

# Machine Learning Bootcamp

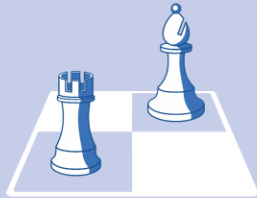
## IDUG NA 2019: June 6, 2019

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# What is Machine Learning?

## Artificial Intelligence (AI)

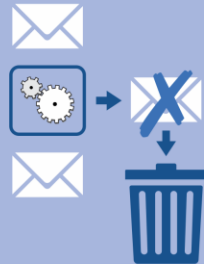
*Human intelligence exhibited by machines*



- Reasoning
- Natural Language Processing (NLP)
- Planning

## Machine Learning (ML)

*An approach to achieve AI*



- Gradient Boosting Machine (GBM)
- Support Vector Machine (SVM)
- Logistic Regression
- Factorization Machines (FM)
- Field-aware Factorization Machines (FFM)

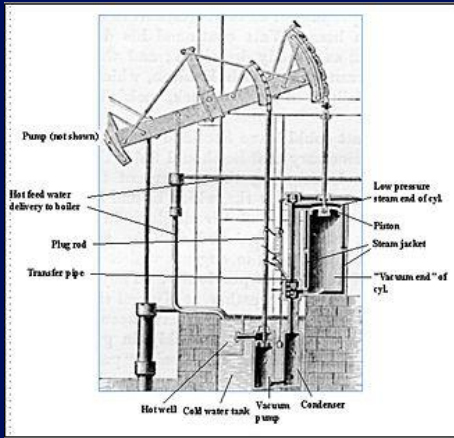
## Deep Learning (DL)

*A technique for implementing ML*



- Deep Neural Networks
- Deep Belief Networks
- Recurrent Neural Networks

# Where are we in the lifecycle of Machine Learning?



1770's:

- Watt's stationary engine
- Capital-intensive one-off applications

*ML era: late 2000s*



1829:

- Stephenson's Rocket
- Standardization and regular service

*ML era: 2019*



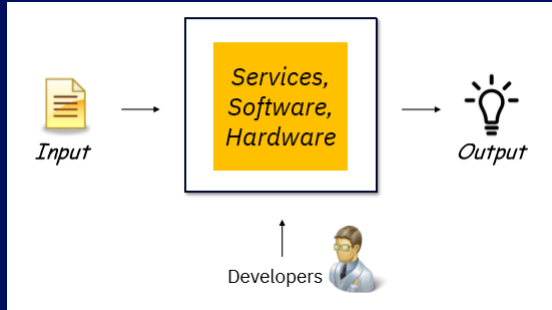
1941:

- Allegheny locomotive
- Apex of steam technology

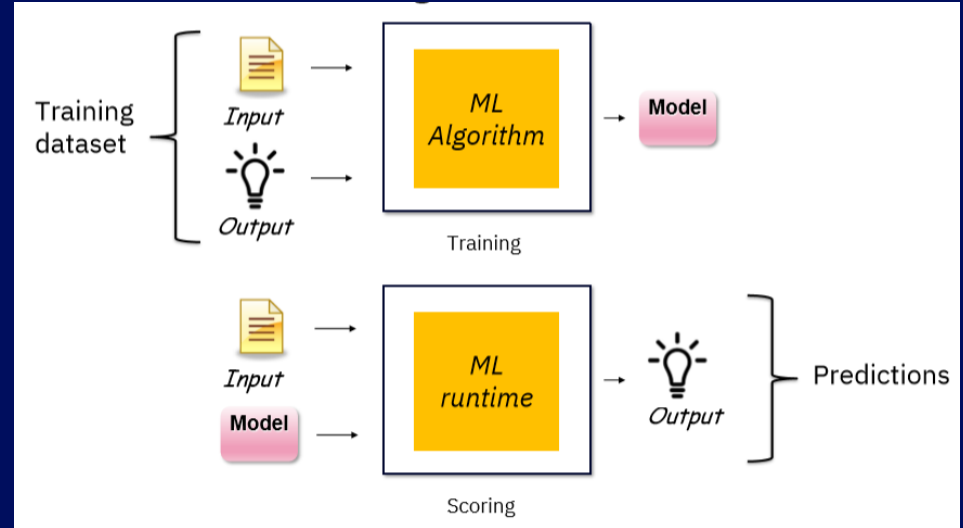
*ML era: 5-10 years from now?*

# What is Machine Learning?

## Classical Programming



## Machine Learning

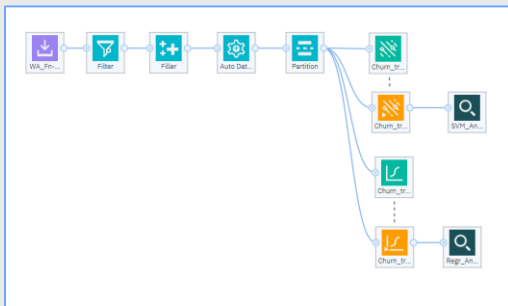


# Customer churn: use case to illustrate machine learning

- **Customer churn:** when a customer ends their relationship with a business
- **PROBLEM:** You need to predict which of your customers are loyal and which are at risk of churning
- **SOLUTION:** Use data you have about clients to build a model that can predict whether a given client is going to churn



# Customer Churn: the game plan



2

Solve the customer churn problem using Python

The model predicts that this client will churn

|   | MonthlyCharges | TotalCharges | InternetService | PaymentMethod           | OnlineSecurity | Contract       | tenure |
|---|----------------|--------------|-----------------|-------------------------|----------------|----------------|--------|
| 0 | 90.5           | 1791.5       | Fiber optic     | Credit card (automatic) | No             | Month-to-month | 20.0   |

1

Solve the customer churn problem using Modeler

## Python: Ingest Dataset

Click on the cell below to highlight it.

Then go to the **File** section to the right of this notebook and click **Insert** **to: code** for the data you have uploaded. Choose **Insert** **google** **DataFrame**.

```
url="https://raw.githubusercontent.com/ryasmack1867/ym2019_96_bootstrap/master/Wa_Fn-UseC_Telco-Customer-Churn.csv"
```

```
customer_data = pd.read_csv(url)
```

```
customer_data.head()
```

```
[1]:
```

|   | customerID | gender | SeniorCitizen | Partner | Dependents | tenure | PhoneService | MultipleLines    | InternetService | OnlineSecurity | DeviceProtection | TechSupport | StreamingTV | StreamingMovies | Contract       | PaperlessBilling | PaymentMethod             | MonthlyCharges |
|---|------------|--------|---------------|---------|------------|--------|--------------|------------------|-----------------|----------------|------------------|-------------|-------------|-----------------|----------------|------------------|---------------------------|----------------|
| 0 | 7580       | Female | 0             | Yes     | No         | 1      | No           | No phone service | DSL             | No             | No               | No          | No          | No              | Month-to-month | Yes              | Electronic check          | 29.85          |
| 1 | 5575       | Male   | 0             | No      | No         | 34     | Yes          | No               | DSL             | Yes            | Yes              | No          | No          | No              | One year       | No               | Mailed check              | 56.95          |
| 2 | 3959       | Female | 0             | No      | No         | 2      | Yes          | No               | DSL             | Yes            | No               | No          | No          | No              | Month-to-month | Yes              | Mailed check              | 53.85          |
| 3 | 7795       | Male   | 0             | No      | No         | 45     | No           | No phone service | DSL             | Yes            | Yes              | Yes         | No          | No              | One year       | No               | Bank transfer (automatic) | 42.30          |
| 4 | 9237       | Female | 0             | No      | No         | 2      | Yes          | No               | Fiber optic     | No             | No               | No          | No          | No              | Month-to-month | Yes              | Electronic check          | 70.70          |

5 rows x 21 columns

3

Define a pipeline in Python to predict if a client will churn

# Customer churn: dataset

- CSV (comma separated values) file with ~7k records; 21 columns
- Numeric columns: **tenure**, **MonthlyCharges**, **TotalCharges**
- Categorical columns: **gender**, **SeniorCitizen**, **Partner**...
- Target / Label: **Churn**

| customerID | gender | SeniorCitizen | Partner | Dependents | tenure | PhoneService | MultipleLines | InternetService | OnlineSecurity | OnlineBack | DevicePro | TechSupp |
|------------|--------|---------------|---------|------------|--------|--------------|---------------|-----------------|----------------|------------|-----------|----------|
| 7590-VHVEG | Female | 0             | Yes     | No         | 1      | No           | No phone serv | DSL             | No             | Yes        | No        | No       |
| 5575-GNVDE | Male   | 0             | No      | No         | 34     | Yes          | No            | DSL             | Yes            | No         | Yes       | No       |
| 3668-QPYBK | Male   | 0             | No      | No         | 2      | Yes          | No            | DSL             | Yes            | Yes        | No        | No       |
| 7795-CFOCW | Male   | 0             | No      | No         | 45     | No           | No phone serv | DSL             | Yes            | No         | Yes       | Yes      |
| 9237-HQITU | Female | 0             | No      | No         | 2      | Yes          | No            | Fiber optic     | No             | No         | No        | No       |
| 9305-CDSKC | Female | 0             | No      | No         | 8      | Yes          | Yes           | Fiber optic     | No             | No         | Yes       | No       |
| 1452-KIOVK | Male   | 0             | No      | Yes        | 22     | Yes          | Yes           | Fiber optic     | No             | Yes        | No        | No       |
| 6713-OKOMC | Female | 0             | No      | No         | 10     | No           | No phone serv | DSL             | Yes            | No         | No        | No       |
| 7892-POOKP | Female | 0             | Yes     | No         | 28     | Yes          | Yes           | Fiber optic     | No             | No         | Yes       | Yes      |
| 6388-TABGU | Male   | 0             | No      | Yes        | 62     | Yes          | No            | DSL             | Yes            | Yes        | No        | No       |
| 9763-GRSKD | Male   | 0             | Yes     | Yes        | 13     | Yes          | No            | DSL             | Yes            | No         | No        | No       |

# Customer churn: preparing the dataset for ML

## Original dataset

| customerID | gender | SeniorCitizen | Partner | Dependents | tenure | PhoneService | MultipleLines | InternetService | OnlineSecurity | OnlineBacDeviceProTechSup |     |     |
|------------|--------|---------------|---------|------------|--------|--------------|---------------|-----------------|----------------|---------------------------|-----|-----|
| 7590-VHVEG | Female | 0             | Yes     | No         | 1      | No           | No phone serv | DSL             | No             | Yes                       | No  | No  |
| 5575-GWDE  | Male   | 0             | No      | No         | 34     | Yes          | No            | DSL             | Yes            | No                        | Yes | No  |
| 3668-QPYBK | Male   | 0             | No      | No         | 2      | Yes          | No            | DSL             | Yes            | Yes                       | No  | No  |
| 7795-CFOCW | Male   | 0             | No      | No         | 45     | No           | No phone serv | DSL             | Yes            | No                        | Yes | Yes |
| 9237-HQITU | Female | 0             | No      | No         | 2      | Yes          | No            | Fiber optic     | No             | No                        | No  | No  |
| 9305-CDSKL | Female | 0             | No      | No         | 8      | Yes          | Yes           | Fiber optic     | No             | No                        | Yes | No  |
| 1452-MQVIR | Male   | 0             | No      | Yes        | 22     | Yes          | Yes           | Fiber optic     | No             | Yes                       | No  | No  |
| 6713-OKMNC | Female | 0             | No      | No         | 10     | No           | No phone serv | DSL             | Yes            | No                        | No  | No  |
| 7892-POOKP | Female | 0             | Yes     | No         | 28     | Yes          | Yes           | Fiber optic     | No             | No                        | Yes | Yes |
| 6388-TABGU | Male   | 0             | No      | Yes        | 62     | Yes          | No            | DSL             | Yes            | Yes                       | No  | No  |
| 9763-GRSKD | Male   | 0             | Yes     | Yes        | 13     | Yes          | No            | DSL             | Yes            | No                        | No  | No  |

**Why?**

**Keep a subset of columns**

**Pick just the columns needed for the model**

**Deal with missing values**

**ML algorithms need numeric input**

**Deal with outliers**

**Control impact of anomalies**

**Scale continuous values**

**Consistent impact of columns**

**Deal with string values**

**ML algorithms need numeric input**

**Split Dataset into Train & Test**

**Need to reserve a portion of the data the model has never seen to validate the model**

| customerID | gender | SeniorCitizen | Partner | Dependents | tenure | PhoneService | MultipleLines | InternetService | OnlineSecurity | OnlineBacDeviceProTechSup |     |     |
|------------|--------|---------------|---------|------------|--------|--------------|---------------|-----------------|----------------|---------------------------|-----|-----|
| 7590-VHVEG | Female | 0             | Yes     | No         | 1      | No           | No phone serv | DSL             | No             | Yes                       | No  | No  |
| 5575-GWDE  | Male   | 0             | No      | No         | 34     | Yes          | No            | DSL             | Yes            | No                        | Yes | No  |
| 3668-QPYBK | Male   | 0             | No      | No         | 2      | Yes          | No            | DSL             | Yes            | Yes                       | No  | No  |
| 7795-CFOCW | Male   | 0             | No      | No         | 45     | No           | No phone serv | DSL             | Yes            | No                        | Yes | Yes |
| 9237-HQITU | Female | 0             | No      | No         | 8      | Yes          | Yes           | Fiber optic     | No             | No                        | No  | No  |
| 9305-CDSKL | Female | 0             | No      | No         | 2      | Yes          | No            | Fiber optic     | No             | No                        | Yes | No  |
| 1452-MQVIR | Male   | 0             | No      | Yes        | 22     | Yes          | Yes           | Fiber optic     | No             | Yes                       | No  | No  |
| 6713-OKMNC | Female | 0             | No      | No         | 10     | No           | No phone serv | DSL             | Yes            | No                        | No  | No  |
| 7892-POOKP | Female | 0             | Yes     | No         | 28     | Yes          | Yes           | Fiber optic     | No             | No                        | Yes | Yes |
| 6388-TABGU | Male   | 0             | No      | Yes        | 62     | Yes          | No            | DSL             | Yes            | Yes                       | No  | No  |
| 9763-GRSKD | Male   | 0             | Yes     | Yes        | 13     | Yes          | No            | DSL             | Yes            | No                        | No  | No  |



# Customer churn: preparing the dataset for ML

## Original dataset

| customerID | gender | SeniorCitizen | Partner | Dependents | tenure | PhoneService | MultipleLines | InternetService | OnlineSecurity | OnlineBacDevicePro | TechSup |
|------------|--------|---------------|---------|------------|--------|--------------|---------------|-----------------|----------------|--------------------|---------|
| 7590-VHVEG | Female | 0             | Yes     | No         | 1      | No           | No phone serv | DSL             | No             | Yes                | No      |
| 5575-GWDE  | Male   | 0             | No      | No         | 34     | Yes          | No            | DSL             | Yes            | No                 | No      |
| 3668-QPYBK | Male   | 0             | No      | No         | 2      | Yes          | No            | DSL             | Yes            | Yes                | No      |
| 7795-CFCOW | Male   | 0             | No      | No         | 45     | No           | No phone serv | DSL             | Yes            | No                 | Yes     |
| 9237-HQITU | Female | 0             | No      | No         | 2      | Yes          | No            | Fiber optic     | No             | No                 | No      |
| 9305-CDKMC | Female | 0             | No      | No         | 8      | Yes          | Yes           | Fiber optic     | No             | No                 | Yes     |
| 1452-MQVIR | Male   | 0             | No      | Yes        | 22     | Yes          | Yes           | Fiber optic     | No             | Yes                | No      |
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| 9763-GRSKD | Male   | 0             | Yes     | Yes        | 13     | Yes          | No            | DSL             | Yes            | No                 | No      |

Keep a subset of columns

Deal with missing values

Deal with outliers

Scale continuous values

Deal with string values

Split Dataset into Train & Test

*Pick the 8 columns used for the model:*

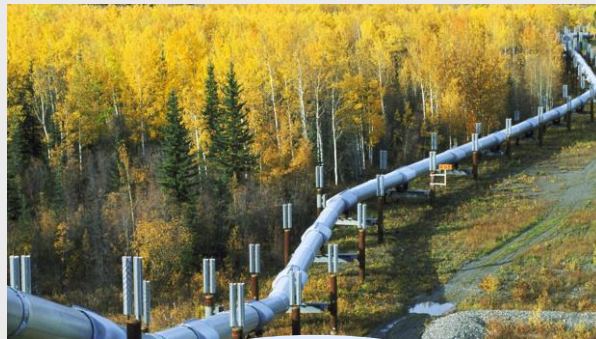
- *tenure*
- *InternetService*
- *OnlineSecurity*
- *Contract*
- *PaymentMethod*
- *MonthlyCharges*
- *TotalCharges*
- *Churn*

| customerID | gender | SeniorCitizen | Partner | Dependents | tenure | PhoneService | MultipleLines | InternetService | OnlineSecurity | OnlineBacDevicePro | TechSup |
|------------|--------|---------------|---------|------------|--------|--------------|---------------|-----------------|----------------|--------------------|---------|
| 7590-VHVEG | Female | 0             | Yes     | No         | 1      | No           | No phone serv | DSL             | No             | Yes                | No      |
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| 6713-QKMC  | Female | 0             | No      | No         | 10     | No           | No phone serv | DSL             | Yes            | No                 | No      |
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| 6388-TABGU | Male   | 0             | No      | Yes        | 62     | Yes          | No            | DSL             | Yes            | Yes                | No      |
| 9763-GRSKD | Male   | 0             | Yes     | Yes        | 13     | Yes          | No            | DSL             | Yes            | No                 | No      |

# Customer churn: the pipeline

## Original dataset

| customerID | gender | SeniorCitizen | Partner | Dependents | tenure | PhoneService | MultipleLines | InternetService | OnlineSecurity | OnlineBac DevicePro TechSup |     |     |
|------------|--------|---------------|---------|------------|--------|--------------|---------------|-----------------|----------------|-----------------------------|-----|-----|
| 7590-VHVEG | Female | 0             | Yes     | No         | 1      | No           | No phone serv | DSL             | No             | Yes                         | No  | No  |
| 5575-GWVDE | Male   | 0             | No      | No         | 34     | Yes          | No            | DSL             | Yes            | No                          | Yes | No  |
| 3668-OPYBK | Male   | 0             | No      | No         | 2      | Yes          | No            | DSL             | Yes            | Yes                         | No  | No  |
| 7795-CFOCW | Male   | 0             | No      | No         | 45     | No           | No phone serv | DSL             | Yes            | No                          | Yes | Yes |
| 9237-HQITU | Female | 0             | No      | No         | 2      | Yes          | No            | Fiber optic     | No             | No                          | No  | No  |
| 9305-CDSKC | Female | 0             | No      | No         | 8      | Yes          | Yes           | Fiber optic     | No             | No                          | Yes | No  |
| 1452-MQVIR | Male   | 0             | No      | Yes        | 22     | Yes          | Yes           | Fiber optic     | No             | Yes                         | No  | No  |
| 6713-OKOMC | Female | 0             | No      | No         | 10     | No           | No phone serv | DSL             | Yes            | No                          | No  | No  |
| 7892-POOKP | Female | 0             | Yes     | No         | 28     | Yes          | Yes           | Fiber optic     | No             | No                          | Yes | Yes |
| 6388-TABGU | Male   | 0             | No      | Yes        | 62     | Yes          | No            | DSL             | Yes            | Yes                         | No  | No  |
| 9763-GRSKD | Male   | 0             | Yes     | Yes        | 13     | Yes          | No            | DSL             | Yes            | No                          | No  | No  |



Split Dataset into Train & Test

Keep a subset of columns

Deal with missing values

Deal with outliers

Scale continuous values

Deal with string values

Logistic Regression model

### ***Pipeline:***

- *Train the data preparation steps and the model in one operation*
- *Apply pipeline to get a churn / no churn prediction for a given client*
  - *Performs data prep on client's data*
  - *Applies model to get a prediction*

# Machine learning models: Logistic Regression

- Classification: churn / no churn
- Extension of **linear regression**
  - simplest algorithm; used to predict continuous values
  - e.g. predict house price from # of bedrooms, sq. ft, frontage
- Logistic regression is “geared” to output between 0 and 1
  - treat 0.5 as the boundary



# Machine learning models: Logistic Regression

- Define function:  $\hat{Y} = h = \text{sigmoid}(X\theta)$
- $\hat{Y}$  is the prediction (*predicted churn values*)
- $X$  is the input
- $\theta$  is an array of weights

$$\text{Sigmoid}(z) = \frac{1}{1 + e^{-z}}$$

Not quite!

**X**

**Y**

| MonthlyCharges | TotalCharges | InternetService | PaymentMethod             | OnlineSecurity | Contract       | tenure |
|----------------|--------------|-----------------|---------------------------|----------------|----------------|--------|
| 29.85          | 29.85        | DSL             | Electronic check          | No             | Month-to-month | 1      |
| 56.95          | 1889.50      | DSL             | Mailed check              | Yes            | One year       | 34     |
| 53.85          | 108.15       | DSL             | Mailed check              | Yes            | Month-to-month | 2      |
| 42.30          | 1840.75      | DSL             | Bank transfer (automatic) | Yes            | One year       | 45     |
| 70.70          | 151.65       | Fiber optic     | Electronic check          | No             | Month-to-month | 2      |

| Churn |
|-------|
| No    |
| No    |
| Yes   |
| No    |
| Yes   |

# Machine learning models: the secret sauce

- Define a **loss function** (delta between predictions  $\hat{\mathbf{Y}}$  and actual values  $\mathbf{Y}$ ):

$$h = g(X\theta)$$
$$J(\theta) = \frac{1}{m} \cdot (-y^T \log(h) - (1 - y)^T \log(1 - h))$$

- Repeatedly update  $\theta$  (weights):
  - Calculate the *partial derivative* of the loss function with respect to the weights =  $\mathbf{X}(\hat{\mathbf{Y}} - \mathbf{Y})$
  - Update the weights by subtracting the partial derivative
- What does making updates to the weights based on “the slope” of the loss function do?
- With these repeated updates to the weights, the loss function gets minimized and the accuracy of the model gets maximized**



# Machine learning models: *all values must be numeric!*

# X

# Y

| MonthlyCharges | TotalCharges | InternetService | PaymentMethod             | OnlineSecurity | Contract       | tenure |
|----------------|--------------|-----------------|---------------------------|----------------|----------------|--------|
| 29.85          | 29.85        | DSL             | Electronic check          | No             | Month-to-month | 1      |
| 56.95          | 1889.50      | DSL             | Mailed check              | Yes            | One year       | 34     |
| 53.85          | 108.15       | DSL             | Mailed check              | Yes            | Month-to-month | 2      |
| 42.30          | 1840.75      | DSL             | Bank transfer (automatic) | Yes            | One year       | 45     |
| 70.70          | 151.65       | Fiber optic     | Electronic check          | No             | Month-to-month | 2      |

| Churn |
|-------|
| No    |
| No    |
| Yes   |
| No    |
| Yes   |



*data preparation*



| MonthlyCharges | TotalCharges | InternetService | PaymentMethod | OnlineSecurity | Contract | tenure    |
|----------------|--------------|-----------------|---------------|----------------|----------|-----------|
| -1.160323      | -0.992611    | 0               | 2             | 0              | 0        | -1.277445 |
| -0.259629      | -0.172165    | 0               | 3             | 2              | 1        | 0.066327  |
| -0.362660      | -0.958066    | 0               | 3             | 2              | 0        | -1.236724 |
| -0.746535      | -0.193672    | 0               | 0             | 2              | 1        | 0.514251  |
| 0.197365       | -0.938874    | 1               | 2             | 0              | 0        | -1.236724 |

| Churn |
|-------|
| 0     |
| 0     |
| 1     |
| 0     |
| 1     |

# Machine learning models: Logistic Regression

- Define function:  $\hat{Y} = h = \text{sigmoid}(X\theta)$
- $\hat{Y}$  is the prediction (*predicted churn values*)
- $X$  is the input
- $\theta$  is an array of weights

$$\text{Sigmoid}(z) = \frac{1}{1 + e^{-z}}$$

Yes!

**X**

**Y**

| MonthlyCharges | TotalCharges | InternetService | PaymentMethod | OnlineSecurity | Contract | tenure    |
|----------------|--------------|-----------------|---------------|----------------|----------|-----------|
| -1.160323      | -0.992611    | 0               | 2             | 0              | 0        | -1.277445 |
| -0.259629      | -0.172165    | 0               | 3             | 2              | 1        | 0.066327  |
| -0.362660      | -0.958066    | 0               | 3             | 2              | 0        | -1.236724 |
| -0.746535      | -0.193672    | 0               | 0             | 2              | 1        | 0.514251  |
| 0.197365       | -0.938874    | 1               | 2             | 0              | 0        | -1.236724 |

| Churn |
|-------|
| 0     |
| 0     |
| 1     |
| 0     |
| 1     |

# Customer churn: exercising the model

- [churn\\_match\\_modeler-scoring.ipynb](#) to exercise the model in a notebook
- [full-blown Python](#) project to deploy and [exercise the model](#):

**Customer Churn Predictor**

Customer Details

|                                 |                               |                         |
|---------------------------------|-------------------------------|-------------------------|
| Tenure Duration<br>100          | Online Security<br>No         | Technical Support<br>No |
| Contract<br>Month-to-month      | Dependents<br>No              | Phone Service<br>No     |
| Internet Service<br>Fiber Optic | Payment Method<br>Credit card | Online Backup<br>No     |
| Monthly Charges<br>30           | Device Protection<br>No       | Paperless Billing<br>No |

Submit



**Customer Churn Predictor**

Results

This customer is not likely to churn  
Probability that the customer will not churn: ~100.00%  
Probability that the customer will churn: ~0.00%

Raw Model Output:  
{"values": [{"tenure": 100, "contract": "Month-to-month", "internet\_service": "Fiber Optic", "monthly\_charges": 30, "online\_security": "No", "dependents": "No", "phone\_service": "No", "online\_backup": "No", "paperless\_billing": "No", "device\_protection": "No"}], "prediction": "probability"}]

Go back and try other values

**Customer Churn Predictor**

Customer Details

|                            |                               |                         |
|----------------------------|-------------------------------|-------------------------|
| Tenure Duration<br>60      | Online Security<br>No         | Technical Support<br>No |
| Contract<br>Month-to-month | Dependents<br>No              | Phone Service<br>No     |
| Internet Service<br>No     | Payment Method<br>Credit card | Online Backup<br>No     |
| Monthly Charges<br>100.00  | Device Protection<br>No       | Paperless Billing<br>No |

Submit



**Customer Churn Predictor**

Results

This customer is likely to churn  
Probability that the customer will not churn: ~0.00%  
Probability that the customer will churn: ~100.00%

Raw Model Output:  
{"values": [{"tenure": 60, "contract": "Month-to-month", "internet\_service": "No", "monthly\_charges": 100.0, "online\_security": "No", "dependents": "No", "phone\_service": "No", "online\_backup": "No", "paperless\_billing": "No", "device\_protection": "No"}], "prediction": "probability"}]

Go back and try other values



# Machine learning: more background

- Overall:
  - Andrew Ng machine learning intro course: <https://www.coursera.org/learn/machine-learning>
  - Fast.ai deep learning course: <https://course.fast.ai/>
- Details:
  - Sklearn pipelines: <https://scikit-learn.org/stable/modules/generated/sklearn.pipeline.Pipeline.html>
  - Logistic Regression math & implementation in Python: [https://ml-cheatsheet.readthedocs.io/en/latest/logistic\\_regression.html](https://ml-cheatsheet.readthedocs.io/en/latest/logistic_regression.html)
  - Articles on a variety of machine learning topics: [https://medium.com/@markryan\\_69718](https://medium.com/@markryan_69718)

