Google Cloud

Getting started with Machine Learning

Data Engineering on Google Cloud Platform

Agenda

What is Machine Learning?

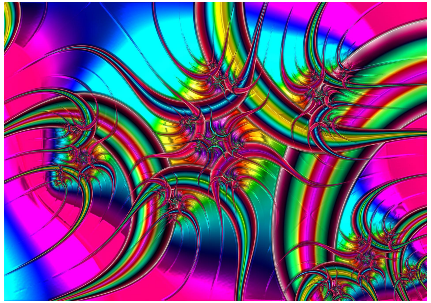
Playing with ML

Effective ML

Creating ML datasets + Lab

Machine Learning: Way to derive insights from data

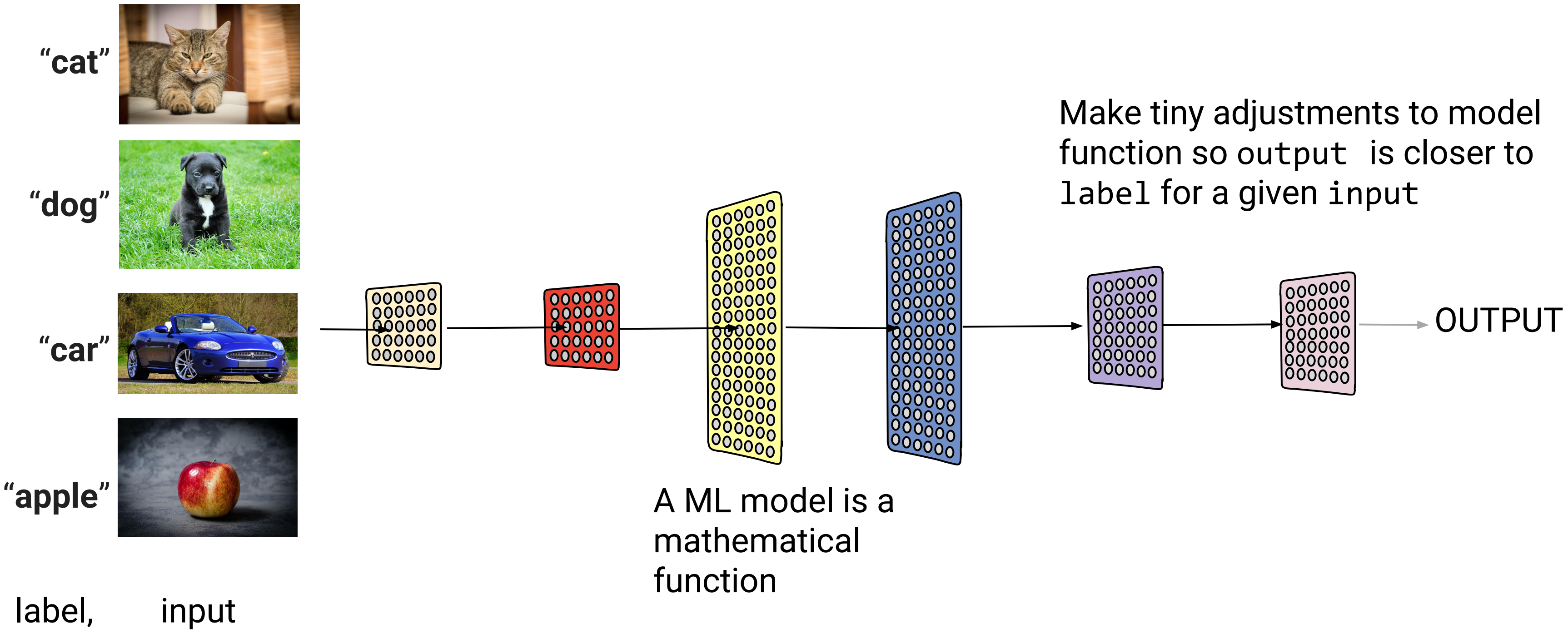
data



algorithm

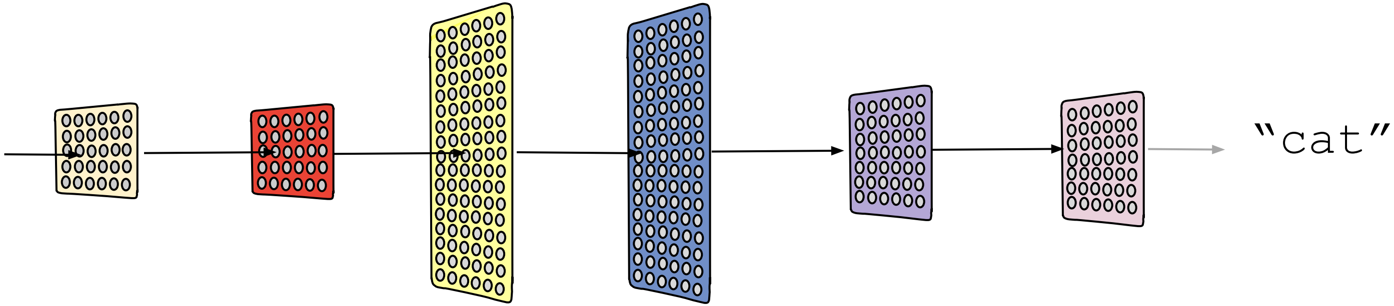
insight

Step 1: Train a ML Model with examples



Step 2: Predict with a trained model

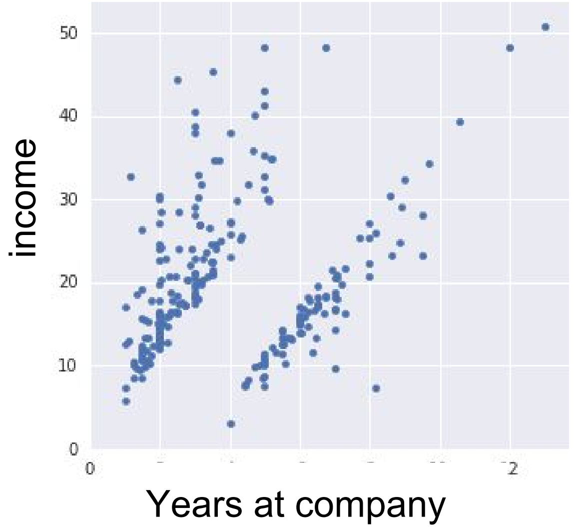
unlabeled photo

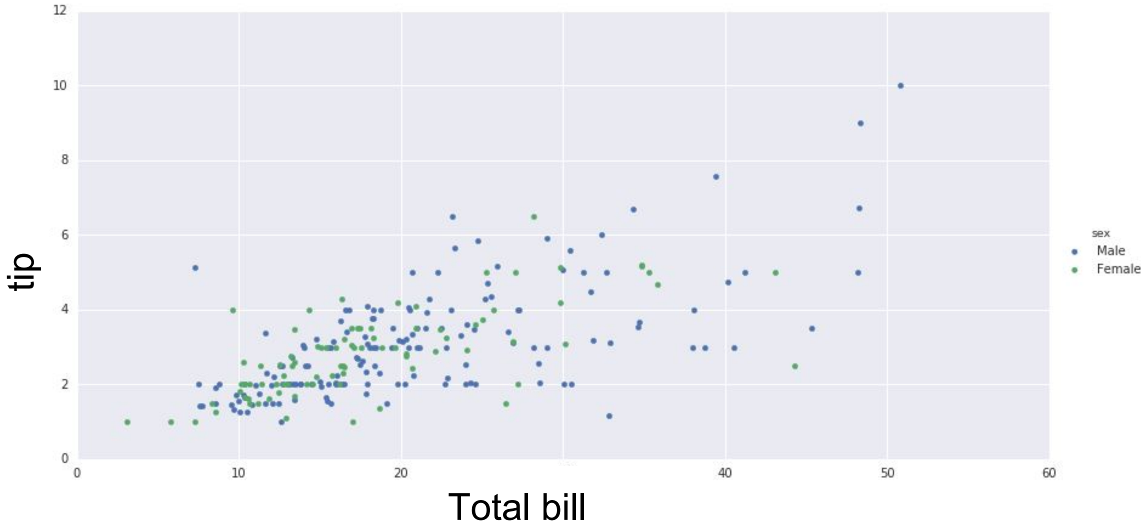


Do Now: In your own words, write down definitions for these ML terms

Term	Meaning
Label	
Input	
Example	
Model	
Training	
Prediction	

Machine Learning use cases



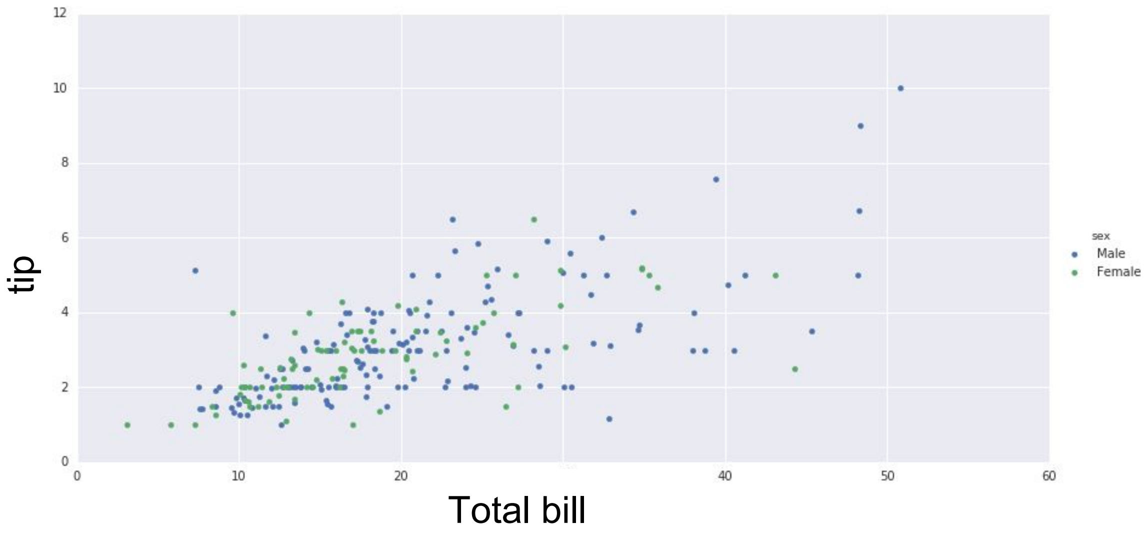


Clustering
Is this employee on the "fast-track" or not?

Regression
Predict the tip amount

Classification
Predict the gender of the customer

We’ll focus on supervised learning



Regression
Predict the tip amount

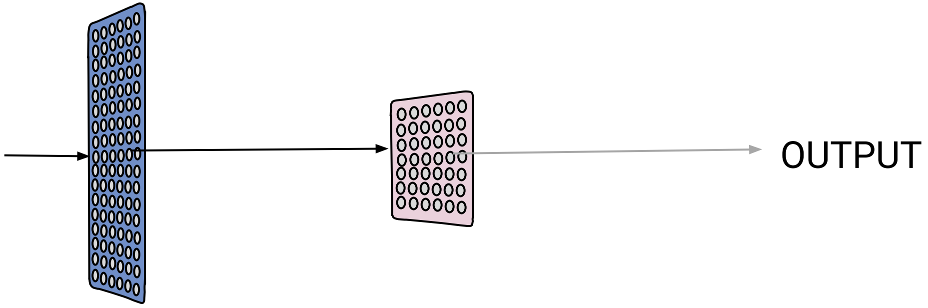
Classification
Predict the gender of the customer

This regression model predicts a continuous number

36

41

gestation_weeks	mother_age	cigarette_use	alcohol_use	weight_gain_pounds
36	23	false	false	70
37	23	false	false	25
38	21	false	false	33
39	16	false	false	26
39	23	true	true	null
41	30	false	false	8



A common source of structured data for ML training is your data warehouse

36

41

gestation_weeks	mother_age	cigarette_use	alcohol_use	weight_gain_pounds
36	23	false	false	70
37	23	false	false	25
38	21	false	false	33
39	16	false	false	26
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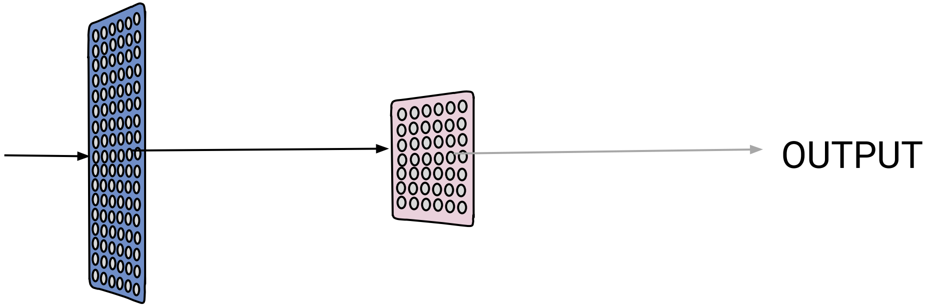
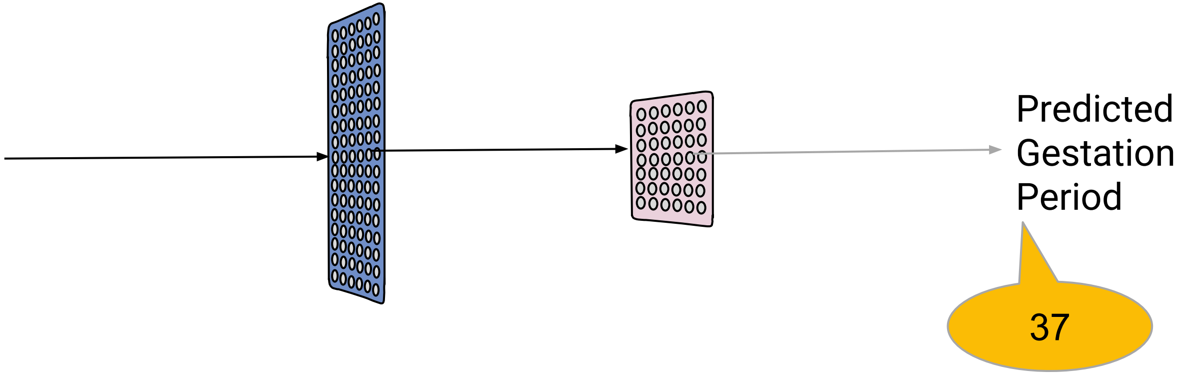



```
SELECT
  gestation_weeks,
  mother_age,
  cigarette_use,
  alcohol_use,
  weight_gain_pounds
FROM
  `bigquery-public-data.samples.natality`
WHERE cigarette_use is not null AND alcohc
```

The model is fed information collected in real-time, and used for prediction

```
{
  "mother_age": 23,
  "cigarette_use": false,
  "alcohol_use": true,
  "weight_gain_pounds": 35
}
```



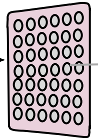
The model may even have only one layer

```
gestation_weeks =   w0 * mother_age
                  + w1 * cigarette_use
                  + w2 * alcohol_use
                  + w3 * weight_gain_pounds
                  + b
```

gestation_weeks	mother_age	cigarette_use	alcohol_use	weight_gain_pounds
36	23	false	false	70
37	23	false	false	25
38	21	false	false	33
39	16	false	false	26
39	23	true	true	null
41	30	false	false	8

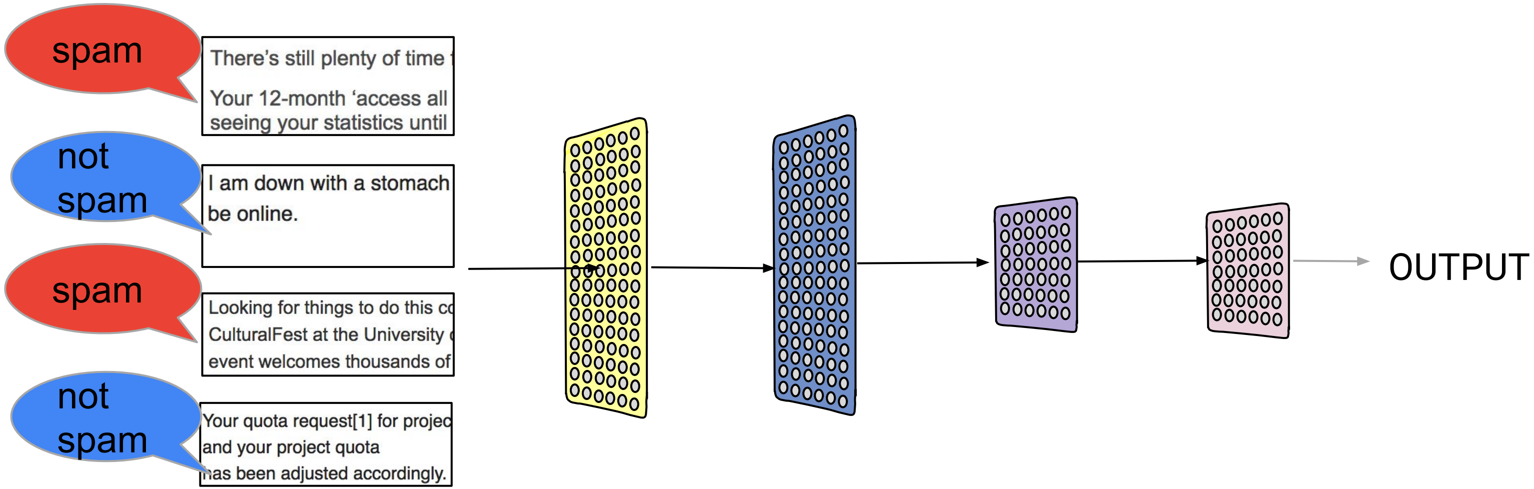
36

41



OUTPUT

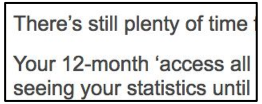
A classification model can be used to detect whether email is spam is not



The input here is text

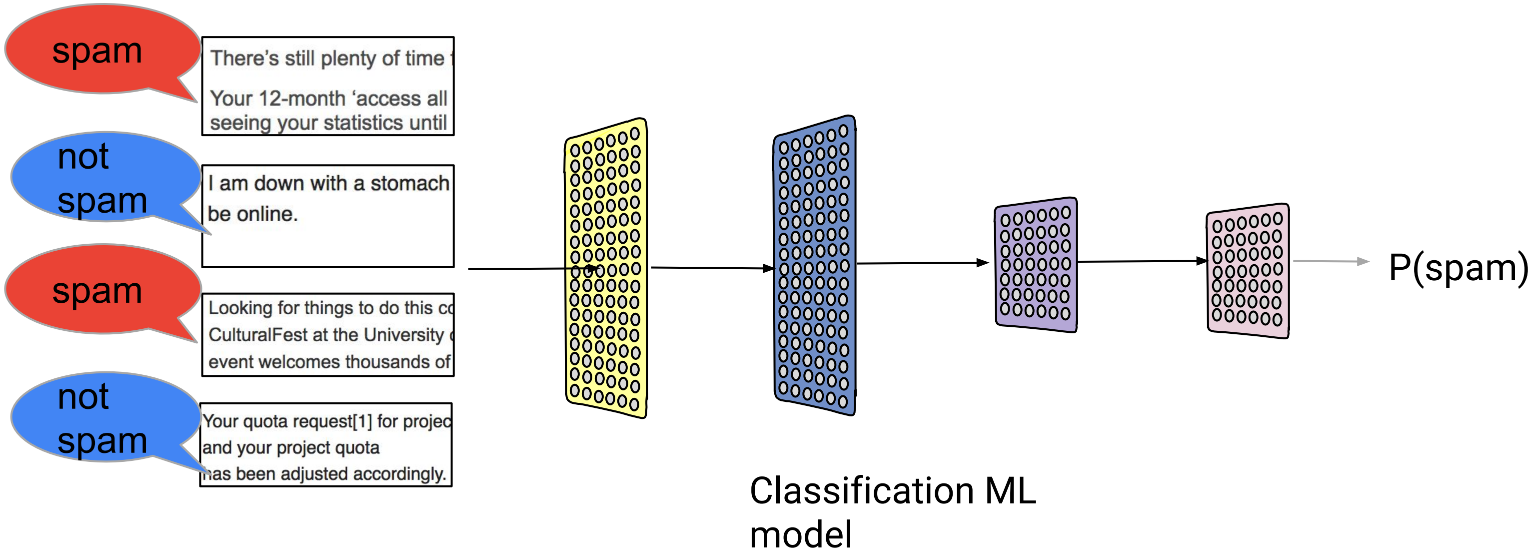
The inputs for unstructured data are still ultimately just numbers

N-dimensional array of pixel values



Each word is mapped to a vector
e.g., "the" could be [0 4 5 0 3 4]
Coming up with an appropriate vector for a word is itself a machine learning problem

The output of the model might be the probability that the email is spam



Machine Learning used in lots of industries

Manufacturing

- Predictive maintenance or condition monitoring
- Warranty reserve estimation
- Propensity to buy
- Demand forecasting
- Process optimization
- Telematics

Retail

- Predictive inventory planning
- Recommendation engines
- Upsell and cross-channel marketing
- Market segmentation and targeting
- Customer ROI and lifetime value

Healthcare and Life Sciences

- Alerts and diagnostics from real-time patient data
- Disease identification and risk satisfaction
- Patient triage optimization
- Proactive health management
- Healthcare provider sentiment analysis

Travel and Hospitality

- Aircraft scheduling
- Dynamic pricing
- Social media—consumer feedback and interaction analysis
- Customer complaint resolution
- Traffic patterns and congestion management

Financial Services

- Risk analytics and regulation
- Customer Segmentation
- Cross-selling and upselling
- Sales and marketing campaign management
- Credit worthiness evaluation

Energy, Feedstock and Utilities

- Power usage analytics
- Seismic data processing
- Carbon emissions and trading
- Customer-specific pricing
- Smart grid management
- Energy demand and supply optimization

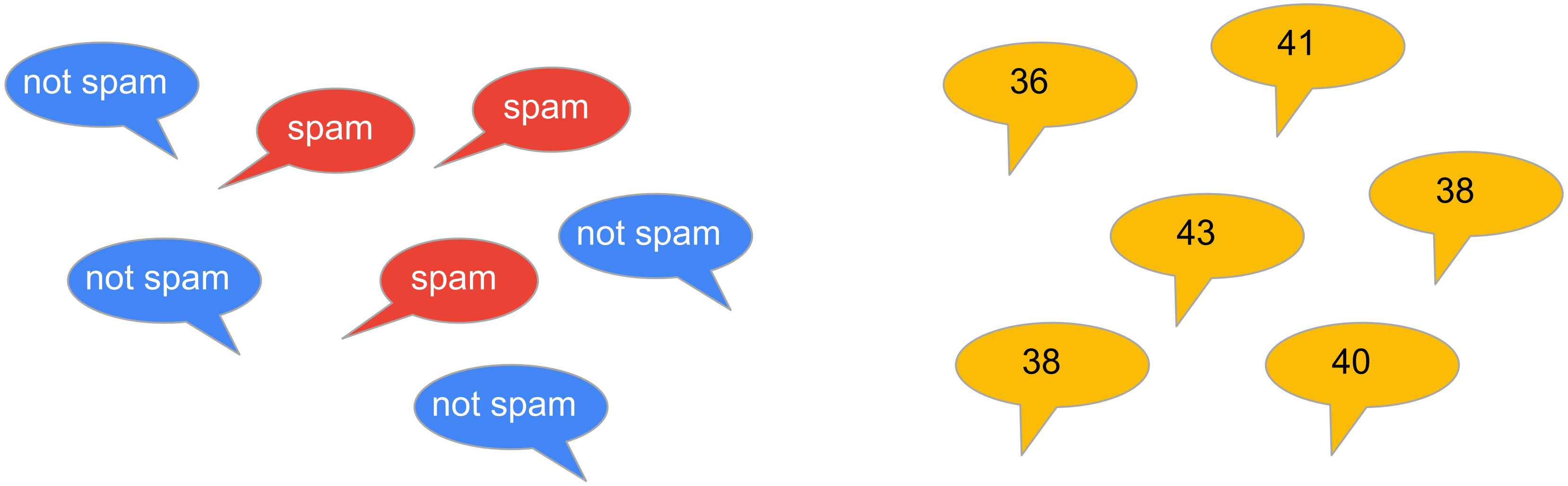
Do Now: Pick 5 use cases from previous slide and fill out this table

Use case	Label	Input(s)	Classification or regression?

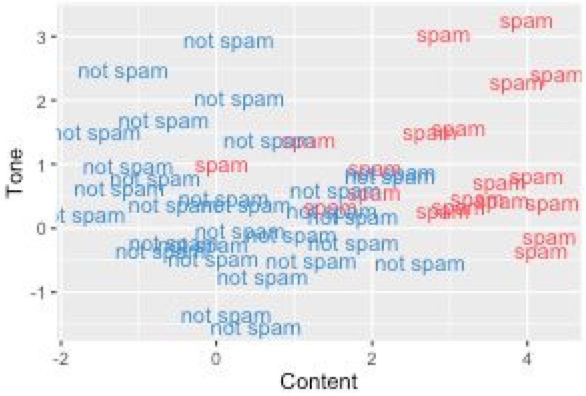
Agenda

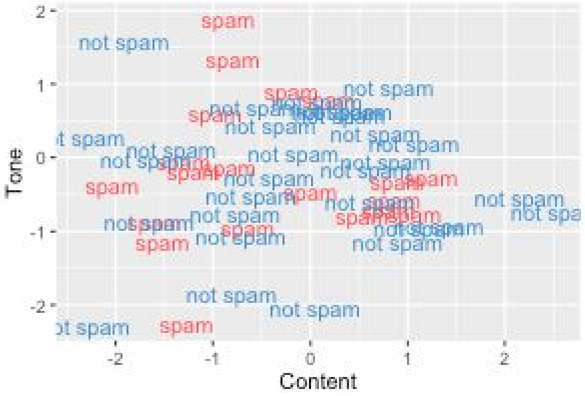
Playing with ML

Machine Learning is an approach to making many similar decisions based on data

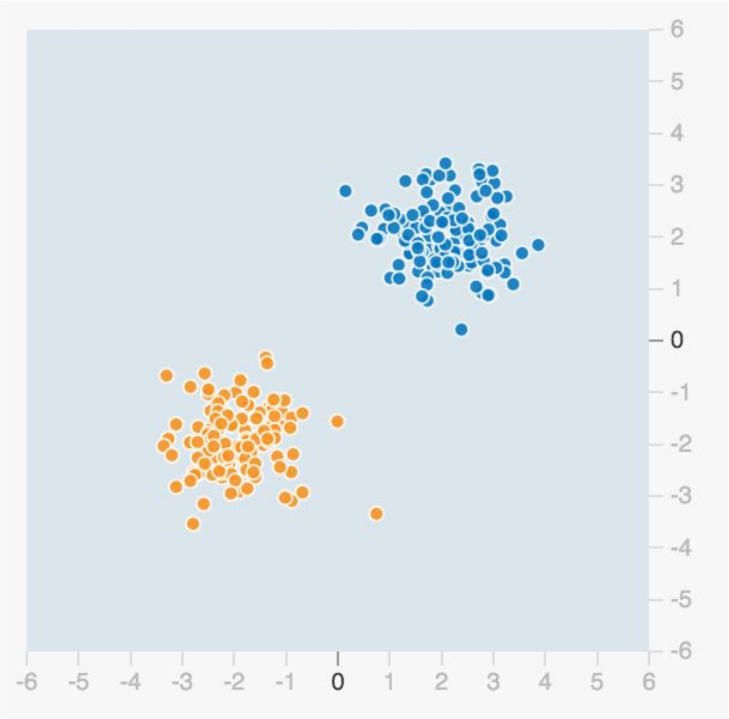


ML = Pattern recognition from examples

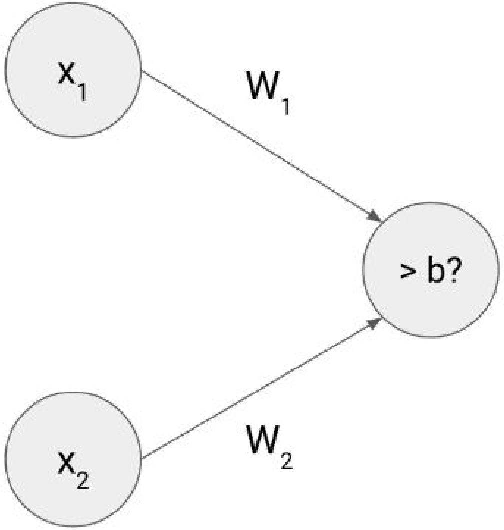




How do you classify these points?

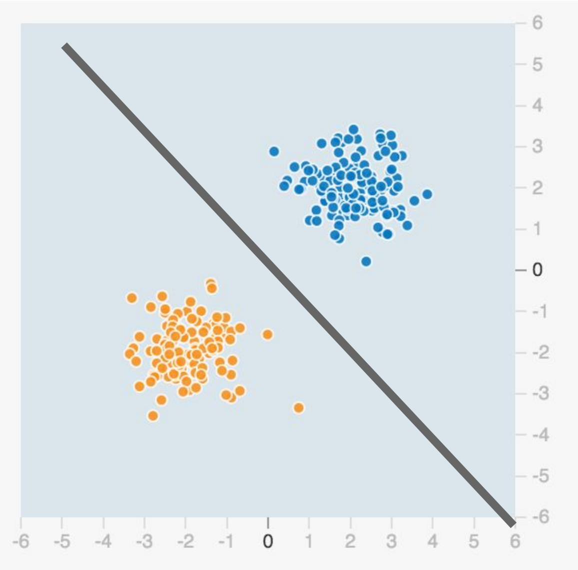


We could create a ML model consisting of a single neuron



$$w_1 x_1 + w_2 x_2 > b$$

Graphically, that translates to: find a line that separates the two sets of points

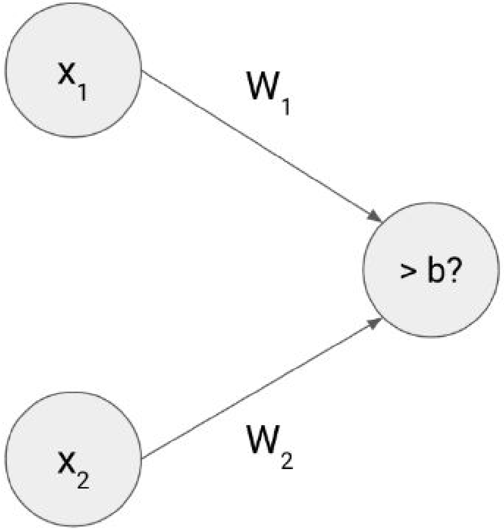


bias
(threshold)

$$\underbrace{\boxed{w_1} x_1 + \boxed{w_2} x_2}_{\textbf{weights}} > \overbrace{\boxed{b}}^{\textbf{bias (threshold)}}$$

weights

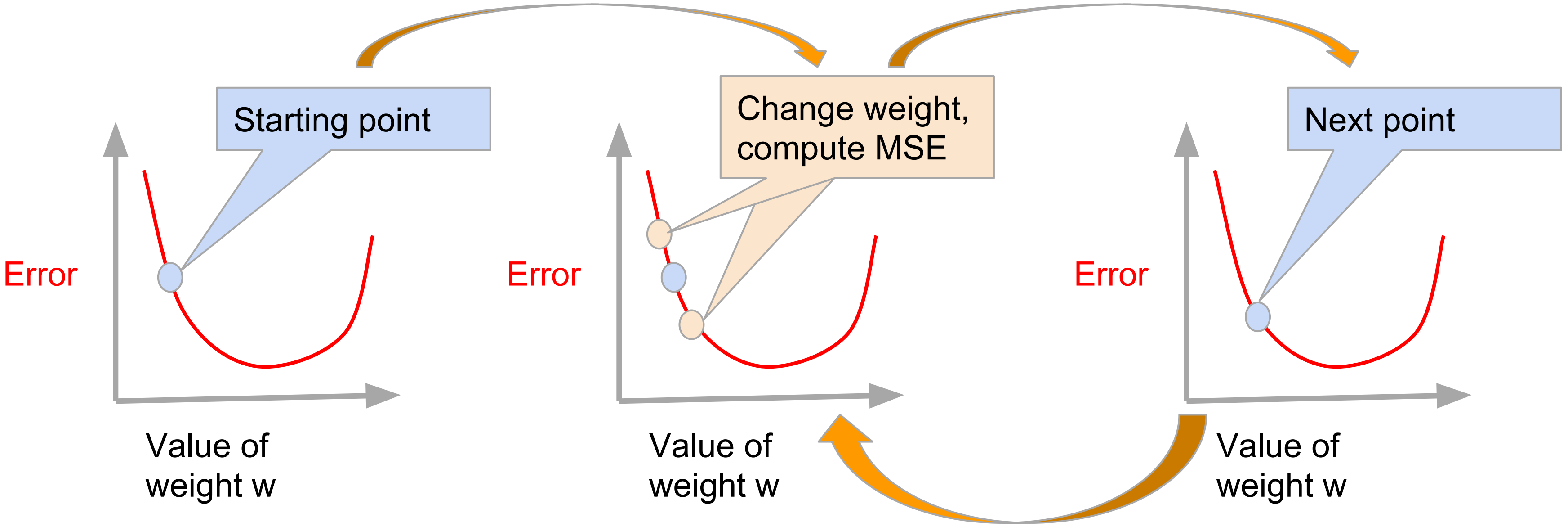
We can use gradient descent to find the best weights and bias



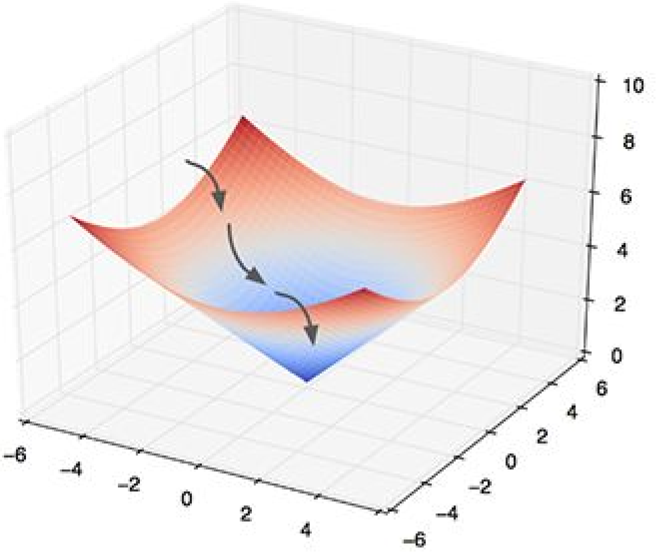
$$\boxed{w_1} x_1 + \boxed{w_2} x_2 > \boxed{b}$$

The computer tries to find the best **parameters**

Recompute error after each batch of examples (not full dataset)

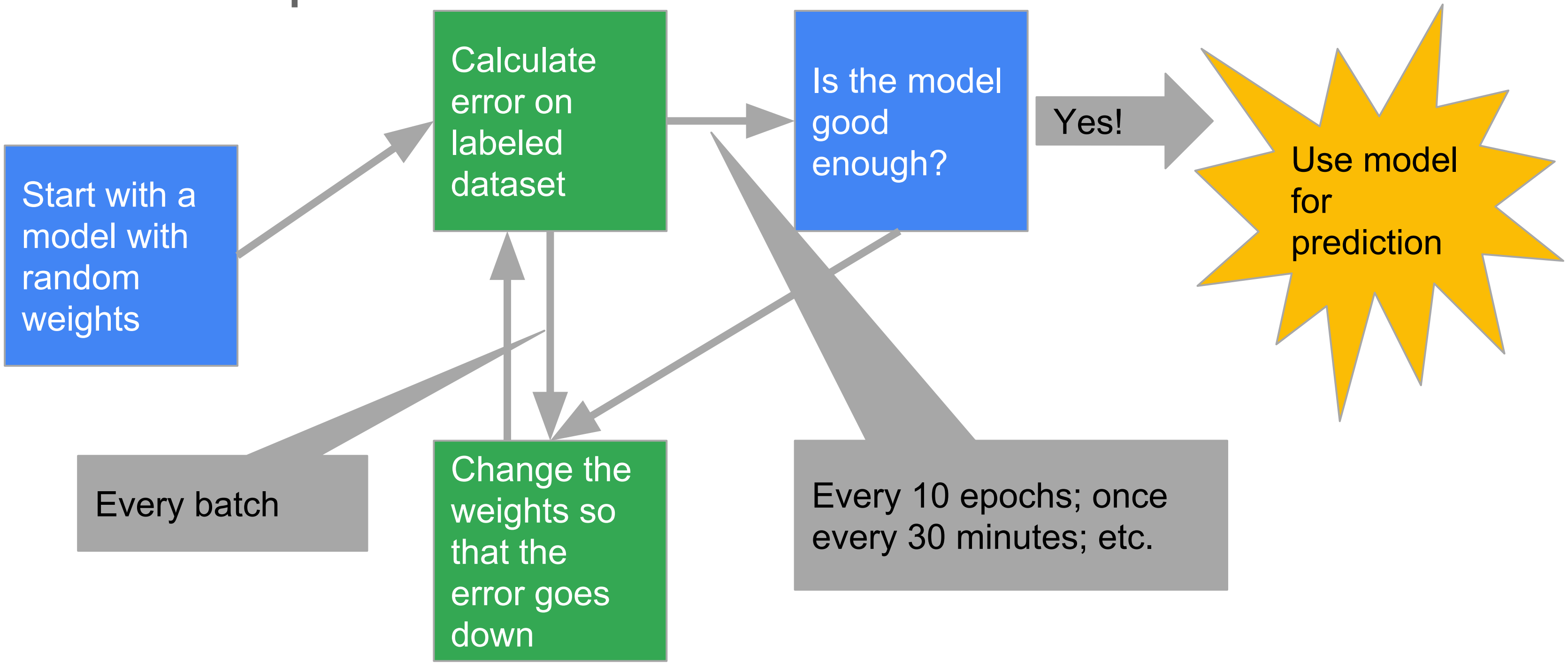


Gradient descent is used to find the best parameters

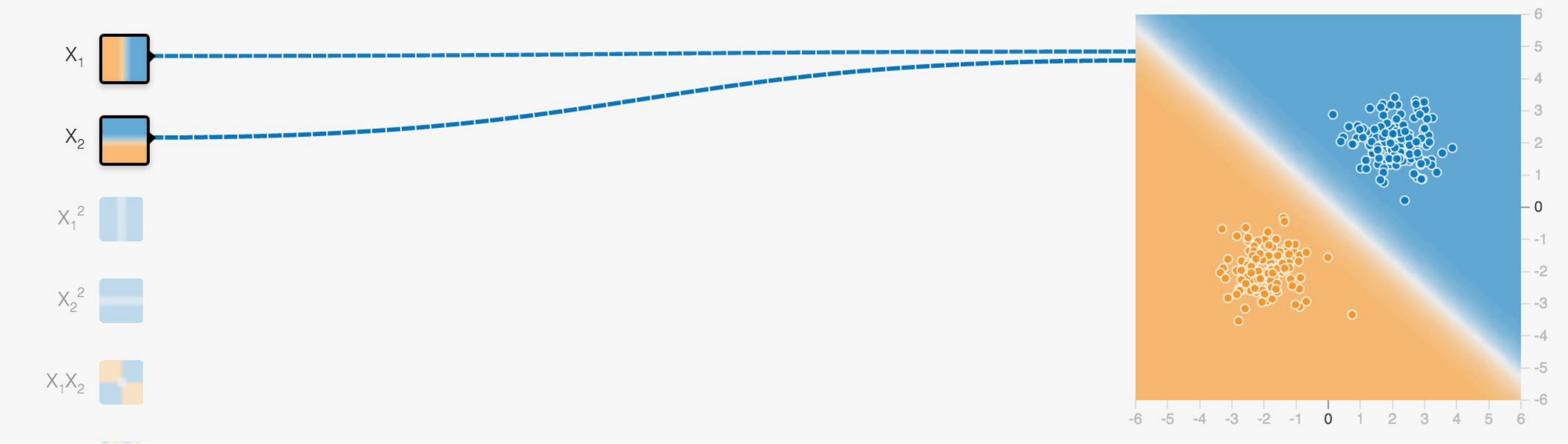


	-5	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
5	**50**	41	34	29	26	25	26	29	34	41	50
4	41	**32**	**25**	20	17	16	17	20	25	32	41
3	34	25	18	**13**	10	9	10	13	18	25	34
2	29	20	13	**8**	5	4	5	8	13	20	29
1	26	17	10	**5**	**2**	**1**	2	5	10	17	26
0	25	16	9	[illegible]	1	**0**	1	4	9	16	25
-1	26	17	10	5	2	1	2	5	10	17	26
-2	29	20	13	8	5	4	5	8	13	20	29
-3	34	25	18	13	10	9	10	13	18	25	34
-4	41	32	25	20	17	16	17	20	25	32	41
-5	50	41	34	29	26	25	26	29	34	41	50

Occasionally, evaluate model to decide whether to stop



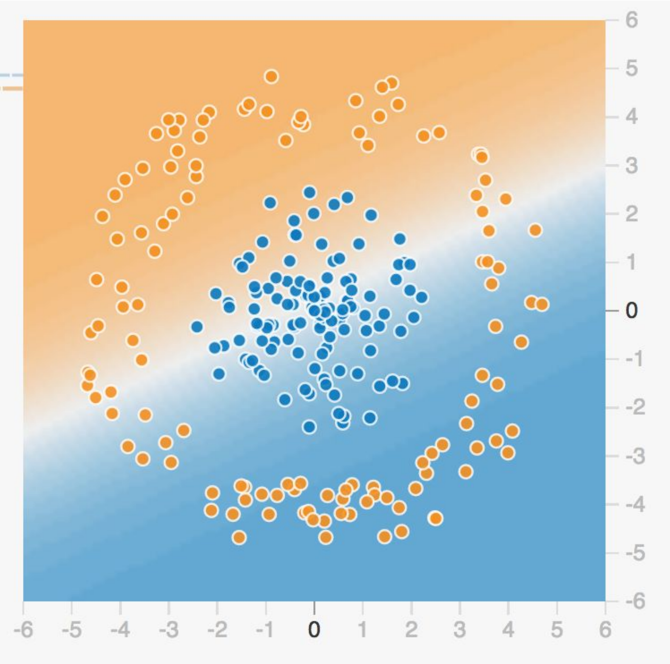
Do Now: http://goo.gl/5aZjBF



Do Now: In your own words, write down definitions for these ML terms

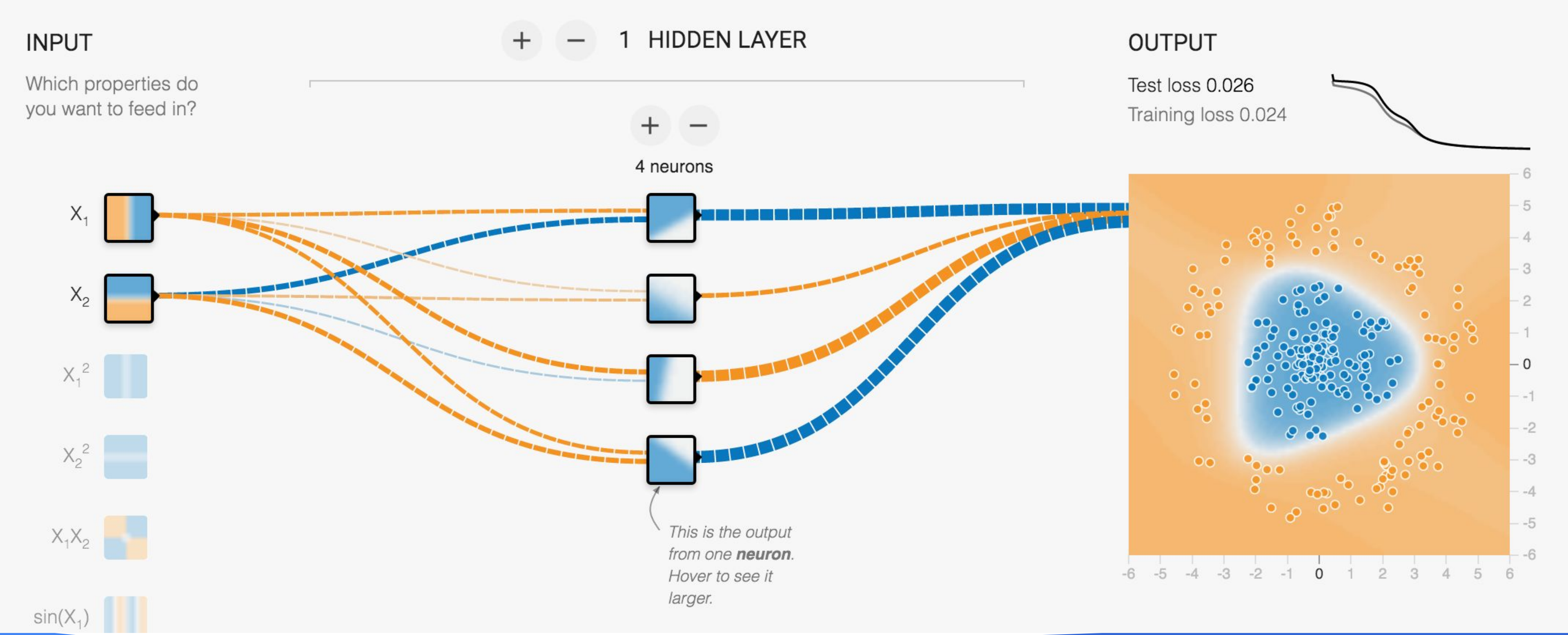
Term	Meaning
Weights	
Batch size	
Epoch	
Gradient descent	
Evaluation	
Training	

Do Now: Can you use a single line to separate these? What do you have to do?

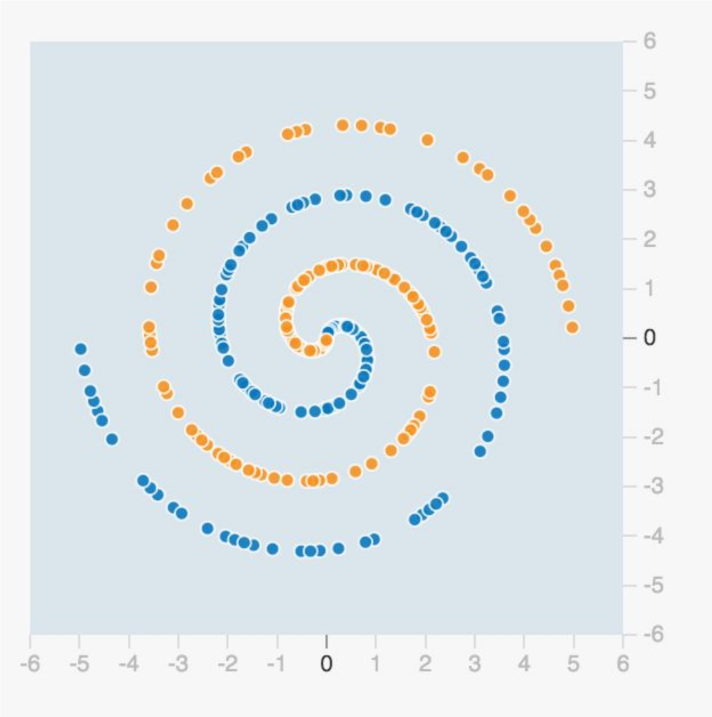


http://goo.gl/v7qM4Q

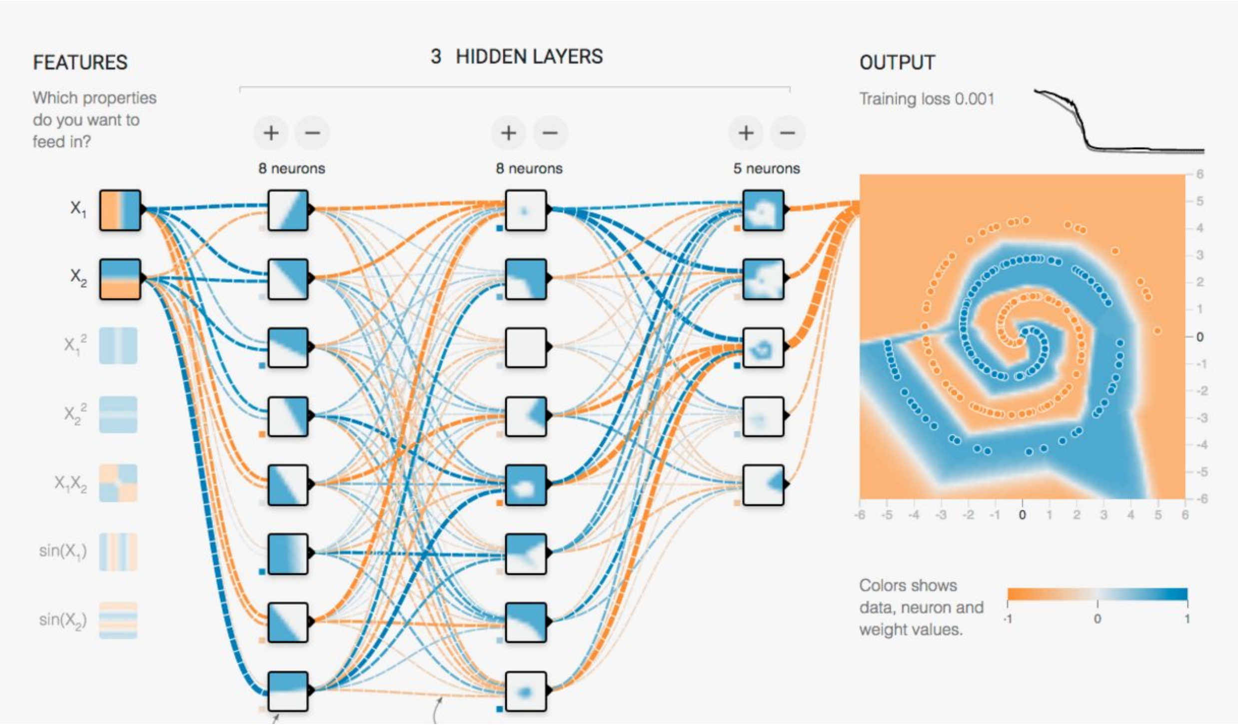
More neurons ⇒ more input combinations (features)



How about this? Will a set of lines work?

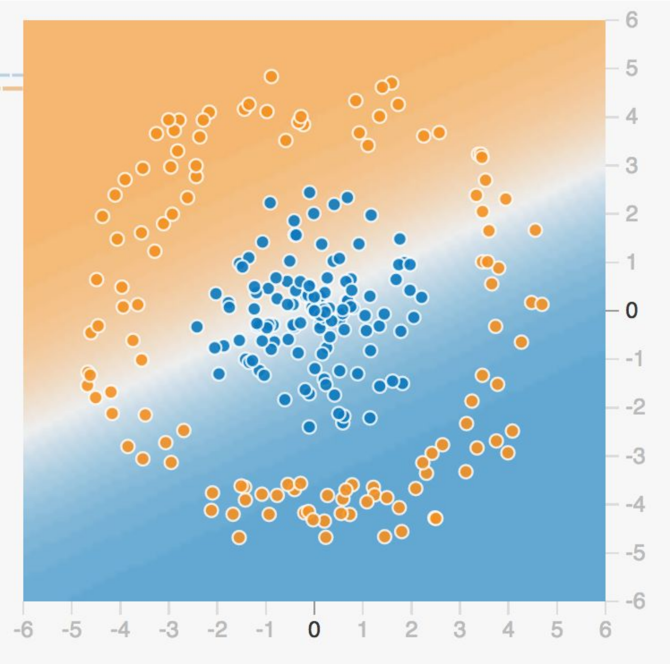


More hidden layers ⇒ more hierarchies of features



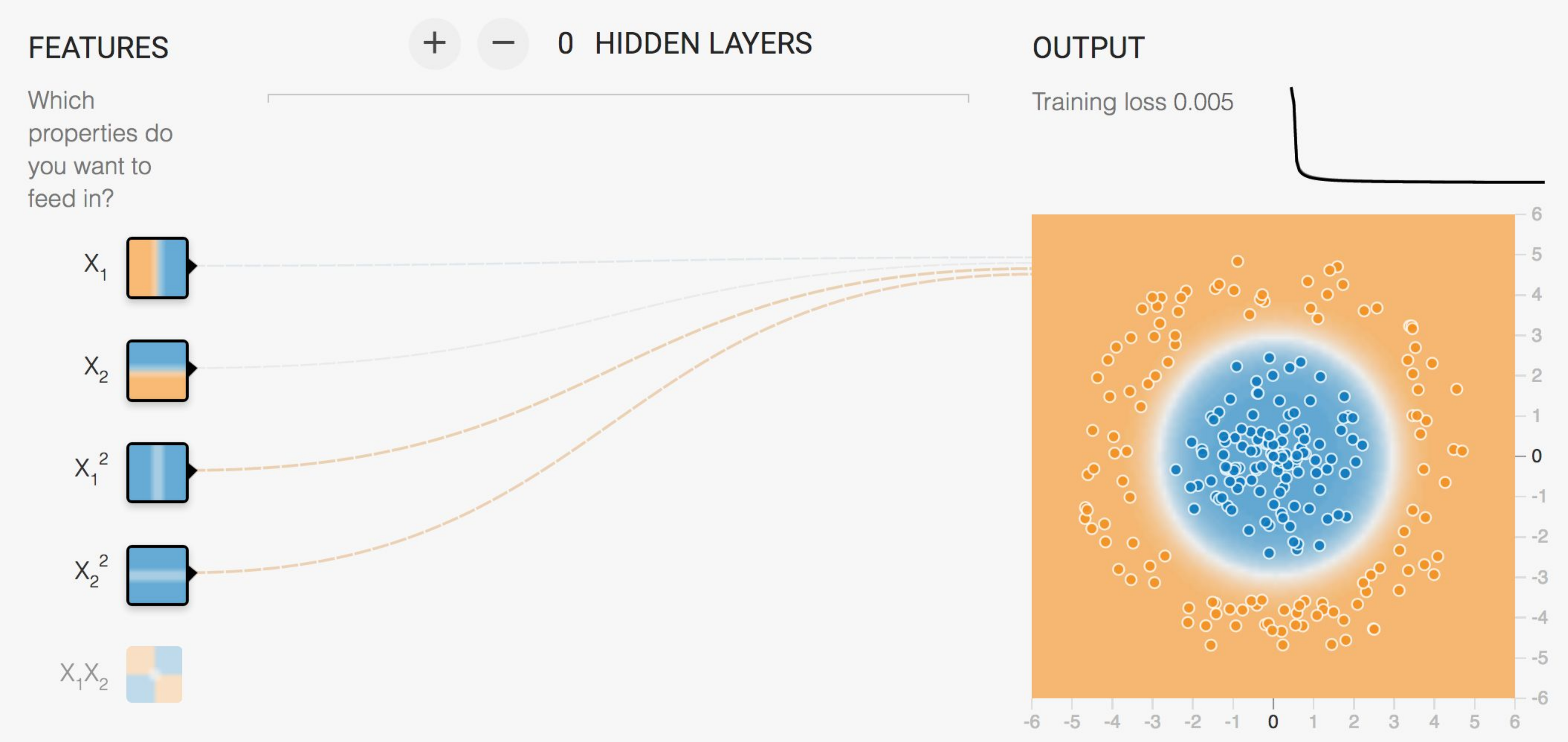
http://goo.gl/fymPMI

Do Now: Can you use a single line to separate these without adding layers?

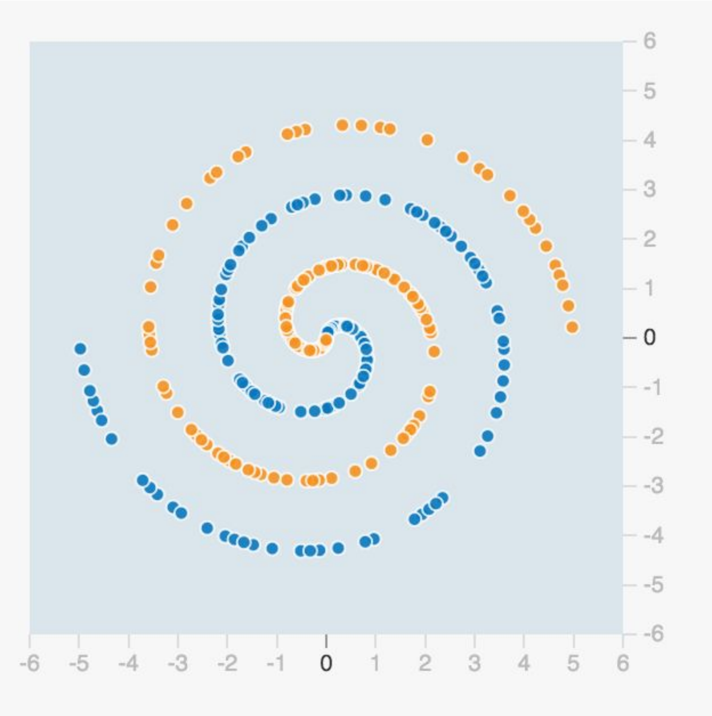


http://goo.gl/v7qM4Q

Engineer some extra features



These features help in the spiral case too...



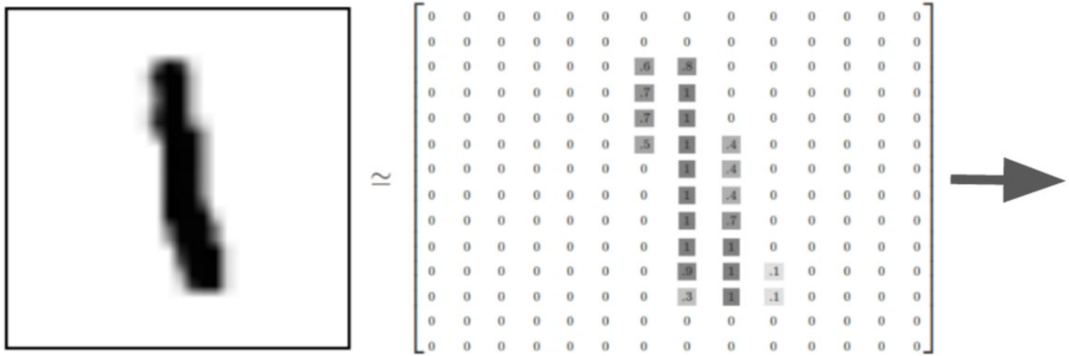
http://goo.gl/jdvKga

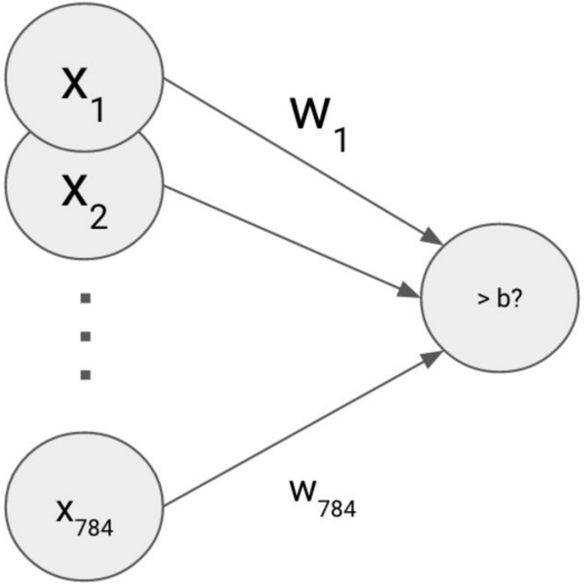
Do Now: In your own words, write down definitions for these ML terms

Term	Meaning
Neurons	
Hidden layer	
Inputs	
Features	
Feature Engineering	

What about images? How does it work?

Each pixel value is an input





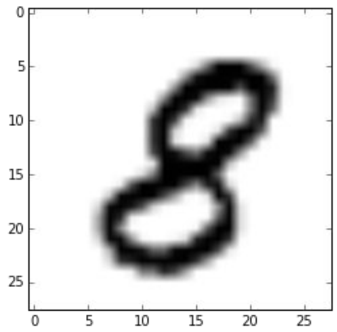
28 x 28 gray scale image =

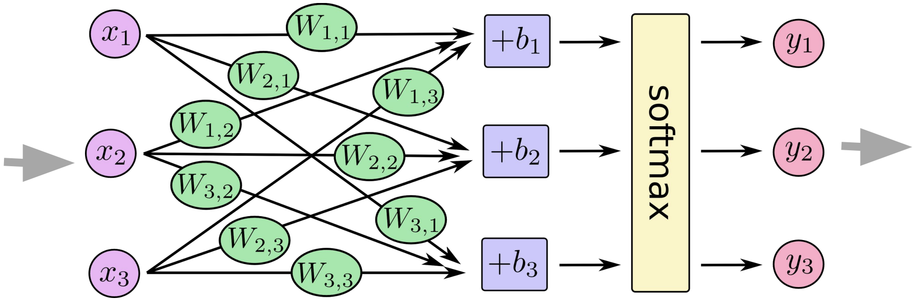
784 numbers

$$\sum_{i}^{n} w_i x_i > b$$

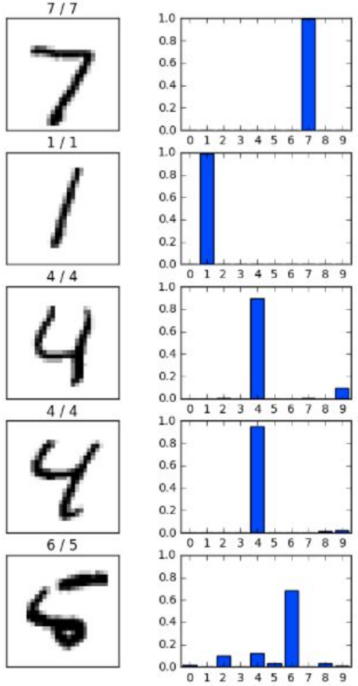
The softmax helps deal with multiple labels

input vector
(pixel data)





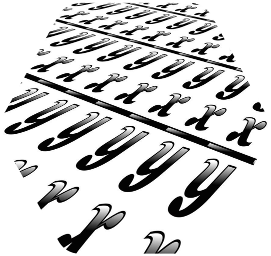
output vector
(probability)

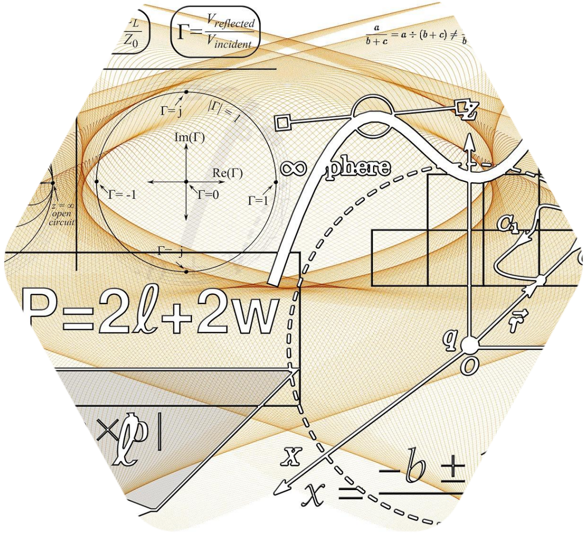


Agenda

Effective ML

The popular imagination of what ML is





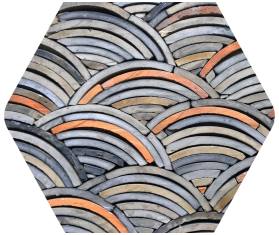
Lots of data

Complex mathematics in multidimensional spaces

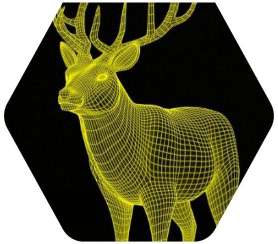
Magical results

In reality, ML is...

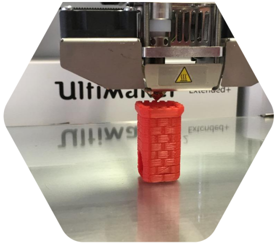
Collect data



Organize data



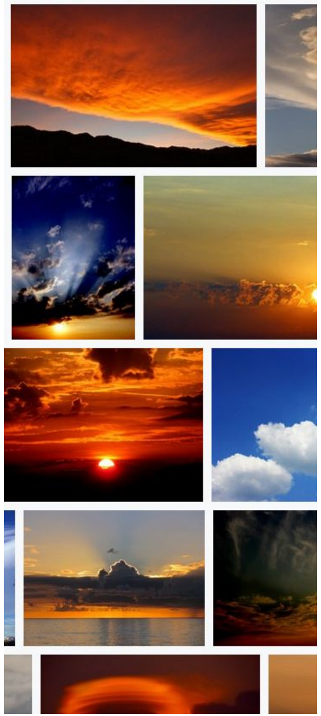
Create model



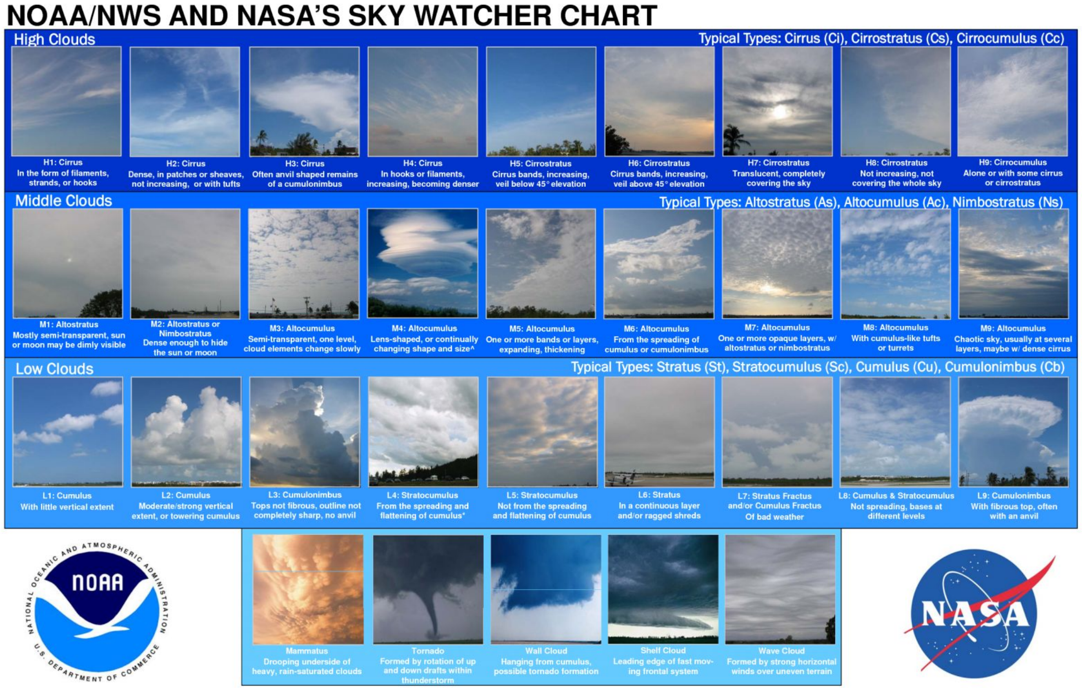
Use machines to flesh out the model from data

Deploy fleshed out model

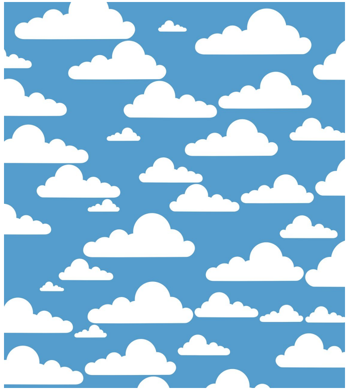
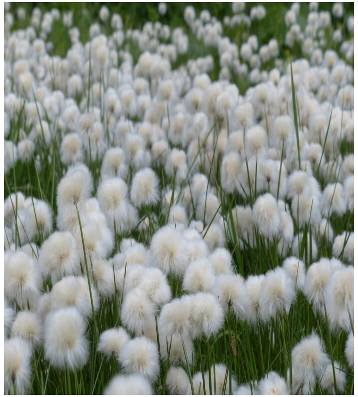
The Dataset should cover all cases



All types covered?

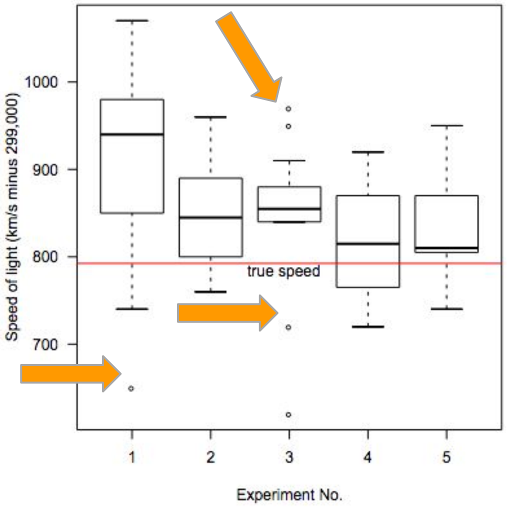


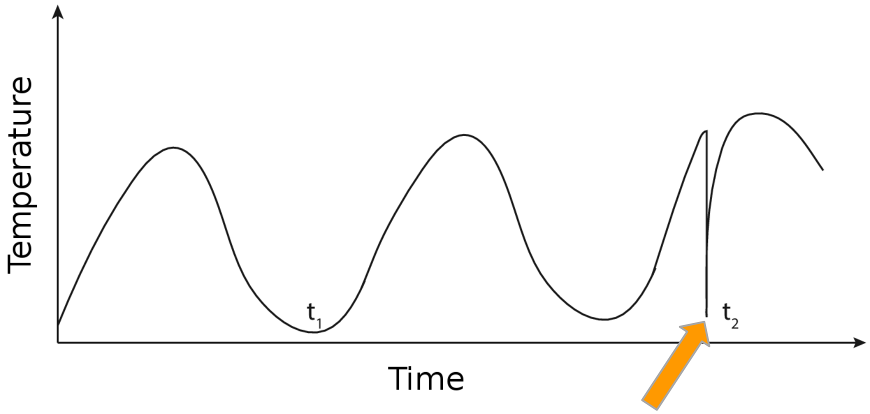
Negative examples and near-misses

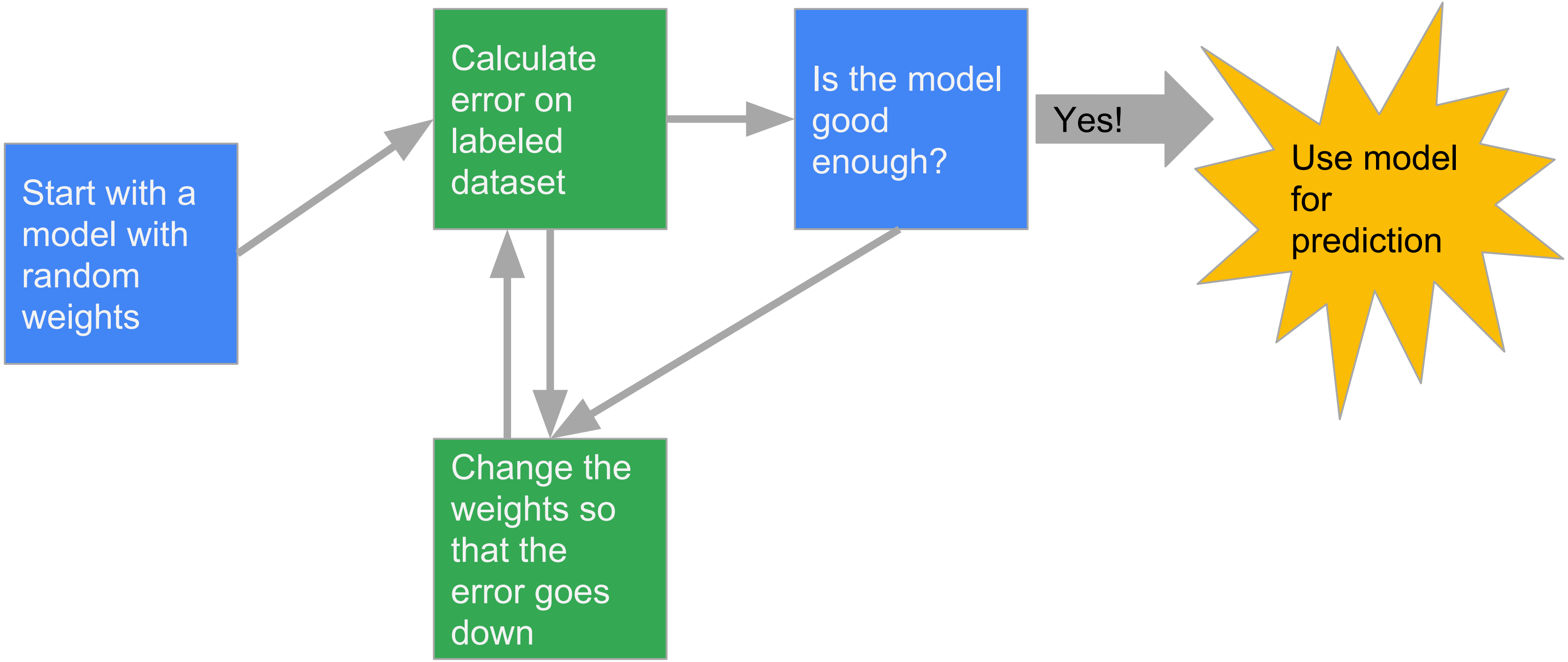


Explore the data you have; fix problems





How do we compute error metrics?



Start from the outcome for a single example

ML system says you'll win $89.

Truth: You lose $14.

Regression error: How far from true outcome?

ML system says you'll win $89.

Truth: You lose $14.

Your outcome is the error.

Error = truth - prediction

= -$14 - $89 = -$103

Calculating regression error—Outcomes

-$103
+$75
-$10
+$99
-$113
+$82
+$56

Calculating regression error

1) Get the error:

-$103
+$75
-$10
+$99
-$113
+$82
+$56

2) Square the error:

10609
5625
100
9801
12769
6724
3136

3) Calculate the mean:

6966

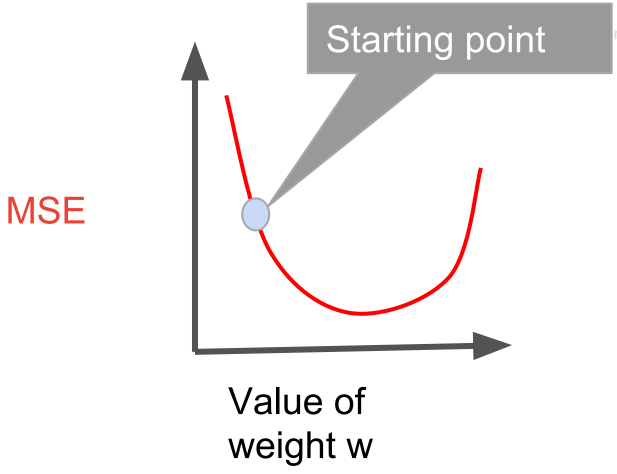
MSE

mean squared error

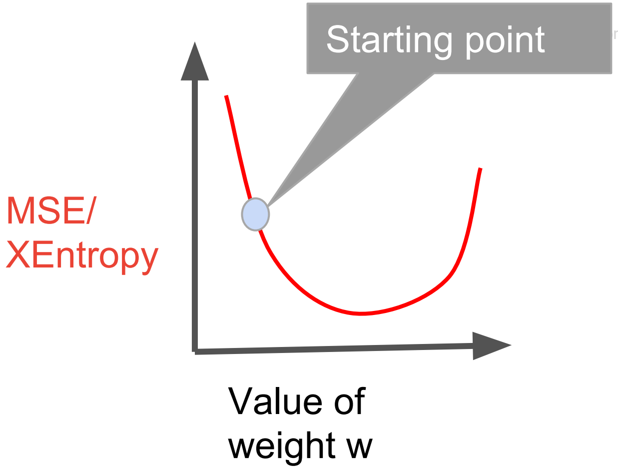
Mathematically...

Y-cap is the model estimate
Y is the labeled value
Mean Square Error (MSE) is:

$$\frac{1}{n}\sum_{i=1}^{n}(\hat{Y}_i - Y_i)^2$$



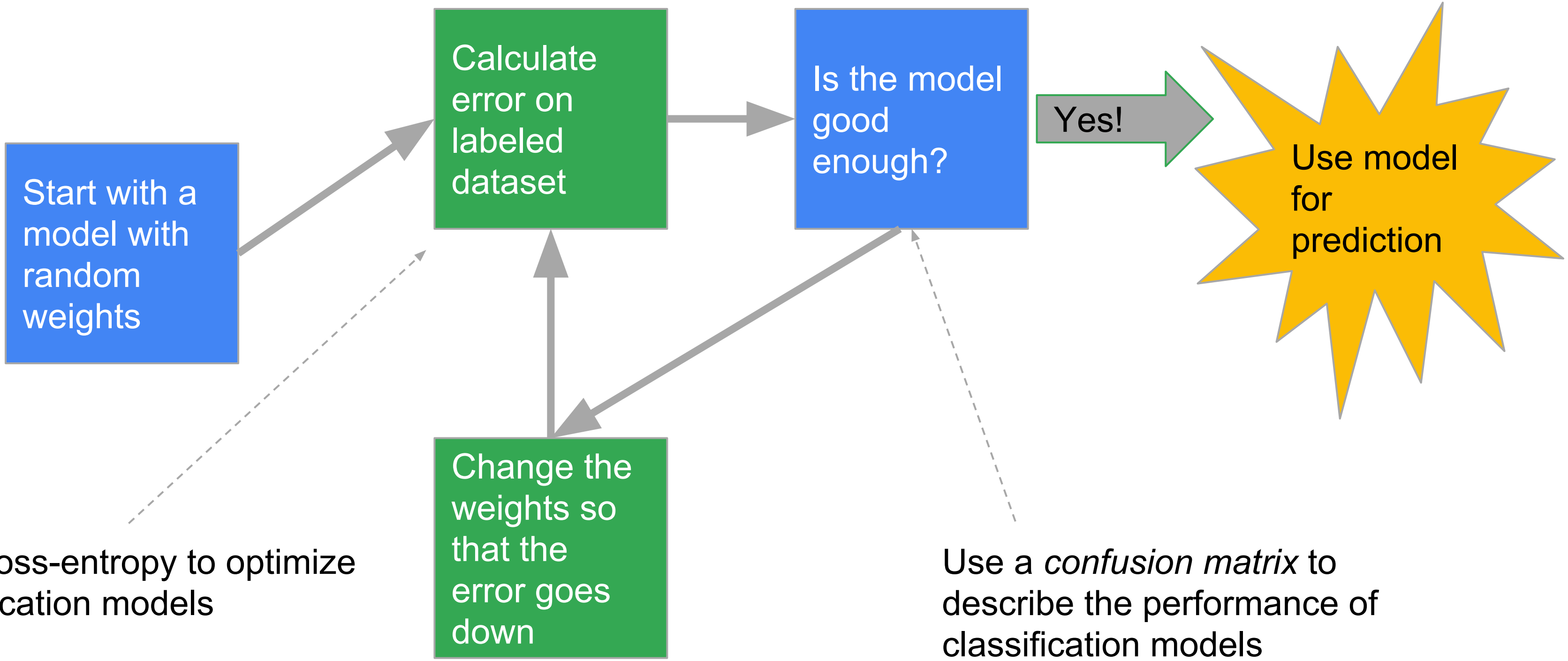
For classification problems, we use cross-entropy



For classification problems, the most commonly used error measure is *cross-entropy*—because it is differentiable:

$$-\frac{1}{N}\sum_{n=1}^{N}\left[y_n \log \hat{y}_n + (1 - y_n)\log(1 - \hat{y}_n)\right]$$

Cross-entropy is not intuitive to business users



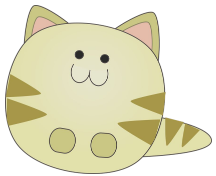
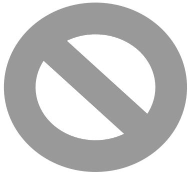
Use cross-entropy to optimize classification models

Use a *confusion matrix* to describe the performance of classification models

Confusion matrix

1) Get the outcomes

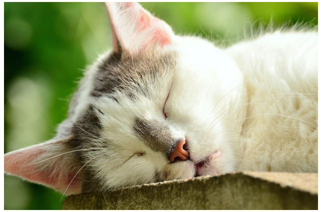
TN
FP
TP
FN
TP
FN

		ML System Says	
		Cat	No Cat
Truth	Cat	True Positive #TP	False Negative #FN
	No Cat	False Positive #FP	True Negative #TN

Accuracy, precision, and recall

Classify the cats!



Hypothetical results from ML

Accuracy is fraction correct

Accuracy = 3 / 8

= 0.375

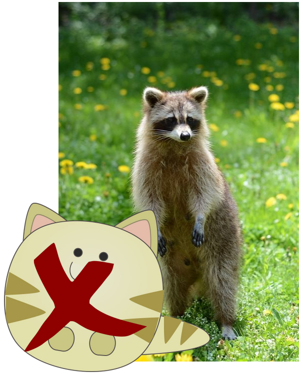
Accuracy fails if dataset unbalanced

1000 parking spaces
990 of them are **taken**
10 are **available**

A ML model that identified only **one** of the ten **available** spaces:

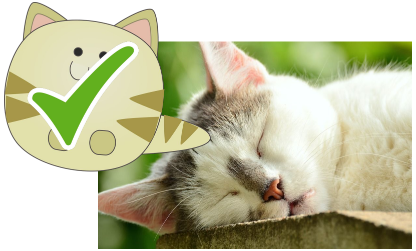
Accuracy = 991/1000
= 0.991!

Precision = Positive Predictive Value



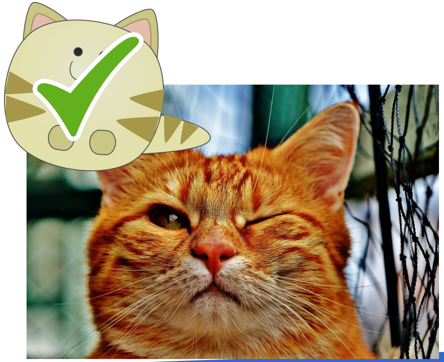
Accuracy when ML says “cat”

TP + FP = 5



Precision = TP / (TP + FP)

= 2 / 5 = 0.40

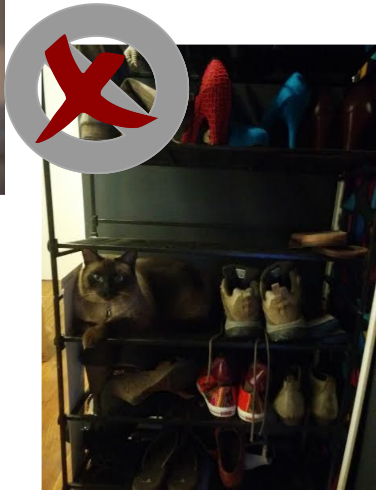


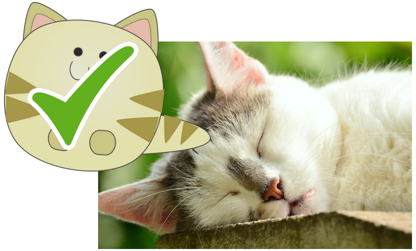
Recall is true positive rate

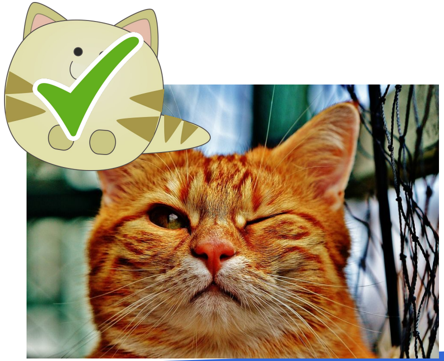
Recall = fraction of cats ML finds

TP + FN = 4

$$\text{Recall} = TP / (TP + FN)$$
$$= 2 / 4 = 0.50$$







Do Now: In your own words, write down definitions for these ML terms

Term	Meaning
MSE	
Cross-entropy	
Accuracy	
Precision	
Recall	

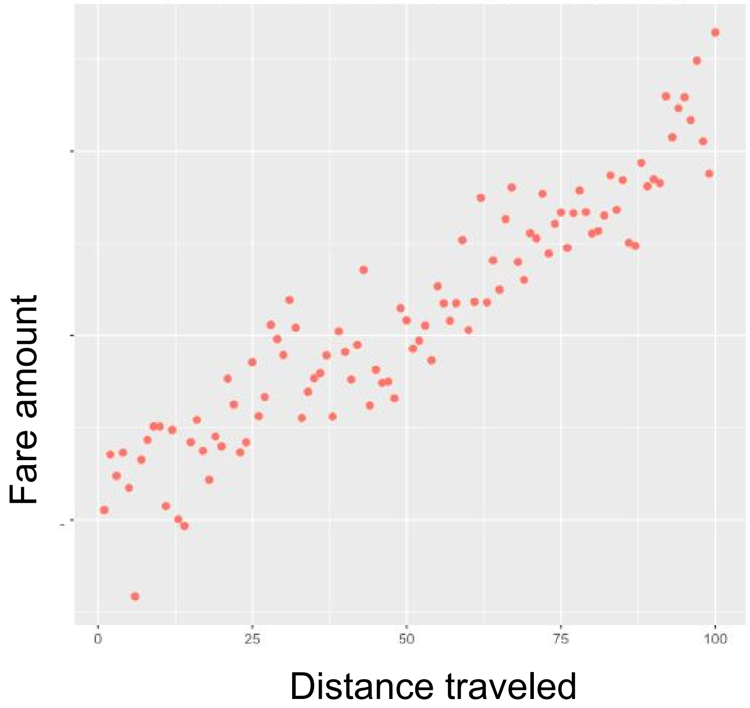
Agenda

Creating ML Datasets + Lab

Regression problem: Predict taxi fare

Problem: predict taxi fare amount based on distance traveled

What is the error measure to optimize?

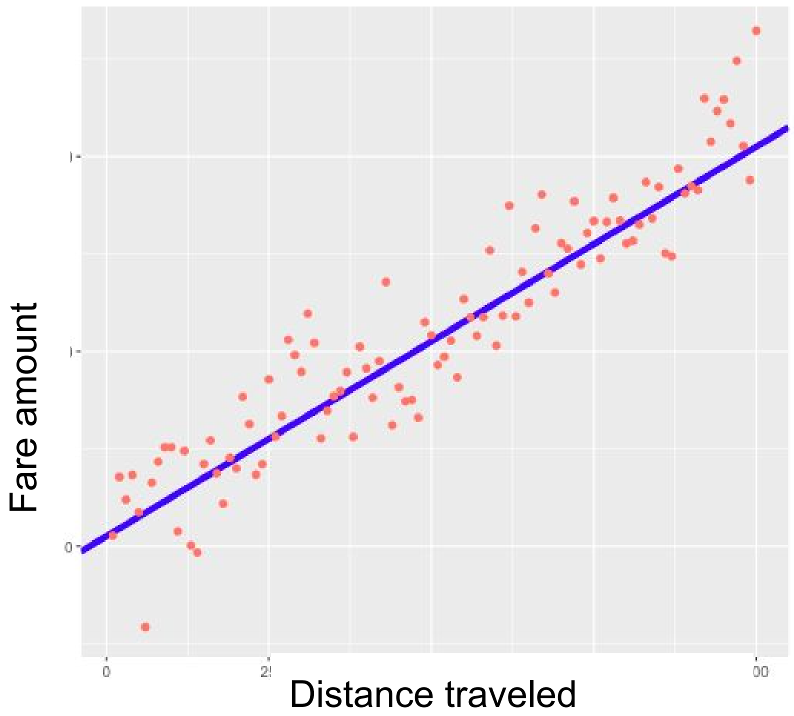


Model 1

Red = training data

Blue = model prediction for each distance traveled

RMSE = 22.24

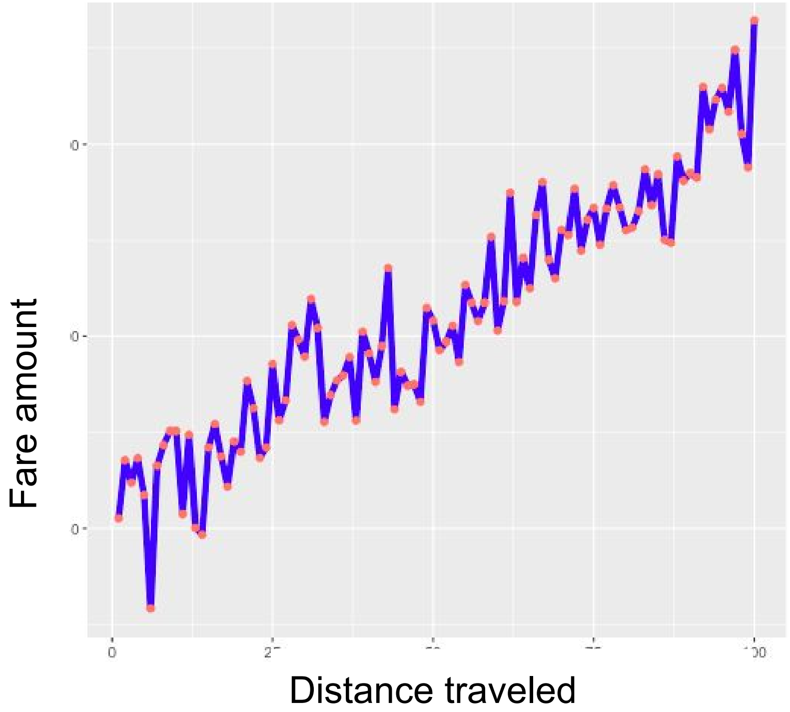


Model 2 has more free parameters

RMSE = 0

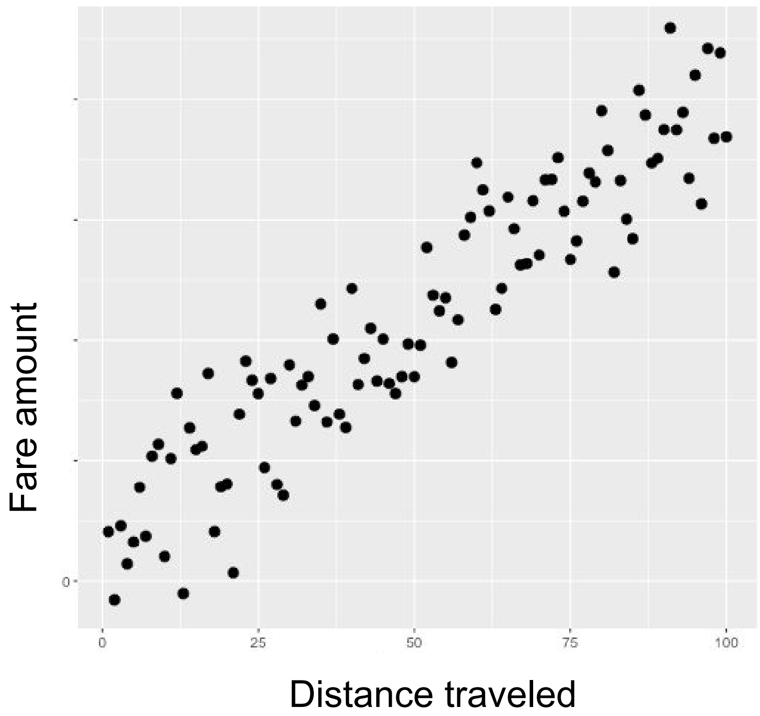
Which model is better?

How can we tell?



Does the model generalize to new data?

Need data that were not used in training

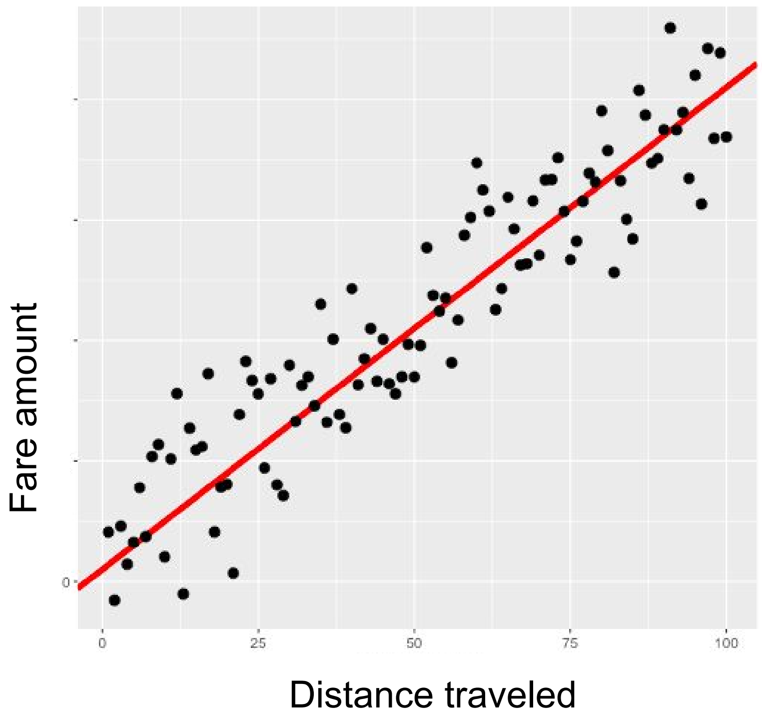


Model 1 generalizes well

Old RMSE = 22.24

New RMSE = 21.98

Pretty similar = good

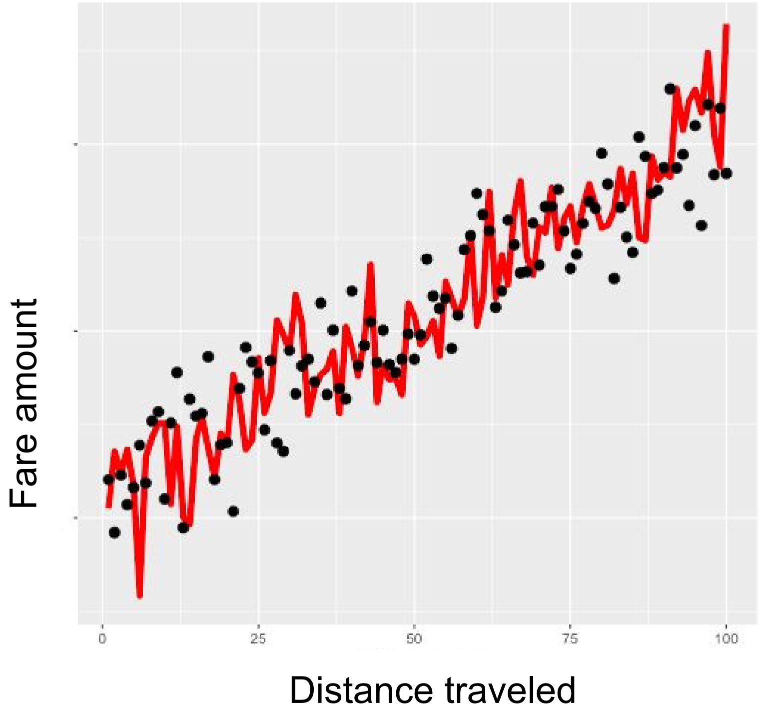


Model 2 does not generalize well

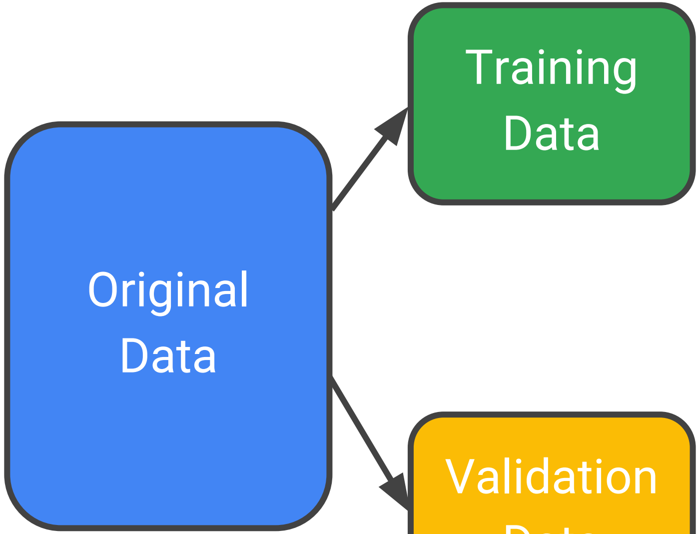
Old RMSE = 0

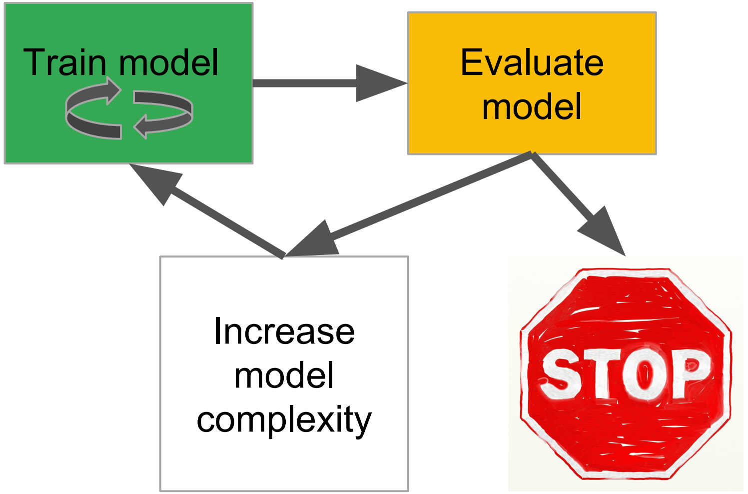
New RMSE = 32

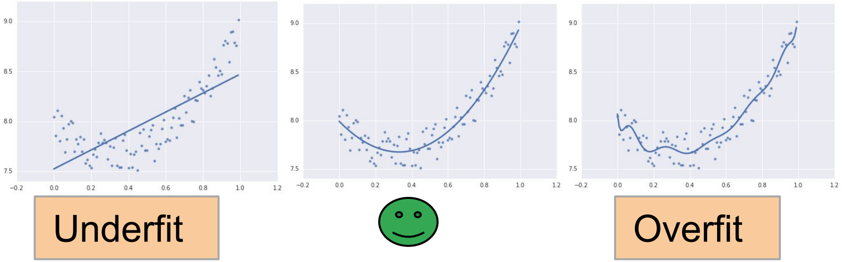
This is a red flag



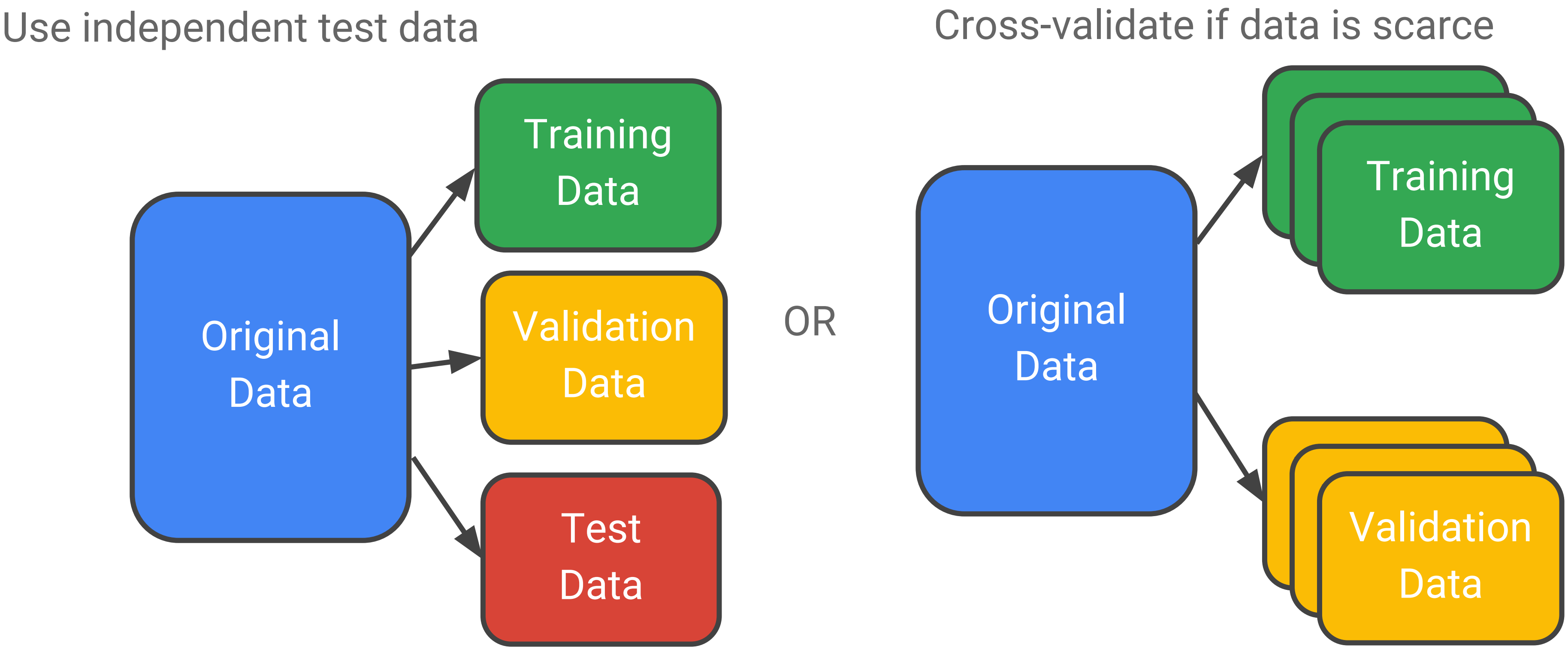
Split dataset, experiment with models



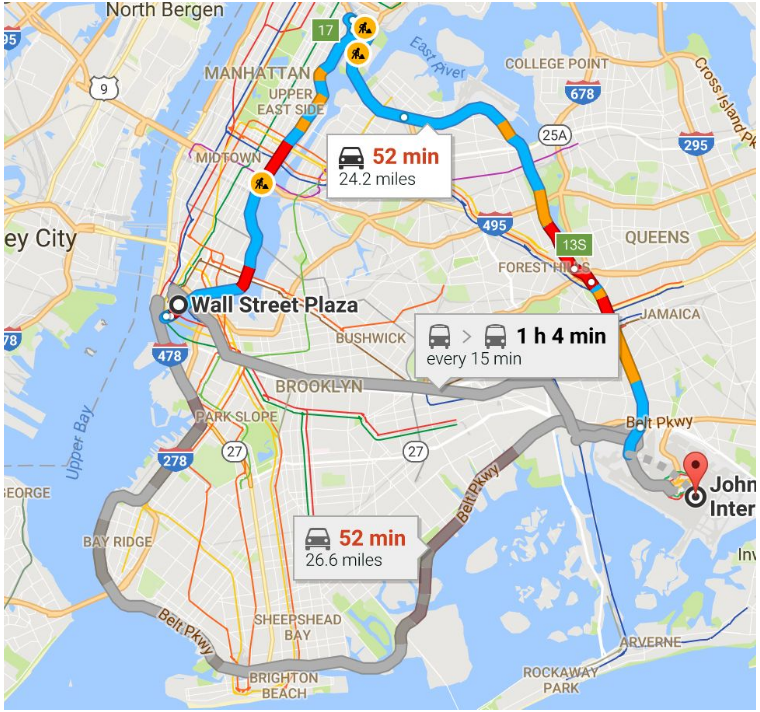


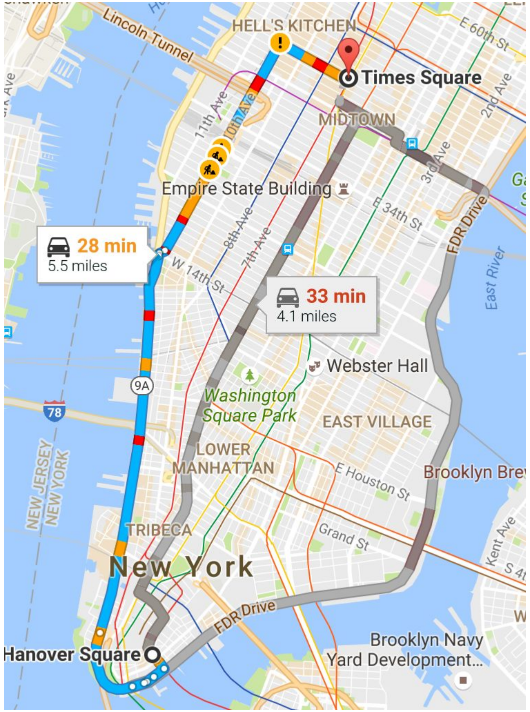


To evaluate the final model...



Goal: To estimate taxi fare





Taxi fares:

$2.50 initial charge

+

50c per ⅕ mile

(or)

50c per minute if stopped

+

Passenger pays tolls

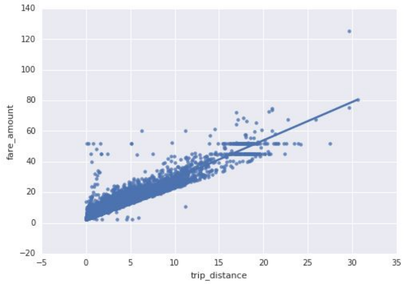
+

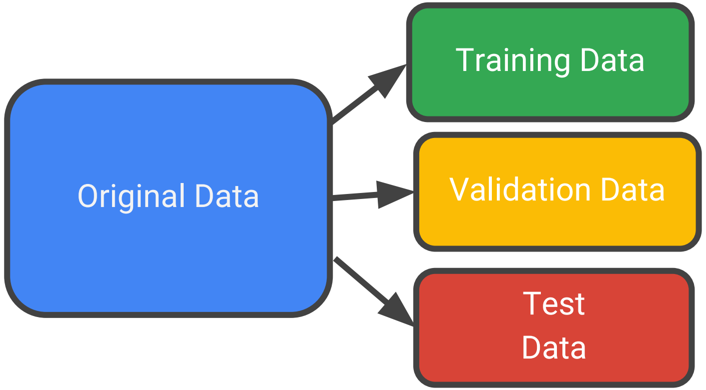
Various special charges

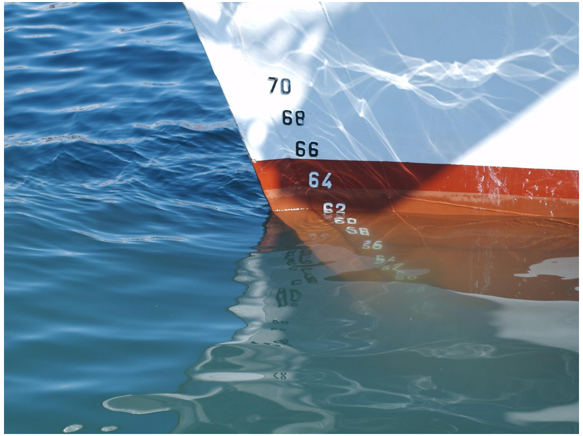
http://www.nyc.gov/html/tlc/html/passenger/taxicab_rate.shtml

Lab: Serverless Machine Learning

Part 1. Explore datasets, create ML datasets,create benchmark







1. Explore

2. Create Datasets

3. Benchmark


cloud.google.com
Images by Connie Zhou