Data Science using Python

Manaranjan Pradhan

About Me

- Consulting and training on Big data, AI & Machine Learning.
- An alumni of *IIM, Bangalore*.
- Has about 20+ years of industry experience.
- Has trained 1000+ professionals on Big Data and AI & ML.
- An adjunct faculty at IIM, Bangalore, ISB, Hyderabad and Jio Institute

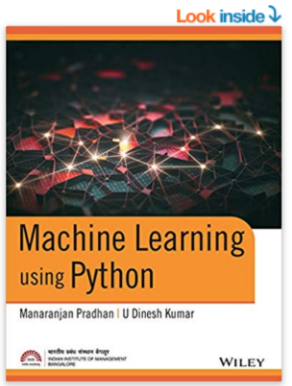
Manaranjan Pradhan | LinkedIn

LinkedIn: https://in.linkedin.com/in/manaranjanpradhan
Personal Website: https://www.manaranjanp.com/

Manaranjan has co-authored the best-selling book Machine Learning using Python

He has published the following machine learning cases in **(HBR) Harvard Business Publishing**:

1. Customer Analytics at Big Basket – Product Recommendations
2. Improving Lead Generation at Eureka Forbes Using Machine Learning Algorithms



Machine Learning using Python Paperback – 2019

by U Dinesh Kumar Manaranjan Pradhan (Author)

★★★★☆ 7 customer reviews

See all 2 formats and editions

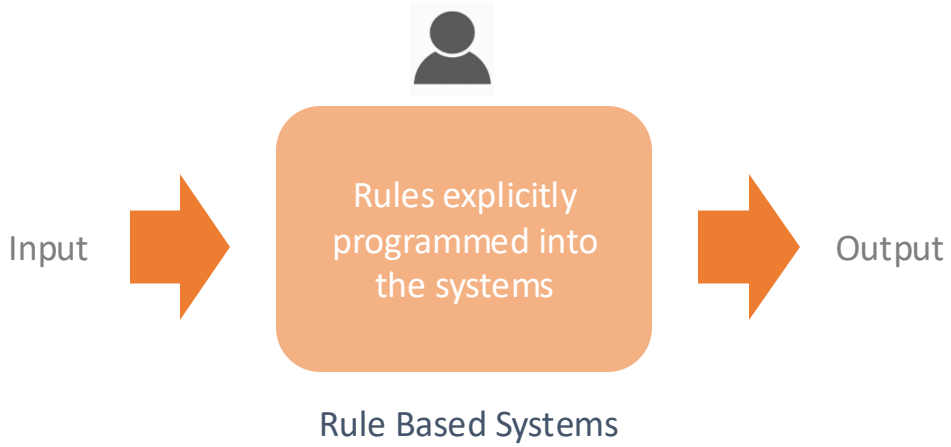
Kindle Edition ₹ 423.20 | Paperback ₹ 529.00 prime

Read with Our Free App | 2 New from ₹ 529.00

This book is written to provide a strong foundation in machine learning using Python libraries by providing real-life case studies and examples. It covers topics such as foundations of machine learning, introduction to Python, descriptive analytics and predictive analytics. Advanced machine learning concepts such as decision tree learning, random forest, boosting, recommended systems, and text analytics are covered. The book takes a balanced approach between theoretical understanding and practical applications. All the topics include real-world examples and provide step-by-step approach on how to explore, build, evaluate, and optimize machine learning models.

https://www.amazon.in/Machine-Learning-Python-Manaranjan-Pradhan-ebook/dp/B07RLQPNRX

Rule Based or Expert Systems



Rule Based Systems

Static Rules:

- If a user's credit card country points to the US but their IP points to Russia, then the transaction should be blocked.

Velocity Rules:

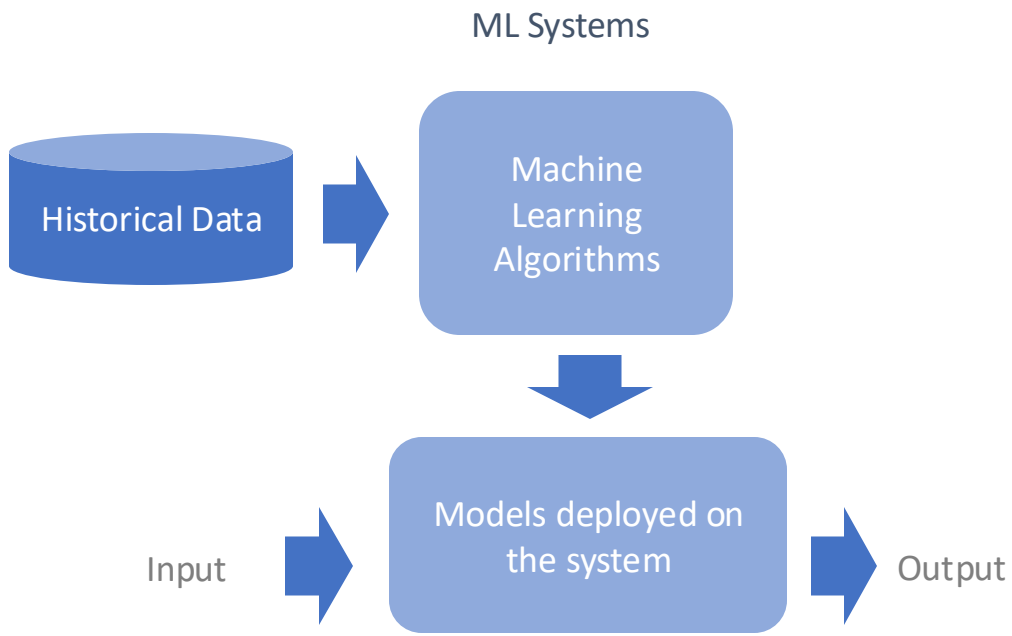
These rules attempt to **understand user behaviour by looking at set actions over a time period**.

- An increase in spending (more than 200%) over a 24-hour period
- A single user attempting to pay with five different frozen credit cards *within ten minutes* is highly suspicious, as even someone in dire straits would likely stop once they realize one or two of their cards have been frozen or cancelled.

https://seon.io/resources/guides/guide-to-fraud-detection-rules/

Limitation of Rule Bases Systems

Machine Learning Systems



What is Machine Learning?

Machine learning is a field of study that gives computers the ability to learn without explicitly being programmed.

Source: MIT Sloan

Examples of problems ML can solve

Examples of Machine Learning Problems

- What will be the price of a stock in next 3 months given its past performances and the current market outlook?
- What is the estimated demand for a specific product (volume of sale in terms of number of units) in the next quarter given the market conditions and competition?
- What is the likelihood of a customer churning in next 3 months given his/her purchase patterns in the last few months?

Examples of Machine Learning Problems

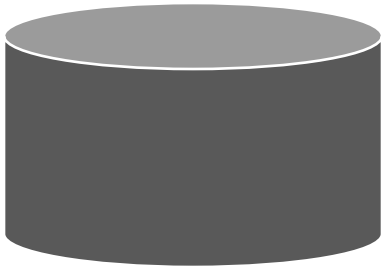
- What is the likelihood of an employee leaving an organization in next 6 months given his/her performance, behavior and skill demand in the market?
- How to cluster customers together based on their demographics and behavior so that appropriate products or promotions can be targeted to them?
- Which products are customers buying together, which can become candidate for cross selling and up selling?

Examples of Machine Learning Problems

- Identify similar products (movies, books etc.) to recommend to customers based on their preferences shown in the past.
- How to identify anomalies in the systems (machines or hardware) so that preventive maintenance can be scheduled rather than periodic maintenance to avoid catastrophic failures?

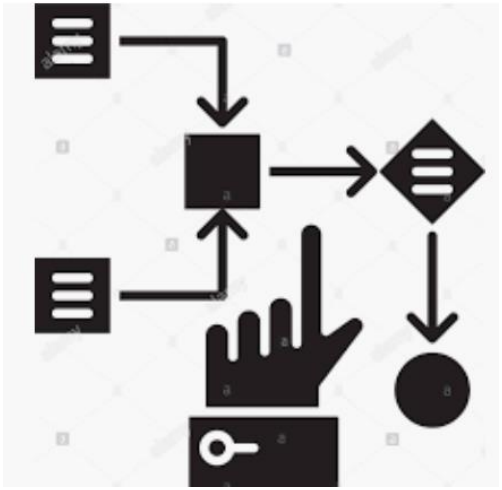
What are key elements of Machine Learning System?

Key Components



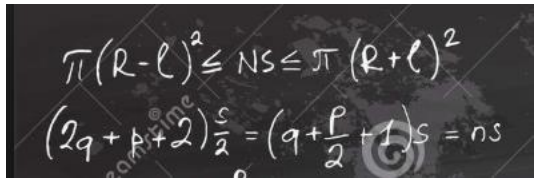
Data

- Samples representing problem context



Learning Algorithm

- Statistical Learning
- Machine Learning or Deep Learning

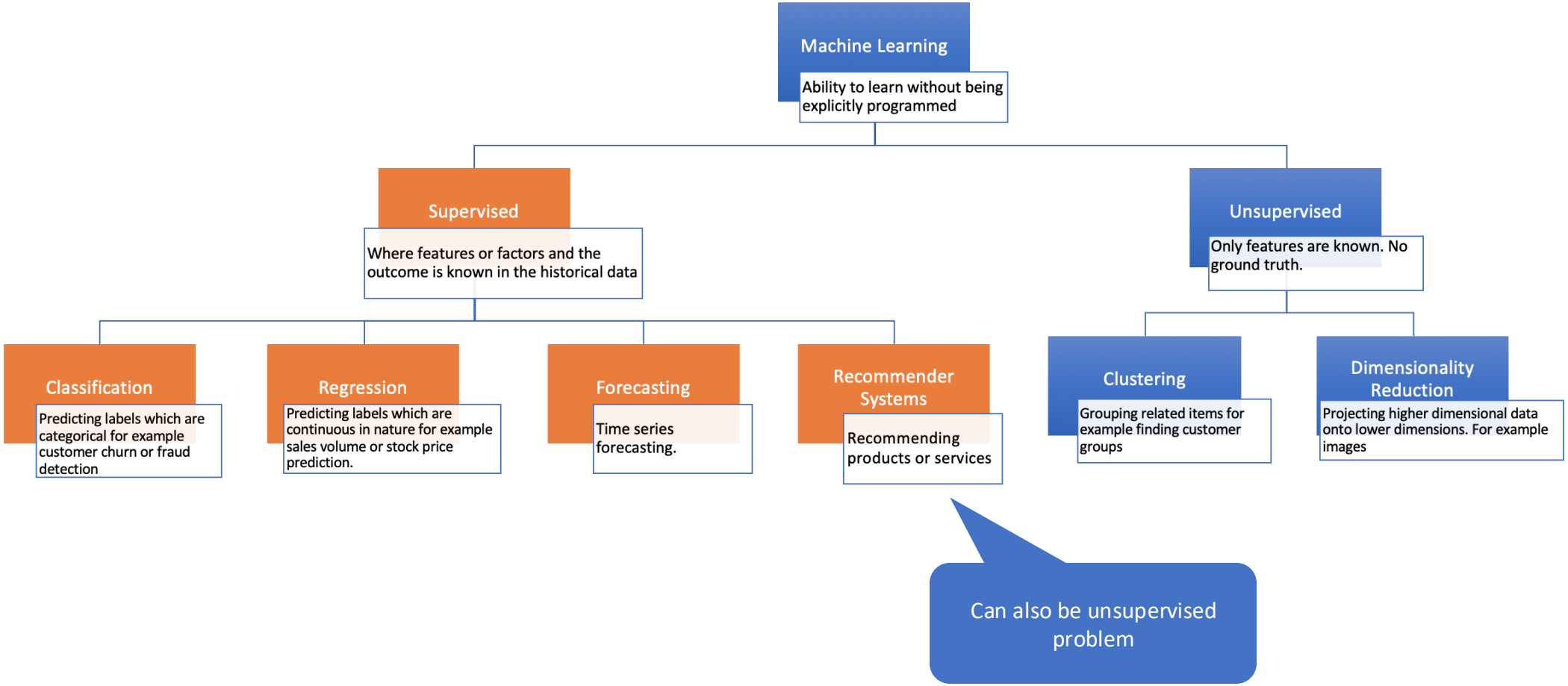


Model

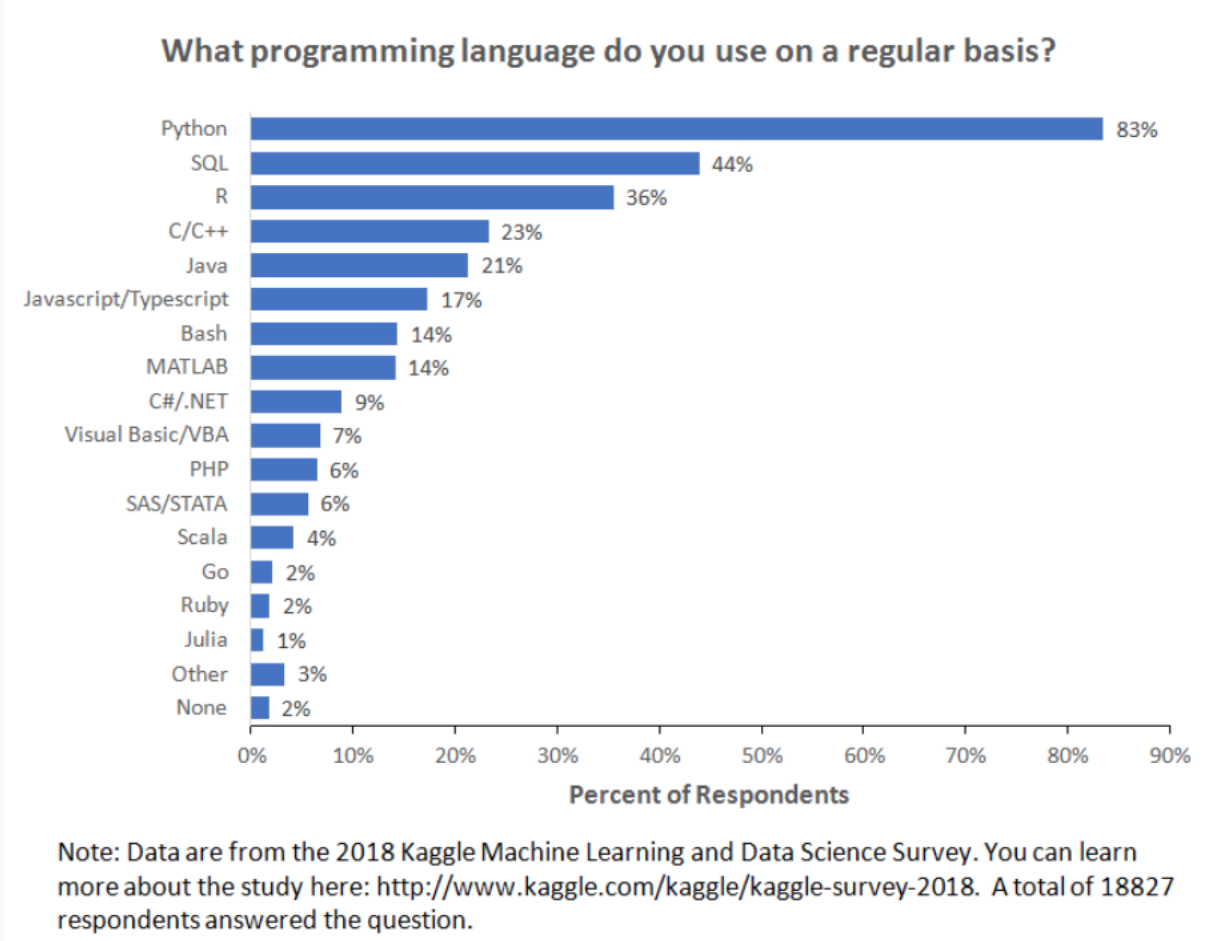
A mathematical expression of the pattern or evidence found in data and can be used to find insights and applied in future to predict.

What are types of problems ML can solve?

Machine Learning Algorithms

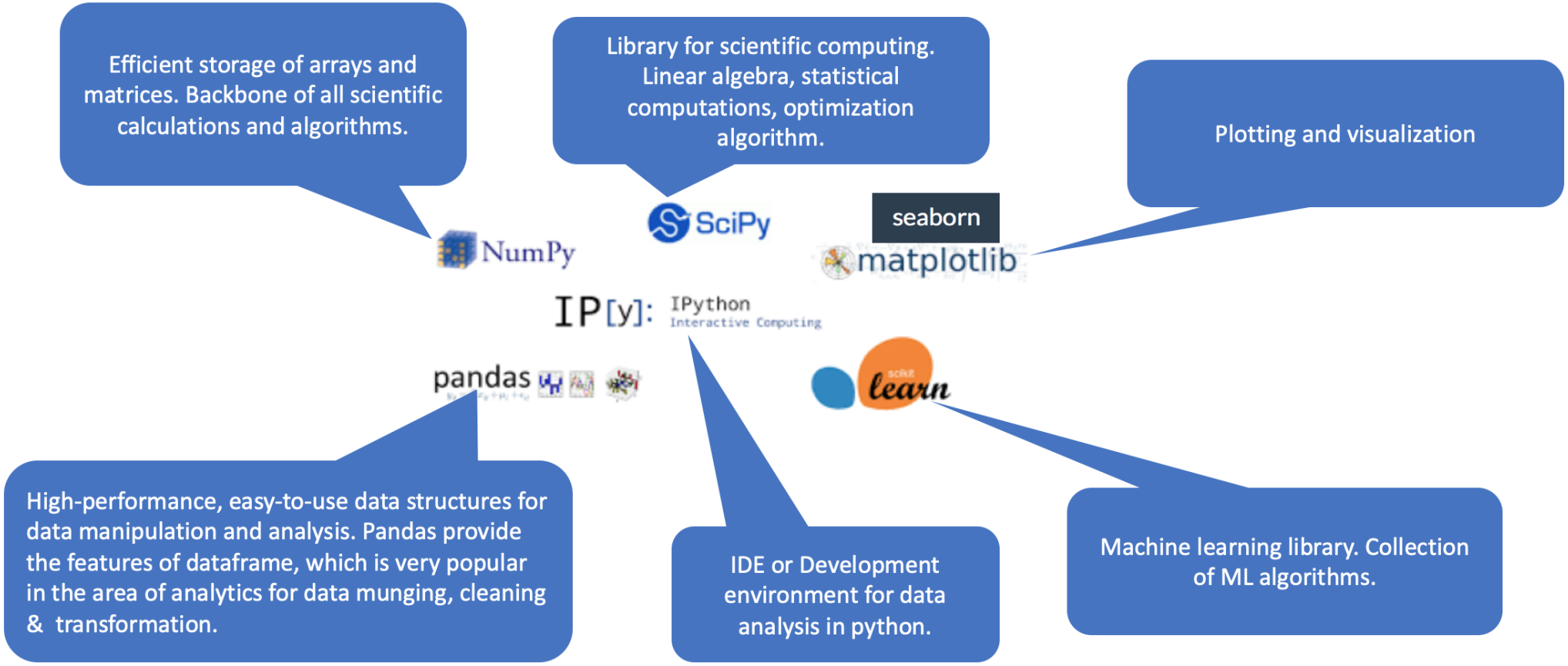


Language for Machine Learning



https://businessoverbroadway.com/2019/01/13/programming-languages-most-used-and-recommended-by-data-scientists/

Python Stack For Data Science



Development Environment and Tools

The Jupyter Notebook is **a web-based interactive computing platform**.

https://www.jupyter.org/

Github

The Jupyter Notebook is **a web-based interactive computing platform**.

https://www.github.com/

Platforms

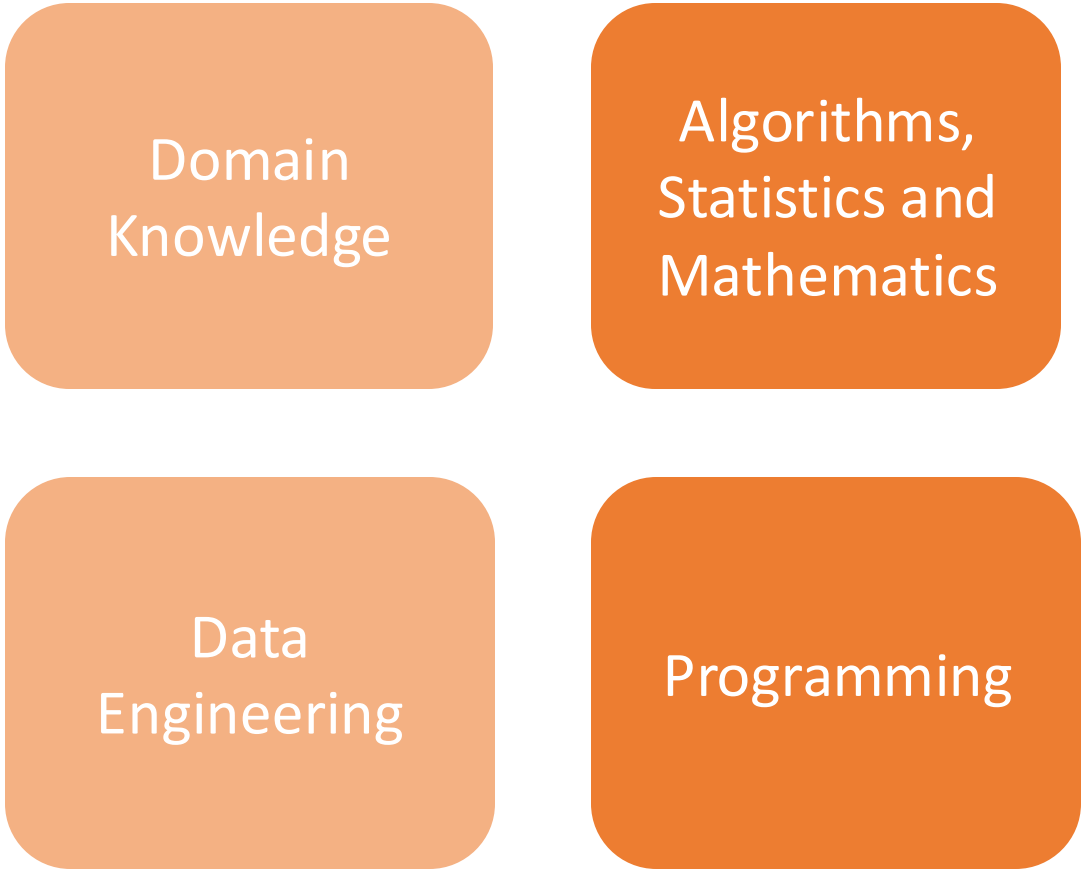
Most popular open-source Python distribution platform

https://www.anaconda.com/products/distribution

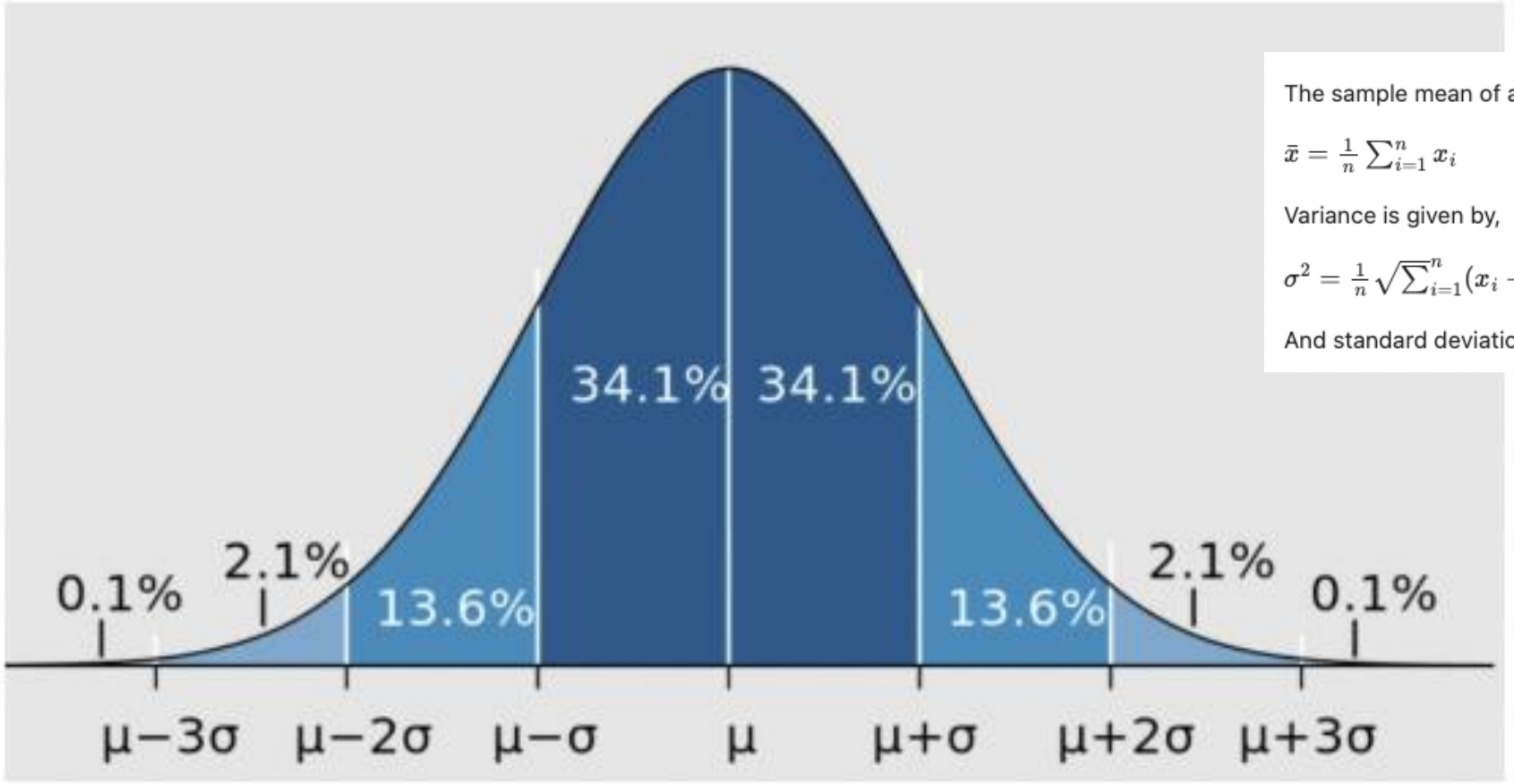
Goole Colaboratory is a hosted Jupyter notebook environment that is free to use and requires no setup.

https://colab.research.google.com/

Key Skills required for Machine Learning



Normal Distribution



The sample mean of a normal distribution is given by,

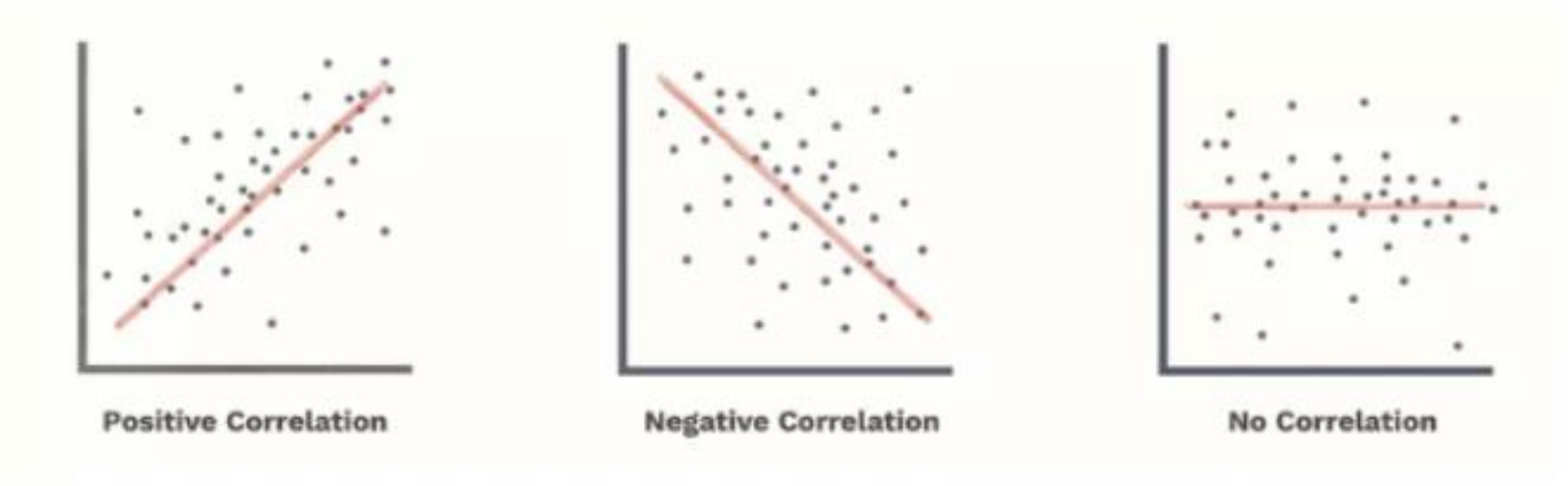
$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$

Variance is given by,

$\sigma^2 = \frac{1}{n}\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}.$

And standard deviation is square root of variance and is denoted by σ.

Correlation



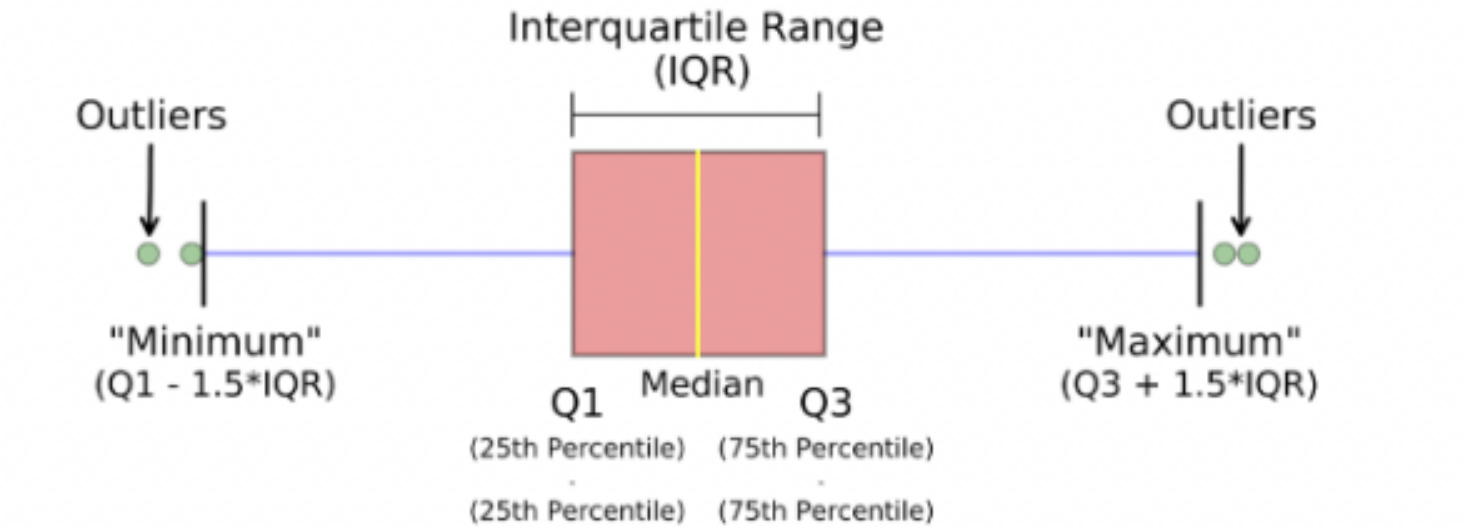
Correlation is given by:

$$\frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sigma_x \sigma_y}$$

This is also known as **Pearson Correlation**.

- | r | < 0.25 - No relationship
- 0.25 < | r | < 0.5 - Weak relationship
- 0.5 < | r | < 0.75 - Moderate relationship
- | r | > 0.75 - Strong relationship

Finding outliers using Box Plot



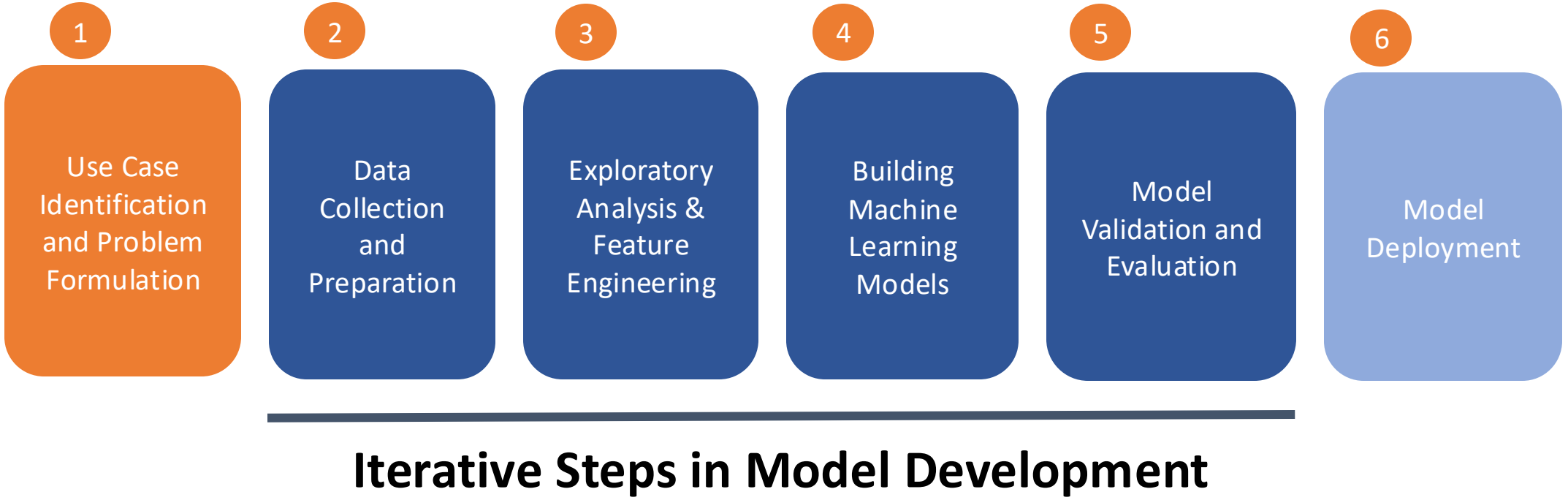
IQR = Q3 – Q1

Though it's not often affected much by them, the interquartile range can be used to detect outliers. This is done using these steps:

- Calculate the interquartile range for the data.
- Multiply the interquartile range (IQR) by 1.5 (a constant used to discern outliers).
- Add 1.5 x (IQR) to the third quartile. Any number greater than this is a suspected outlier.
- Subtract 1.5 x (IQR) from the first quartile. Any number less than this is a suspected outlier.

Technology and Skills

ML Lifecycle



Sale of Used Cars

Problem of underquoting, and overquoting the sale price.

How to estimate the sale price of an used car?

In used car showrooms, an indicative selling price is typically **generated by an sales agent who has on-the-ground experience of the used car market as he/she interacts with buyers and understands the demand.**

How do we collect data?

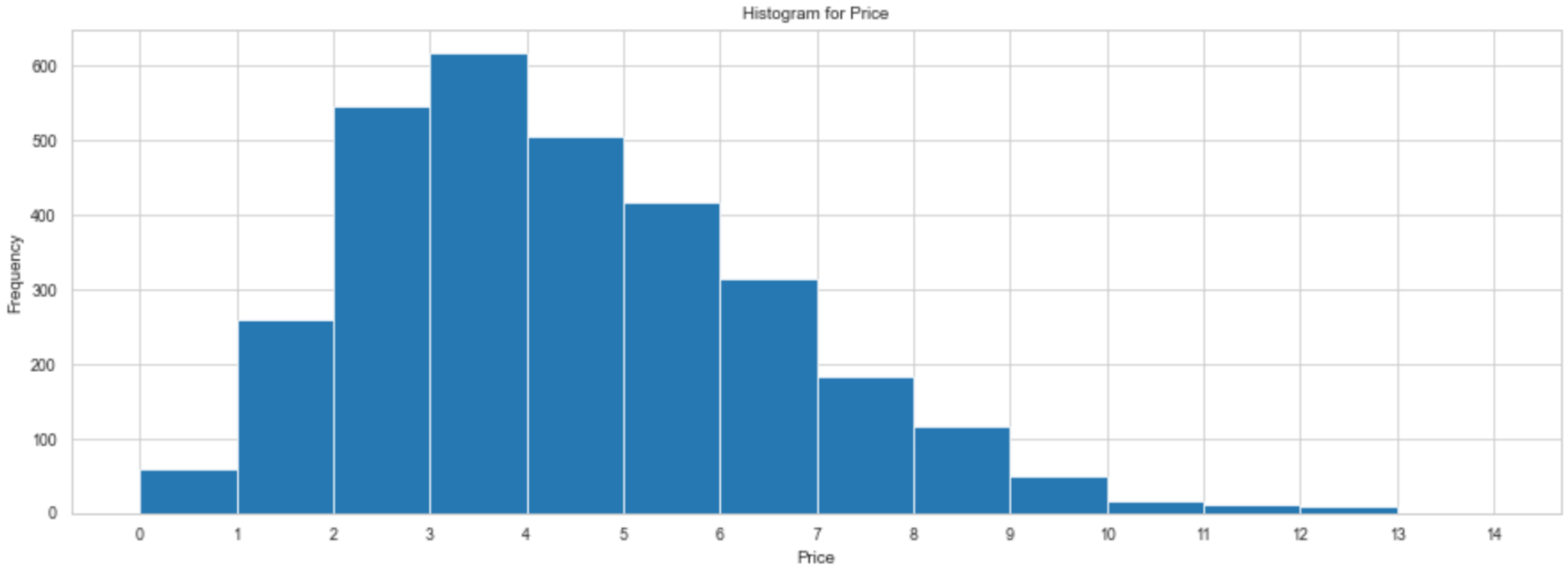
Dataset

Name	Location	Year	Kilometers_Driven	Fuel_Type	Transmission	Owner_Type	Mileage	Engine	Power	Seats	New_Price	Price
Maruti Swift VXI	Mumbai	2016	23555	Petrol	Manual	First	22.0 kmpl	1197 CC	81.80 bhp	5.0	7 Lakh	5.10
Maruti Alto 800 LXI	Jaipur	2015	25000	Petrol	Manual	First	22.74 kmpl	796 CC	47.3 bhp	5.0	NaN	2.75
Hyundai Santro Xing GLS	Bangalore	2008	46000	Petrol	Manual	Second	17.92 kmpl	1086 CC	62.1 bhp	5.0	NaN	2.22
Maruti Wagon R LXI BS IV	Delhi	2015	13008	Petrol	Manual	First	20.51 kmpl	998 CC	67.04 bhp	5.0	NaN	3.50
Hyundai Elite i20 Petrol Sportz	Kochi	2018	14223	Petrol	Manual	First	18.6 kmpl	1197 CC	81.86 bhp	5.0	NaN	7.32
Honda Jazz 1.2 V AT i VTEC Privilege	Pune	2016	21000	Petrol	Automatic	First	19.0 kmpl	1199 CC	88.7 bhp	5.0	NaN	6.35
Hyundai i20 1.4 Asta (AT)	Chennai	2009	72000	Petrol	Automatic	Third	15.0 kmpl	1396 CC	100 bhp	5.0	NaN	3.25
Honda Amaze S Petrol	Kolkata	2013	32576	Petrol	Manual	First	19.5 kmpl	1199 CC	88.76 bhp	5.0	7.36 Lakh	3.15
Honda Amaze SX i-VTEC	Coimbatore	2014	28246	Petrol	Manual	Second	17.8 kmpl	1198 CC	86.7 bhp	5.0	NaN	4.94
Maruti Swift Dzire VDi	Hyderabad	2014	123900	Diesel	Manual	First	19.3 kmpl	1248 CC	73.9 bhp	5.0	NaN	5.40

Exploratory Data Analysis

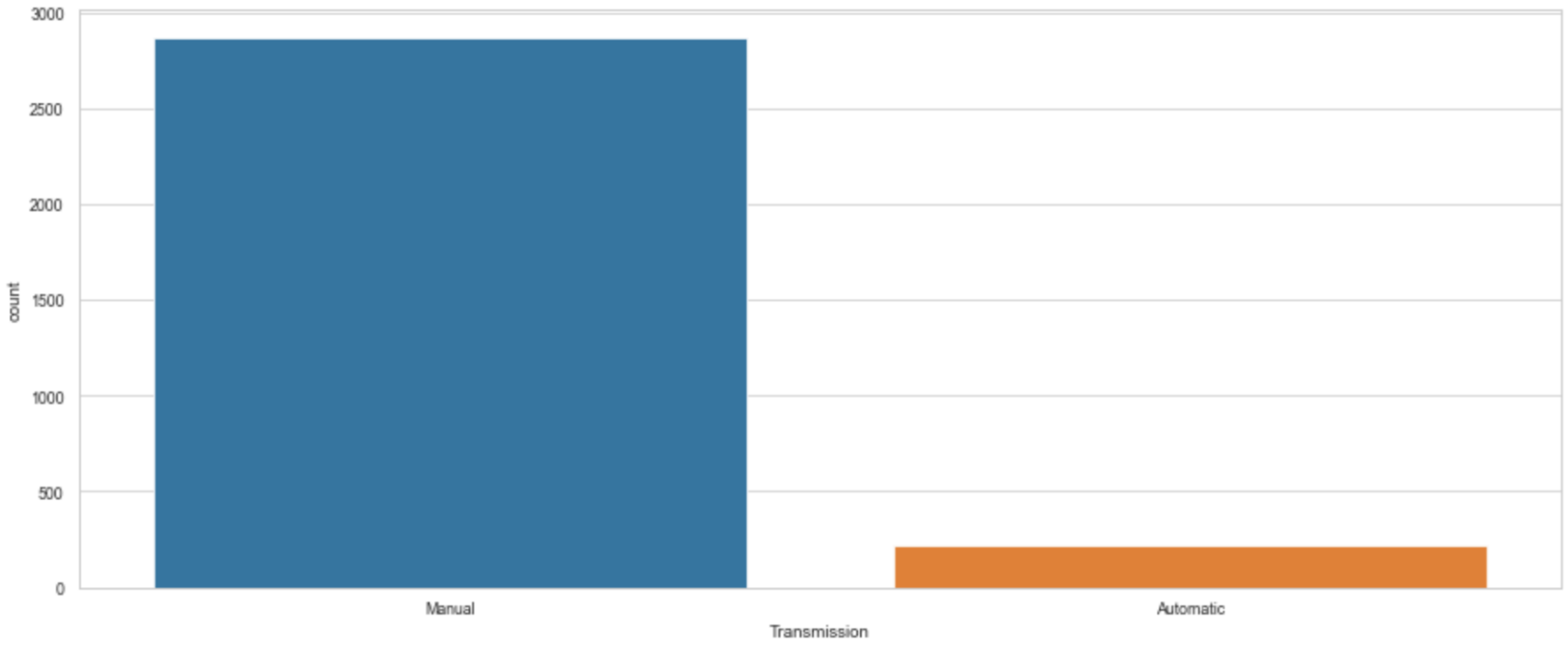
- Understand Distribution of the variables
  - Make use of charts
- Is the data representative?
- Are there any outliers?
- Are there any missing values
  - What is the volume of missing values?
  - Can it be imputed?
- Do we need to transform the variables?
  - Unit transformation?
  - Scaling?

Histogram



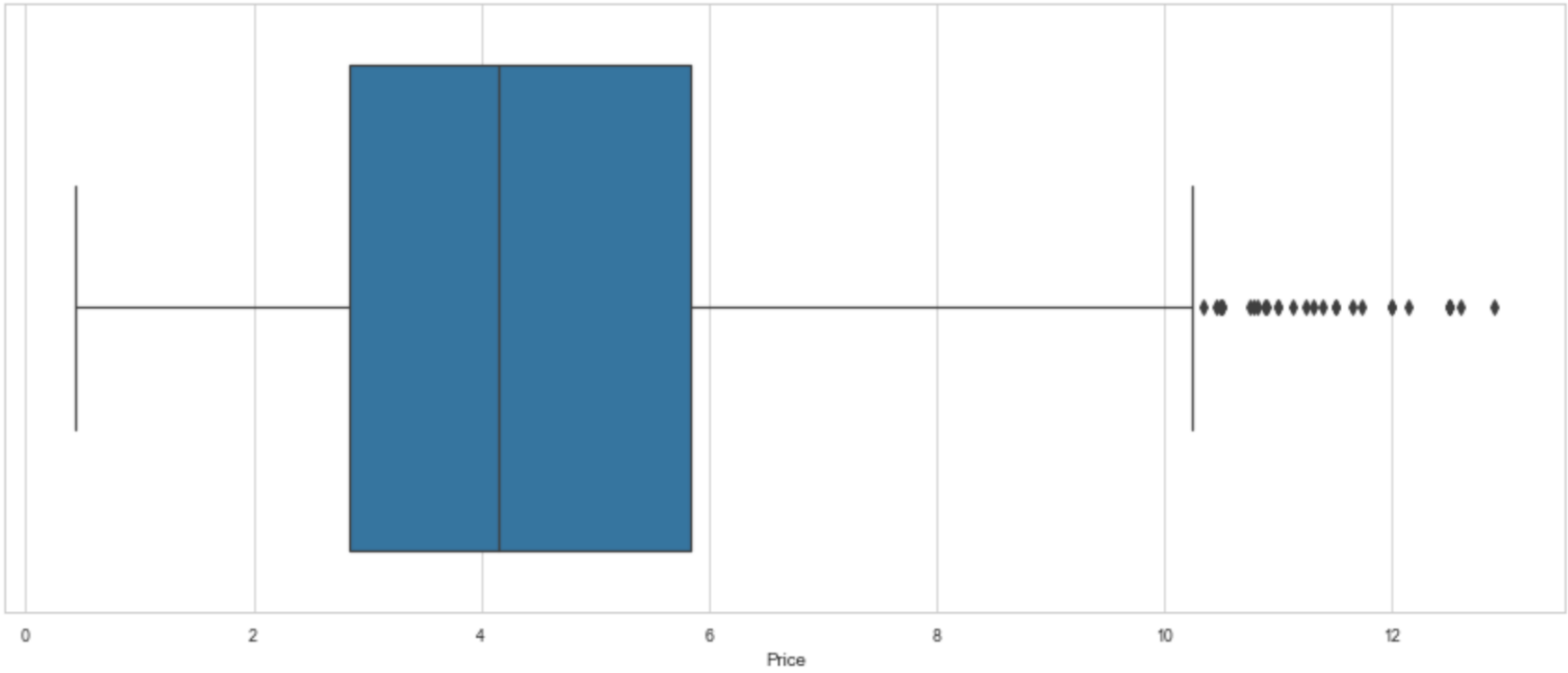

```
plt.figure(figsize=(15,5))
hist_data = plt.hist(cars_df['Price'], bins=list(range(0, 15, 1)));
```

Bar Plot



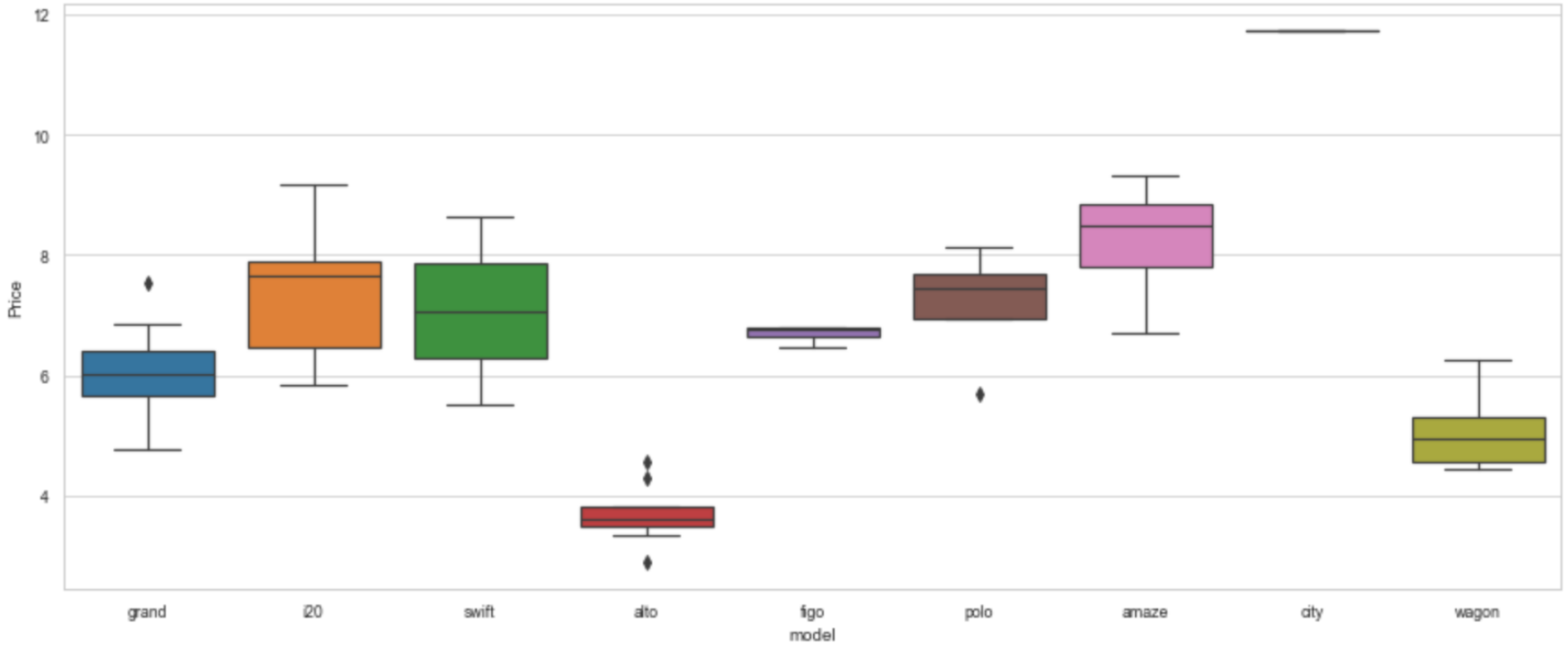

```
plt.figure(figsize=(15, 6))
sn.countplot(data = cars_df,
             x = 'Transmission');
```

Outlier Analysis



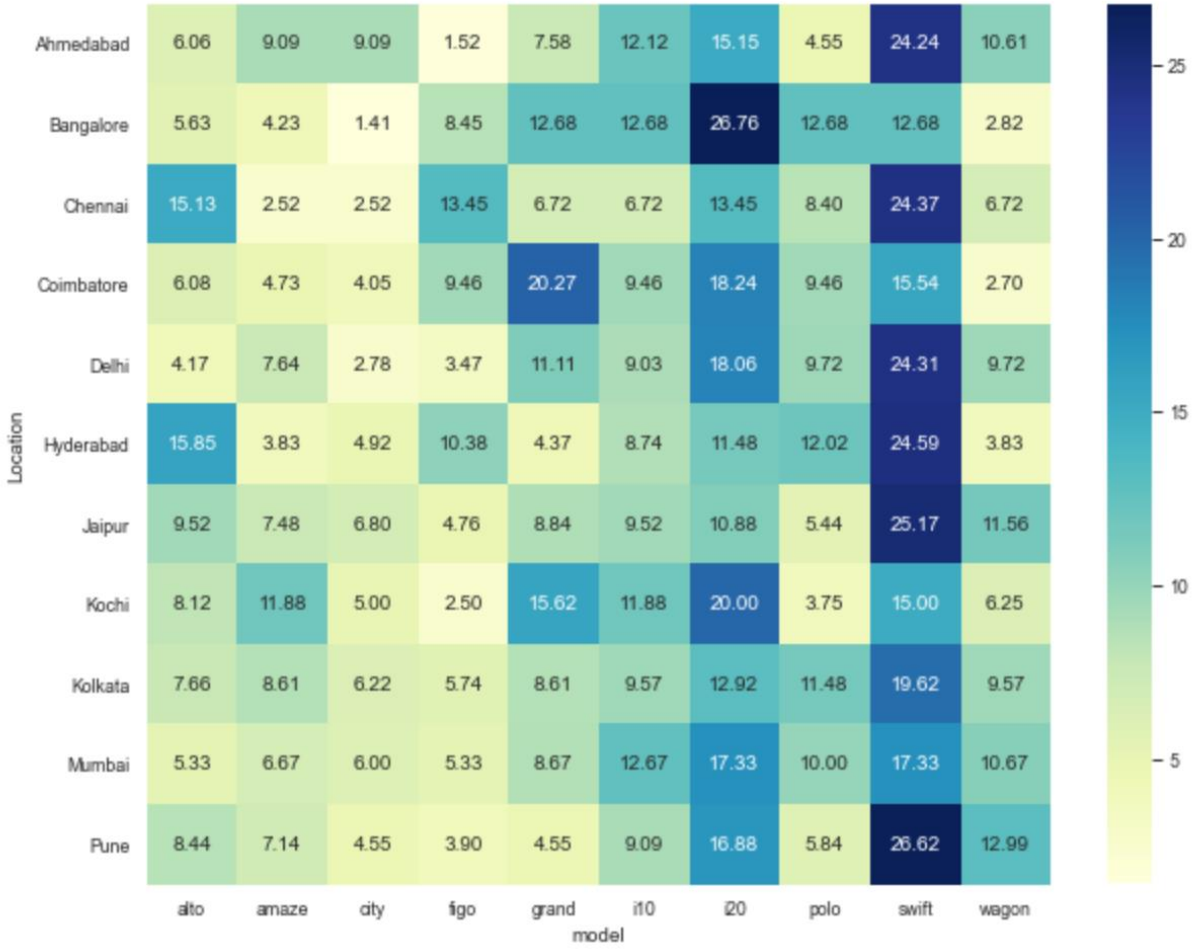

```
plt.figure(figsize=(15,6))
boxp = sn.boxplot(cars_df['Price']);
```

Bivariate: Numerical vs Categorical




```
plt.figure(figsize=(15, 6))
sn.boxplot(data = top_10_models_df,
           x = 'model',
           y = 'Price');
```

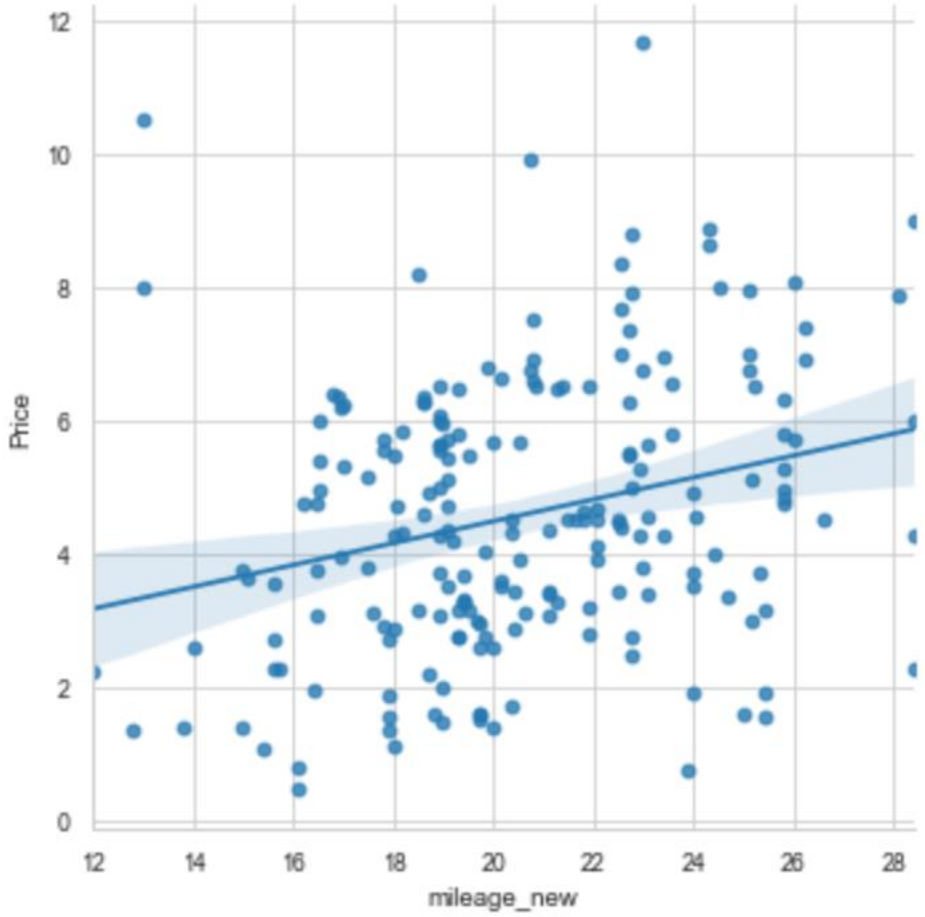
Bivariate: Categorical Variables




```
models_ct = pd.crosstab(top_10_models_df.Location,
                        top_10_models_df.model,
                        normalize = 'index') * 100
```

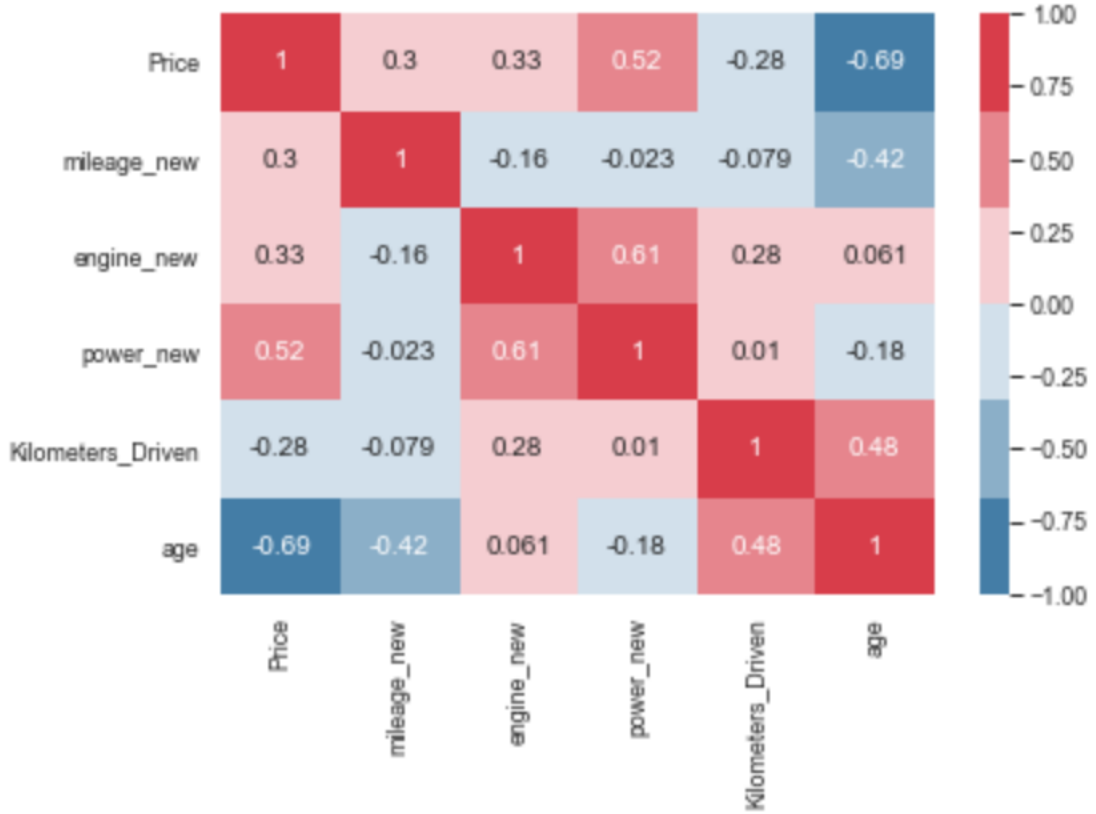
```
plt.figure(figsize=(10, 8))
sn.heatmap(models_ct, annot=True, fmt = "0.2f", cmap="YlGnBu");
```

Bivariate: Two Numerical Variables




```
sn.lmplot(data = cars_df.sample(200),
          x = 'mileage_new',
          y = 'Price');
```

Heatmap




```
sn.heatmap(corr_mat,
           annot=True,
           vmin = -1.0,
           vmax = 1.0,
           cmap = sn.diverging_palette(240, 10));
```

Rules for Plotting

- Single Variable (Univariate Analysis)
  - Continuous -> Histogram, boxplot, distribution plot
  - Categorical -> Count Plot/Bar Plot
- Two Variables (Bivariate Analysis)
  - Continuous + Categorical -> Box plot, Overlapped Distribution Plot
  - Continuous + Continuous -> Scatter Plot, heatmap
  - Categorical + Categorical -> Bar Plot / Count Plot, heatmap

Regression: Loss Function

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

$\mathbf{MSE}$ = mean squared error

n = number of data points

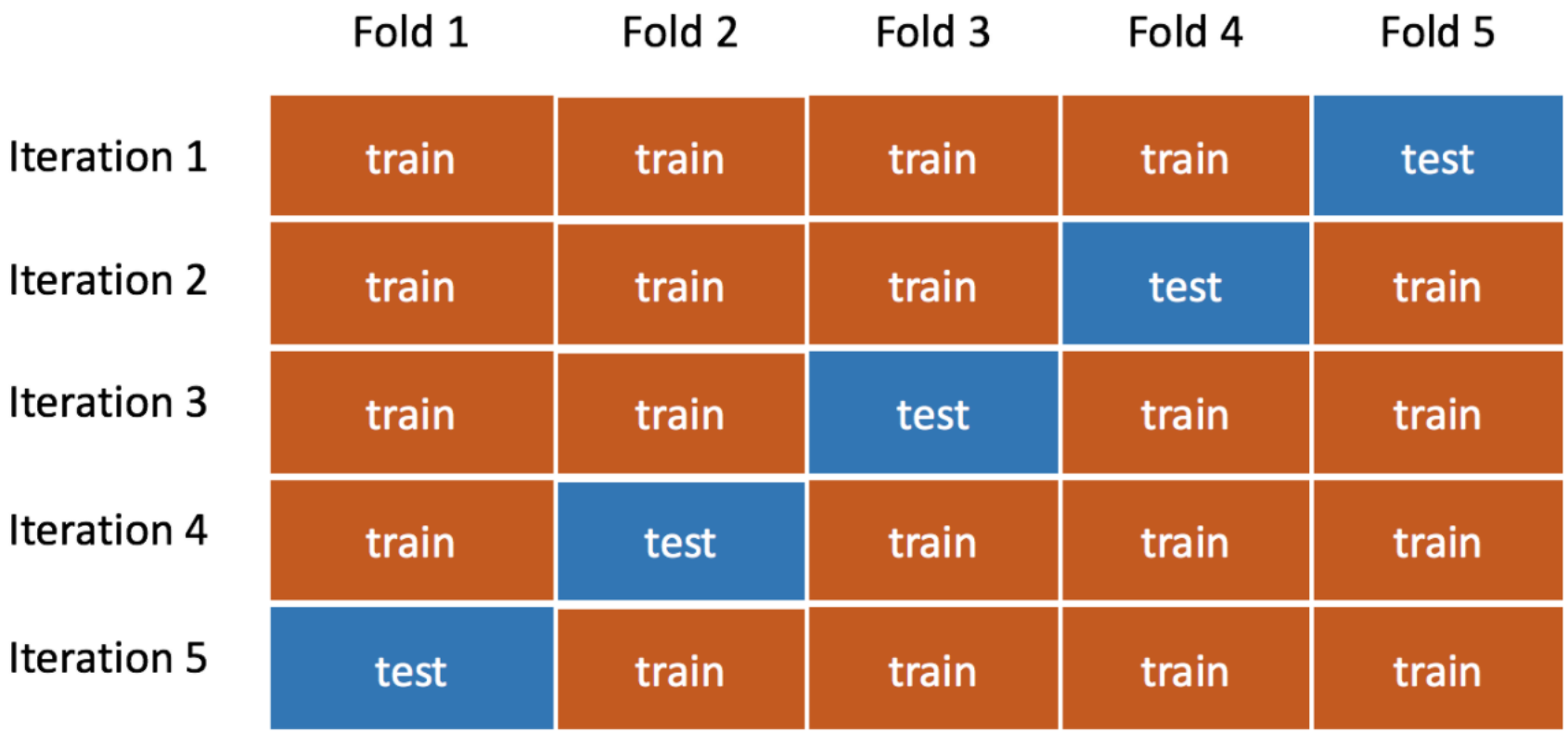
Y_i = observed values

$\hat{Y}_i$ = predicted values

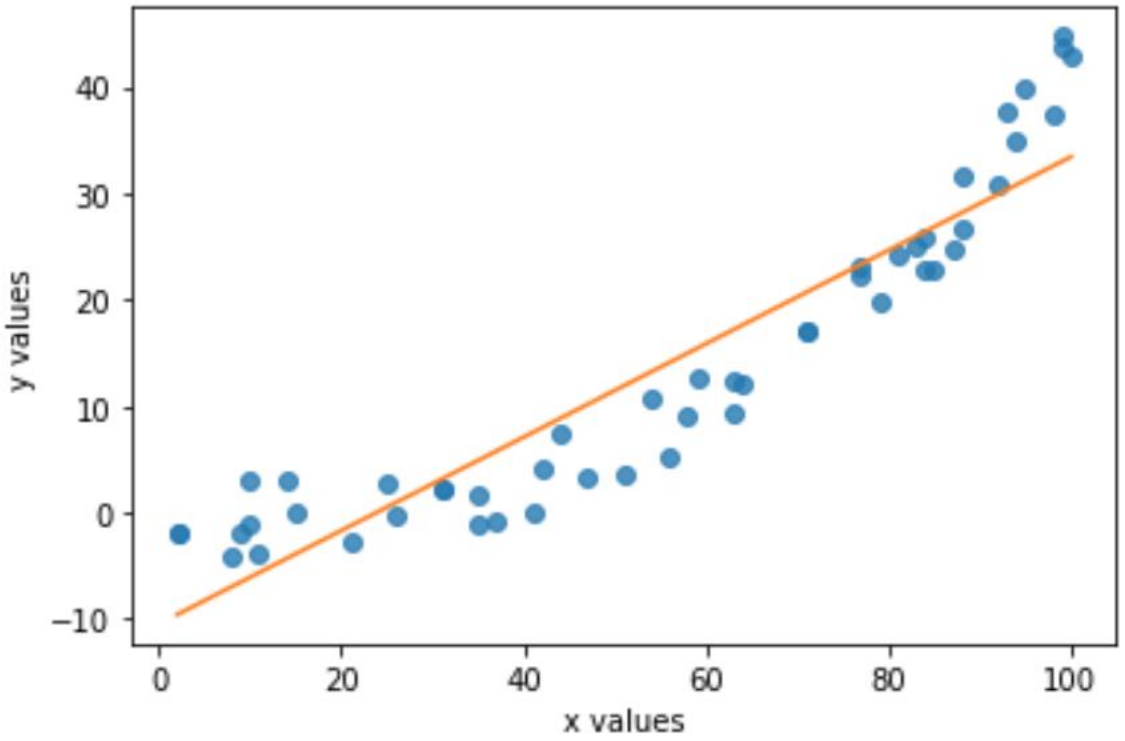
R Squared

$$R^2 = \frac{\text{Variance explained by the model}}{\text{Total Variance}}$$

K-Fold Cross Validation

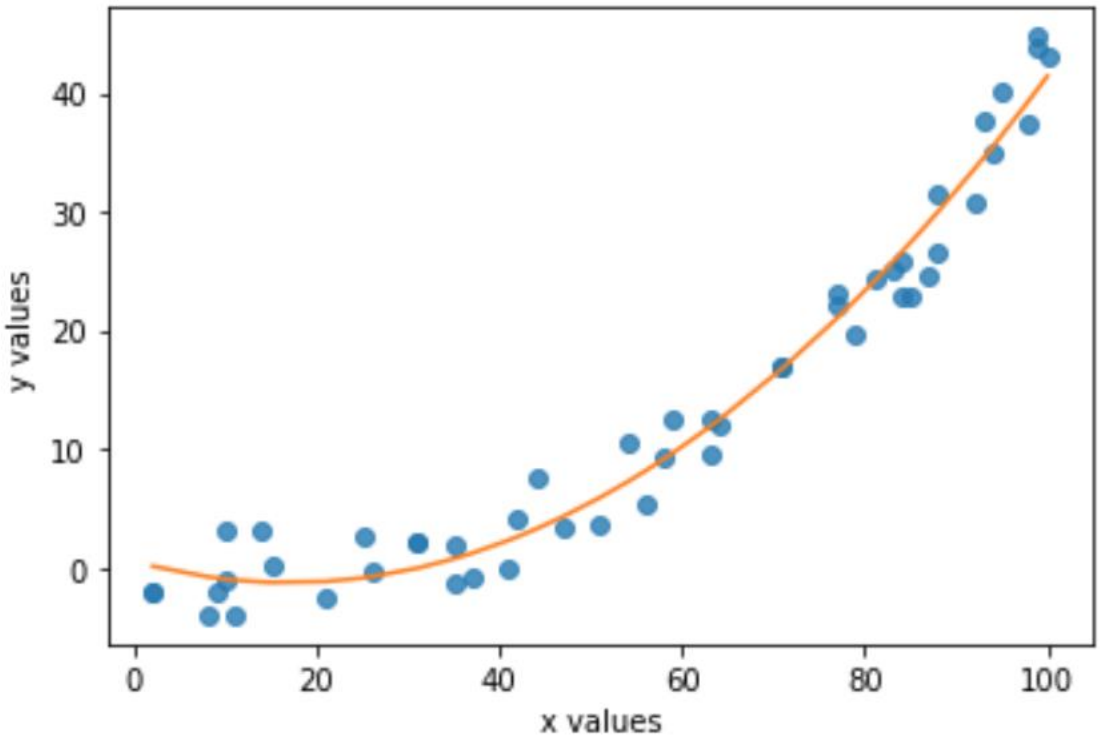


Bias – Variance Trade off



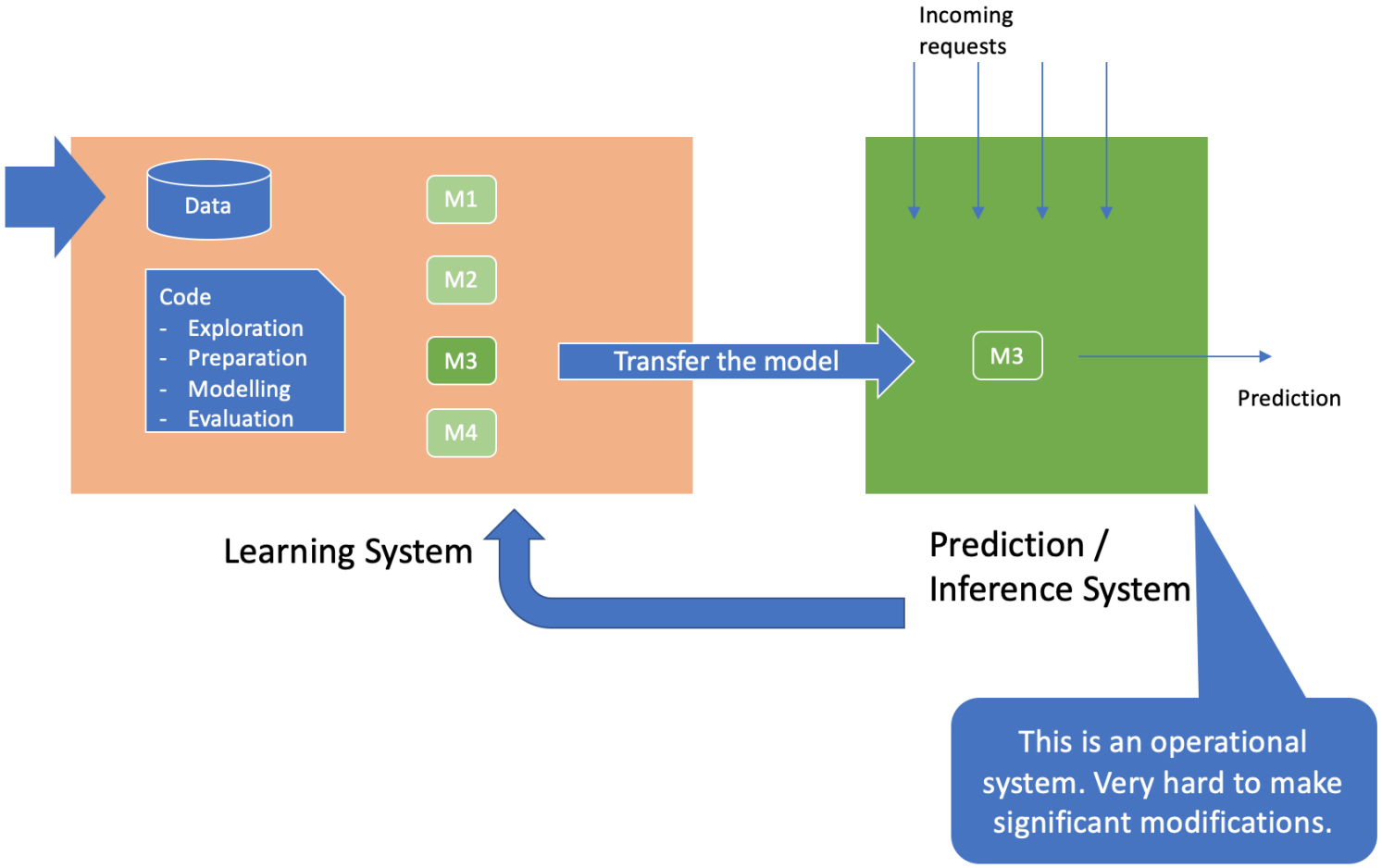
$$y = \beta_1 x_1 + \varepsilon_i$$

Bias – Variance Trade off

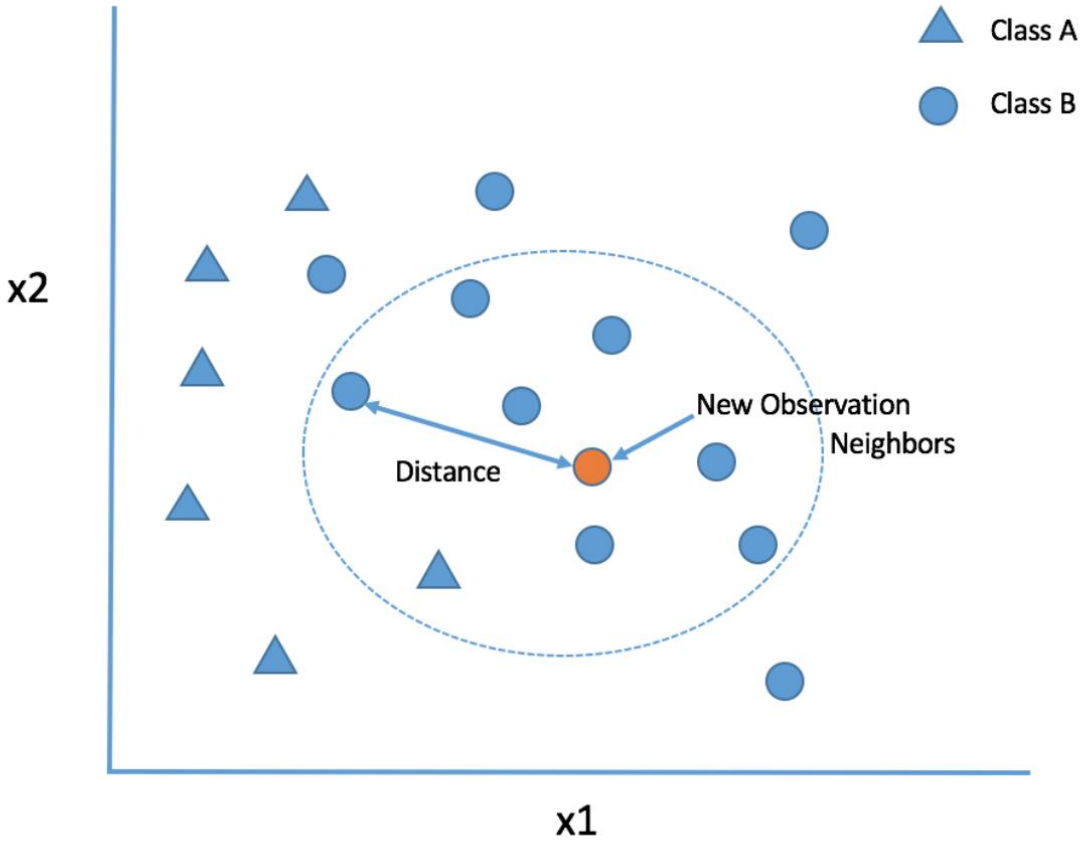


$$y = \beta_1 x_1 + \beta_2 x_1^2 + \varepsilon_i$$

ML Systems



KNN

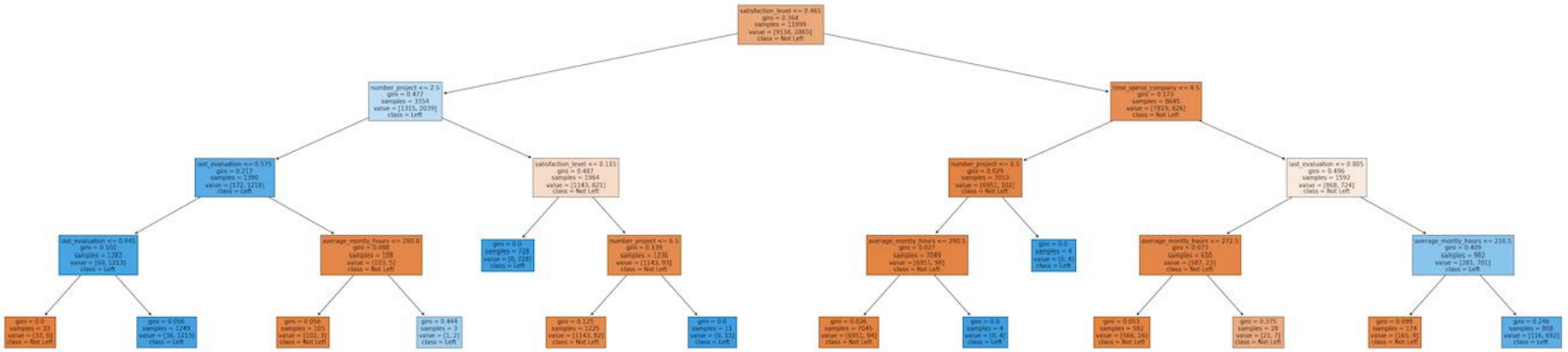


Euclidean Distance

$$D(X1, X2) = \sqrt{\sum_{i=1}^{n} (x_{i1} - x_{i2})^2}$$

Where, X_1 and X_2 are two data points, there are n attributes and x_i is i^{th} attribute of each data points.

Decision Tree



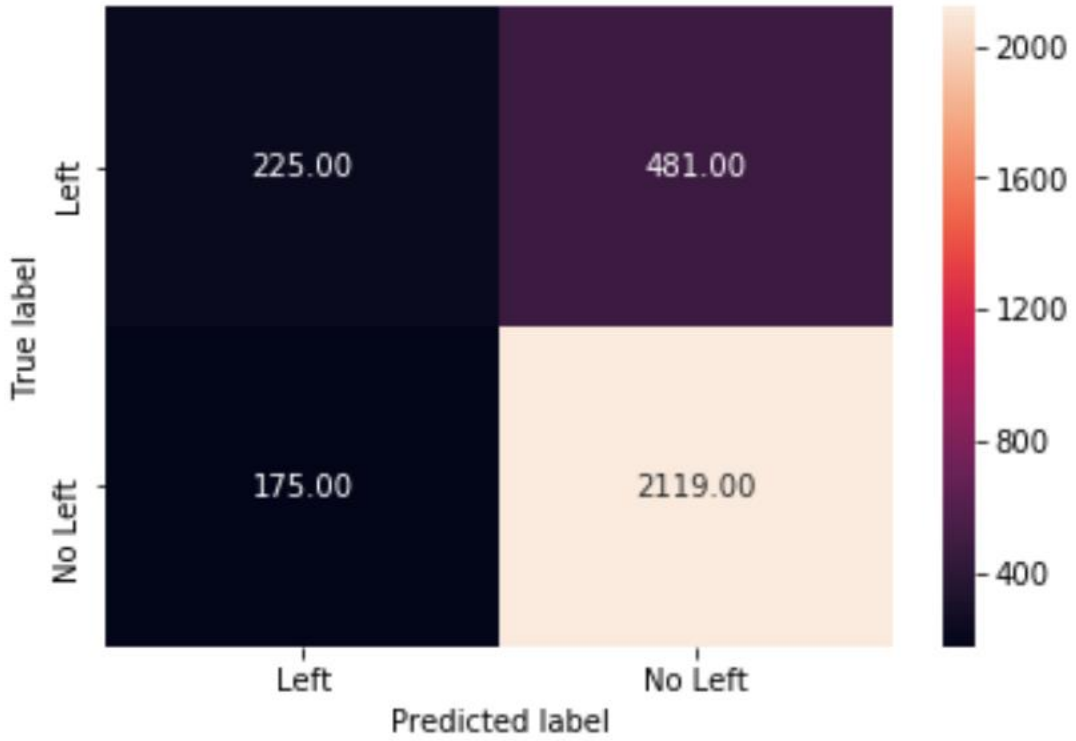
Gini & Entropy

$$Gini = 1 - \sum_{i=1}^{n} p^2(c_i)$$

$$Entropy = \sum_{i=1}^{n} -p(c_i)log_2(p(c_i))$$

where $p(c_i)$ is the probability/percentage of class c_i in a node.

Confusion Matrix



Classification Metrics

Precision is defined as how many are actual positives out of total number of positives identified by the model and is defined as

$$TPR = (\frac{TP}{TP+FP})$$

True Positive Rate (TPR) or Recall or Sensitivity is how many actual positive are properly identified by the model out of total number actual positive in the test set and is defined as

$$TPR = (\frac{TP}{TP+FN})$$

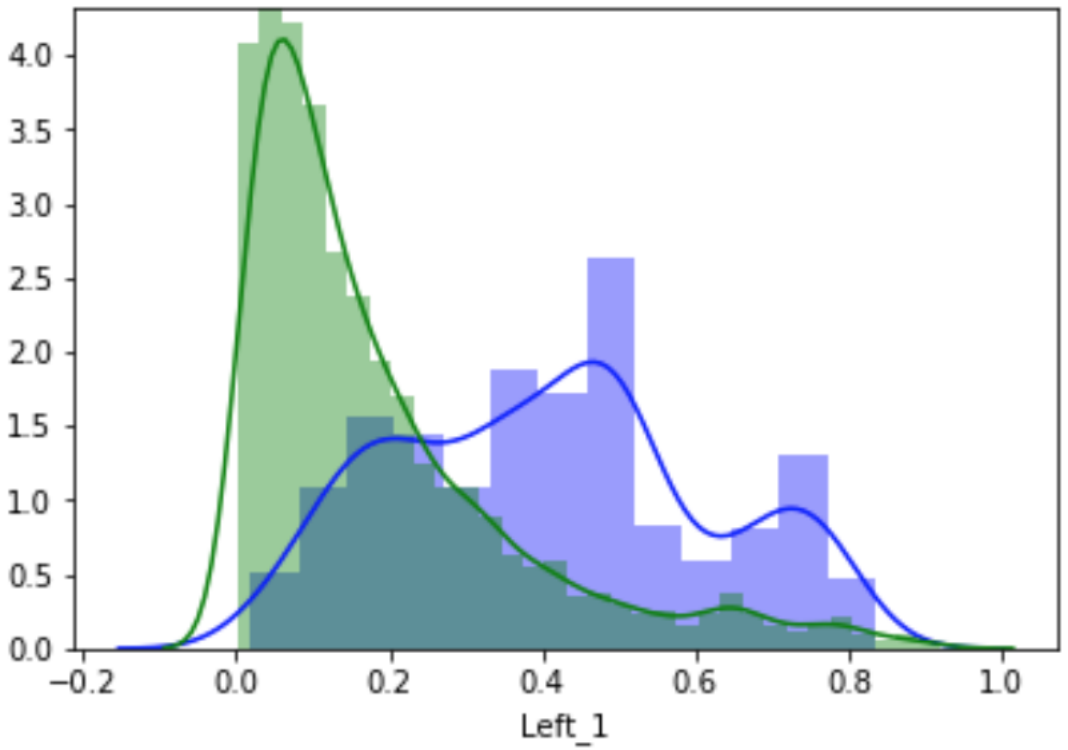
True Negative Rate (TNR) or Specificity is how many are correctly indentified as correct negatives out of all acutal negative present in the test set and is defined as

$$TNR = (\frac{TN}{FP+TN})$$

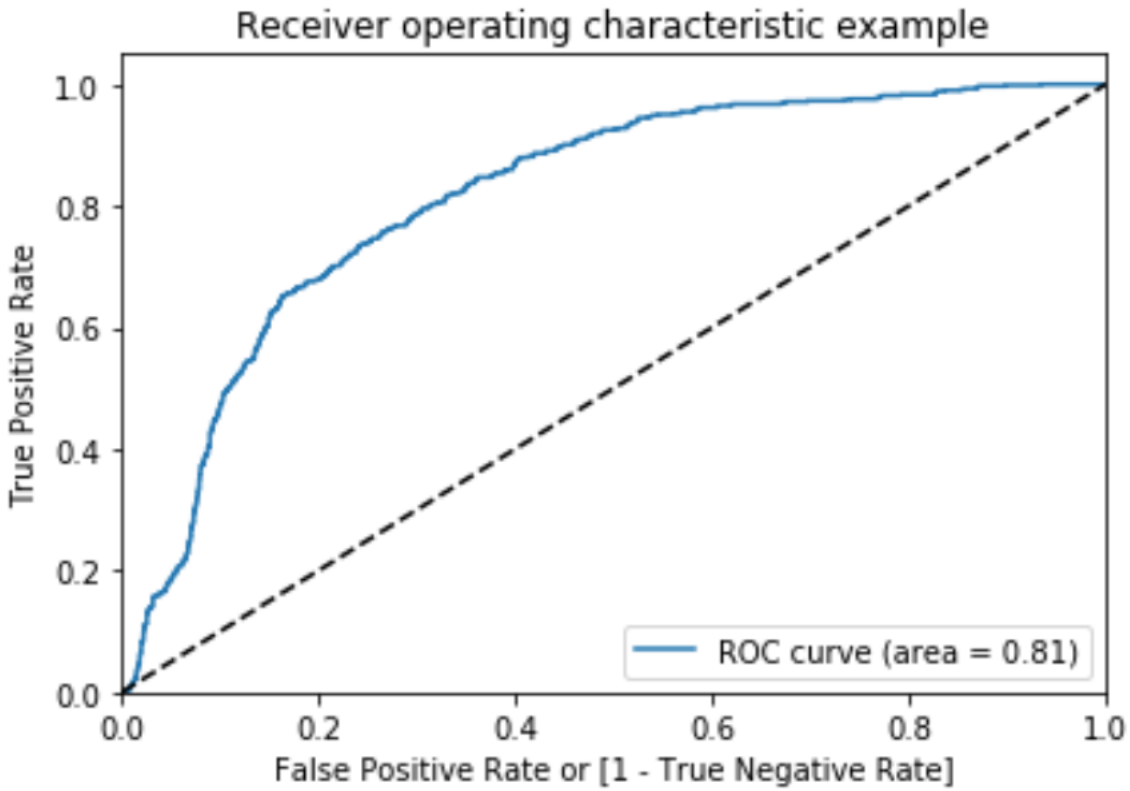
F-Score (F-Measure) is another measure used in binary logistic regression that combines both precision and recall (harmonic mean of precision and recall) and is given by

$$F1 - score = (\frac{2xPrecisionxRecall}{Precision+Recall})$$

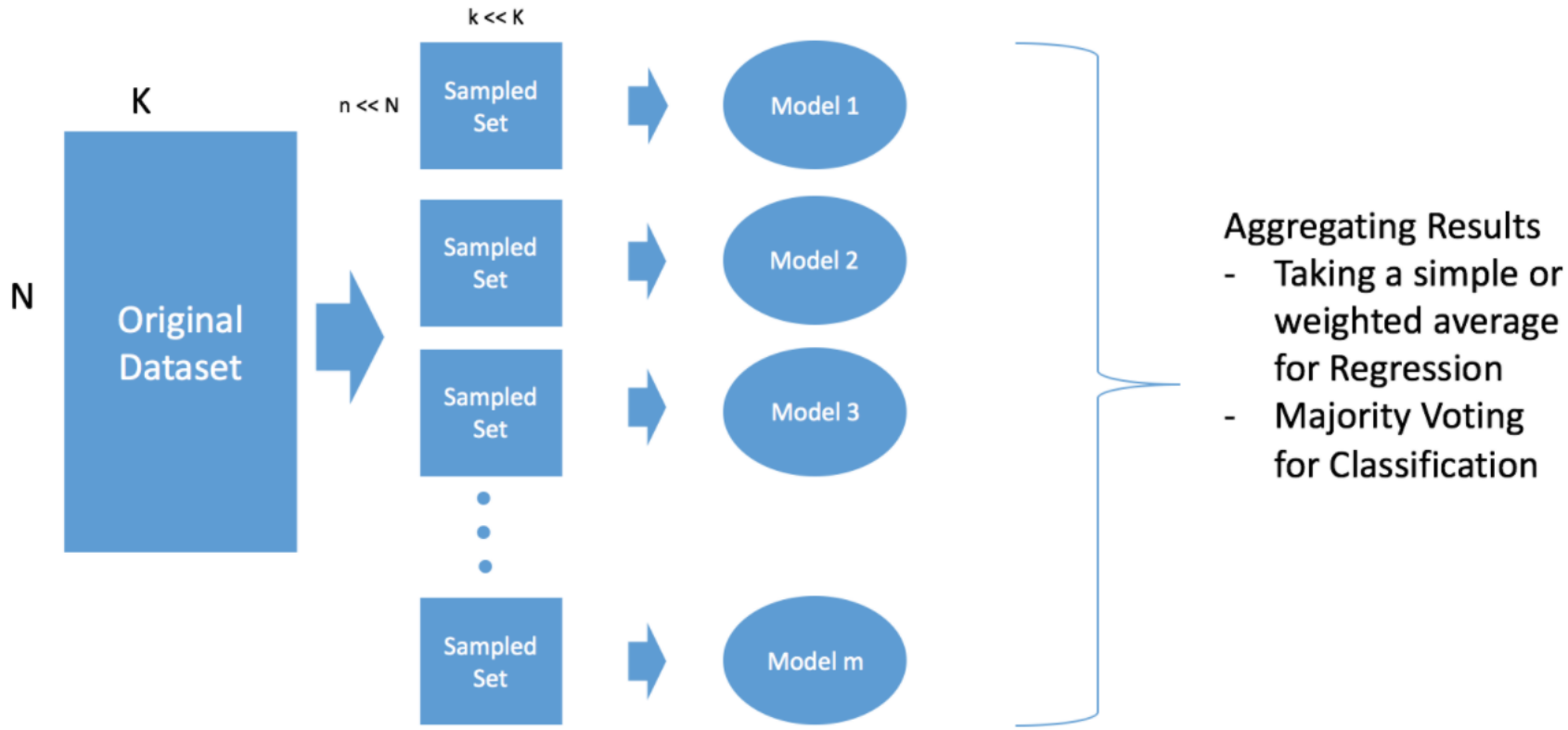
Probability Distribution



ROC AUC



Ensemble



Random Forest