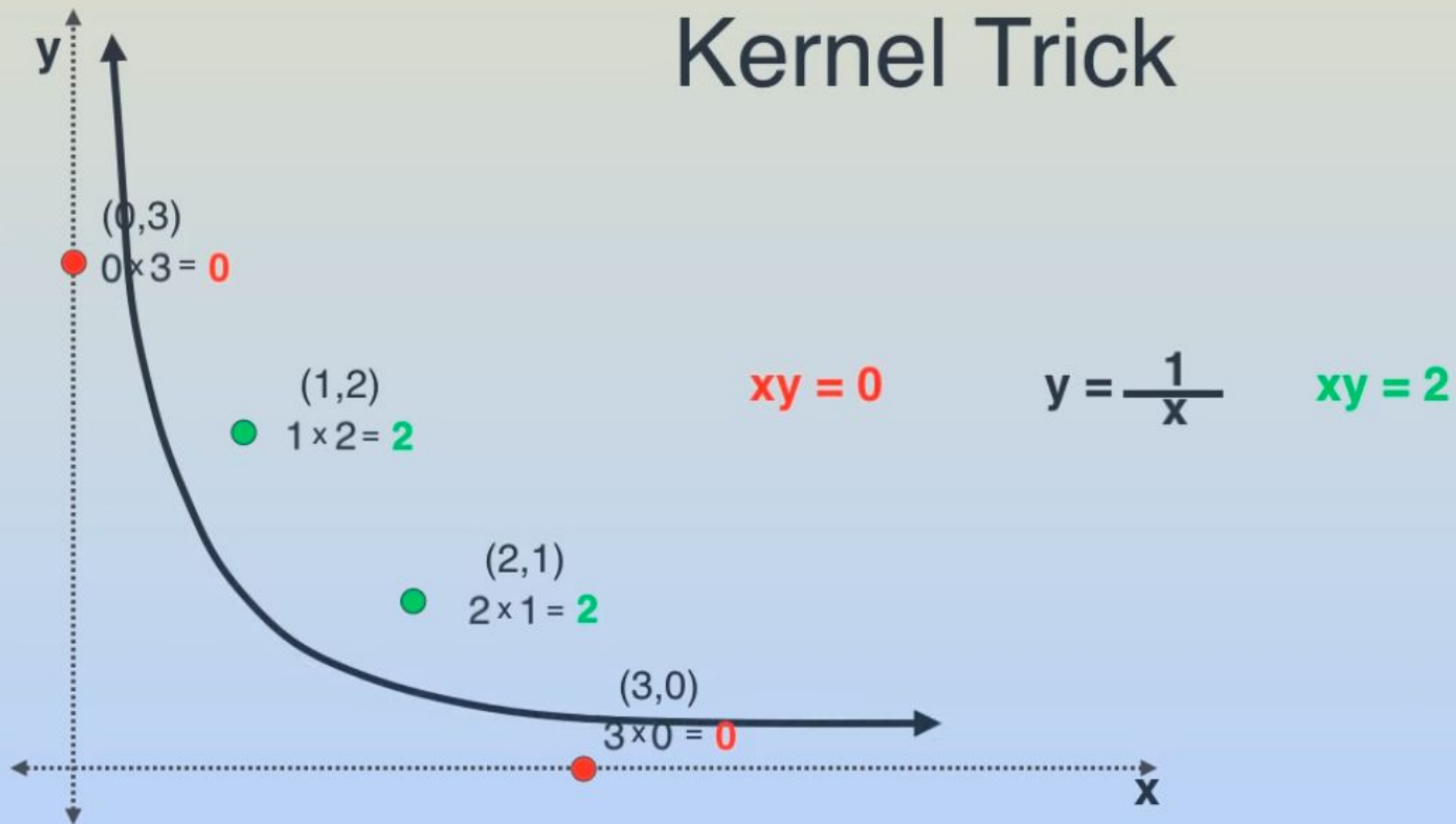
	(0,3)	(1,2)	(2,1)	(3,0)
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Kernel Trick



Kernel Trick



Kernel Trick

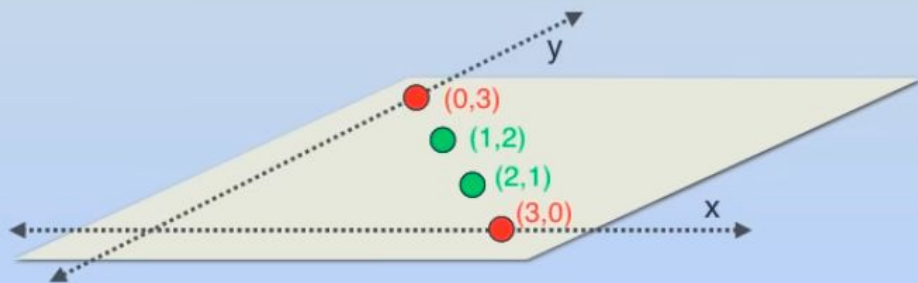
(x,y)

$(0,3)$

$(1,2)$

$(2,1)$

$(3,0)$



Kernel Trick

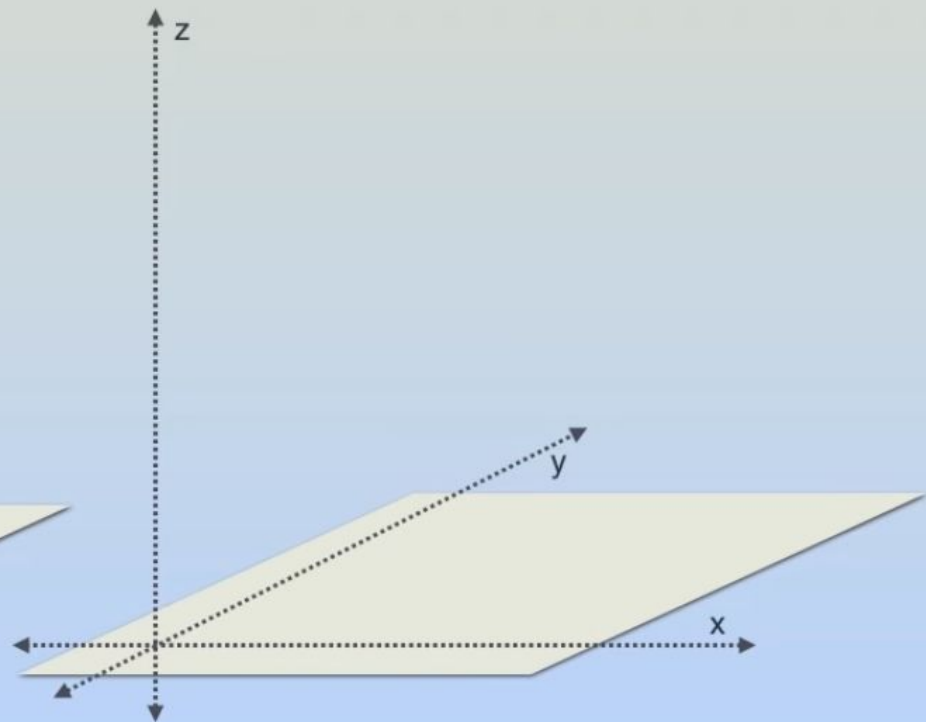
$(x,y) \longrightarrow (x,y,xy)$

$(0,3)$

$(1,2)$

$(2,1)$

$(3,0)$



Kernel Trick

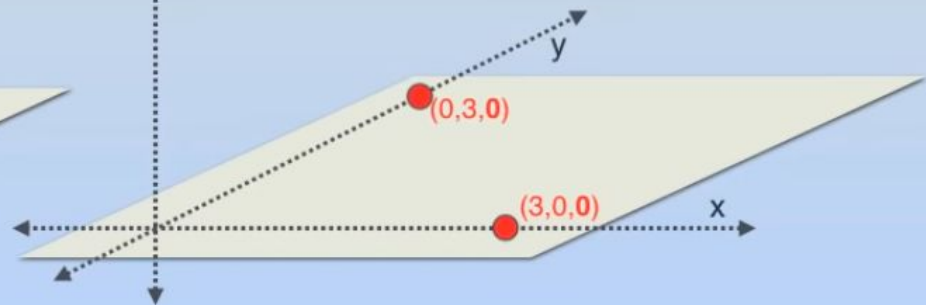
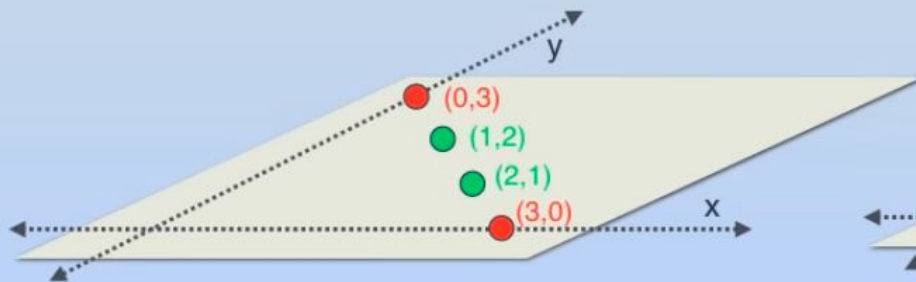
$(x,y) \longrightarrow (x,y,xy)$

$(0,3) \longrightarrow (0,3,0)$

$(1,2) \longrightarrow (1,2,2)$

$(2,1) \longrightarrow (2,1,2)$

$(3,0) \longrightarrow (3,0,0)$



Kernel Trick

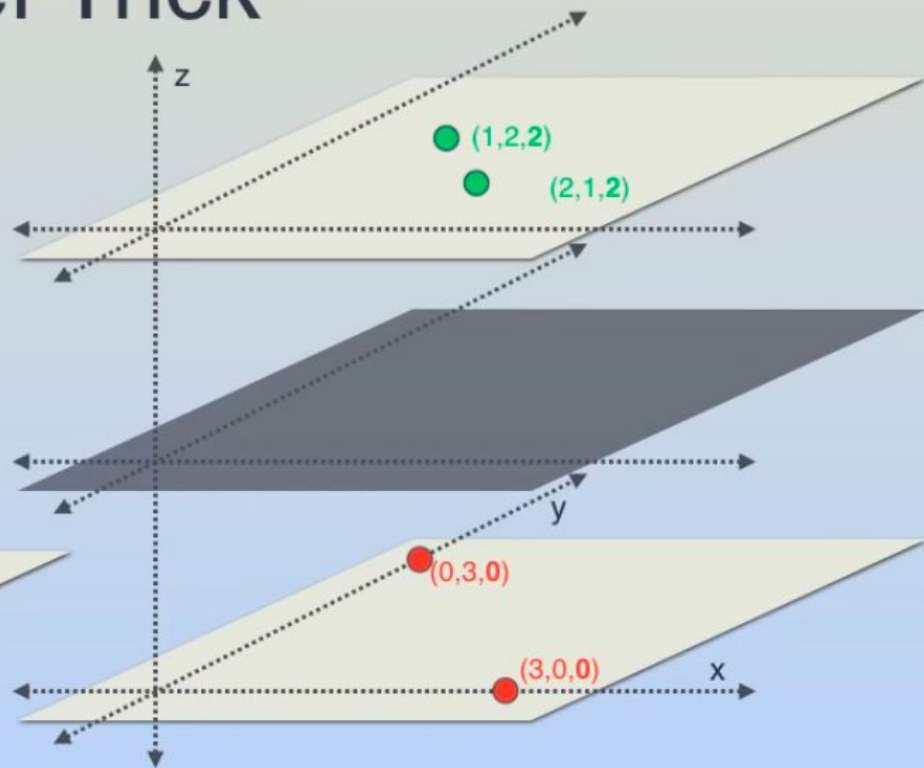
$(x,y) \longrightarrow (x,y,xy)$

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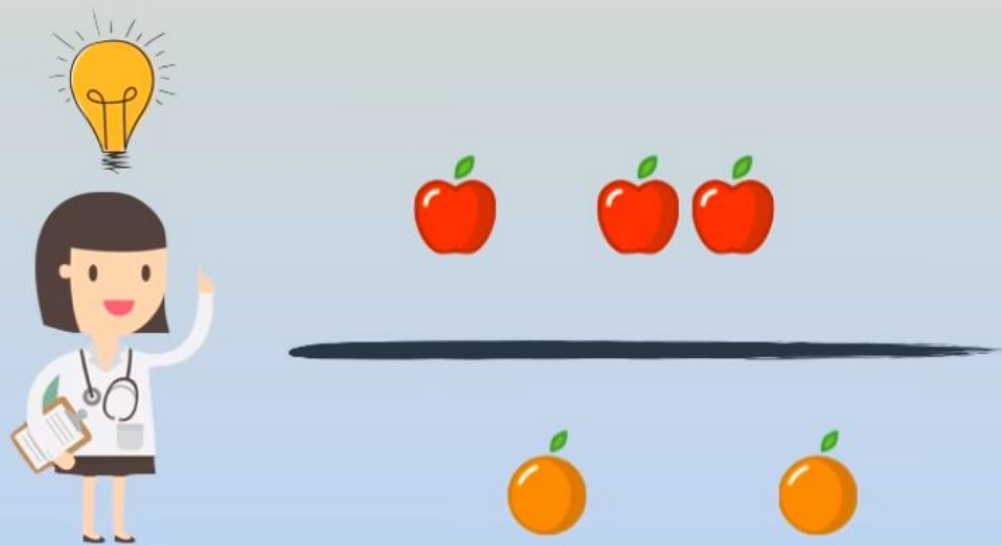
$(3,0) \longrightarrow (3,0,0)$



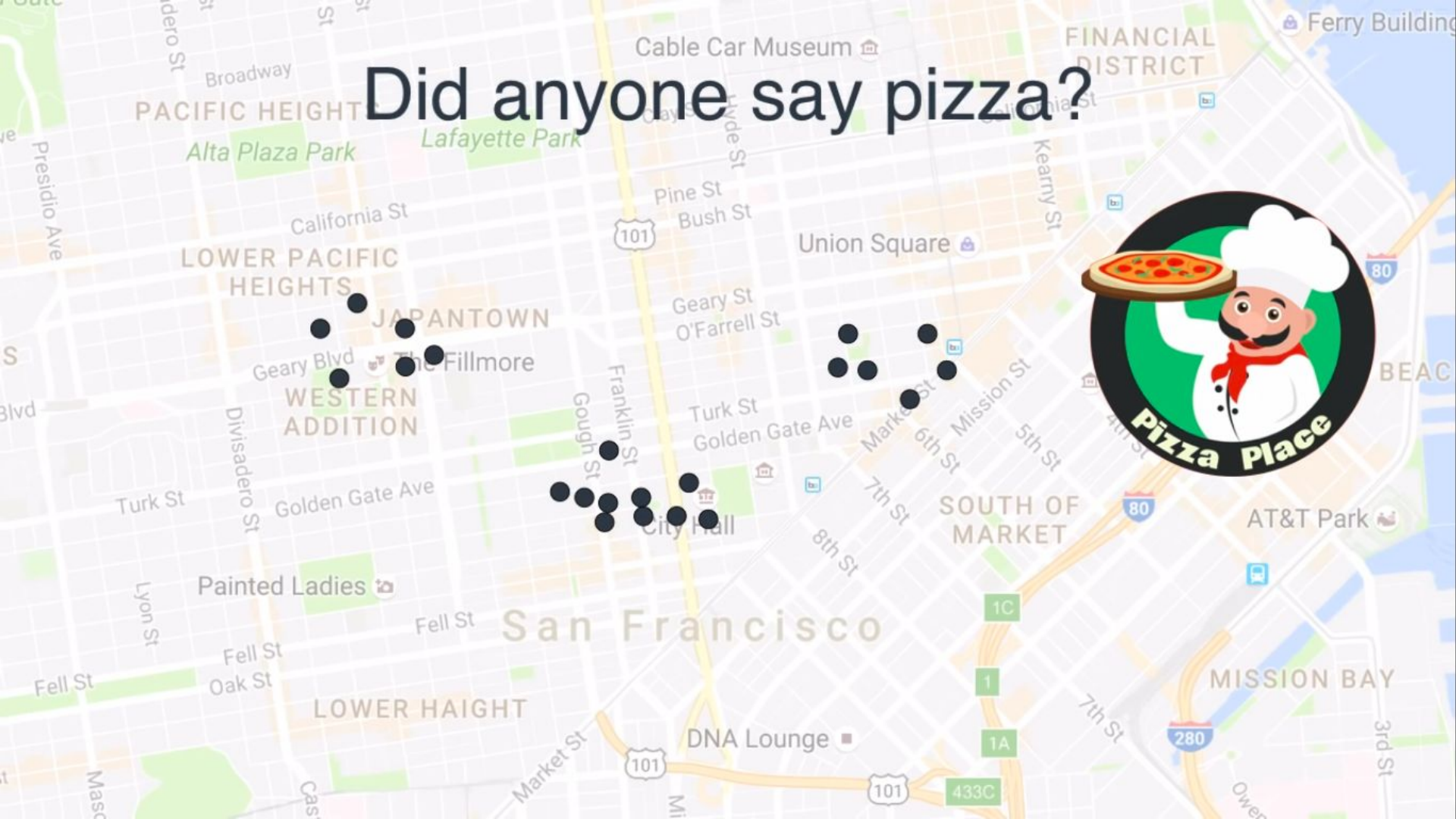
Support Vector Machine Kernel Trick



Support Vector Machine Kernel Trick



Did anyone say pizza?



Did anyone say pizza?



Did anyone say pizza?



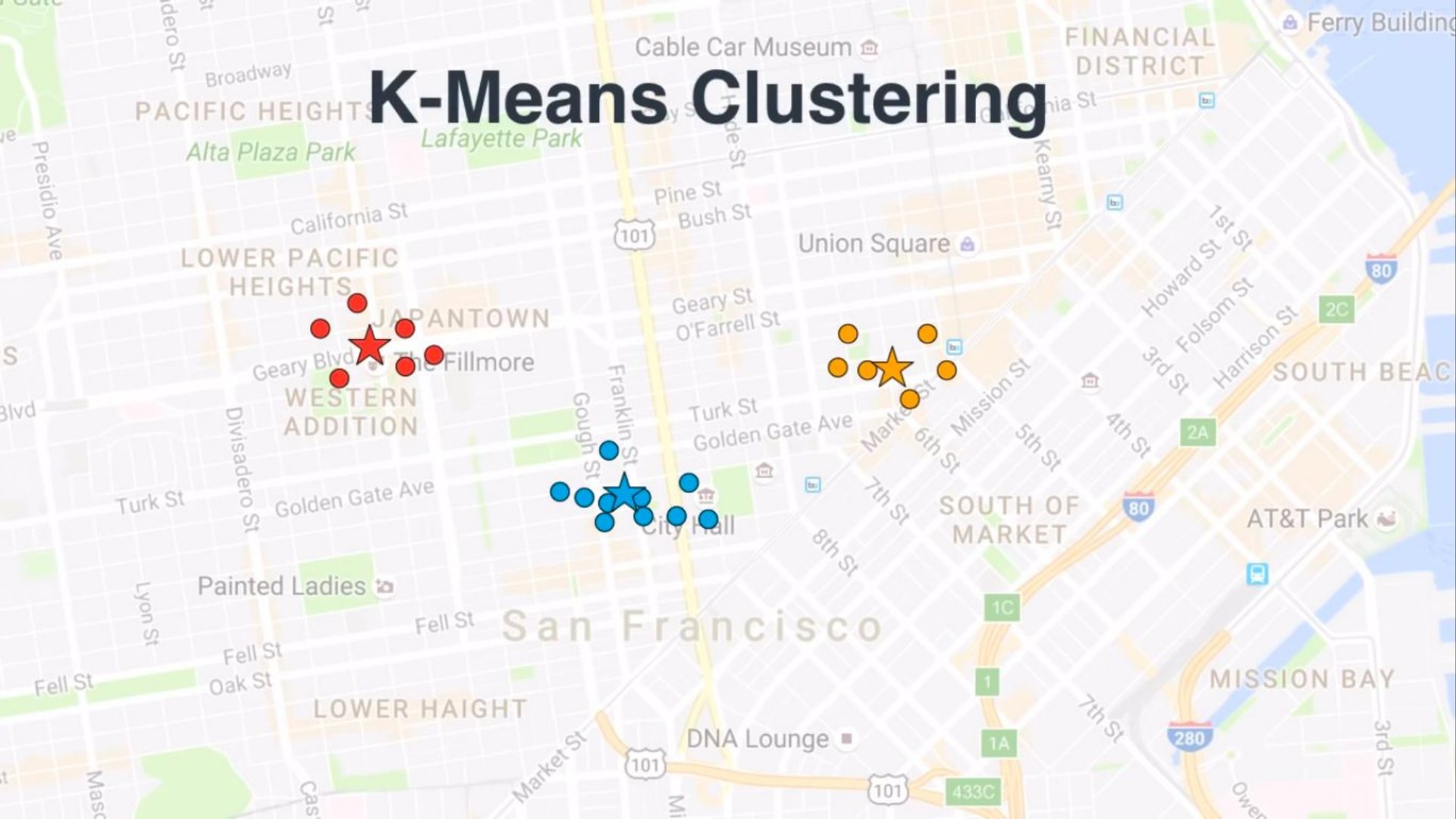
Did anyone say pizza?



Did anyone say pizza?



K-Means Clustering



Summary

- ❑ Linear Regression
- ❑ Naive Bayes
- ❑ Decision Tree
- ❑ Logistic Regression
- ❑ Neural Network
- ❑ SVN (Kernel Trick)
- ❑ Clustering (K-Means)