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A Friendly Introduction to Machine Learning

What is Machine Learning?

Learn from experience



Follow instructions



What is Machine Learning?

Learn from experience



Learn from experience



Follow instructions



What is Machine Learning?

Learn from experience



Learn from ~~experience~~^{data}



Follow instructions



Price of a house



Price of a house



\$70,000

Price of a house



\$70,000



\$160,000

Price of a house



\$70,000



?



\$160,000

Price of a house



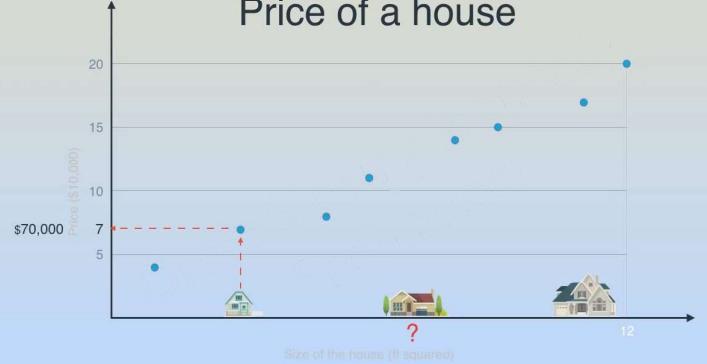
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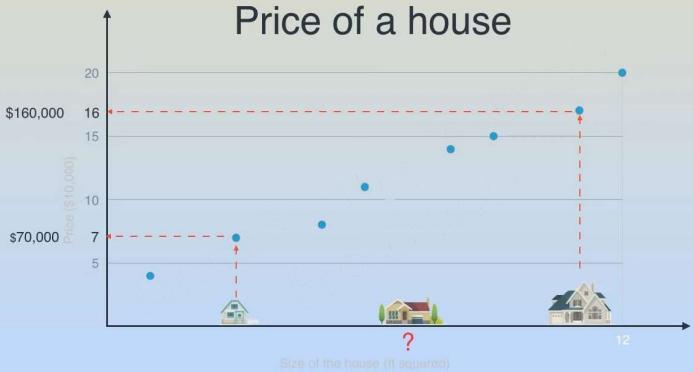
Price of a house



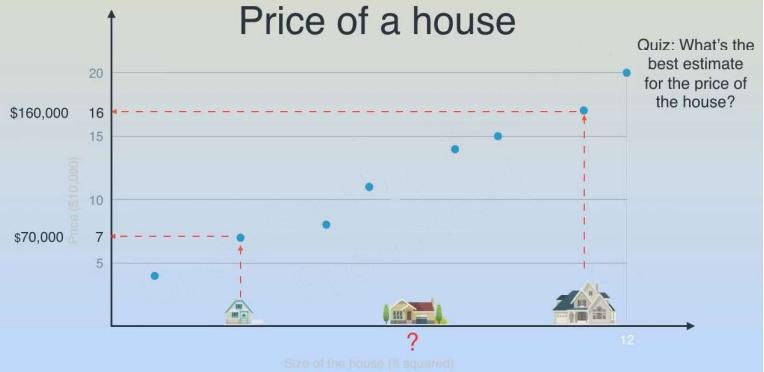
Price of a house



Price of a house



Price of a house



Price of a house



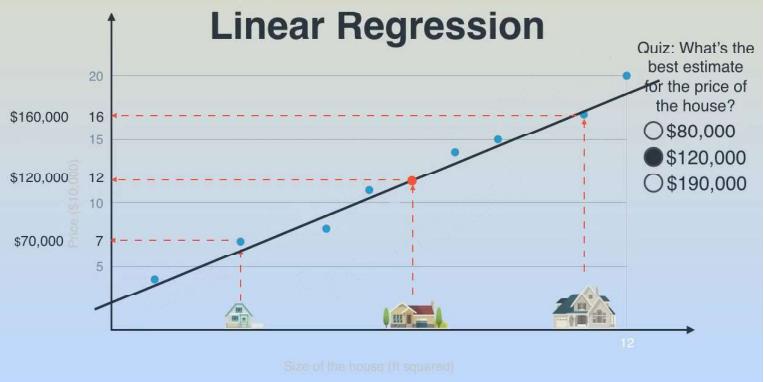
Price of a house



Price of a house



Linear Regression



Linear Regression

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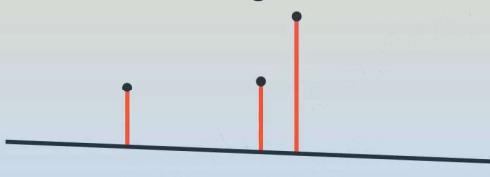
Linear Regression

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Linear Regression

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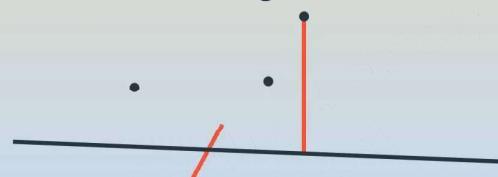
Error:



Linear Regression

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Error: —



Linear Regression

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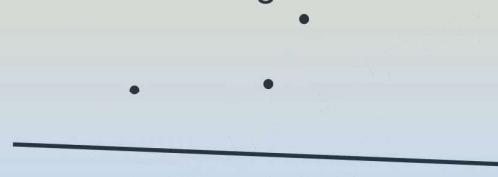
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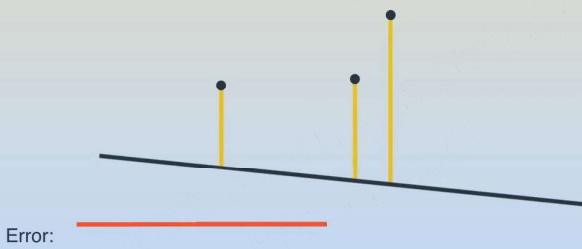
Linear Regression

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•

Error: —



Linear Regression



Linear Regression



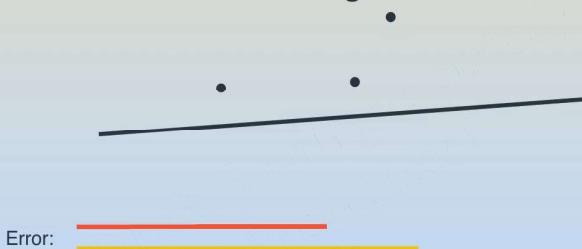
Linear Regression



Linear Regression



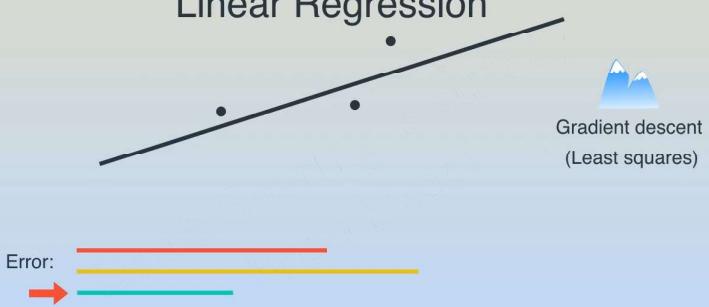
Linear Regression



Linear Regression



Linear Regression



Gradient descent

Gradient descent
(Least squares)

Mount Errorest

Gradient descent



Mount Errorest

Error:

Gradient descent



Mount Errorest

Gradient descent



Mount Errorest

Mount Errorest

Mount Errorest

Gradient descent



Mount Errorest

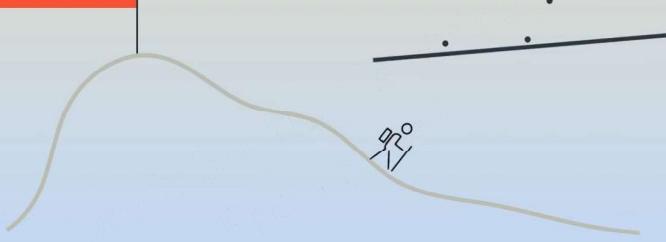
Gradient descent



Mount Errorest

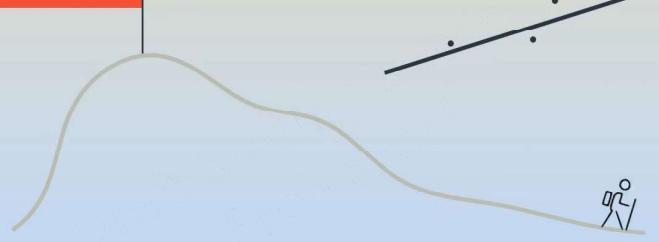
Gradient descent 🏔

Mount Errorest



Gradient descent 🏔

Mount Errorest



Gradient descent 🏔

Mount Errorest



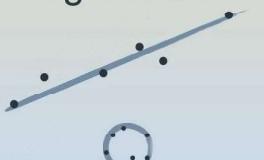
Linear and Polynomial Regression



Linear and Polynomial Regression



Linear and Polynomial Regression



Linear and Polynomial Regression



Linear and Polynomial Regression



Detecting Spam e-mails

Detecting Spam e-mails



Non-spam

Detecting Spam e-mails

⚠ “Cheap”



Non-spam

Detecting Spam e-mails

⚠ "Cheap"



Detecting Spam e-mails

⚠ "Cheap"



Detecting Spam e-mails

⚠ "Cheap"



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

⚠ "Cheap"

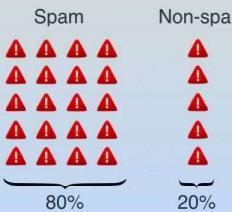


Quiz: If an e-mail contains the word "cheap", what is the probability of it being spam?

- 40%
- 60%
- 80%

Detecting Spam e-mails

⚠ "Cheap"



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

Conclusion:

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

⚠ "Cheap" → 80%

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%

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%

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%
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- ! etc...

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Conclusion:

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

Naive Bayes Algorithm

- ! "Cheap" → 80%
- ! Spelling mistake → 70%
- ! Missing title → 95%
- ! etc...

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 60%
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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	
F	25	
M	32	
F	40	
M	12	
M	14	

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

- Gender
 Age

Recommendng Apps

Gender	Age	App
F	15	Pokémon Go
F	25	WhatsApp
M	32	Snapchat
F	40	WhatsApp
M	12	Pokémon Go
M	14	Pokémon Go

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Recommendng Apps

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Recommendng Apps

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F	25	WhatsApp
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Recommendng Apps

Gender	Age	App
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M	32	Snapchat
F	40	WhatsApp



Recommendng Apps

Gender	Age	App
F	25	WhatsApp
M	32	Snapchat
F	40	WhatsApp



Recommending Apps

Gender	Age	App
F	25	WhatsApp
M	32	Facebook
F	40	WhatsApp



Decision Tree

Gender	Age	App
F	15	Pokémon Go
F	25	WhatsApp
M	32	Facebook
F	40	WhatsApp
M	12	Pokémon Go
M	14	Pokémon Go



Acceptance at a University



Test

Acceptance at a University



Test



Grades

Acceptance at a University



Test

Acceptance at a University



Test



Grades

Student 1
Test: 9/10 ✓
Grades: 8/10

Acceptance at a University



Test



Grades

Student 1
Test: 9/10 ✓
Grades: 8/10

Acceptance at a University



Test



Grades

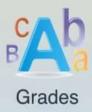
Student 1
Test: 9/10 ✓
Grades: 8/10

Student 2
Test: 3/10 ✗
Grades: 4/10

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



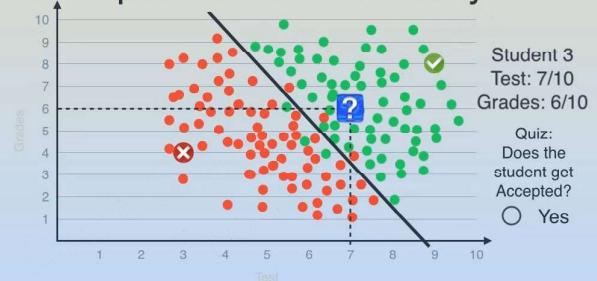
Acceptance at a University



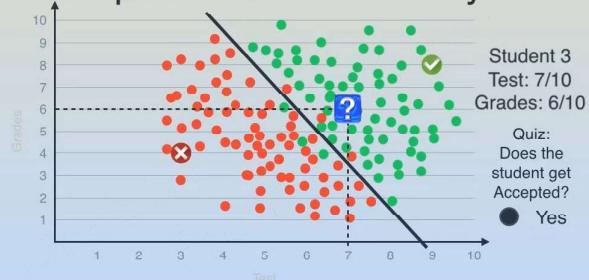
Acceptance at a University



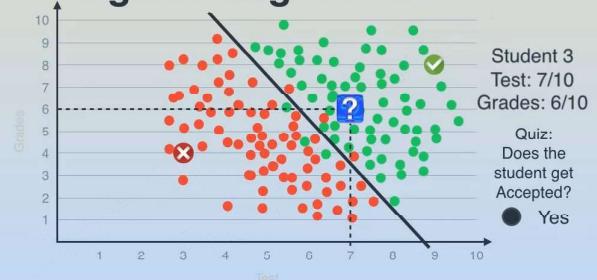
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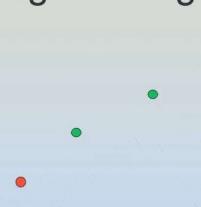
Acceptance at a University



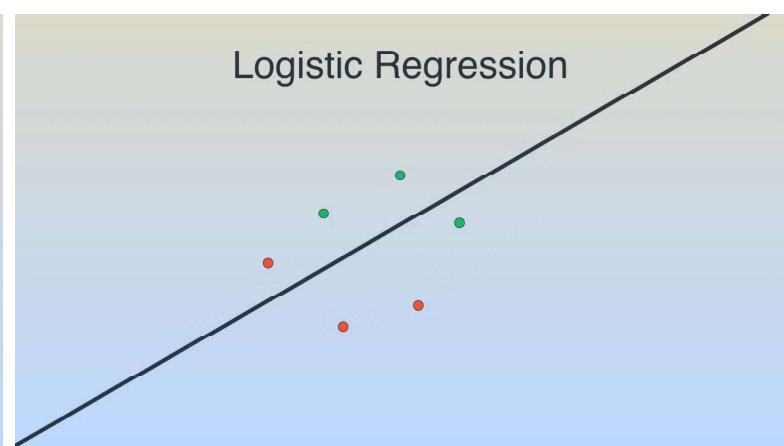
Logistic Regression



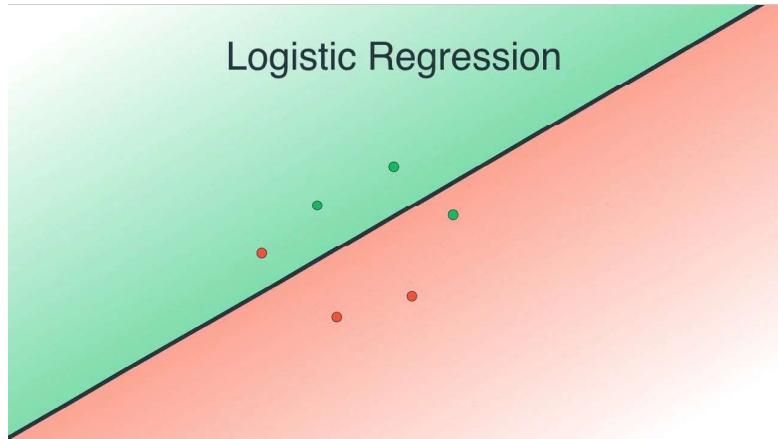
Logistic Regression



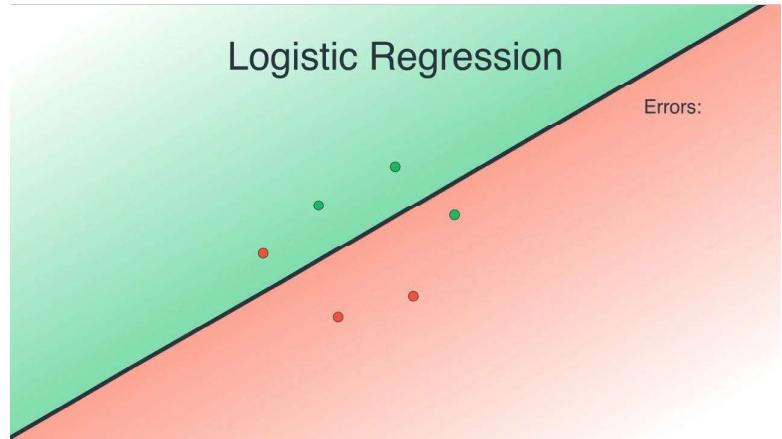
Logistic Regression



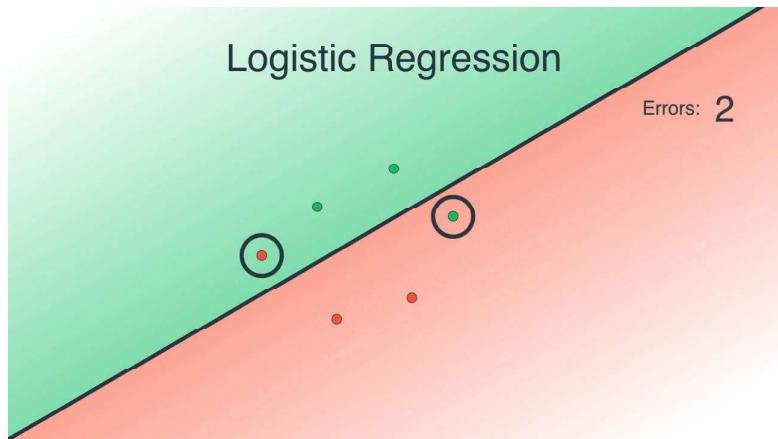
Logistic Regression



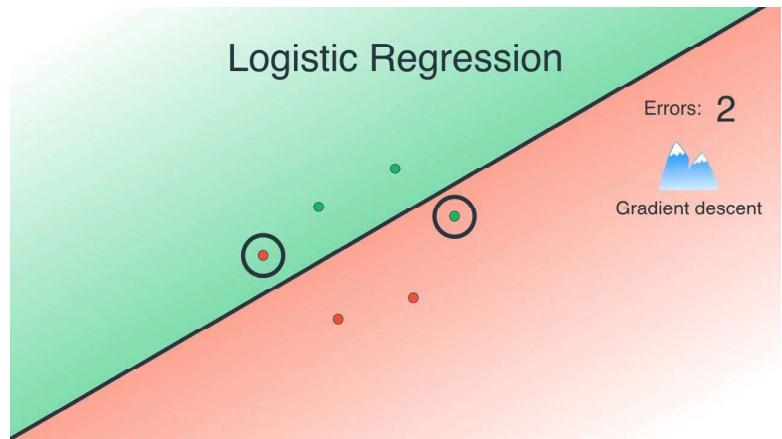
Logistic Regression



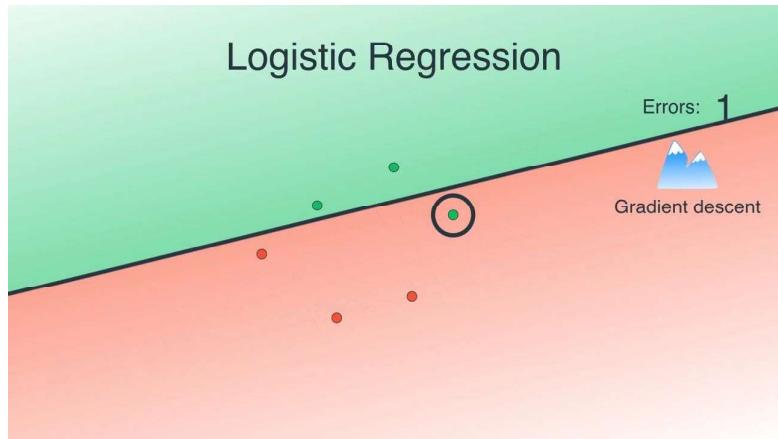
Logistic Regression



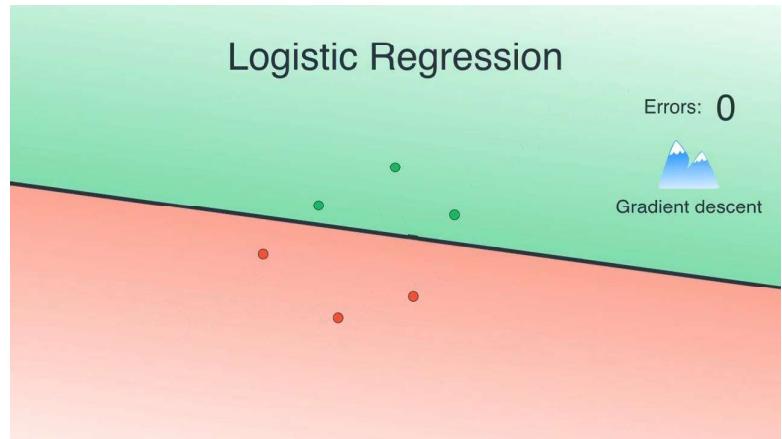
Logistic Regression



Logistic Regression



Logistic Regression

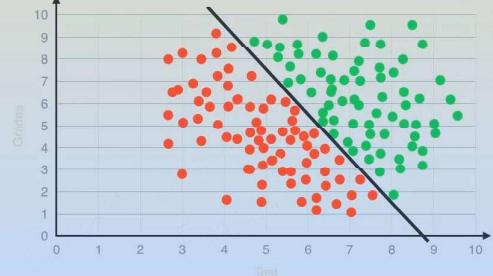


Logistic Regression

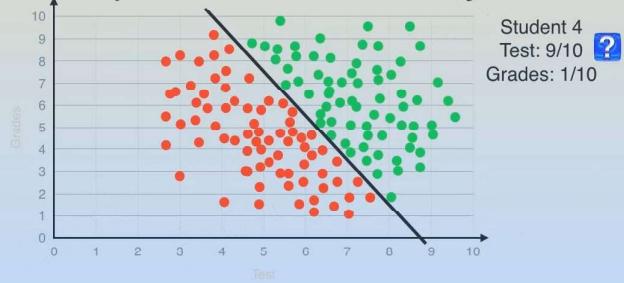
— Errors: 0

Gradient descent
Log-loss Function

Acceptance at a University

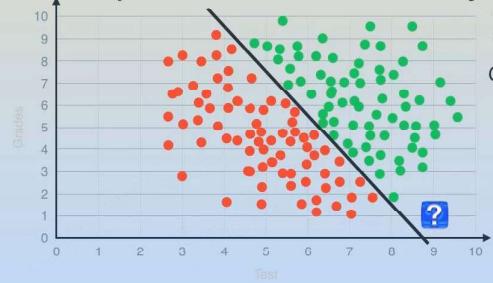


Acceptance at a University



Acceptance at a University

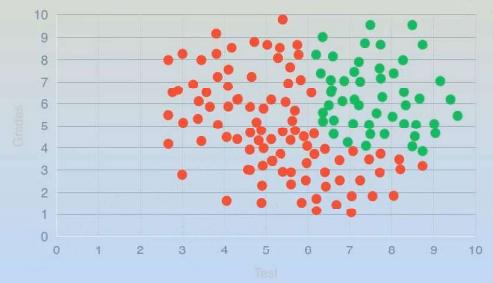
Student 4
Test: 9/10
Grades: 1/10



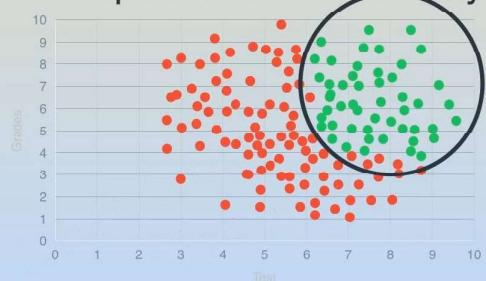
Acceptance at a University



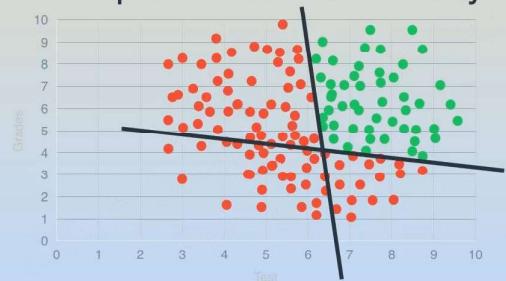
Acceptance at a University



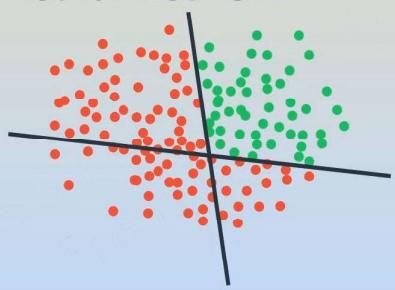
Acceptance at a University



Acceptance at a University



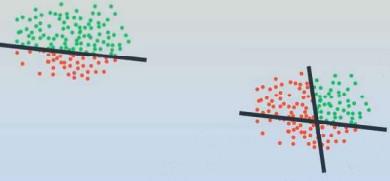
Neural Network



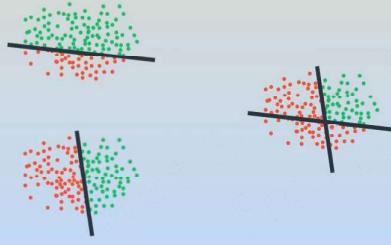
Neural Network



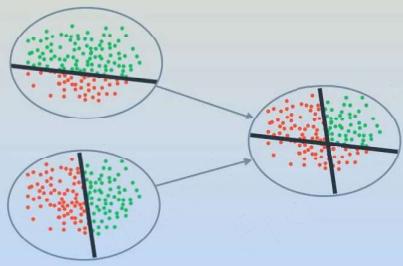
Neural Network



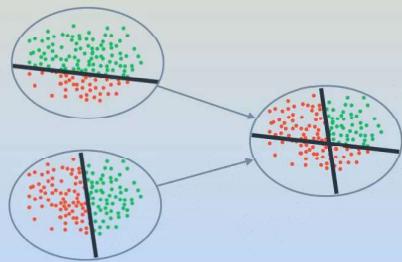
Neural Network



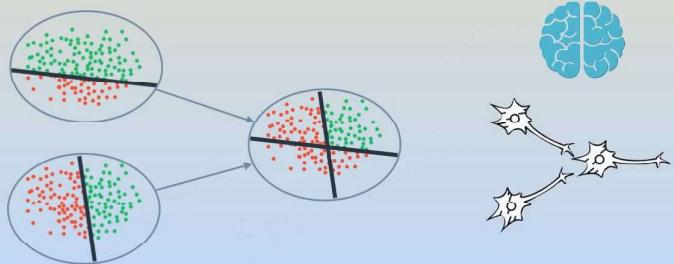
Neural Network



Neural Network

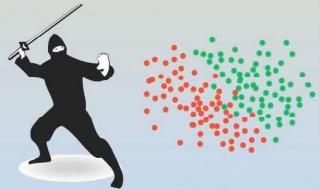


Neural Network



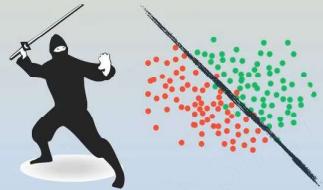
Logistic Regression & Neural Networks

Logistic Regression & Neural Networks



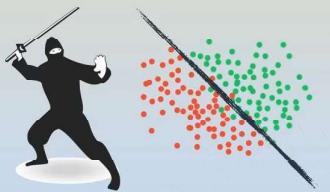
Logistic Regression

Logistic Regression & Neural Networks

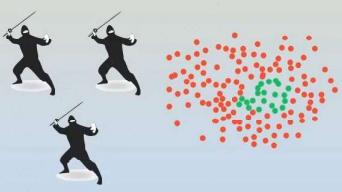


Logistic Regression

Logistic Regression & Neural Networks

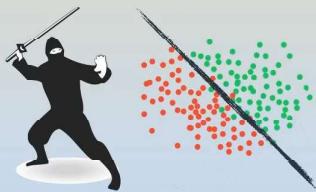


Logistic Regression

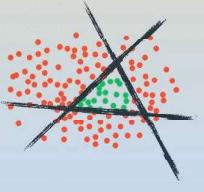


Neural Network

Logistic Regression & Neural Networks

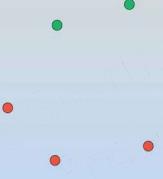


Logistic Regression



Neural Network

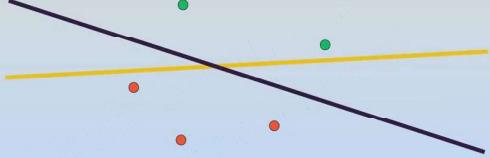
Cutting data with style



Cutting data with style



Cutting data with style



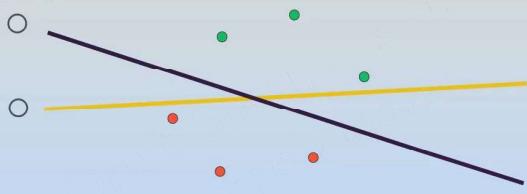
Quiz:
Which one is a
better line?

Cutting data with style



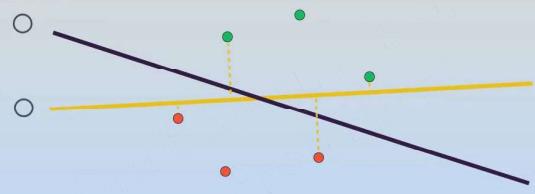
Cutting data with style

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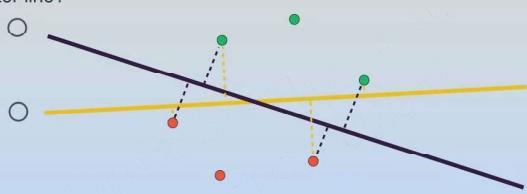
Cutting data with style

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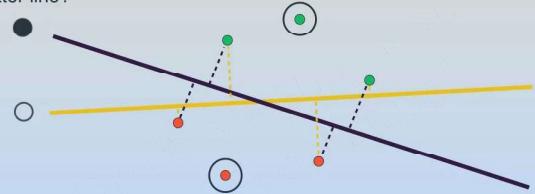
Cutting data with style

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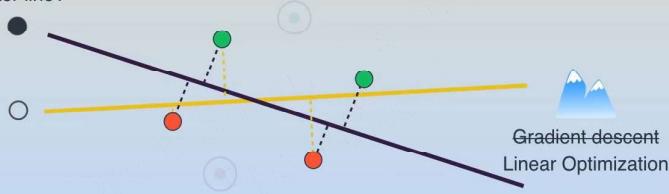
Cutting data with style

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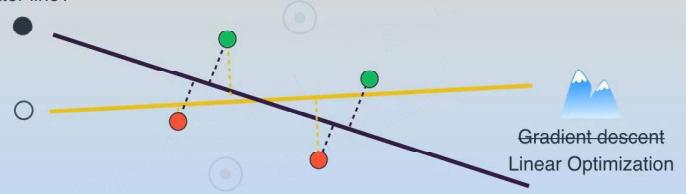
Cutting data with style

Quiz:
Which one is a
better line?



Support Vector Machine

Quiz:
Which one is a
better line?



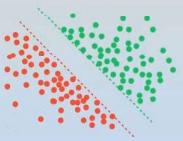
Support Vector Machines



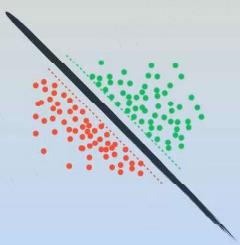
Support Vector Machines



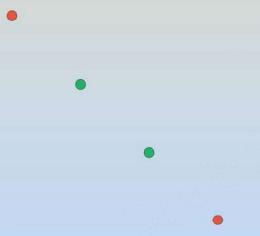
Support Vector Machines



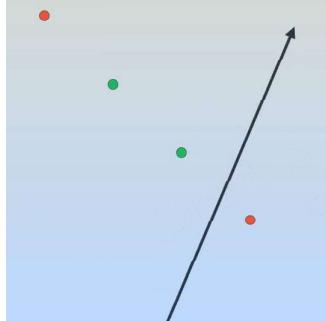
Support Vector Machines



When a line is not enough...



When a line is not enough...



When a line is not enough...



When a line is not enough...

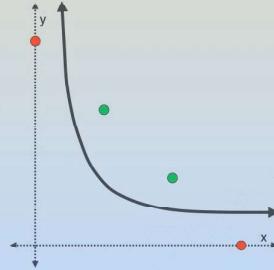


When a line is not enough...

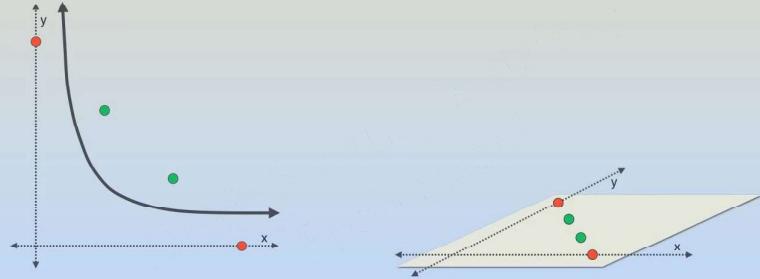


When a line is not enough...

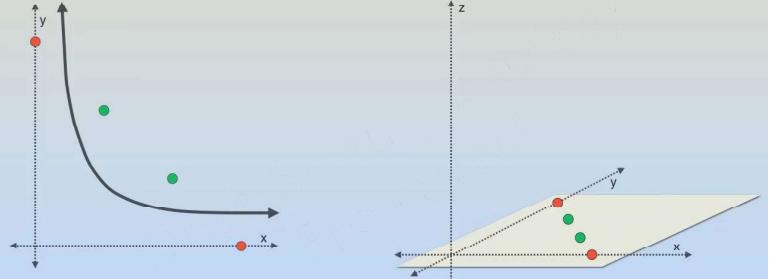
When a line is not enough...



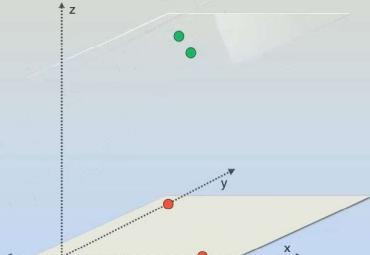
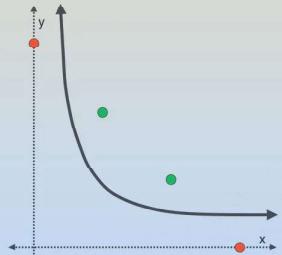
When a line is not enough...



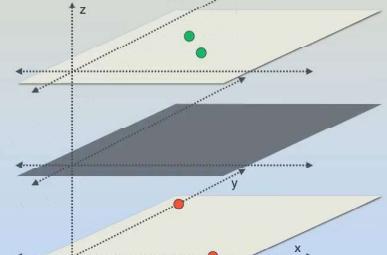
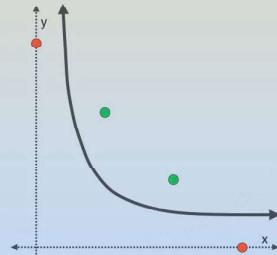
When a line is not enough...



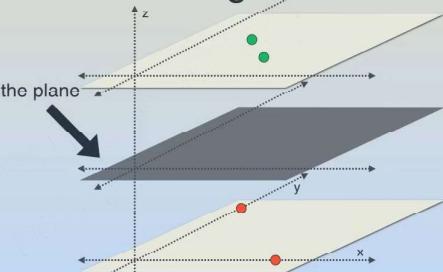
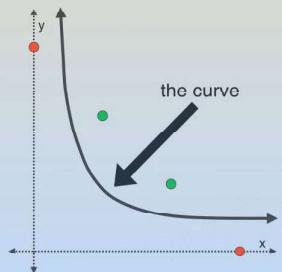
When a line is not enough...



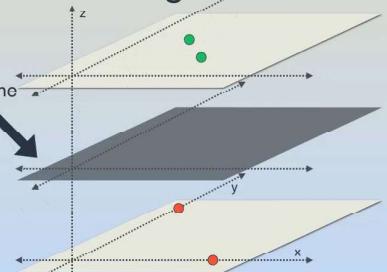
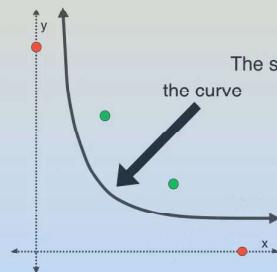
When a line is not enough...



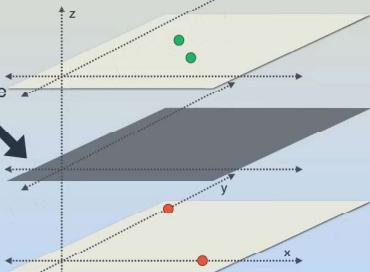
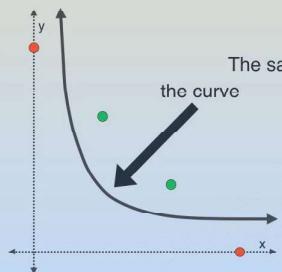
When a line is not enough...



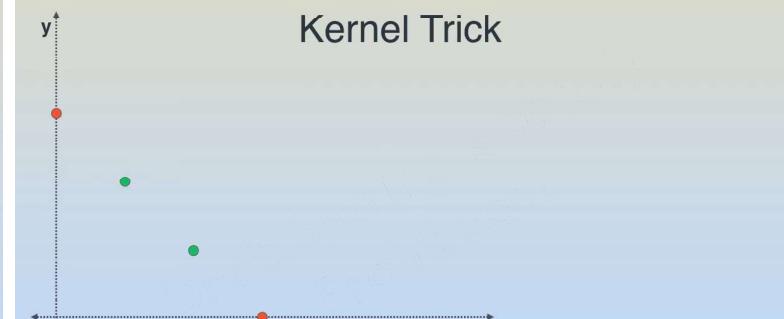
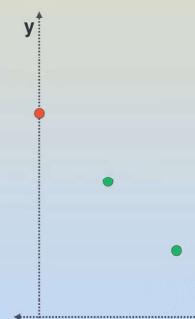
When a line is not enough...



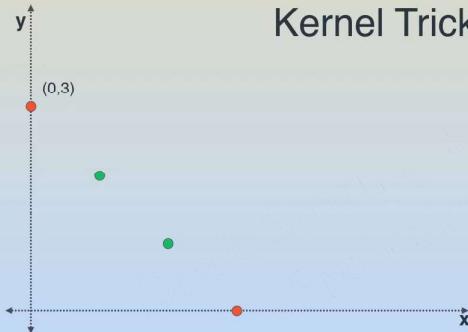
Kernel Trick



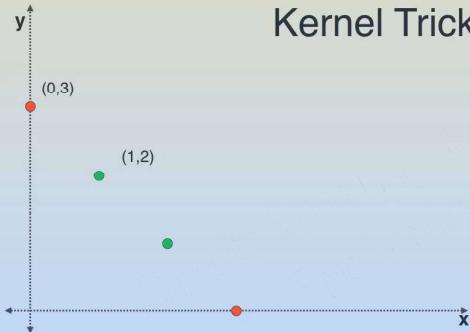
Kernel Trick



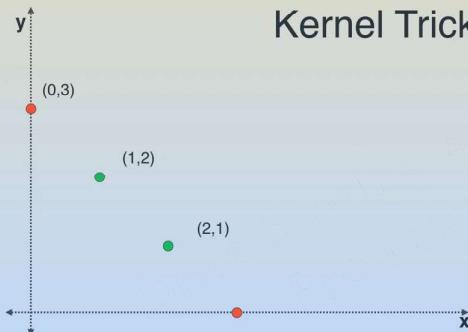
Kernel Trick



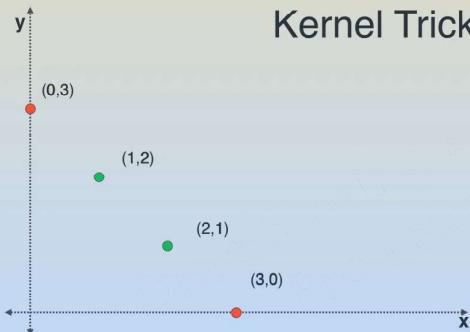
Kernel Trick



Kernel Trick

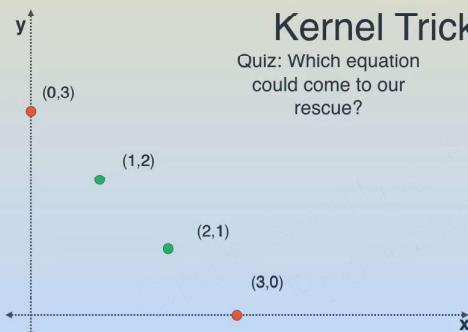


Kernel Trick



Kernel Trick

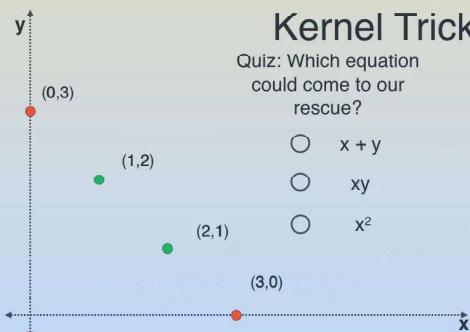
Quiz: Which equation could come to our rescue?

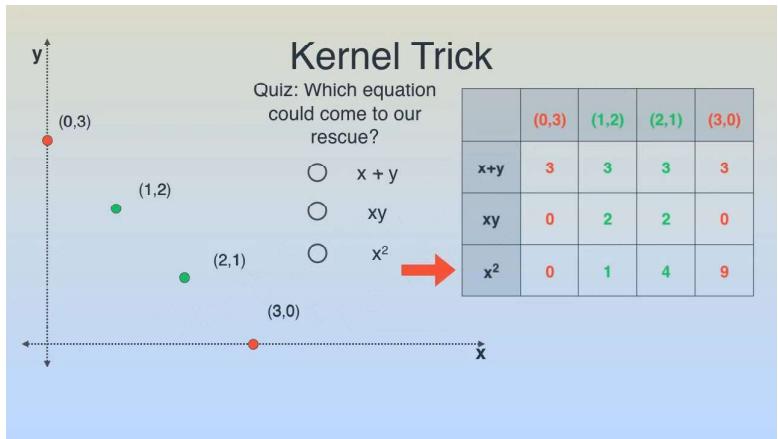
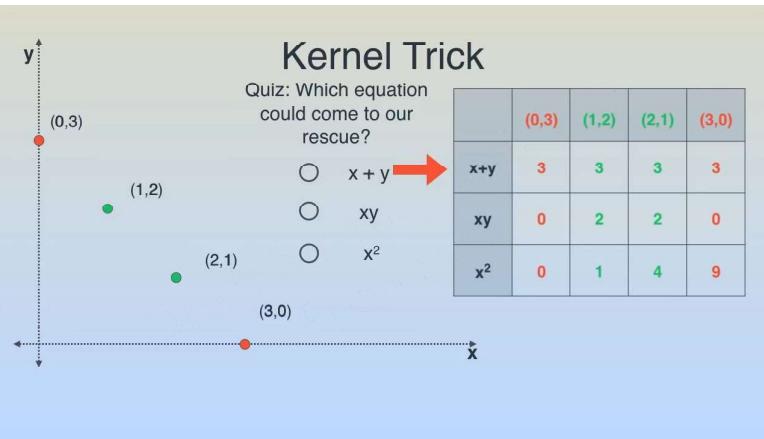
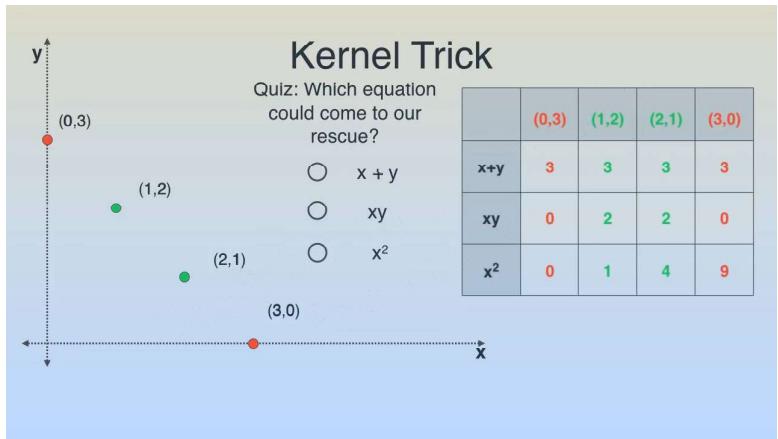
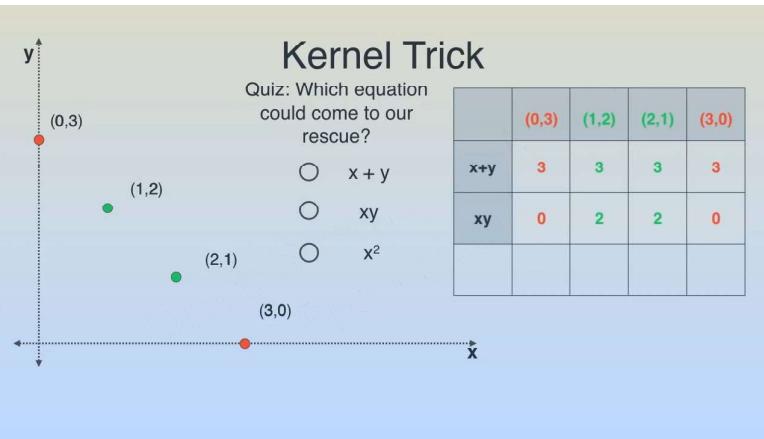
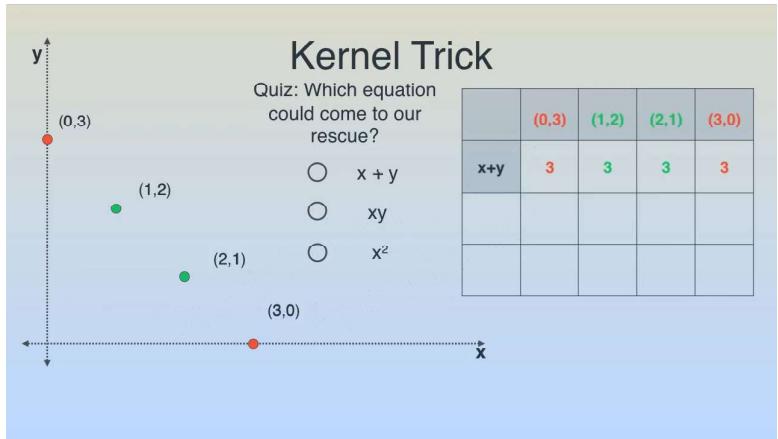
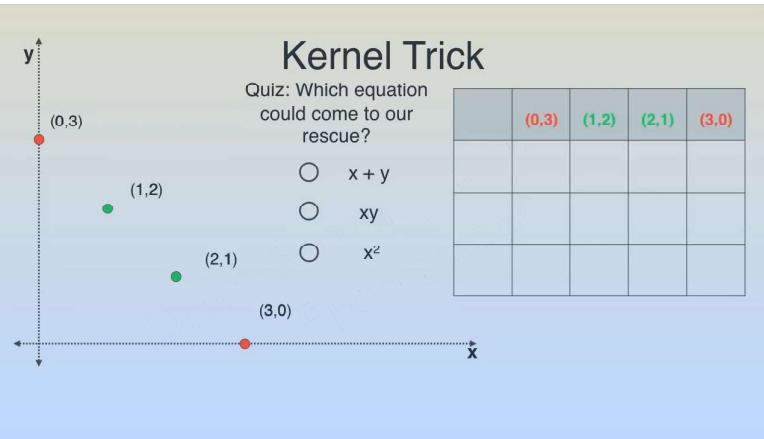


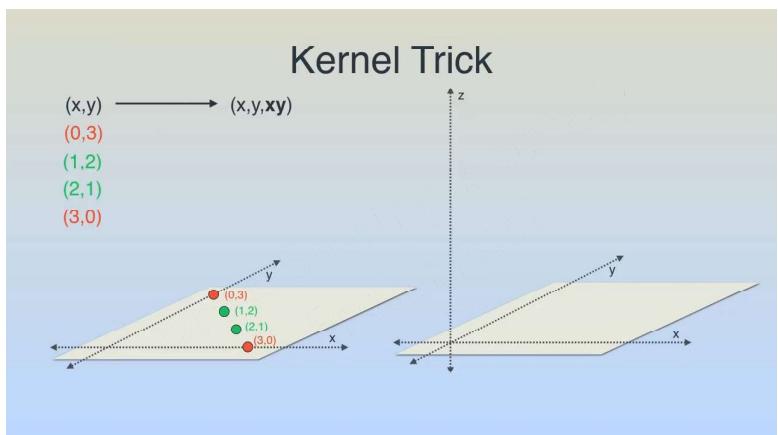
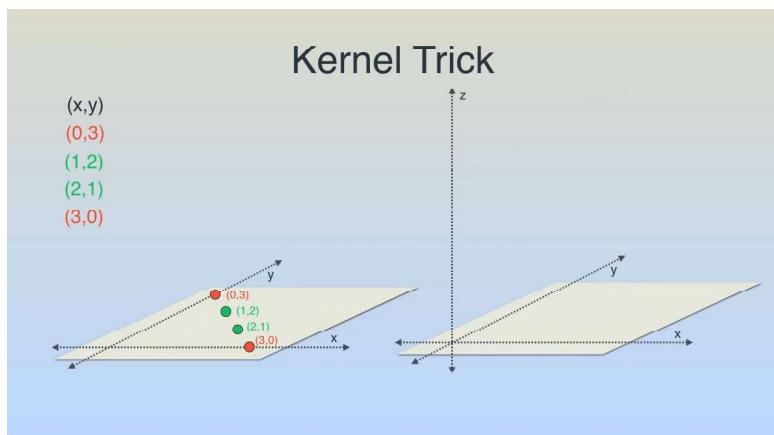
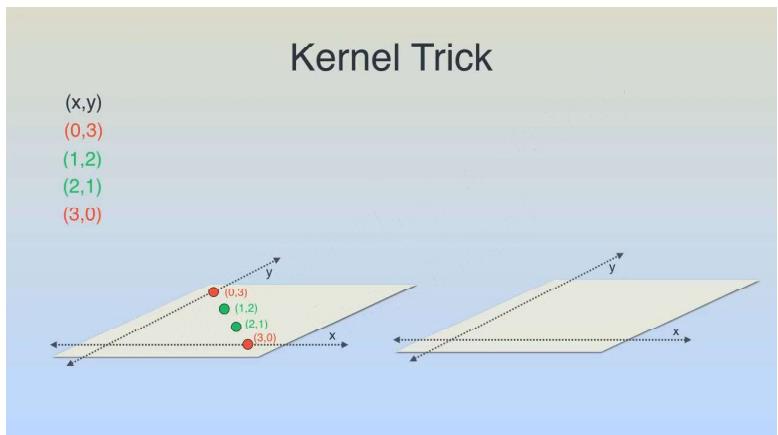
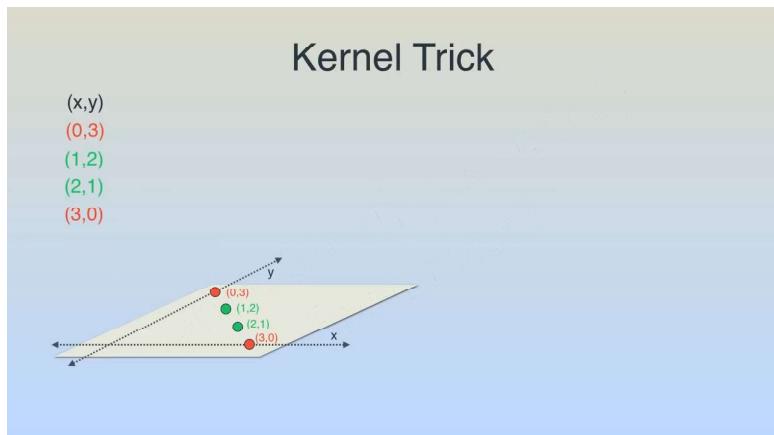
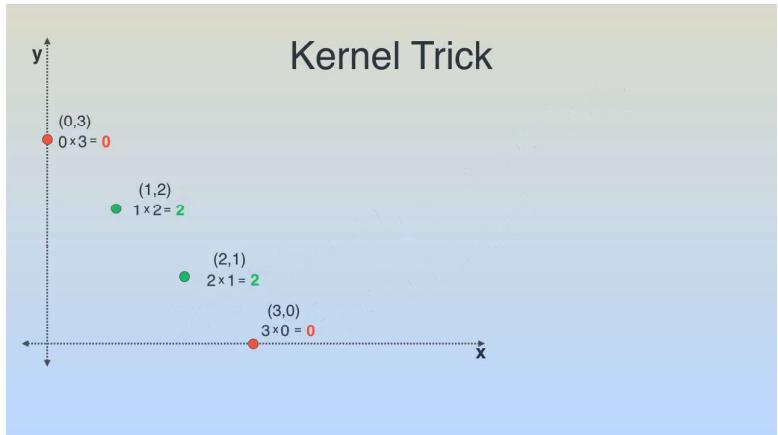
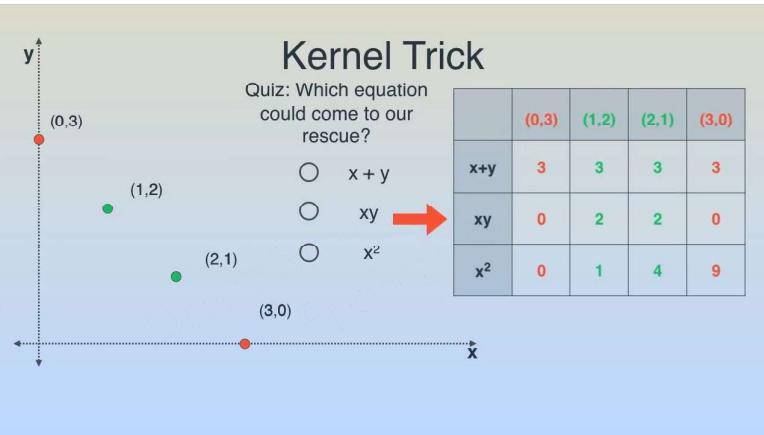
Kernel Trick

Quiz: Which equation could come to our rescue?

- $x + y$
- xy
- x^2







Kernel Trick

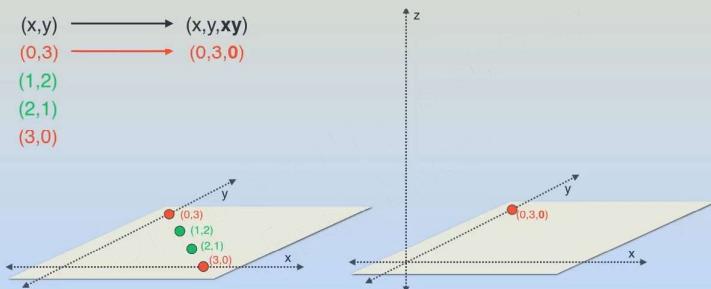
$(x,y) \rightarrow (x,y,xy)$

$(0,3) \rightarrow (0,3,0)$

$(1,2) \rightarrow (1,2,2)$

$(2,1) \rightarrow (2,1,2)$

$(3,0) \rightarrow (3,0,0)$



Kernel Trick

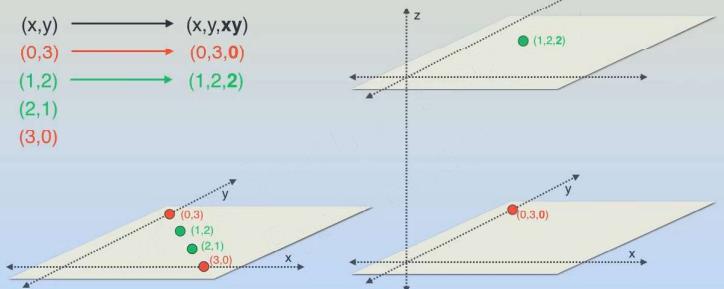
$(x,y) \rightarrow (x,y,xy)$

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Kernel Trick

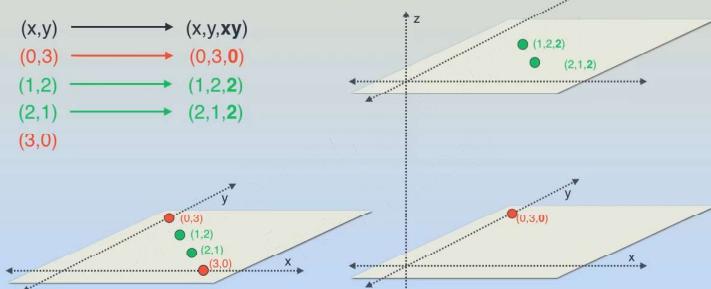
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Kernel Trick

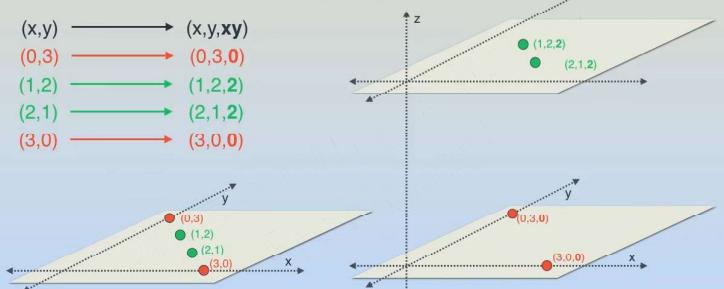
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Kernel Trick

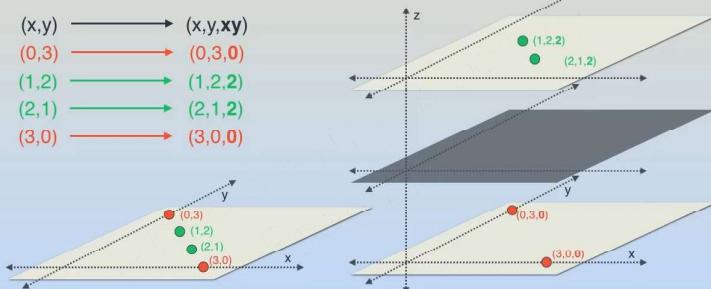
$(x,y) \rightarrow (x,y,xy)$

$(0,3) \rightarrow (0,3,0)$

$(1,2) \rightarrow (1,2,2)$

$(2,1) \rightarrow (2,1,2)$

$(3,0) \rightarrow (3,0,0)$



Kernel Trick

$(0,3)$
 $0 \times 3 = 0$

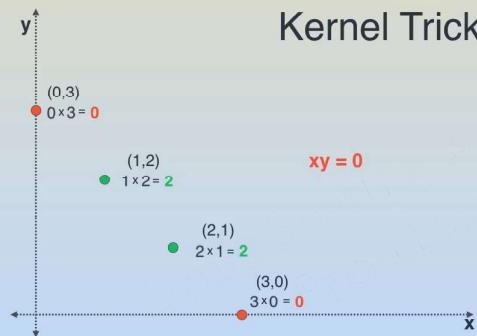
$(1,2)$
 $1 \times 2 = 2$

$xy = 0$

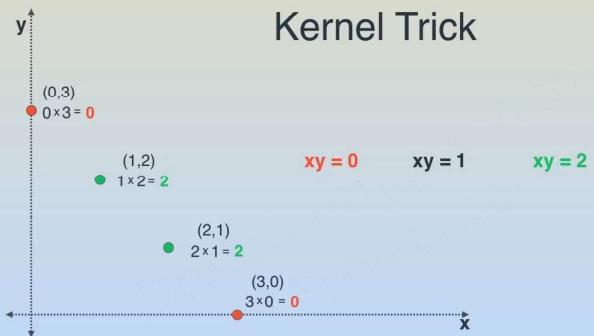
$(2,1)$
 $2 \times 1 = 2$

$(3,0)$
 $3 \times 0 = 0$

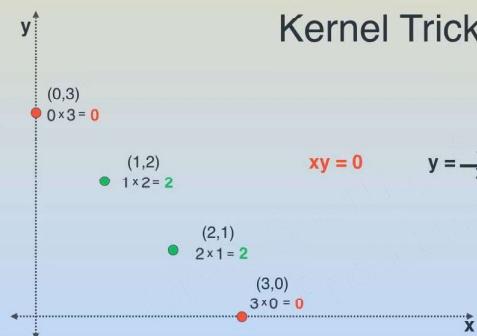
Kernel Trick



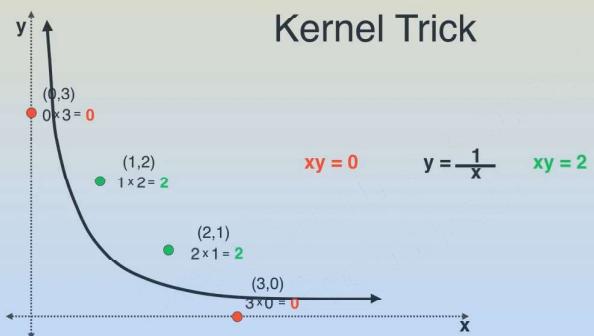
Kernel Trick



Kernel Trick



Kernel Trick



Support Vector Machine Kernel Trick



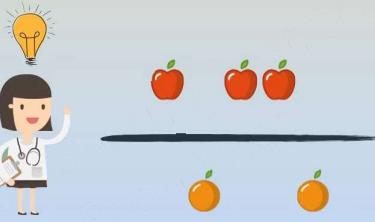
Support Vector Machine Kernel Trick



Support Vector Machine Kernel Trick



Support Vector Machine Kernel Trick



Did anyone say pizza?



Did anyone say pizza?



Did anyone say pizza?

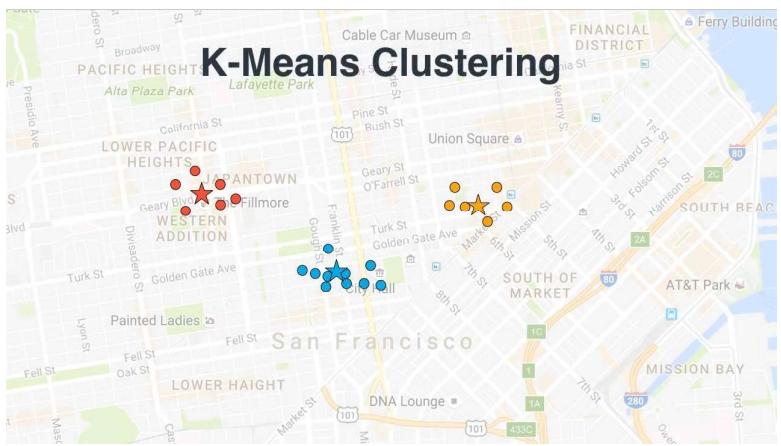


Did anyone say pizza?













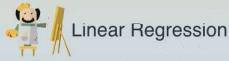
Summary

Summary

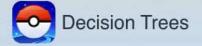
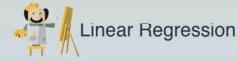


Linear Regression

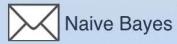
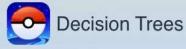
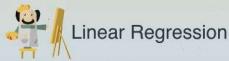
Summary



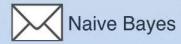
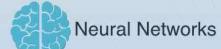
Summary



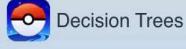
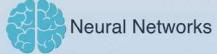
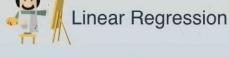
Summary



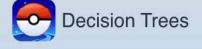
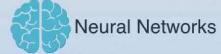
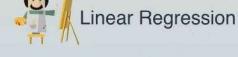
Summary



Summary



Summary



Questions

Are there more?

Questions

Are there more?

Which one to use?

Questions

Are there more?

Which one to use?

How to compare/evaluate them?

Questions

Are there more?

Which one to use?

How to compare/evaluate them?

Examples, projects, real life data?

THANK YOU!

Drafts are strictly
for internal use only