An Introduction to WEKA: The All in One Machine Learning Software in Java

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Main Goal of the Paper:

To be able to compute first little machine learning projects after reading the paper!

Table of Contents

Introduction

- Intelligence: “the ability to learn, understand, and make judgments or have opinions that are based on reason”

- Alan Turing in 1950: Machines could be capable of making decisions similarly to humans with the help of information and reason

Overview: Machine Learning

- Data + Algorithms → Gain new information

- Tasks:
  - Description
  - Prediction
  - Causal Inference

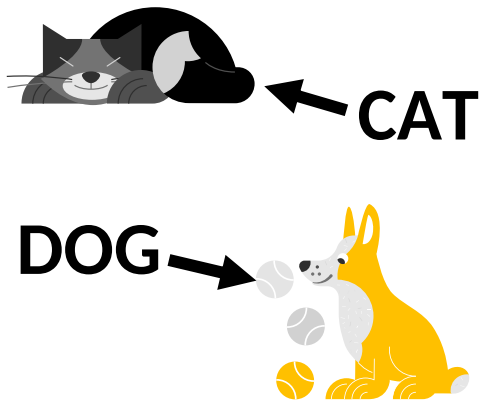
- Types:
  - Supervised Machine Learning
  - Unsupervised Machine Learning
  - Reinforcement Machine Learning
  - Semisupervised Machine Learning

Types of Machine Learning

Supervised ML

- Labeled data

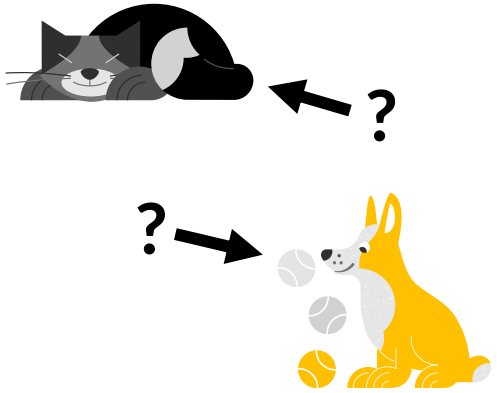
- Regression
  - Housing Prices
- Classification
  - Dog or Cat



Unsupervised ML

- Unlabeled data

- Clustering
- Dimensionality Reduction
- Association Rules



Reinforcement ML

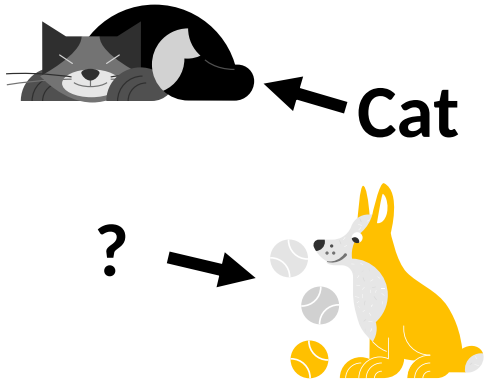
- Unlabeled data

- Learning by doing
- Get feedback

Semisupervised ML

- Small amount labeled

- Self-Training
- Pseudo-Labeling



WEKA

- All in one software for machine learning
  - Preparing the data
  - Building machine learning models
  - Visualizing the data

- How to use?
  - Graphical User Interface (GUI)
  - Application Programming Interface (API)

GNU General Public Licence

- Found by Richard Stallman in 1989
- Free Software
- Freedoms to:
  - Run
  - Study
  - Share
  - Modify

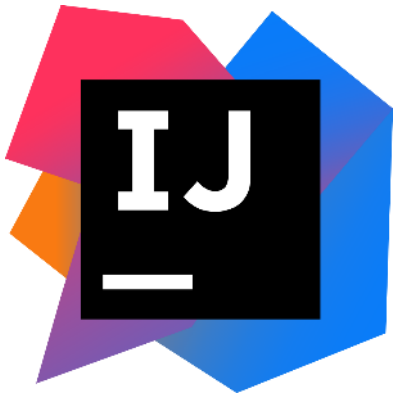
Graphical User Interface (GUI)

- Complete a machine learning project without a single line of code

- GUI Chooser
  - Explorer
  - KnowledgeFlow
  - Experimenter
  - Workbench
  - SimpleCLI

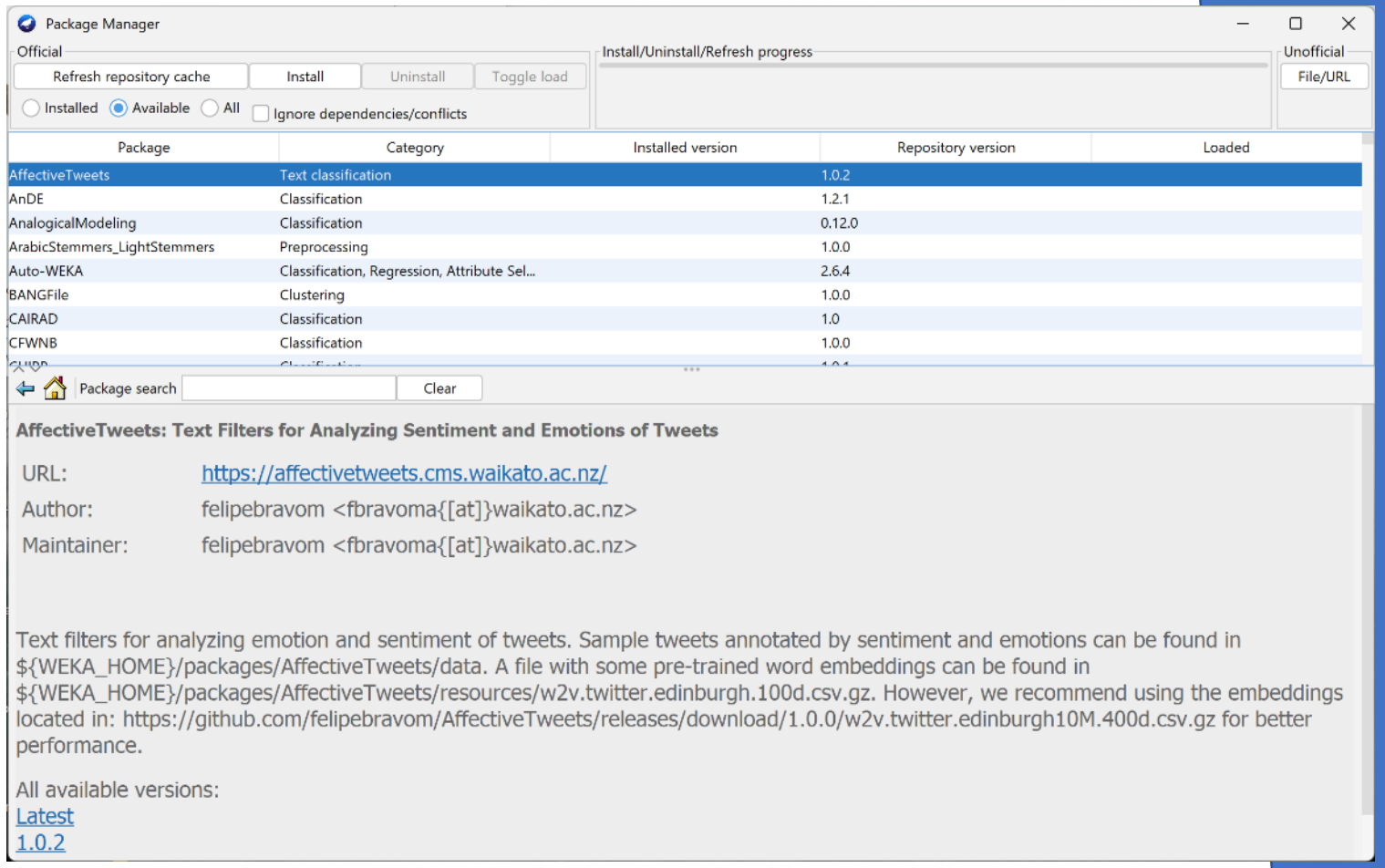
Application Programming Interface (API)

- Required:
  - WEKA
  - Java
- Optional:
  - Integrated Development Environment (IDE)



Package Manager

- Over 200 official packages
- Unofficial packages



Attribute-Relation File Format (ARFF)

- Sections:
  - Header
  - Information
- Data Types:
  - Numeric
  - String
  - Date
  - Nominal-specification

```
@relation housing

@attribute city {London,Paris,Berlin,Madrid,Rome,Amsterdam,Vienna,Athens,Stockholm,Dublin}
@attribute country {'United Kingdom',France,Germany,Spain,Italy,Netherlands,Austria,Greece,Sweden,Ireland}
@attribute type {Apartment,House}
@attribute sqr_metre numeric
@attribute price numeric

@data
London,'United Kingdom',Apartment,?,200000
Paris,France,House,120,350000
Berlin,Germany,Apartment,60,150000
Madrid,Spain,Apartment,90,180000
Rome,Italy,House,150,400000
Amsterdam,Netherlands,Apartment,70,250000
Vienna,Austria,House,110,300000
Athens,Greece,Apartment,75,160000
Stockholm,Sweden,Apartment,85,220000
Dublin,Ireland,House,130,380000
```

Data Preparation

- Importing Data
  - JSONLOADER
  - XRFFLOADER
  - CSV, ARFF:

```
//Import Data set CSV
DataSource src = new DataSource( location: "./housing.csv");
Instances housing = src.getDataSet();
//System.out.println(housing);

//Import Data set ARFF
DataSource src2 = new DataSource( location: "./housing_newColumns.arff");
Instances housing_newcol = src2.getDataSet();
//System.out.println(housing_cities);
```

- Combining Data
  - Merging Data

```
//Merge 2 datasets (column)
Instances housing_new = Instances.mergeInstances(housing, housing_newcol);
//System.out.println(housing_new);
```

- Appending Data

```
//Append 2 datasets (rows)
for(int i = 0; i < housing_newrow.numInstances(); i++) {
    housing_new.add(housing_newrow.instance(i));
}
```

Data Preparation

- Understanding Data
  - Look at the Data
  - Get summary

```
//Get Summary
System.out.println(housing_new.toSummaryString());
```

```
     Name                     Type  Nom  Int Real     Missing       Unique  Dist
 1 city                      Nom 100%   0%   0%     0 /  0%     5 / 33%    10
 2 country                   Nom 100%   0%   0%     0 /  0%     5 / 33%    10
 3 type                      Nom  93%   0%   0%     1 /  7%     0 /  0%     2
 4 sqr_metre                 Num   0%  93%   0%     1 /  7%    12 / 80%    13
 5 price                     Num   0% 100%   0%     0 /  0%     9 / 60%    12
 6 ROOMS                     Num   0% 100%   0%     0 /  0%     3 / 20%     6
 7 balcony_y/n               Nom 100%   0%   0%     0 /  0%     0 /  0%     2
```

  - Print Mean/Mode
  - Print Minimum/Maximum

- Selecting Data
  - Columns

```
//Delete unnecessary Attribute (balcony_y/n)
housing_new.deleteAttributeAt( position: 6);
```

  - Rows

```
//Filter every value below 170000
RemoveWithValues filter2 = new RemoveWithValues();

String[] options = new String[4];
options[0] = "-C";
options[1] = "5";
options[2] = "-S";
options[3] = "170000";
filter2.setOptions(options);

filter2.setInputFormat(housing_new);
Instances housing_expensive = Filter.useFilter(housing_new, filter2);
//System.out.println(housing_expensive);
```

Data Preparation

- Clean Data
  - Remove duplicates

```
//Duplicate Detection
RemoveDuplicates filter = new RemoveDuplicates();
filter.setInputFormat(housing_expensive);

Instances housing_nodup = Filter.useFilter(housing_expensive, filter);
//System.out.println(filteredData);
```

  - Remove missing values

```
//Remove missing values
housing_nodup.removeIf(Instance::hasMissingValue);
```

  - Rename variable

```
//Rename Attribute
housing_nodup.renameAttribute( att: 5, name: "rooms");
//System.out.println(housing_expensive);
```

- Make new data

```
//Create new data
AddExpression addExpressionFilter = new AddExpression();
addExpressionFilter.setExpression("a5 / a4");
addExpressionFilter.setName("price_per_sqrm");
addExpressionFilter.setInputFormat(housing_nodup);

Instances housing_prepared = Filter.useFilter(housing_nodup, addExpressionFilter);
System.out.println(housing_prepared);
```

Data Preparation

- Train/Test Split

```
//Split Data set into training/test data set
housing.setClassIndex(housing.numAttributes() - 1);

int seed = 42;

double trainPercentage = 80.0;

housing.randomize(new Random(seed));

int trainSize = (int) Math.round(housing.numInstances() * trainPercentage / 100.0);
int testSize = housing.numInstances() - trainSize;

Instances trainData = new Instances(housing,  first: 0, trainSize);
Instances testData = new Instances(housing, trainSize, testSize);

//System.out.println(trainData);
//System.out.println(testData);
```

Linear Regression

- Regression

- Types:
  - Simple Linear Regression
  - Multiple Linear Regression

- Evaluation:
  - Root Mean Squared Error (RMSE)

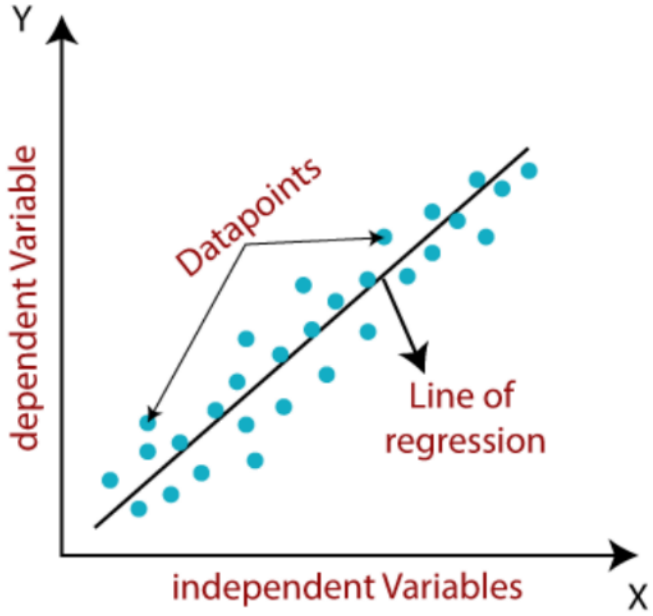


Figure 2: Linear Regression
Source: ("Linear Regression in Machine learning - Javatpoint," n.d.)

- Price = 1138.9569 * SquareMeters + 57701.7943 * Bathrooms + 1570.6529
- RMSE = 20315.711

Linear Regression

```
//Calculate Linear Regression
LinearRegression lr = new LinearRegression();
trainData.setClassIndex(trainData.numAttributes() - 1);
lr.buildClassifier(trainData);
System.out.println(lr);

//Evaluate Model
Evaluation eval = new Evaluation(trainData);
testData.setClassIndex(testData.numAttributes()-1);
eval.evaluateModel(lr, testData);
System.out.println(eval.toSummaryString());
```

Logistic Regression

- Classification

- Types:
  - Binomial
  - Multinomial
  - Ordinal

- Evaluation:
  - Confusion Matrix

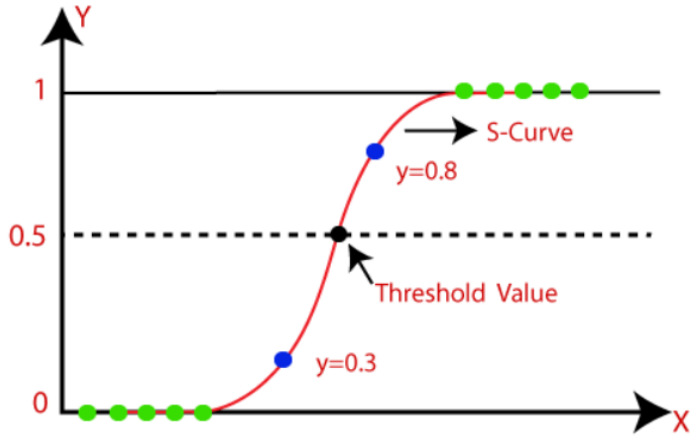


Figure 3: Logistic Regression
Source: ("Logistic Regression in Machine Learning - Javatpoint," n.d.)

```
=== Confusion Matrix ===

 a b   <-- classified as
 2 1 | a = yes
 2 1 | b = no
```

Decision tree & Random Forest

- Regression / Classification

- Process:
  - Root node with all data
  - Detect best attribute
  - Divide data set based on attribute
  - Repeat

- Pruning the tree

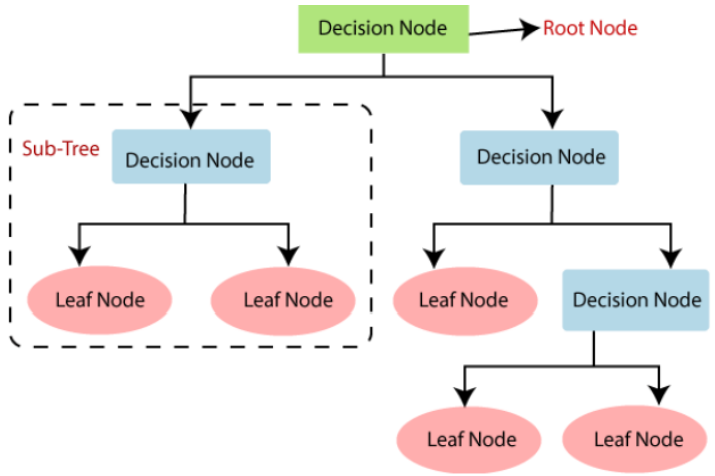


Figure 4: Decision Tree
Source: ("Decision Tree Algorithm in Machine Learning - Javatpoint," n.d.)

- Multiple Decision Trees = Random Forrest

Support Vector Machine

- Regression / Classification

- Types:
  - Linear SVM
  - Non-linear SVM

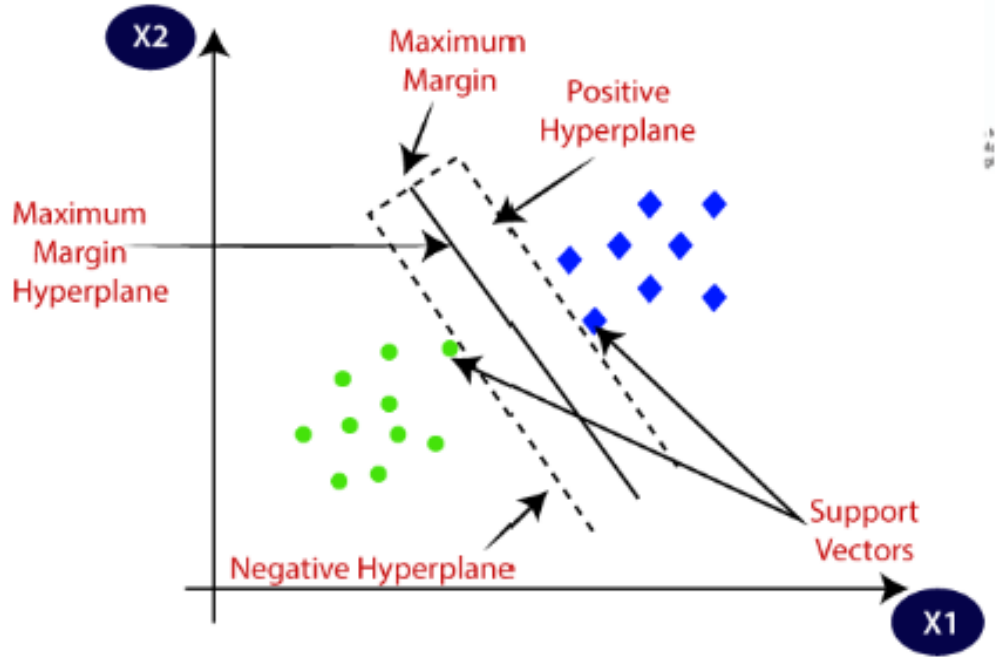


Figure 6: Support Vector Machine
Source: ("Support Vector Machine (SVM) Algorithm - Javatpoint," n.d.)

Naive Bayes

- Classification
- Naive
  - No dependencies between attributes
- Bayes
  - Bayes Theorem

$$P(A|B) = \frac{P(B|A)\,P(A)}{P(B)}$$

K-Nearest Neighbor

- Regression / Classification

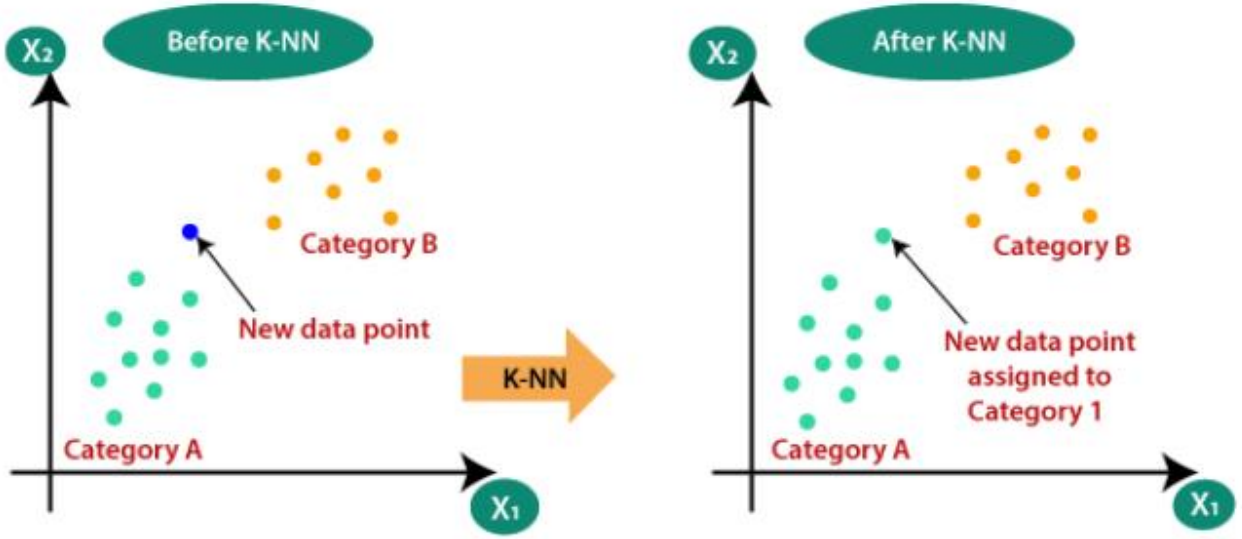


Figure 7: K-Nearest Neighbor
Source: ("K-Nearest Neighbor(KNN) Algorithm for Machine Learning - Javatpoint," n.d.)

Principal Components Analysis

- Problem with high dimensionality:
  - Increases complexity
  - Hard to visualize
- Solution: Dimensionality Reduction
- Dimensions:
  - No correlation between them
  - Principal components decrease in importance

```
//Calculate PCA
PrincipalComponents pca = new PrincipalComponents();

// Apply the filter to the data
pca.setInputFormat(housing);
Instances transformedData = Filter.useFilter(housing, pca);
System.out.println(transformedData);
```

K-Means Clustering

- Clustering

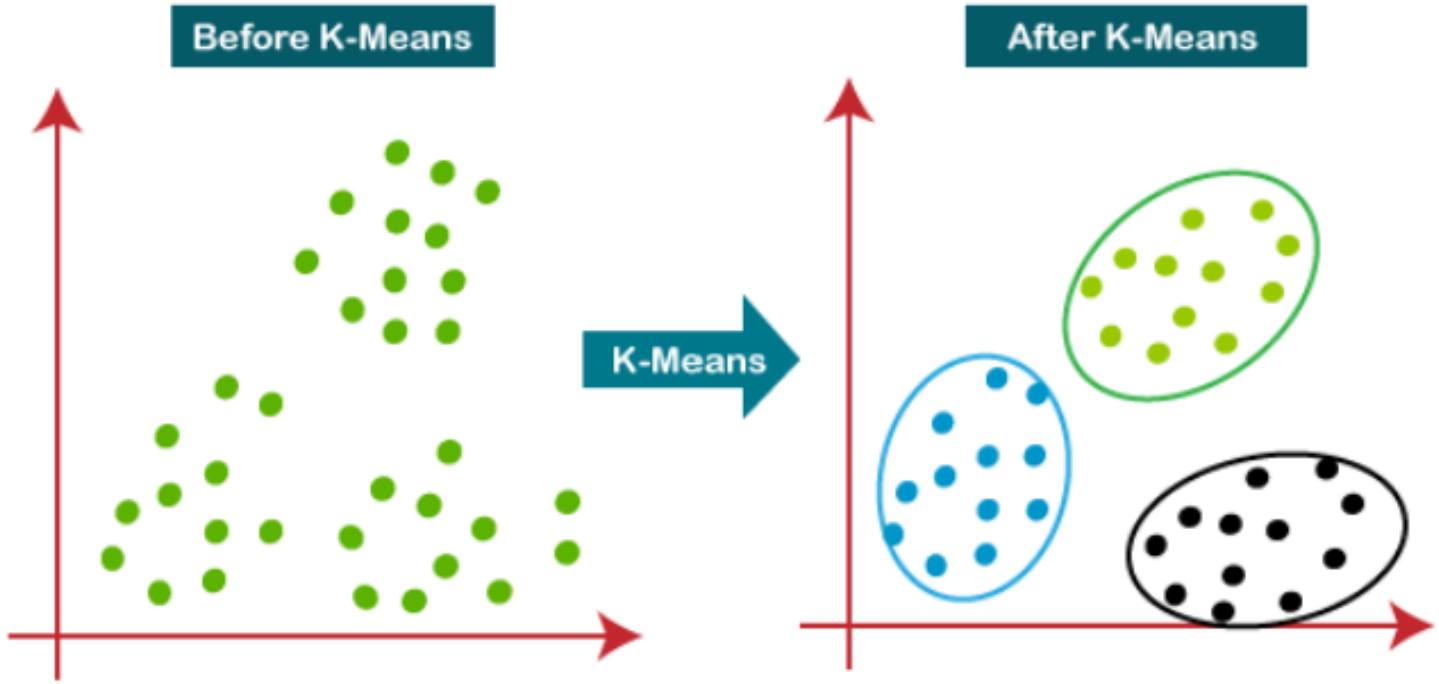


Figure 8: K-Nearest Neighbor
Source: ("K-Means Clustering Algorithm - Javatpoint," n.d.)

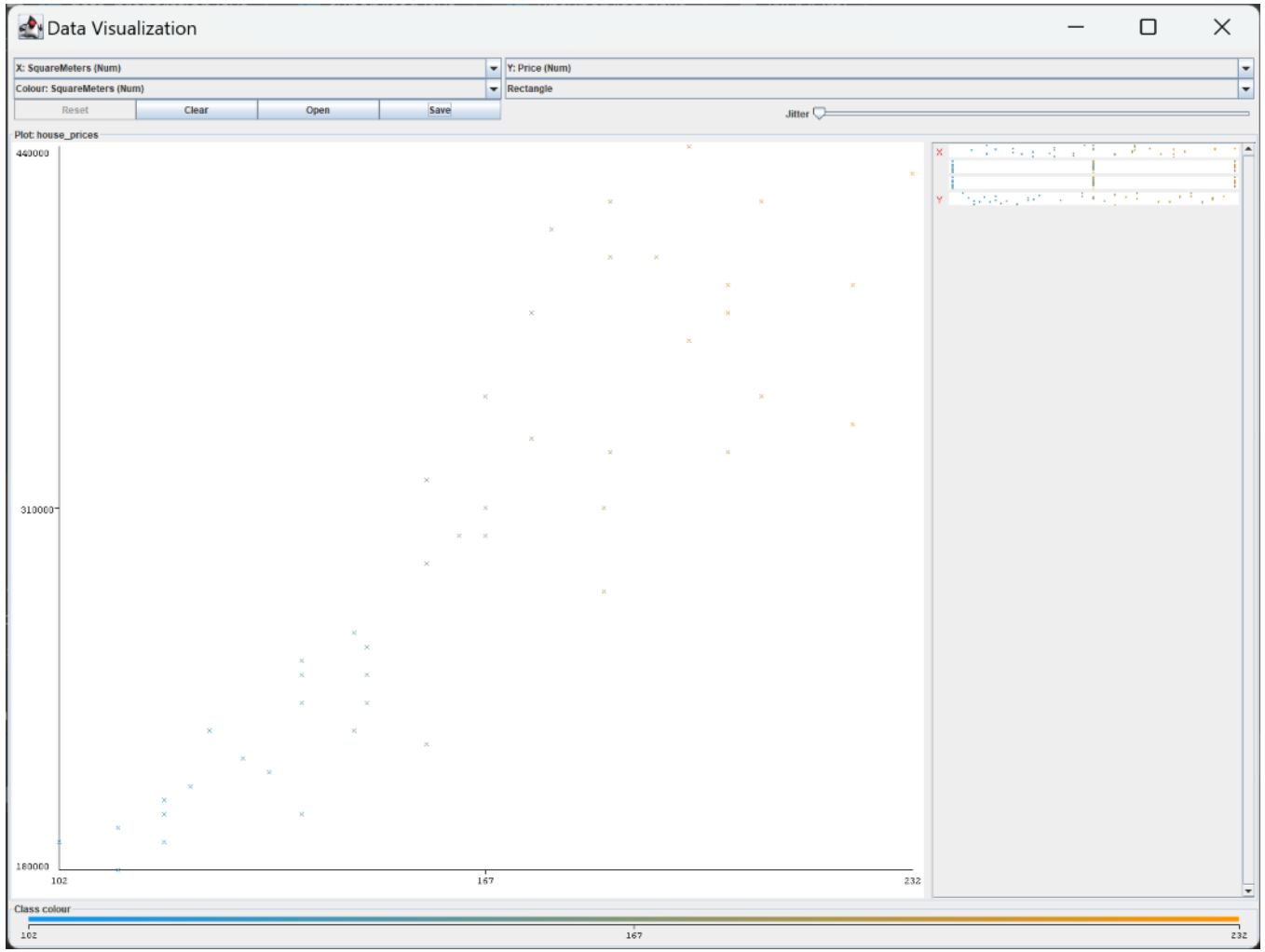
Data Visualization

- Making the results understandable for everyone

```
//DATA VISUALIZATION
// Create the plot data
PlotData2D plotData = new PlotData2D(housing);
plotData.setPlotName("DATA");

// Create the visualization panel
VisualizePanel panel = new VisualizePanel();
panel.addPlot(plotData);

// Create a JFrame to hold the visualization panel
JFrame frame = new JFrame( title: "Data Visualization");
frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
frame.setSize( width: 1600,  height: 1200);
frame.getContentPane().add(panel);
frame.setVisible(true);
```



Thank you for your attention!