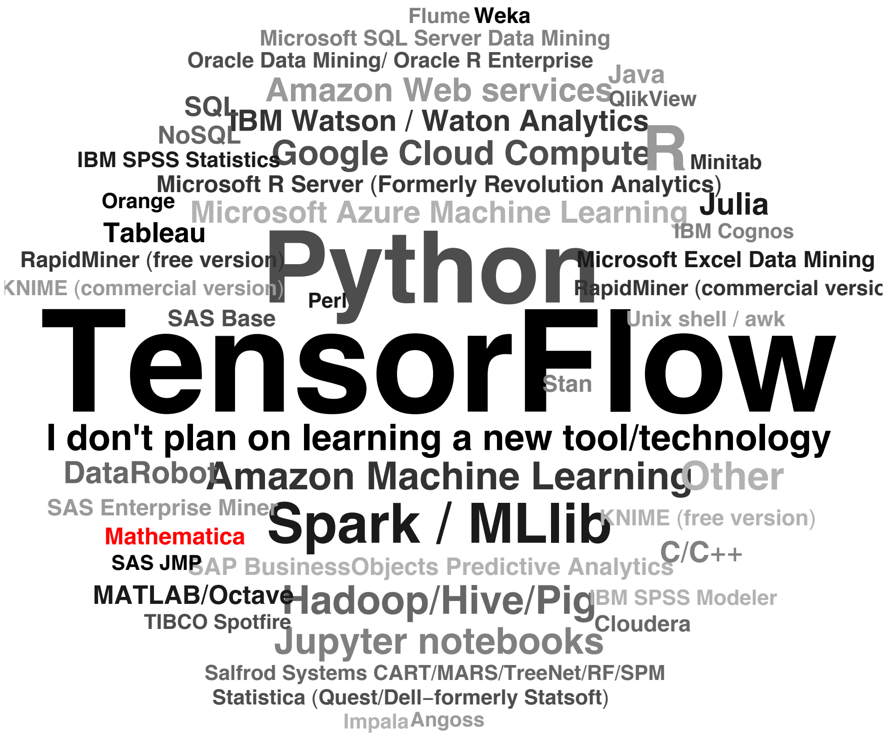
Mathematica Project: Exploratory Data Analysis on ‘**Data Scientists**’

A big picture view of the state of data scientists and machine learning engineers.


Flume
Weka
Microsoft SQL Server Data Mining
Oracle Data Mining/ Oracle R Enterprise
Java
Amazon Web services
QlikView
SQL
IBM Watson / Waton Analytics
NoSQL
R
IBM SPSS Statistics
Google Cloud Compute
Minitab
Microsoft R Server (Formerly Revolution Analytics)
Orange
Julia
Microsoft Azure Machine Learning
Tableau
IBM Cognos
RapidMiner (free version)
Python
Microsoft Excel Data Mining
KNIME (commercial version)
Perl
RapidMiner (commercial versic
SAS Base
Unix shell / awk
TensorFlow
Stan
I don't plan on learning a new tool/technology
DataRobot
Amazon Machine Learning
Other
SAS Enterprise Miner
Spark / MLlib
KNIME (free version)
Mathematica
C/C++
SAS JMP
SAP BusinessObjects Predictive Analytics
MATLAB/Octave
Hadoop/Hive/Pig
IBM SPSS Modeler
TIBCO Spotfire
Cloudera
Jupyter notebooks
Salfrod Systems CART/MARS/TreeNet/RF/SPM
Statistica (Quest/Dell–formerly Statsoft)
Impala
Angoss

In this Mathematica project, we will explore the capabilities of Mathematica to better understand the state of data science enthusiasts. The dataset consisting of more than 10,000 rows is obtained from Kaggle, which is a result of ‘Kaggle Survey 2017’. We will explore various capabilities of Mathematica in Data Analysis and Data Visualizations. Further, we will utilize Machine Learning techniques to train models and Classify features with several algorithms, such as Nearest Neighbors, Random Forest.

Dataset : https : // www.kaggle.com/kaggle/kaggle - survey - 2017

Introduction

Data science is a “concept to unify statistics, data analysis, machine learning and their related methods” in order to “understand and analyze actual phenomena” with data. It employs tech-

niques and theories drawn from many fields within the context of mathematics, statistics, information science, and computer science.
Since we are learning Data Science and Mathematica, it makes sense that we dig deeper in the current trends and the state of Data Scientists around the world. The dataset consisting of more than 16,000 rows is obtained from Kaggle, which is a result of ‘Kaggle Survey 2017’. With this dataset, we will explore the capabilities of Mathematica to gain insights n the data. Firstly, we will dive into Data Analysis and Data Visualization. Further, we will utilize Machine Learning techniques to train models and Classify features with several algorithms, such as Logistic Regression and Neural Network.

Let us import our Dataset using **Dataset** function and see what our data is.

```
In[•]:= DatasetCSV = Import["/ABHI/Workspace/Study/UCD/SEM 1/MATHEMATICA FOR
           RESEARCH/Project/EDA-Data-Scientists/Dataset/multipleChoiceResponses.csv"];
        header = DatasetCSV[[1]];
        data = DatasetCSV[[2 ;;]];
        DataSet = Thread[header → #] & /@ data // Map[Association] // Dataset
```

Out[•]=

Gen	Cou	Age	Emp
Non-binary,		NA	Employed full-time
Female	United States	30	Not employed, but looking for work
Male	Canada	28	Not employed, but looking for work
Male	United States	56	Independent contractor, freelancer, or self-employe
Male	Taiwan	38	Employed full-time
Male	Brazil	46	Employed full-time
Male	United States	35	Employed full-time
Female	India	22	Employed full-time
Female	Australia	43	Employed full-time
Male	Russia	33	Employed full-time
Female	Russia	20	Not employed, and not looking for work
Male	India	27	Employed full-time
Male	Brazil	26	Employed full-time
Male	Netherlands	54	Employed full-time
Male	Taiwan	26	Employed full-time
Male	United States	58	Independent contractor, freelancer, or self-employe
Male	Italy	58	Employed full-time
Male	United Kingdom	24	Employed full-time
Male	United States	26	Not employed, but looking for work
Male	Brazil	39	Not employed, but looking for work

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Parameters

We have 16000+ rows and 200+ columns. Of all the columns, we are particularly interested in the following:

- Gender: Gender of the individuals.
- Country: Native country of the person.
- Age: Individual’s Age in years.
- Employment Status: Indicating their occupation.
- Language: The most used programming language for Data Science.
- JobTitle: Their Job Title.
- Education: Their most recent degree.
- Major: Their Major in College/University.
- Tenure: Their experience in Data Science in years.
- CompensationAmount: Their annual salary.
- CompensationCurrency: Currency of salary.
- MLTool: Preferred Machine Learning technology.
- CoursePlatform: Preferred Platform for learning.

Data Analysis

Data Duplication Removal

As the first step of Analysis, let us remove the duplicate rows so that we can better analyze the data:

```
In[•]:= OriginalLength = Length[DataSet];
        DataSet = DeleteDuplicates[DataSet];
        NewLength = Length[DataSet];
        OriginalLength - NewLength

Out[•]= 321
```

We removed 321 duplicated rows.

Dealing with Empty values

Now that we have removed duplicated data, let us deal with the empty values in the dataset.
While we visualize data, it is inconvenient to have empty values in the data.
So, we have a function to remove the empty values:

```
In[•]:= RemoveEmptyElements[list_] :=
          Module[{returnList = {}},
           Quiet[For[i = 0, i < Length[list], i++,
             If[StringLength[list[[i]]] > 0,
              AppendTo[returnList, list[[i]]]]]];
           returnList];
```

Now that we have our function in place, we will use this while we visualize data.

Salary Normalization

Notice that the Salaries (Column CompensationAmount) of Data Scientists are in different currencies (CompensationCurrency). To be able to visualize this and for Machine Learning, it is fair that all the salaries are in the same currencies. So, Let us convert all the salaries to USD so that we can standardize the currency.
The currency conversion rates are in another Dataset file. Let us import it and convert all our currencies to USD:

```
In[∘]:= CurrencyDatasetCSV = Import["/ABHI/Workspace/Study/UCD/SEM 1/MATHEMATICA FOR
             RESEARCH/Project/EDA-Data-Scientists/Dataset/conversionRates.csv"];
        CurrencyHeader = CurrencyDatasetCSV[[1]];
        CurrencyData = CurrencyDatasetCSV[[2 ;;]];
        CurrencyDataSet =
          Thread[CurrencyHeader → #] & /@ CurrencyData // Map[Association] // Dataset
```

Out[∘]=

	originCountry	exchangeRate
1	USD	1
2	EUR	1.19583
3	INR	0.01562
4	GBP	1.32419
5	BRL	0.32135
6	RUB	0.017402
7	CAD	0.823688
8	AUD	0.80231
9	JPY	0.009108
10	CNY	0.153
11	PLN	0.281104
12	SGD	0.742589
13	ZAR	0.077002
14	CHF	1.04338
15	MXN	0.056414
16	TWD	0.033304
17	COP	0.000342
18	PKR	0.009476
19	TRY	0.29178
20	DKK	0.16073

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Let us create a list with Standardized salaries (All salaries in USD):

```
In[•]:= NormalizedSalaryList = {};
        For[i = 1, i ≤ Length[DataSet[All, "CompensationAmount"]], i++,
         If[StringLength[DataSet[All, "CompensationCurrency"][[i]]] > 0,
           Multiplier = CurrencyDataSet[SelectFirst[#originCountry ==
                Normal[DataSet[All, "CompensationCurrency"][[i]]] &], "exchangeRate"];
           AppendTo[NormalizedSalaryList, Times[Multiplier,
             Normal[DataSet[All, "CompensationAmount"][[i]]]]],
           AppendTo[NormalizedSalaryList, 0]
          ];
        ]
```

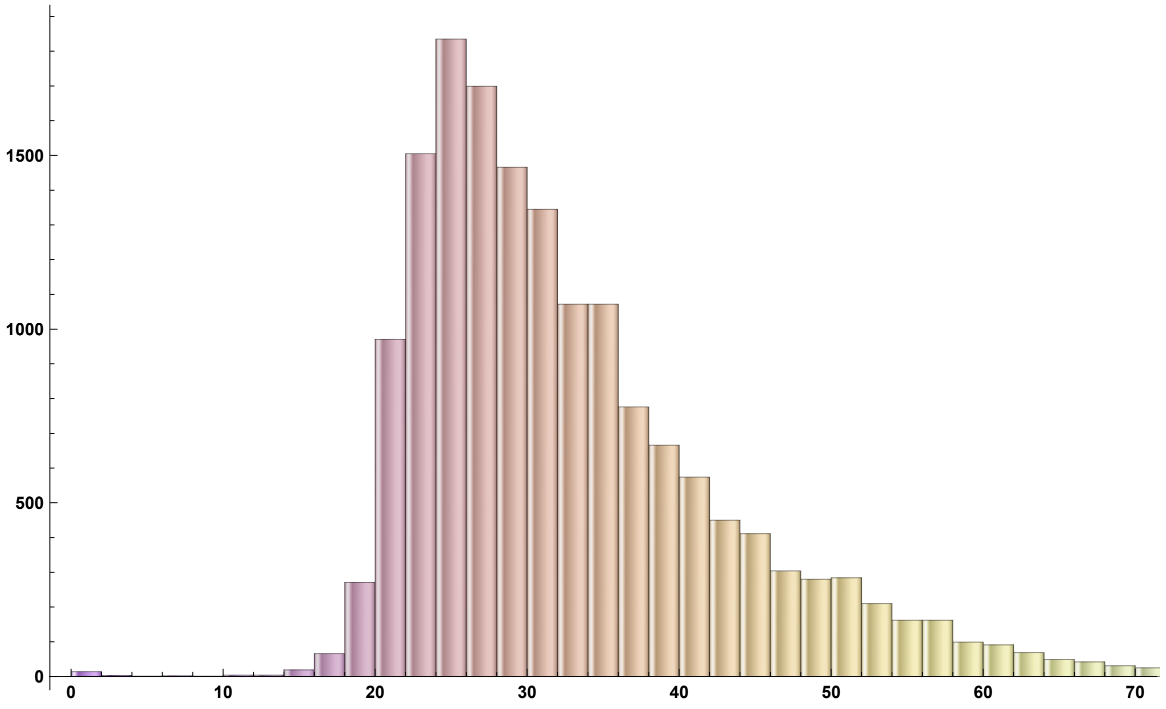
We will use this list **NormalizedSalaryList** in Machine Learning later.

Data Visualization

Let us have a look at the age of Data Scientists:

```
In[•]:= Histogram[DataSet[All, "Age"], 30,
         ChartStyle → {"Pastel"},
         ChartLabels → Automatic,
         ChartElementFunction → "GlassRectangle",
         AxesLabel → Automatic,
         ImageSize → {600, 400}]
```

Out[•]=

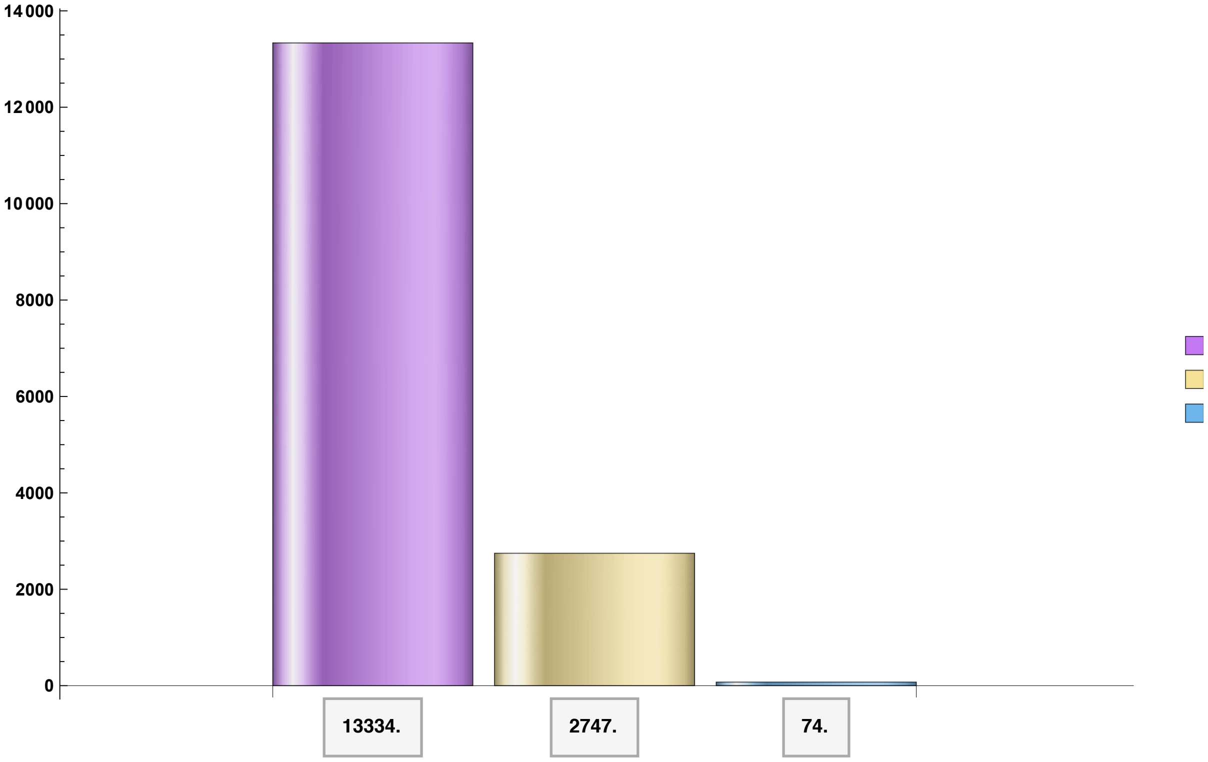


We can infer that the median age is between 20 and 35 years.

Gender diversification of Data Scientists:

```
In[∘]:= BarChart[Reverse[Sort[Counts[DataSet[All, "GenderSelect"]][[ ;; 3]]]],
         ChartElementFunction → "GlassRectangle",
         ChartStyle → "Pastel",
         ImageSize → {600, 400},
         ChartLegends → Automatic,
         LabelingFunction → (Placed[Panel[NumberForm[N@#1]], Below] &)]
```

Out[∘]=

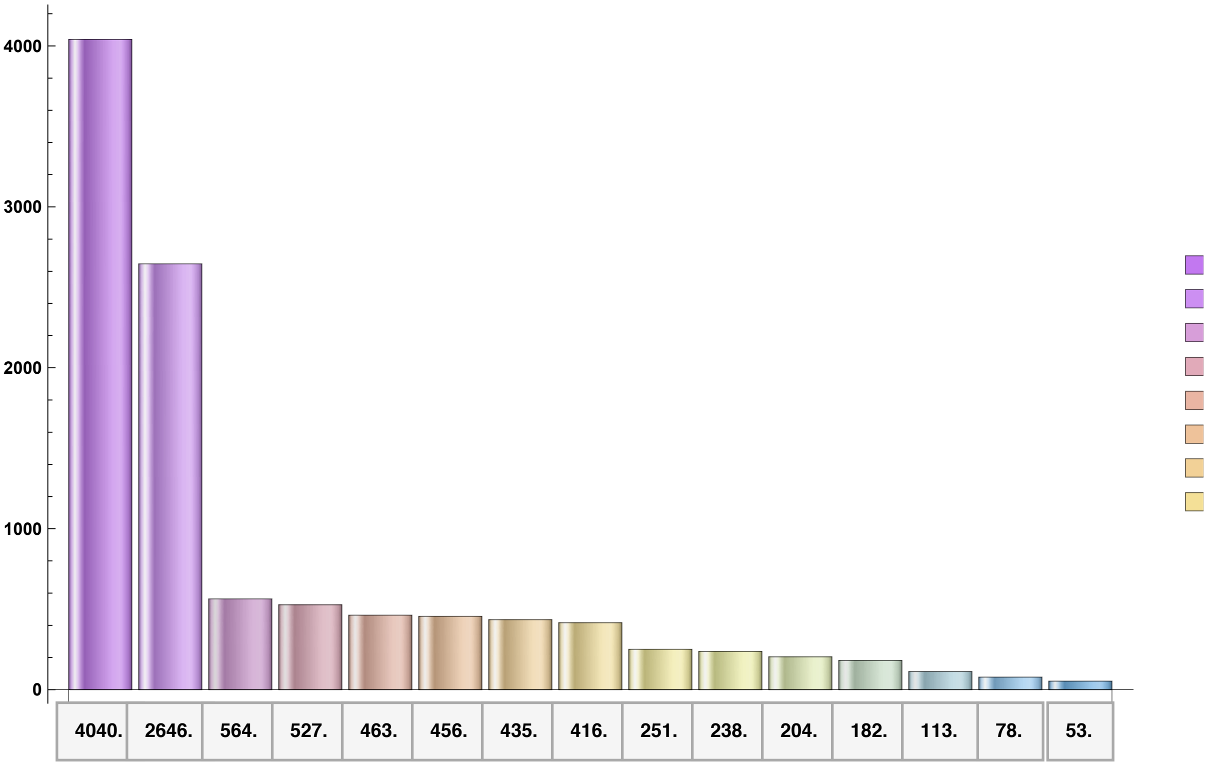


While most of the Data Scientists are Male, Females are picking up in the recent years.

Coming to the distribution of Data Scientists around the world, here are the top 15 countries with maximum number of Data Science enthusiasts:

```
In[•]:= BarChart[
         Reverse[Sort[Counts[RemoveEmptyElements[DataSet[All, "Country"]]][[ ;; 15]]]],
         ChartLegends → Automatic,
         ChartElementFunction → "GlassRectangle",
         ChartStyle → "Pastel",
         ImageSize → {600, 400},
         LabelingFunction → (Placed[Panel[NumberForm[N@#1]], Below] &)]
```

Out[•]=

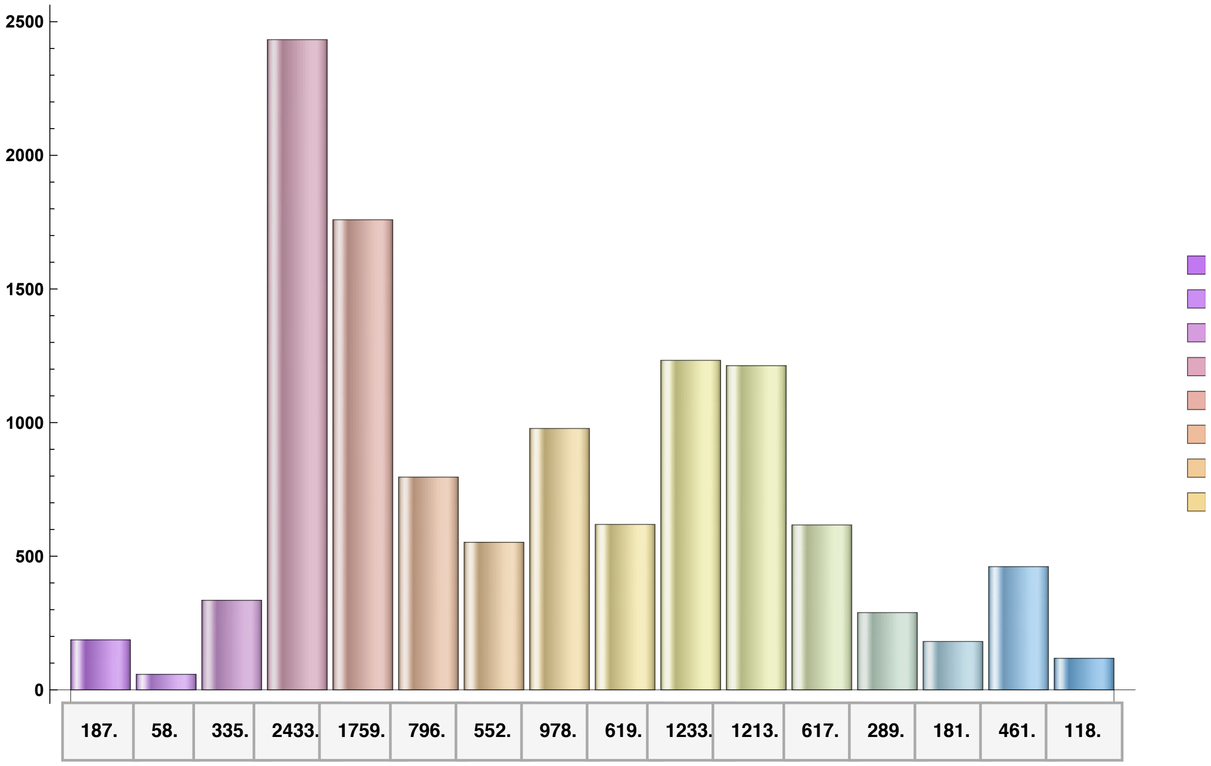


Most of them are concentrated in United States and India.
Also, notice that we have used our function **RemoveEmptyElements[]** to remove entries that are empty.

Regarding the Job Titles:

```
In[•]:= Jobs = RemoveEmptyElements[Normal[DataSet[All, "CurrentJobTitleSelect"]]];
        BarChart[Counts[Jobs],
         ChartLegends → Automatic,
         ChartElementFunction → "GlassRectangle",
         ChartStyle → "Pastel",
         ImageSize → {600, 400},
         LabelingFunction → (Placed[Panel[NumberForm[N@#1]], Below] &)]
```

Out[•]=

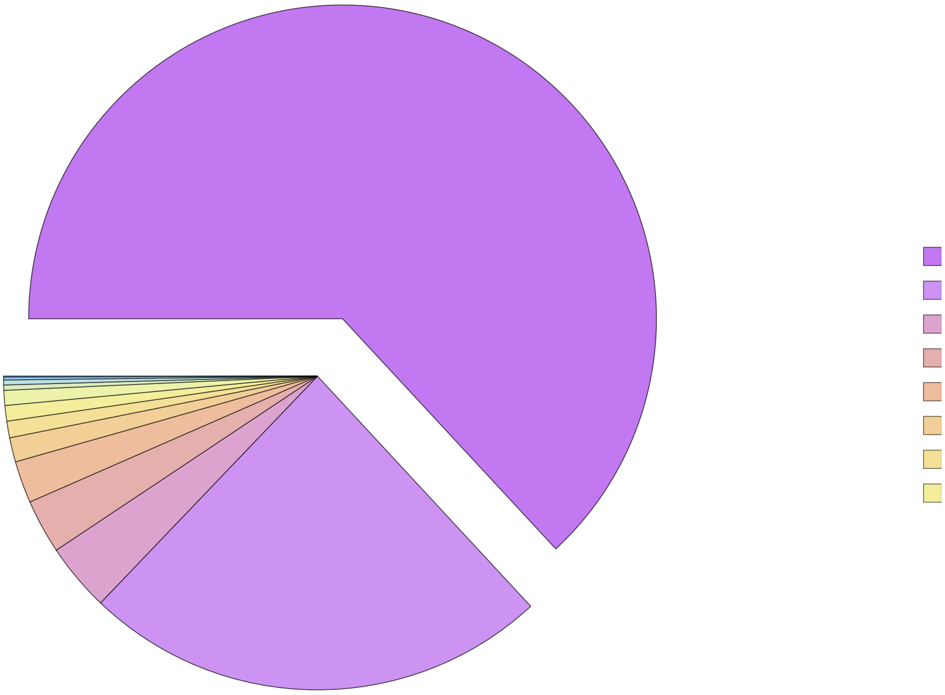


Most have “Data Scientist” and “Software Developer/Software Engineer” as the Job Position.

The most preferred programming language:

```
In[•]:= Languages =
          RemoveEmptyElements[Normal[DataSet[All, "LanguageRecommendationSelect"]]];
        PieChart[Reverse[Sort[Counts[Languages]]],
         ChartLegends → Automatic,
         ChartStyle -> "Pastel",
         ImageSize → {600, 400},
         LabelingFunction → (Placed[Panel[NumberForm[N@#1]], Below] &)]
```

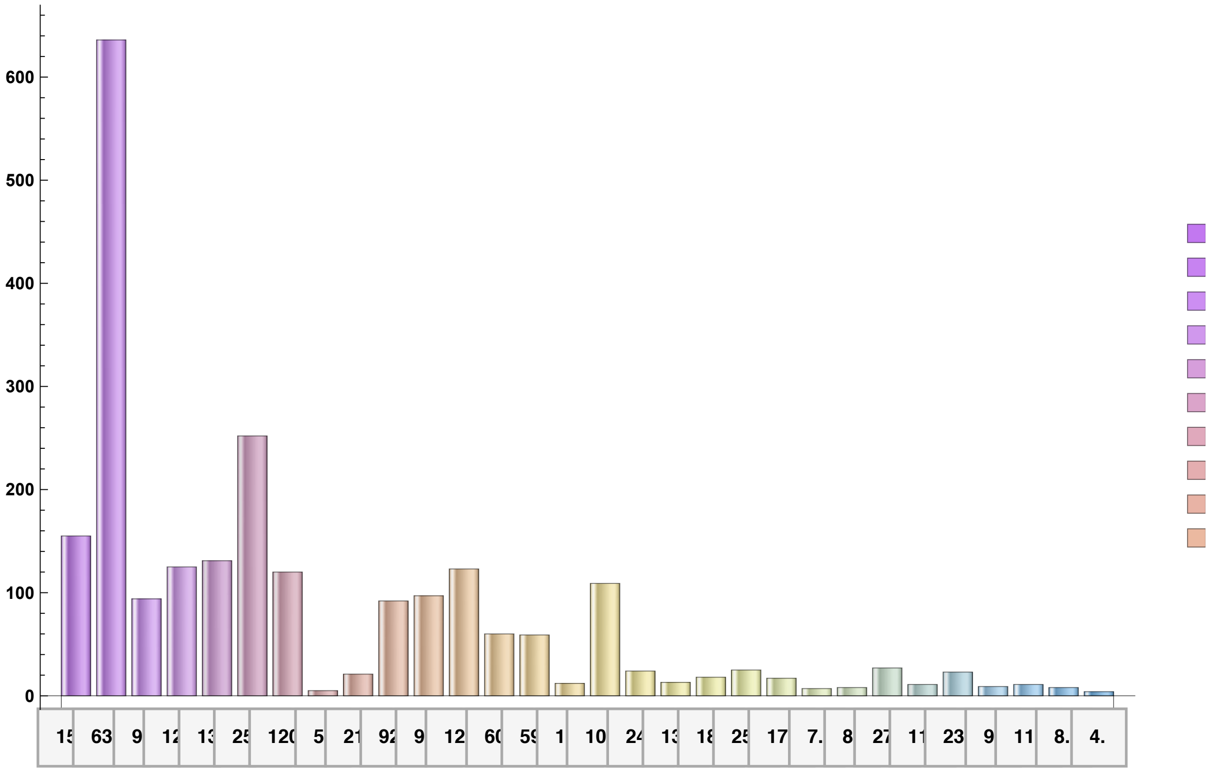
Out[•]=



More than half use Python as their primary language and around 25% use R.

```
In[•]:= Jobs = RemoveEmptyElements[Normal[DataSet[All, "CoursePlatformSelect"]]];
        BarChart[Counts[Jobs],
         ChartLegends → Automatic,
         ChartElementFunction → "GlassRectangle",
         ChartStyle → "Pastel",
         ImageSize → {600, 400},
         LabelingFunction → (Placed[Panel[NumberForm[N@#1]], Below] &)]
```

Out[•]=

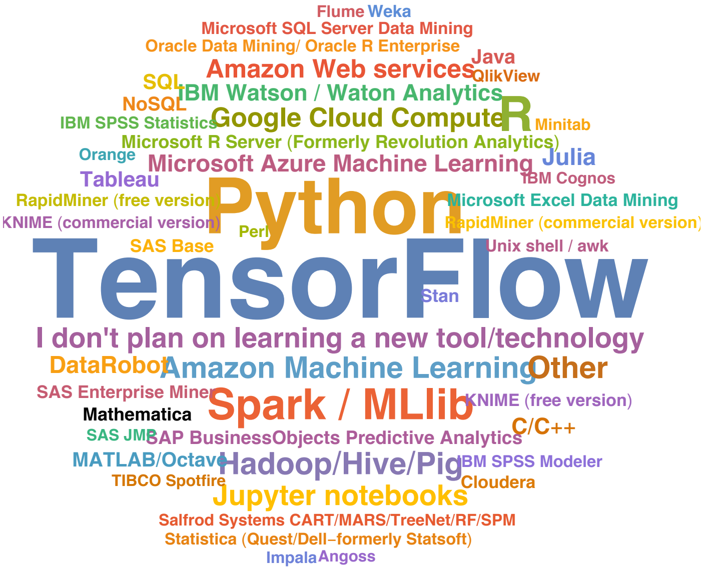


Many people prefer “Coursera” to learn Data Science.

Here is a Word Cloud of the most used Machine Learning Technologies:

```
In[•]:= WordCloud[RemoveEmptyElements[Normal[DataSet[All, "MLToolNextYearSelect"]]]] /.
         "Mathematica" → Style["Mathematica", Bold, Black]
```

Out[•]=

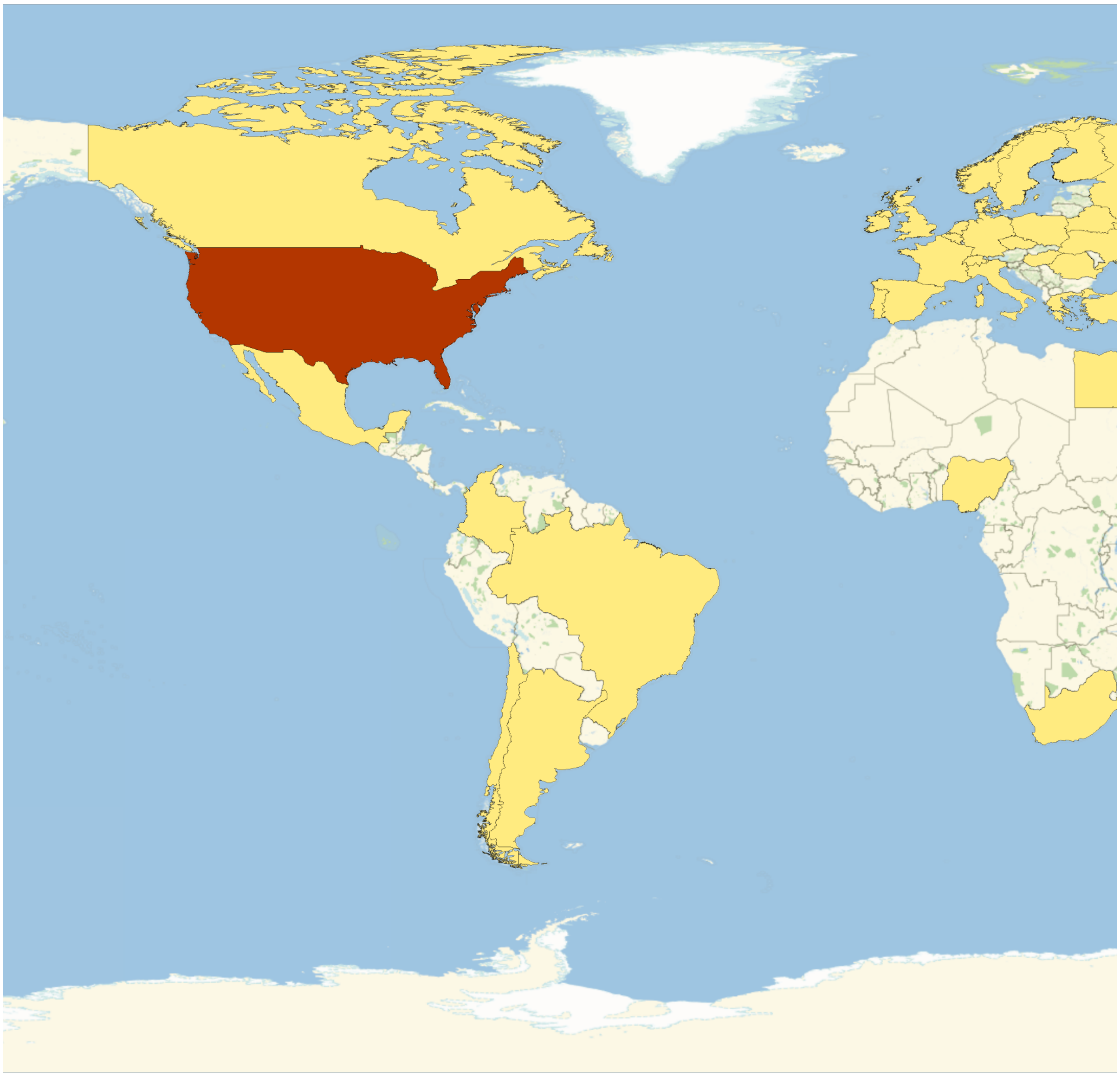


We notice that even Mathematica is used for Machine Learning (Marked in Black). TensorFlow, Python and R are used a lot.

Let us have a look at the map of countries, with most number of Data Scientists:

```
In[•]:= CountryList = RemoveEmptyElements[DataSet[All, "Country"]];
        CountryList /. "People 's Republic of China" → "China";
        For[i = 0, i < Length[CountryList], i++,
          Country[CountryList[[i]]] = Count[CountryList, CountryList[[i]]]
         ];
        CountryValueList = {};
        For[i = 0, i < Length[CountryList], i++,
          AppendTo[CountryValueList,
           Interpreter["Country"][CountryList[[i]]] → Country[CountryList[[i]]]]
         ];
        GeoRegionValuePlot[Union[CountryValueList],
         ImageSize → {1200, 800},
         GeoLabels → (Tooltip[#1, #2] &)]
```

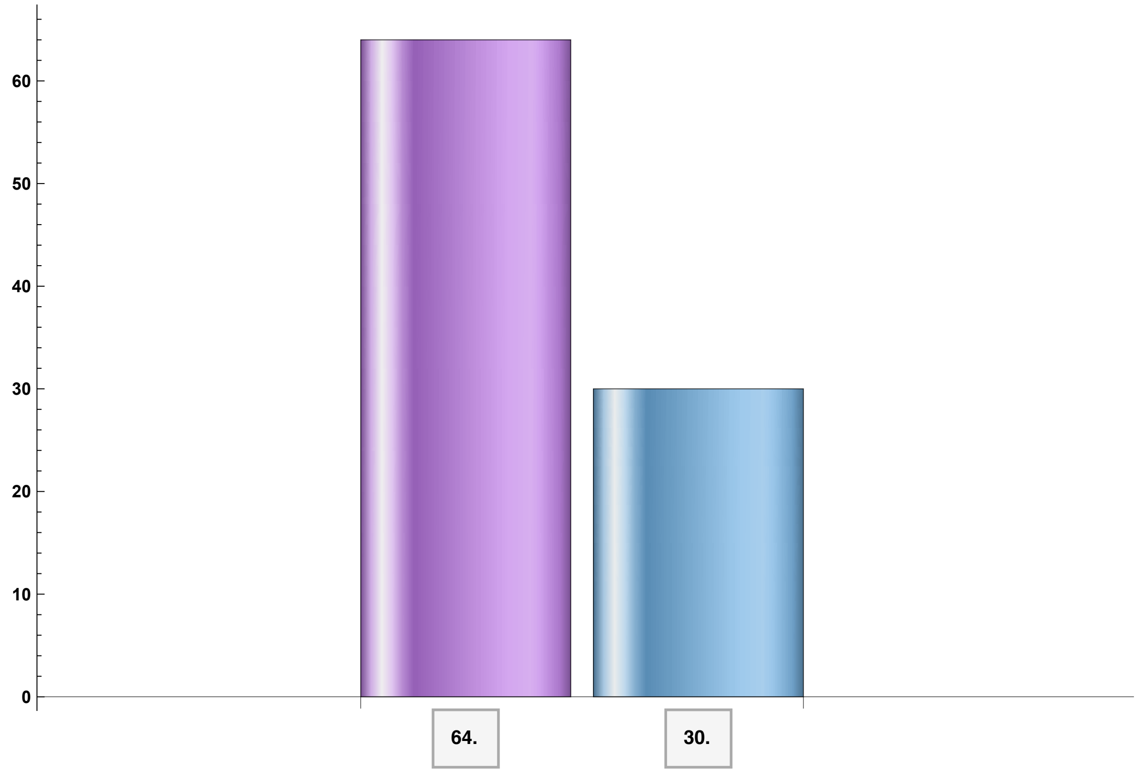
Out[ ]=



Let us look at some Statistics of Irish Data Scientists:

```
In[◦]:= BarChart[Reverse[
          Sort[Counts[DataSet[Select[#Country == "Ireland" &] , {"GenderSelect"}]]]],
        ChartLegends → Automatic,
        ChartElementFunction → "GlassRectangle",
        ChartStyle → "Pastel",
        ImageSize → {600, 400},
        ChartLegends → Automatic,
        LabelingFunction → (Placed[Panel[NumberForm[N@#1]], Below] &)]
```

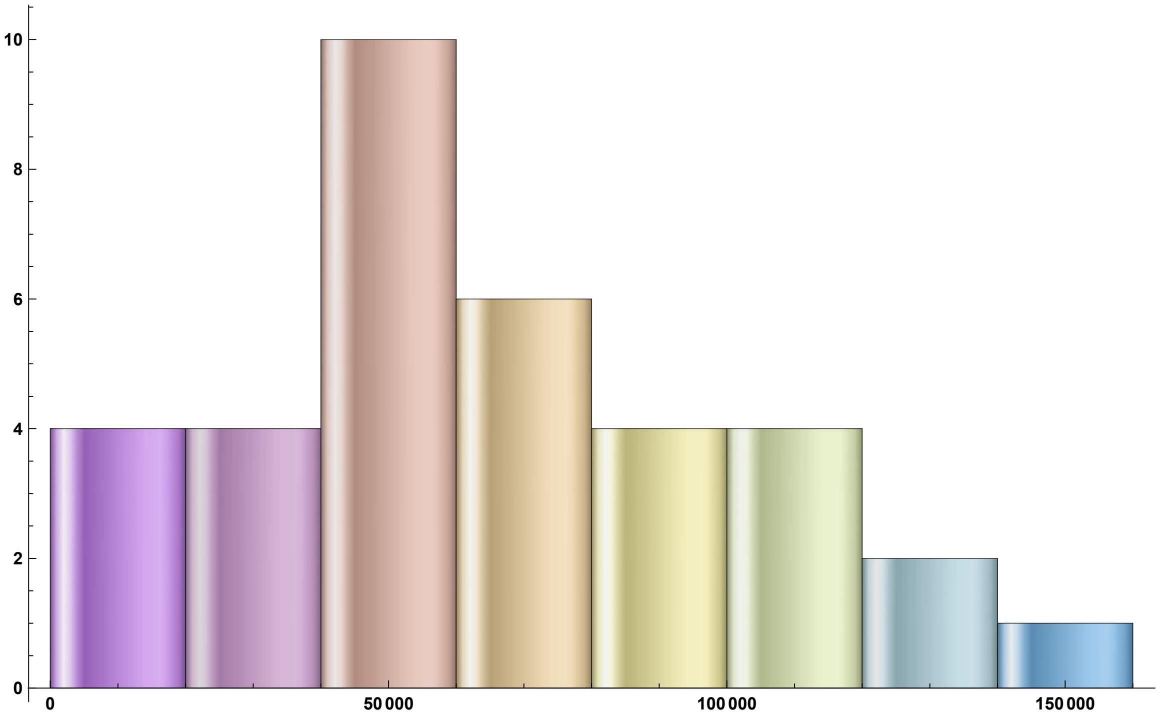
Out[◦]=



Following the global trend, around one third of Irish Data Scientists are women.

```
Histogram[DataSet[Select[#Country == "Ireland" &], "CompensationAmount"], 10,
 ChartStyle → {"Pastel"},
 ChartLabels → Automatic,
 ChartElementFunction → "GlassRectangle",
 AxesLabel → Automatic,
 ImageSize → {600, 400}]
```

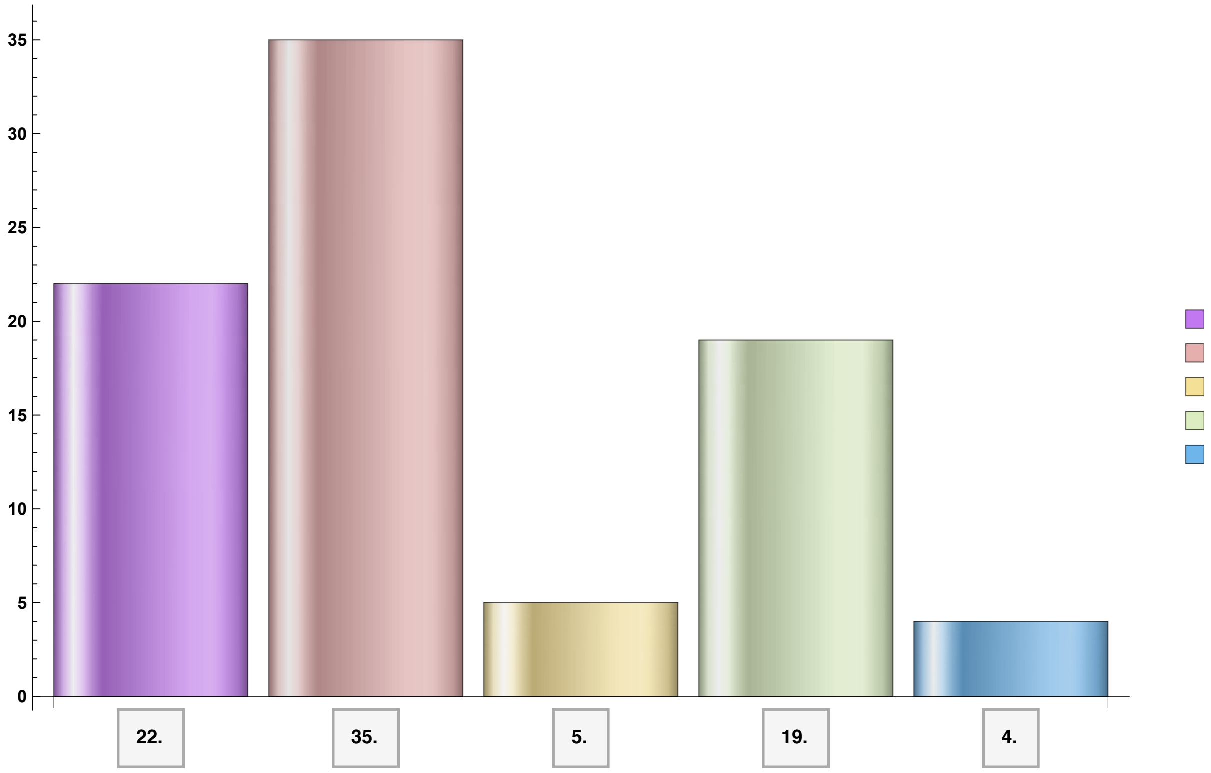
Out[ ]=



Coming to the Salary diversification, many have around EUR 50000 salary with wide variation till EUR 150000.

```
In[•]:= Edu = RemoveEmptyElements[
          Normal[DataSet[Select[#Country == "Ireland" &], "FormalEducation"]]];
        BarChart[Counts[Edu],
         ChartLegends → Automatic,
         ChartElementFunction → "GlassRectangle",
         ChartStyle → "Pastel",
         ImageSize → {600, 400},
         LabelingFunction → (Placed[Panel[NumberForm[N@#1]], Below] &)]
```

Out[•]=



Most Irish Data scientists have a Masters or a Bachelors degree.

Machine Learning

Preparation

Let us explore Machine Learning techniques in Mathematica.
We will try and classify the Salary in 3 classes based on all other parameters. Then, we predict the Salary class when the parameters are given.

Firstly, we will construct a dataset with the required columns:

```
In[•]:= DataSubSet =
         DataSet[All, {"GenderSelect", "Country", "Age", "CurrentJobTitleSelect",
           "LanguageRecommendationSelect", "FormalEducation", "MajorSelect",
           "Tenure", "CompensationAmount", "CompensationCurrency"}]
```

Out[•]=

GenderSelect	Country	Age
Non-binary, genderqueer, or gender non-conforming		NA
Female	United States	30
Male	Canada	28
Male	United States	56
Male	Taiwan	38
Male	Brazil	46
Male	United States	35
Female	India	22
Female	Australia	43
Male	Russia	33
Female	Russia	20
Male	India	27
Male	Brazil	26
Male	Netherlands	54
Male	Taiwan	26
Male	United States	58
Male	Italy	58
Male	United Kingdom	24
Male	United States	26
Male	Brazil	39

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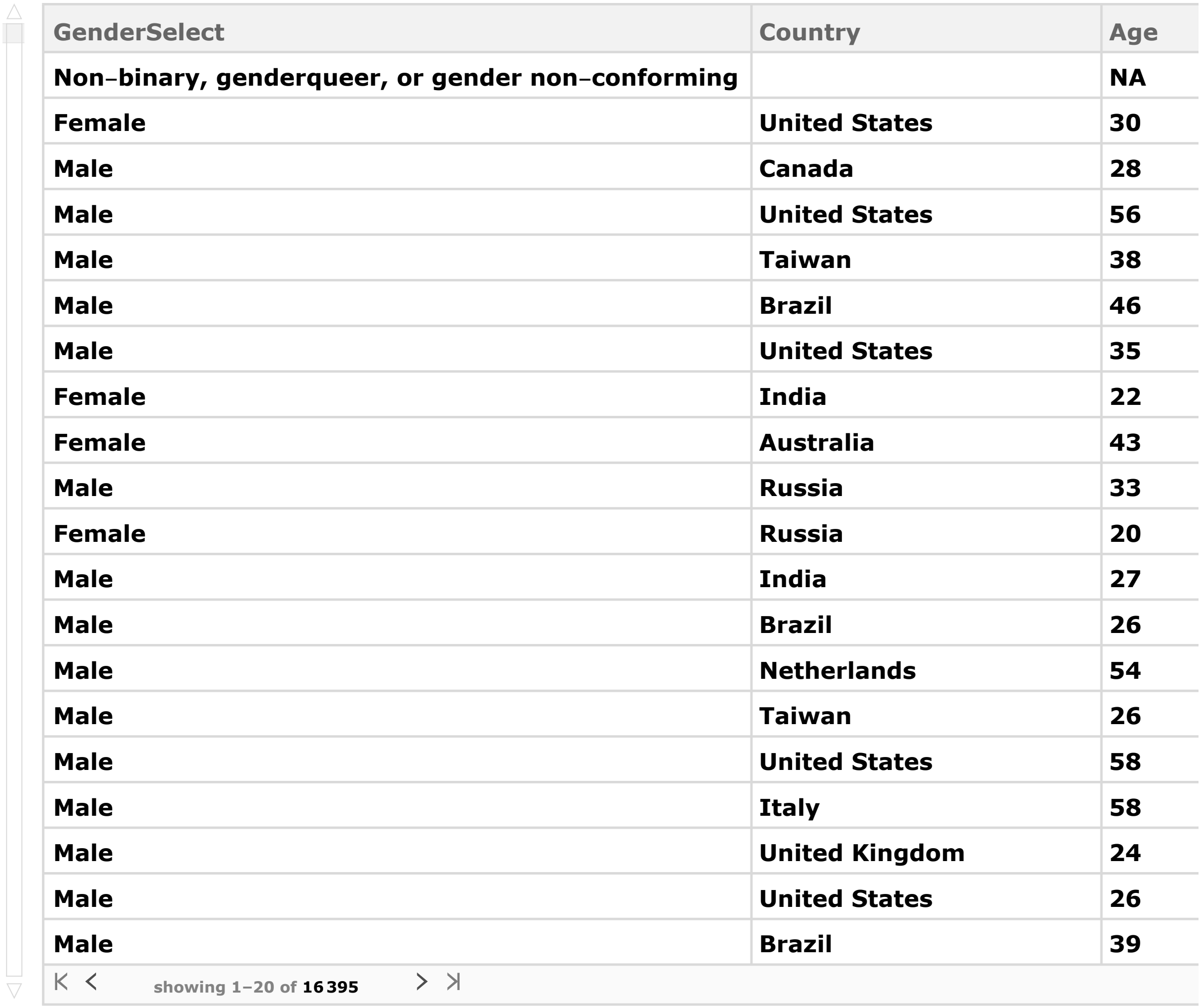
And add a new column with standardized salary: **StandardSalary**

```
In[•]:= DataSubSet = MapThread[Append, {Normal[DataSubSet],
          Thread["StandardSalary" → NormalizedSalaryList]}] // Dataset
```

Out[•]=



GenderSelect	Country	Age
Non-binary, genderqueer, or gender non-conforming		NA
Female	United States	30
Male	Canada	28
Male	United States	56
Male	Taiwan	38
Male	Brazil	46
Male	United States	35
Female	India	22
Female	Australia	43
Male	Russia	33
Female	Russia	20
Male	India	27
Male	Brazil	26
Male	Netherlands	54
Male	Taiwan	26
Male	United States	58
Male	Italy	58
Male	United Kingdom	24
Male	United States	26
Male	Brazil	39

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We will partition Salary into 3 levels:

```
In[•]:= SalaryClassify[x_] := If[StringLength[ToString[x]] > 0,
          Which[x < 25000, 1, 25000 < x < 100000, 2, x > 100000, 3, True, 0], 0]
```

```
In[•]:= ClassColumn = Map[SalaryClassify, NormalizedSalaryList] // Normal;
        For[i = 1, i ≤ Length[ClassColumn], i++,
         If[Length[Characters[ToString[ClassColumn[[i]]]]] > 1, ClassColumn[[i]] = 0,];
        ]
```

For erred values, we assign class 0.

Then, we add this column to our Dataset:

```
In[•]:= DataSubSet = MapThread[Append,
          {Normal[DataSubSet], Thread["Class" → ClassColumn]}] // Dataset;
```

Now, we will split our dataset into **Training** and **Test** Datasets with 70:30 ratio.

```
In[•]:= train = {};
        test = {};
        For[i = 1, i ≤ Length[DataSubSet], i++,
         If[RandomInteger[{1, Length[DataSubSet]}] < Length[DataSubSet] 70 / 100,
          AppendTo[train, Normal[DataSubSet[i, All]]],
          AppendTo[test, Normal[DataSubSet[i, All]]]]
        ]
        N[Length[train] / Length[DataSubSet]]
        N[Length[test] / Length[DataSubSet]]
        trainDataSet = Dataset[train];
        testDataSet = Dataset[test];

Out[•]= 0.698811

Out[•]= 0.301189
```

We prepare the Datasets for ML:

```
In[•]:= trainsetFeatures = trainDataSet[1 ;; Length[trainDataSet] - 2,
           {"GenderSelect", "Country", "Age", "CurrentJobTitleSelect",
            "LanguageRecommendationSelect", "FormalEducation",
            "MajorSelect", "Tenure", "StandardSalary", "Class"}];
        testsetFeatures = testDataSet[1 ;; Length[testDataSet] - 2, {"GenderSelect",
            "Country", "Age", "CurrentJobTitleSelect", "LanguageRecommendationSelect",
            "FormalEducation", "MajorSelect", "Tenure", "StandardSalary", "Class"}];
        trainsetFinal = Flatten[Normal@trainsetFeatures[
             1 ;; Length[trainDataSet] - 2, {Most@# → Last@#} &], 1];
        testsetFinal = Flatten[Normal@testsetFeatures[
             1 ;; Length[testDataSet] - 2, {Most@# → Last@#} &], 1];
```

Notice that we have removed columns “CompensationAmount” and “CompensationCurrency” since we have added Standardized Salary column.

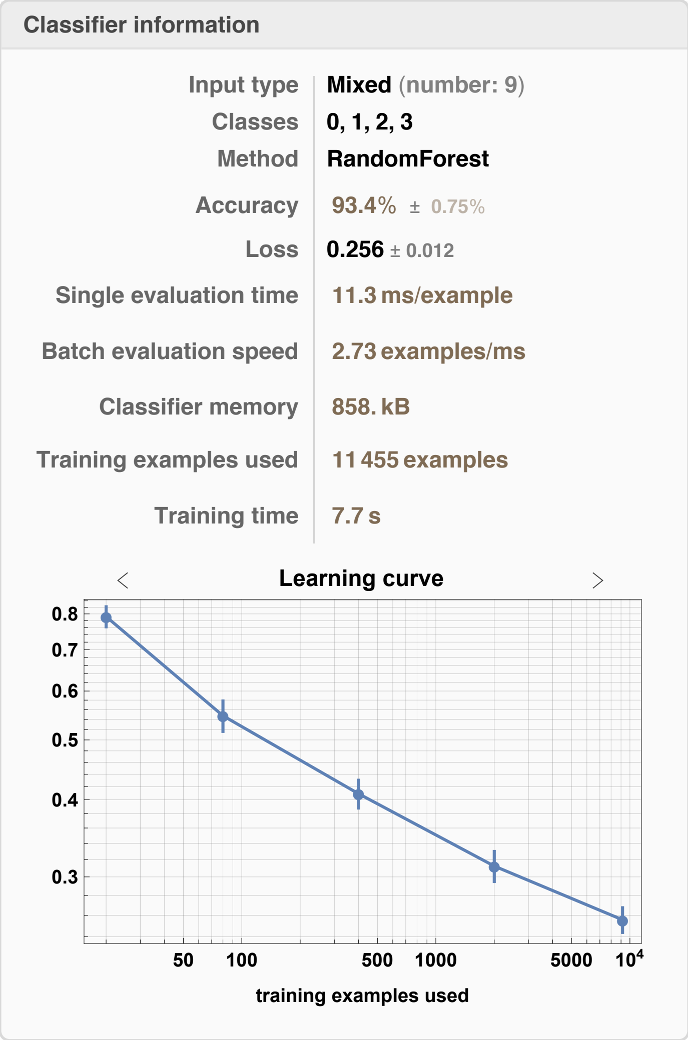
Classification

Now, we Classify with algorithms:

Random Forest:

```
In[•]:= algoRandomForest = Classify[trainsetFinal, Method → "RandomForest"];
        ClassifierInformation[algoRandomForest]
        MeasurementsRandomForest =
          ClassifierMeasurements[algoRandomForest, testsetFinal];
        ClassifierMeasurements[algoRandomForest, testsetFinal, "Accuracy"]
```

Out[•]=



Classifier information

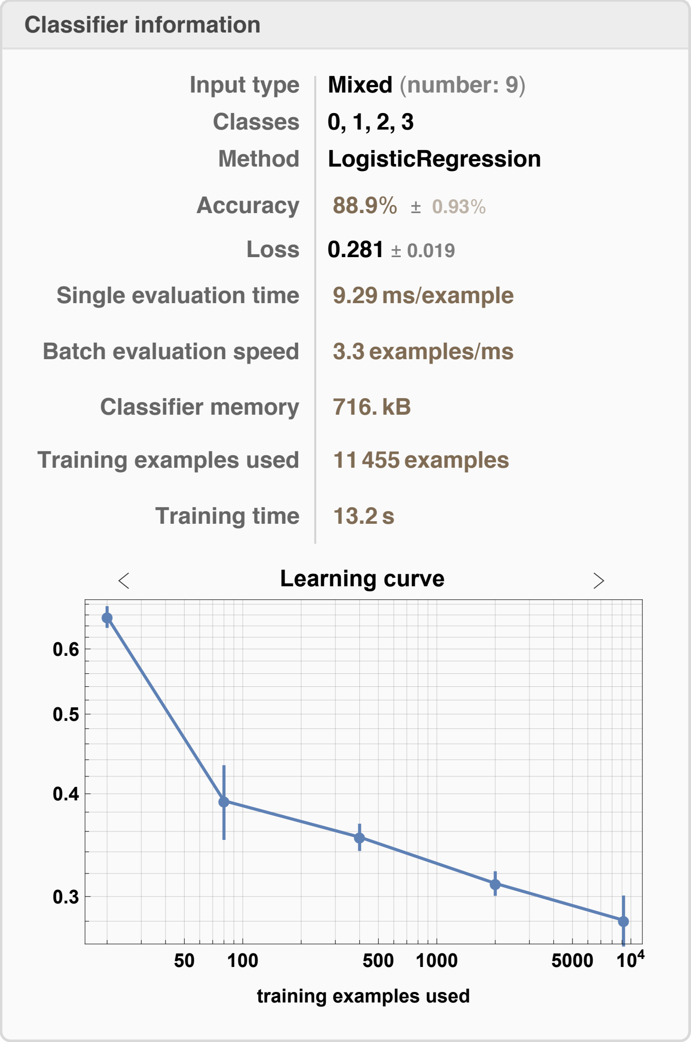
Input type	Mixed (number: 9)
Classes	0, 1, 2, 3
Method	RandomForest
Accuracy	93.4% ± 0.75%
Loss	0.256 ± 0.012
Single evaluation time	11.3 ms/example
Batch evaluation speed	2.73 examples/ms
Classifier memory	858. kB
Training examples used	11 455 examples
Training time	7.7 s

```
Out[•]= 0.937399
```

Logistic Regression:

```
In[•]:= algoLogisticRegression = Classify[trainsetFinal, Method → "LogisticRegression"];
ClassifierInformation[algoLogisticRegression]
MeasurementsLogisticRegression =
  ClassifierMeasurements[algoLogisticRegression, testsetFinal];
ClassifierMeasurements[algoLogisticRegression, testsetFinal, "Accuracy"]
```

Out[•]=



Classifier information

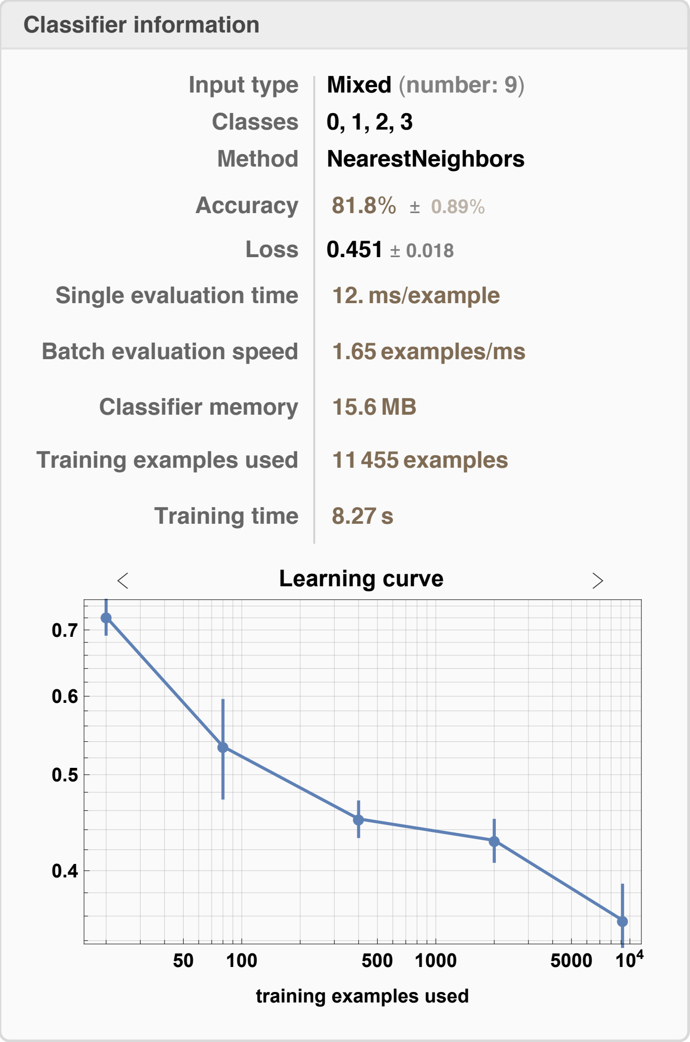
Input type	Mixed (number: 9)
Classes	0, 1, 2, 3
Method	LogisticRegression
Accuracy	88.9% ± 0.93%
Loss	0.281 ± 0.019
Single evaluation time	9.29 ms/example
Batch evaluation speed	3.3 examples/ms
Classifier memory	716. kB
Training examples used	11 455 examples
Training time	13.2 s

```
Out[•]= 0.883306
```

Nearest Neighbors:

In[∘]:=
```
algoNearestNeighbors = Classify[trainsetFinal, Method → "NearestNeighbors"];
ClassifierInformation[algoNearestNeighbors]
MeasurementsNearestNeighbors =
  ClassifierMeasurements[algoNearestNeighbors, testsetFinal];
ClassifierMeasurements[algoNearestNeighbors, testsetFinal, "Accuracy"]
```

Out[∘]=



Classifier information

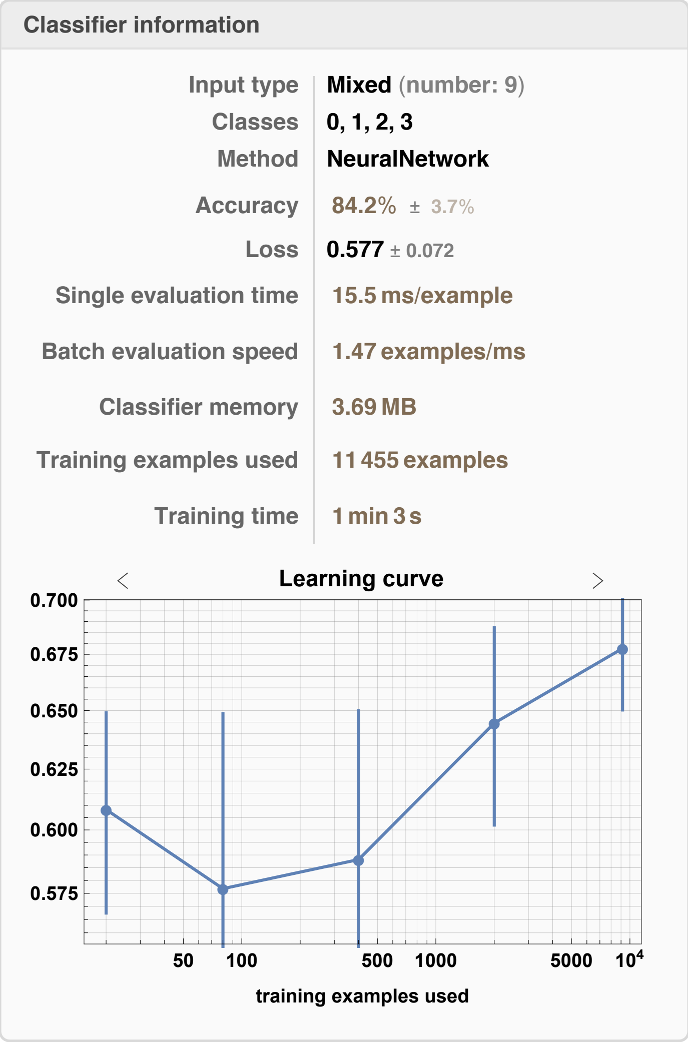
Input type	Mixed (number: 9)
Classes	0, 1, 2, 3
Method	NearestNeighbors
Accuracy	81.8% ± 0.89%
Loss	0.451 ± 0.018
Single evaluation time	12. ms/example
Batch evaluation speed	1.65 examples/ms
Classifier memory	15.6 MB
Training examples used	11 455 examples
Training time	8.27 s

Out[∘]=
```
0.830429
```

Neural Network:

```
In[•]:= algoNeuralNetwork = Classify[trainsetFinal, Method → "NeuralNetwork"];
        ClassifierInformation[algoNeuralNetwork]
        MeasurementsNeuralNetwork =
          ClassifierMeasurements[algoNeuralNetwork, testsetFinal];
        ClassifierMeasurements[algoNeuralNetwork, testsetFinal, "Accuracy"]
```

Out[•]=



Classifier information

Input type	Mixed (number: 9)
Classes	0, 1, 2, 3
Method	NeuralNetwork
Accuracy	84.2% ± 3.7%
Loss	0.577 ± 0.072
Single evaluation time	15.5 ms/example
Batch evaluation speed	1.47 examples/ms
Classifier memory	3.69 MB
Training examples used	11 455 examples
Training time	1 min 3 s

```
Out[•]= 0.807536
```

Prediction

We predict the Salary class given other parameters using several Machine Learning Algorithms:

Nearest Neighbors:

```
In[•]:= PredictionNearestNeighbors =
          Predict[trainsetFinal, Method → "NearestNeighbors"];
        PredictionNearestNeighbors[
         {<|"GenderSelect" → "Female", "Country" → "United States", "Age" → 30,
           "CurrentJobTitleSelect" → "", "LanguageRecommendationSelect" → "Python",
           "FormalEducation" → "Master's degree", "MajorSelect" → "Computer Science",
           "Tenure" → "Less than a year", "StandardSalary" → 15 000|>}]

Out[•]= {1.}
```

Decision Tree:

```
In[•]:= PredictionNearestNeighbors = Predict[trainsetFinal, Method -> "DecisionTree"];
        PredictionNearestNeighbors[
         {<|"GenderSelect" → "Female", "Country" → "United States", "Age" → 30,
           "CurrentJobTitleSelect" → "", "LanguageRecommendationSelect" → "Python",
           "FormalEducation" → "Master's degree", "MajorSelect" → "Computer Science",
           "Tenure" → "Less than a year", "StandardSalary" → 15 000|>}]

Out[•]= {1.}
```

Neural Network:

```
In[•]:= PredictionNearestNeighbors = Predict[trainsetFinal, Method -> "NeuralNetwork"];
        PredictionNearestNeighbors[
         {<|"GenderSelect" → "Female", "Country" → "United States", "Age" → 30,
           "CurrentJobTitleSelect" → "", "LanguageRecommendationSelect" → "Python",
           "FormalEducation" → "Master's degree", "MajorSelect" → "Computer Science",
           "Tenure" → "Less than a year", "StandardSalary" → 15 000|>}]

Out[•]= {1.233}
```

Insights

Global

We gained the following insights regarding Data Scientists from our analysis and visualization:

- Median age is between 20 and 35 years.
- Most of the Data Scientists are Male.
- Most of them are concentrated in United States and India.
- Most have “Data Scientist” and “Software Developer/Software Engineer” as the Job Position.
- More than half use Python as their primary language and around 25% use R.
- Many people prefer “Coursera” to learn Data Science.

- TensorFlow, Python and R are used a lot for Machine Learning.

Irish Data Scientists

- Around one third of Irish Data Scientists are women.
- Many have around EUR 50000 salary .
- Most Irish Data scientists have a Masters or a Bachelors degree.

Conclusion

We gained so many insights from the data regarding Data Scientists and Machine Learning enthusiasts. Regarding the capabilities of Mathematica, it offers excellent features to work with Datasets. Though our Dataset is so large, Mathematica handles the iterations and other intensive tasks withe ease. Even if it takes some processing time, the Machine Learning classifications and predictions run smooth.
In this project, we learned how to work with data, gained insights and explored Mathematica. In conclusion, in addition to its capabilities in Mathematics applications, Mathematica is very well suited for Data Science.