Stroke prediction model comparison

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“Globally, the World Health Organisation estimates that there are at least 62 million stroke survivors. In Australia, 50,000 people suffer a stroke each year, leaving them with physical and mental disabilities that create an enormous emotional, social, and financial burden on our community.”

Stroke facts - Queensland Brain Institute - University of Queensland (uq.edu.au)

- **Aim:**

Develop a model that can be used to predict stroke based on personal status and health condition

- **Objectives:**

(1) Data import and pre-processing (PySpark, Pandas) by remove outlier, null value, non-informative features

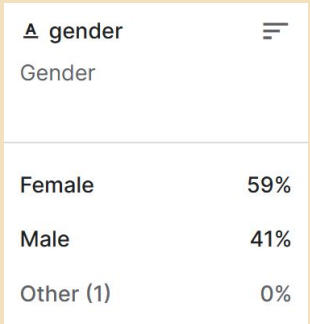
(2) Building predicting models (K-means, PCA, Neural Network...)

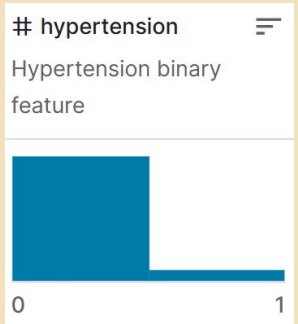
(3) Compare and suggest the best model

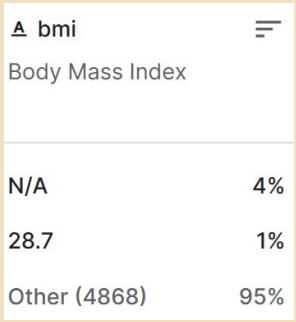
Objective 1 - Data import and pre-processing

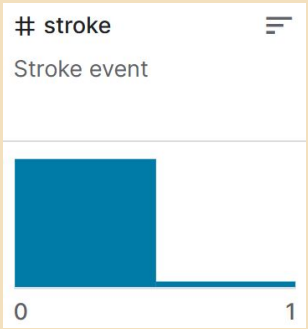
- Import data using Spark
- Inspect data
  Features: Id, gender, age, hypertension, heart_disease, ever_married, work_type, Residence_type, avg_glucose_level, bmi, smoking_status
  Label: stroke

id	gender	age	hypertension	heart_disease	ever_married	work_type	Residence_type	avg_glucose_level	bmi	smoking_status	stroke
9046	Male	67	0	1	Yes	Private	Urban	228.69	36.6	formerly smoked	1
51676	Female	61	0	0	Yes	Self-employed	Rural	202.21	N/A	never smoked	1
31112	Male	80	0	1	Yes	Private	Rural	105.92	32.5	never smoked	1
60182	Female	49	0	0	Yes	Private	Urban	171.23	34.4	smokes	1
1665	Female	79	1	0	Yes	Self-employed	Rural	174.12	24	never smoked	1
56669	Male	81	0	0	Yes	Private	Urban	186.21	29	formerly smoked	1
53882	Male	74	1	1	Yes	Private	Rural	70.09	27.4	never smoked	1
10434	Female	69	0	0	No	Private	Urban	94.39	22.8	never smoked	1
27419	Female	59	0	0	Yes	Private	Rural	76.15	N/A	Unknown	1









Data pre-processing

- Remove row with “Other” value from “gender” feature
- Remove non-informative feature “Id”
- Remove rows with “N/A” value in the “bmi”
- Remove missing value from “stroke”

Number of Data point

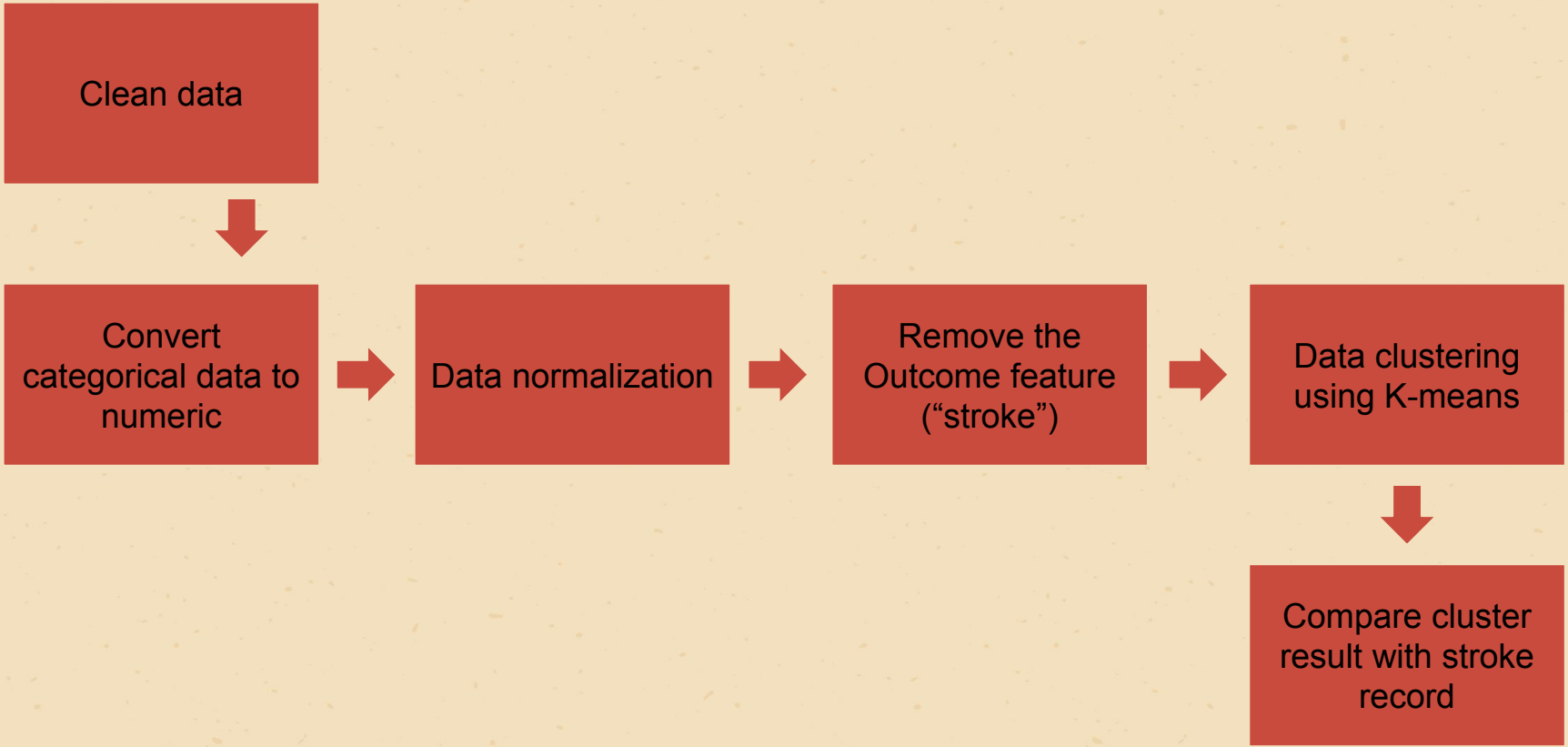
Female	2994
Male	2115
Other	1

Number of Data point

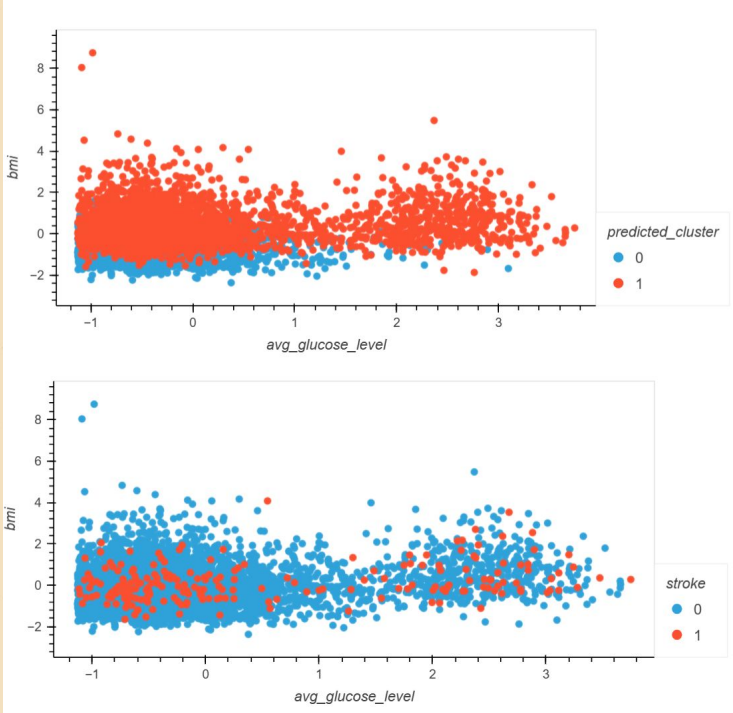
Female	2897
Male	2011

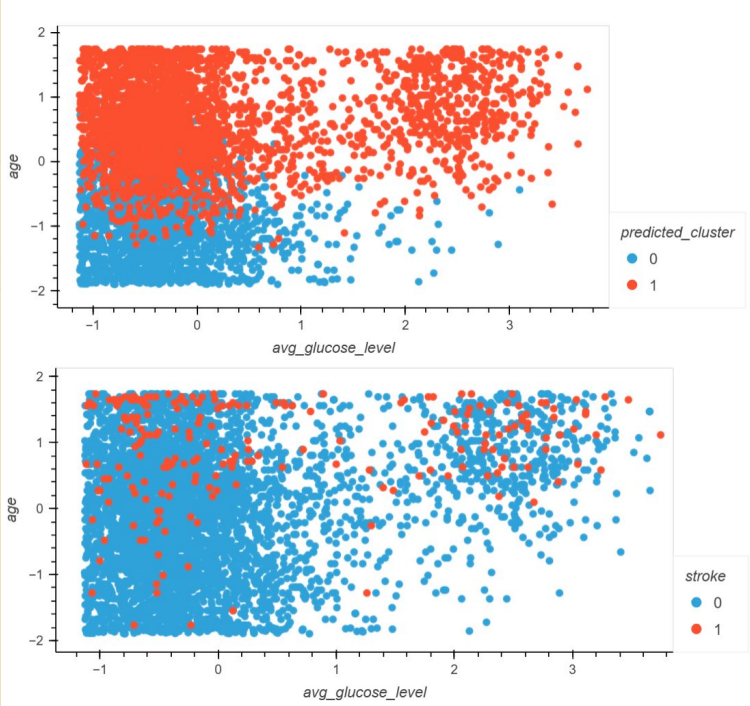
Objective 2 - Building predicting models

K-mean Clustering



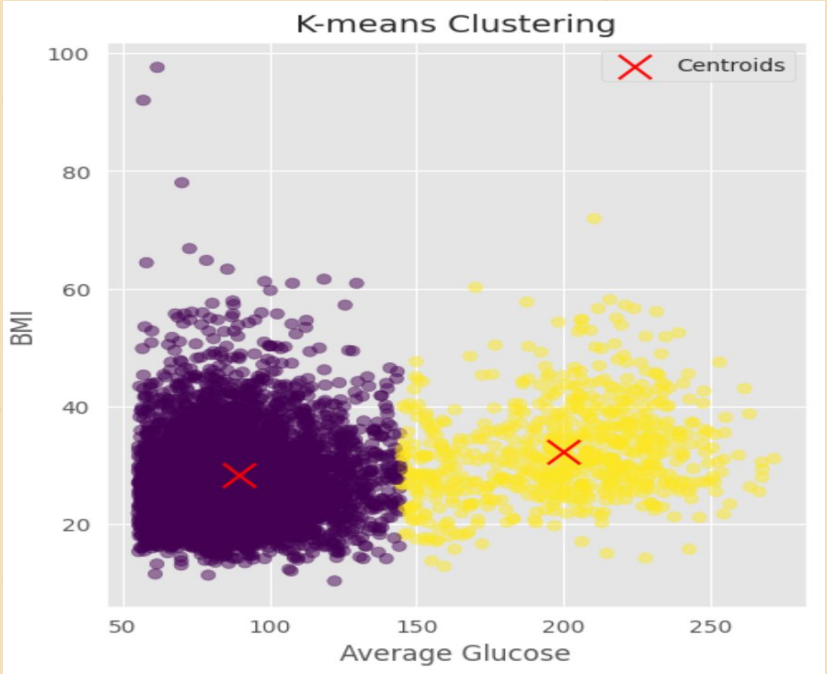
K-mean Clustering

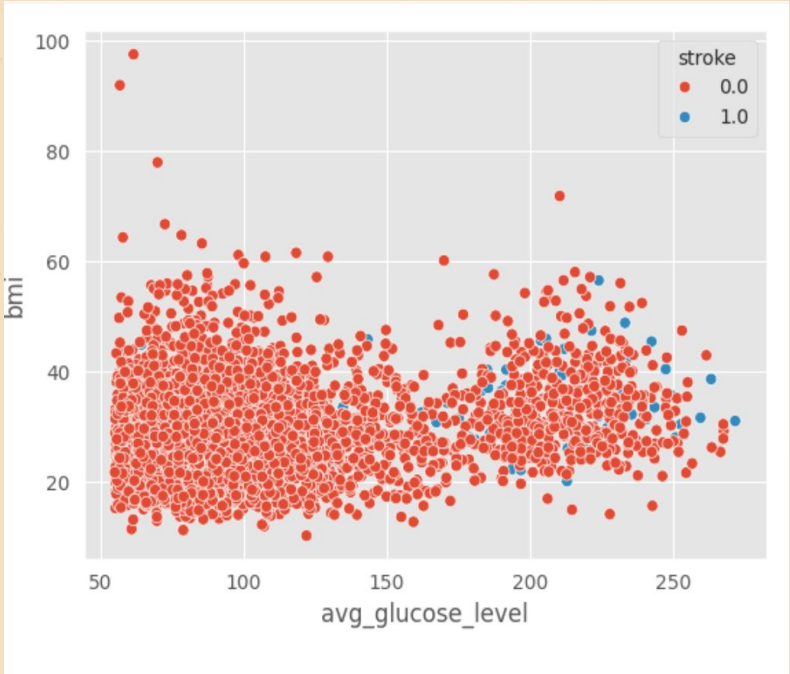




- K-mean clustering method appears to cluster the patients differently when compared to actual stroke record from patients. Therefore, using K-mean clustering might not be a good option for this dataset.

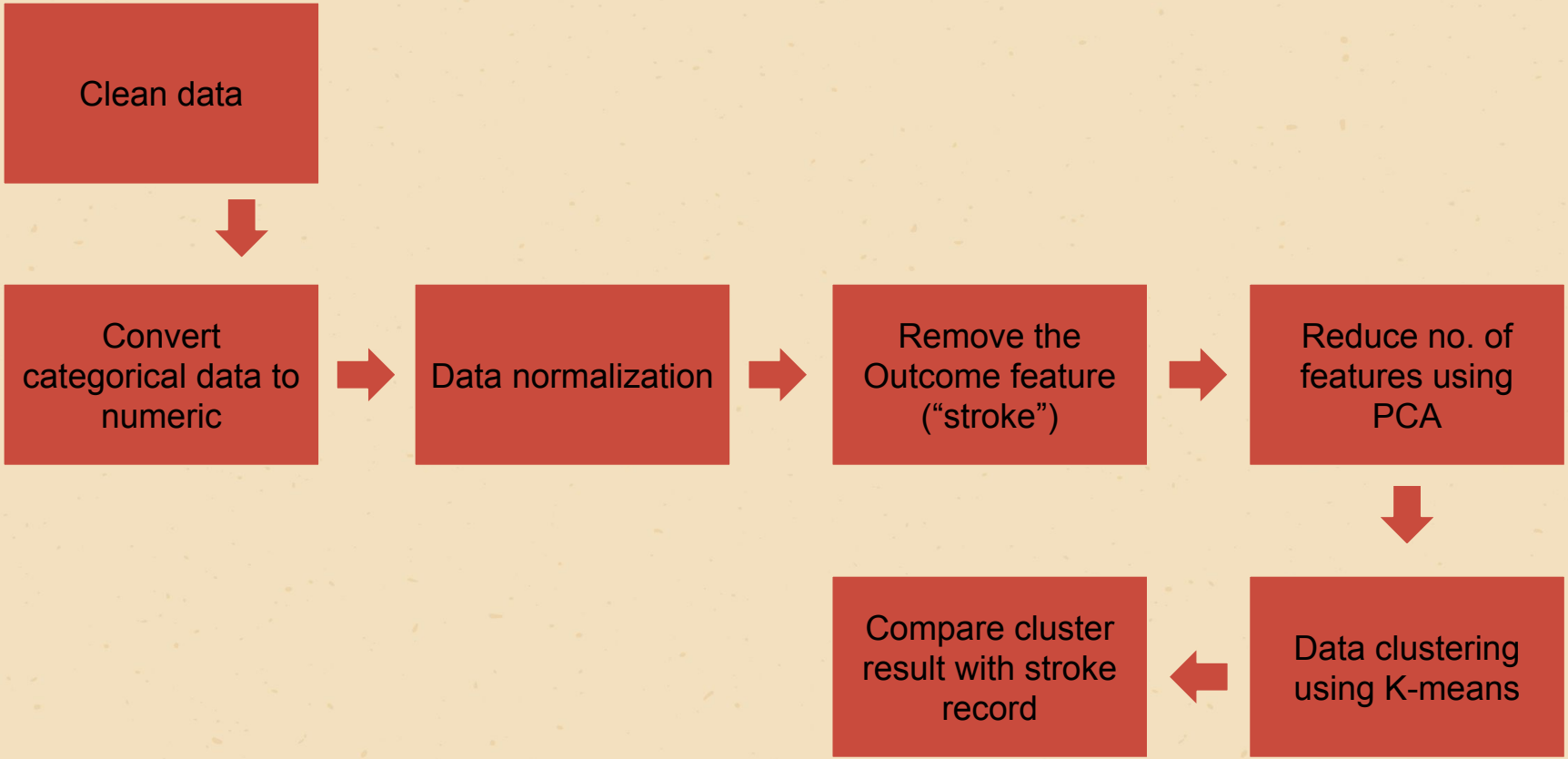
K means clustering



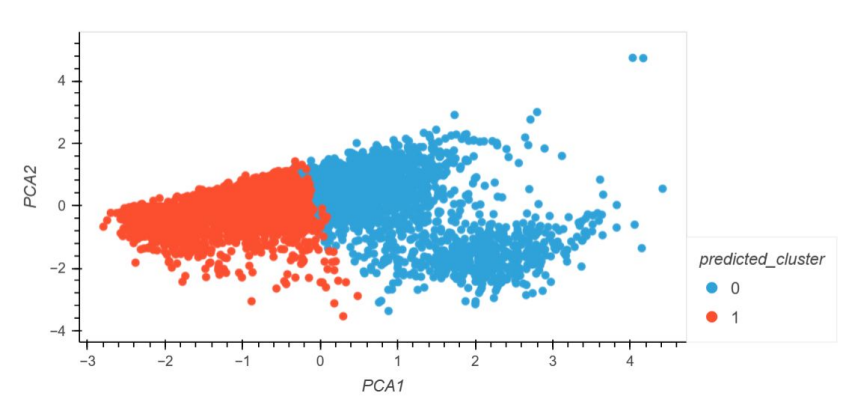


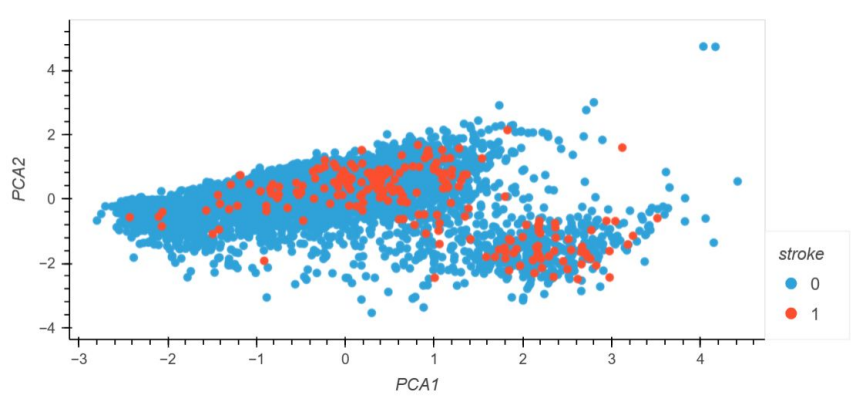
- Comparing the k means clustering the to the scatter plot, people who had strokes can be seen as leaning towards the bottom right corner, so if you have a low BMI and higher glucose levels, you are more likely to have a stoke. However as there are so many red

K-mean with PCA



K-mean with PCA





- K-mean clustering with PCA method appears to cluster the patients differently when compared to actual stroke record from patients. Therefore, using K-mean clustering might not be a good option for this dataset.

Random Forest model

- Convert data to fit in model
- All values converted in to binary values except age, bmi, avg_glucose level.

ever_married	Residence_type	gender_Female	gender_Male	gender_Other	hypertension_0	...	heart_disease_1
1	1	0	1	0	1	...	1
1	0	1	0	0	1	...	0
1	0	0	1	0	1	...	1
1	1	1	0	0	1	...	0
1	0	1	0	0	0	...	0

Female 2994
Male 2115
Other 1

Yes 3353
No 1757
Name: ever_married, dtype: int64

Private 2925
Self-employed 819
children 687
Govt_job 657
Never_worked 22
Name: work_type, dtype: int64

Creating and train random forest classifier

- X is features or independent variables
- Y is targeted variable

```
# Separate features (X) and target variable (y)
X = df_dummies.drop(columns=['stroke'])
y = df_dummies['stroke']
```

- Split data into training and testing set by 80%:20%

```
# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, shuffle=True, random_state=42)
```

- Create random forest classifier and train

```
# Create a RandomForestClassifier instance
rf_classifier = RandomForestClassifier(n_estimators=500, random_state=48)

# Train the classifier on the training data
rf_classifier.fit(X_train, y_train)
```

Random Forest Model

- Accuracy: The proportion of correctly classified instances out of the total instances is 93%-94%
- Precision: proportion of true positive predictions out of all positive predictions made by the model is - For class 0 (94%),
- Recall (Sensitivity): The proportion of true positive predictions out of all actual positive instances in the dataset.1%
- F1 Score: The harmonic mean of precision and recall, providing a balance between the two metrics is Based on the achieved confusion matrix and classification report: 97% .

```
Confusion Matrix:
          Predicted 0  Predicted 1
Actual 0          960            0
Actual 1           62            0
Accuracy: 0.9393346379647749
Mean Squared Error: 0.060665362035225046
Classification Report:
              precision    recall  f1-score   support

           0       0.94      1.00      0.97       960
           1       0.00      0.00      0.00        62
```

Overall presented data set contains more no strokes then strokes

Performance of a RandomForest Model

- Using iterative Model Training
- Used 11 ITERATIONS to train and predict data ,, each time creating a new instance of a RandomForestClassifier with a different random state and different shuffled data from given set
- Accuracy is 93%-94%

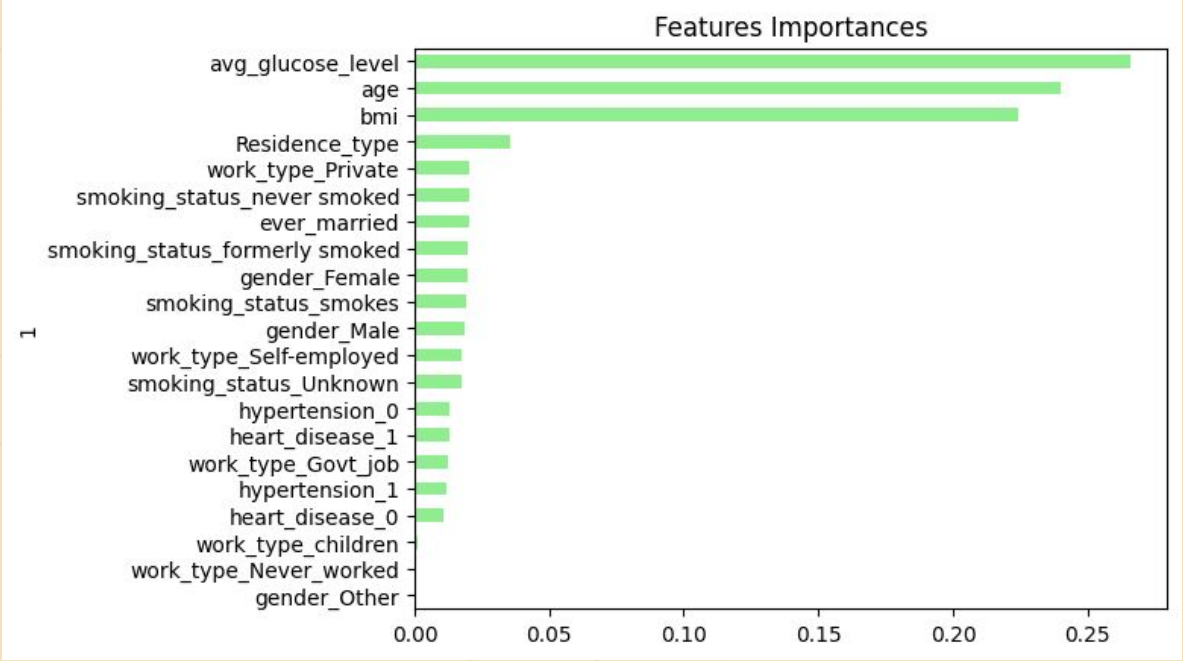
Iteration	Accuracy	Precision	Recall	F1-score
1	0.938356	0	0	0
2	0.938356	0	0	0
3	0.938356	0	0	0
4	0.939335	0.5	0.016129	0.03125
5	0.938356	0	0	0
6	0.940313	0.666667	0.0322581	0.0615385
7	0.938356	0	0	0
8	0.938356	0	0	0
9	0.940313	0.666667	0.0322581	0.0615385
10	0.940313	0.666667	0.0322581	0.0615385
11	0.939335	0.5	0.016129	0.03125

Features importances

Top Features :

- Age
- Average glucose level,
- BMI

Used to predict stroke data



Logistic Regression

Build Model using numeric features

- Age
- Hypertension
- Heart Disease (True or False)
- Average Glucose Level

```
#get the features
X.head()
```

	age	hypertension	heart_disease	avg_glucose_level
0	67	0	1	228.69
1	61	0	0	202.21
2	80	0	1	105.92
3	49	0	0	171.23
4	79	1	0	174.12

High accuracy score with given features to predict stroke status.

```
print(f"Training Data Score: {classifier.score(X_train, y_train)}")
print(f"Testing Data Score: {classifier.score(X_test, y_test)}")
```

```
Training Data Score: 0.9511876794570608
Testing Data Score: 0.9514866979655712
```

Logistic Regression - Optimisation

- Conversion of additional features to int data types
- Feature Coefficient Analysis
- Retraining the model including only values with
- No increase to performance / accuracy score

```
#add and convert additional features
X = pandas_df.drop(['stroke', 'id','work_type','Residence_type','smoking_status','bmi'],axis=1)
X['ever_married'].fillna('No', inplace=True)
X['ever_married'] = X['ever_married'].map({'Yes': 1, 'No': 0})
X['gender'] = X['gender'].map({'Male': 1, 'Female': 0})
X.head()
```

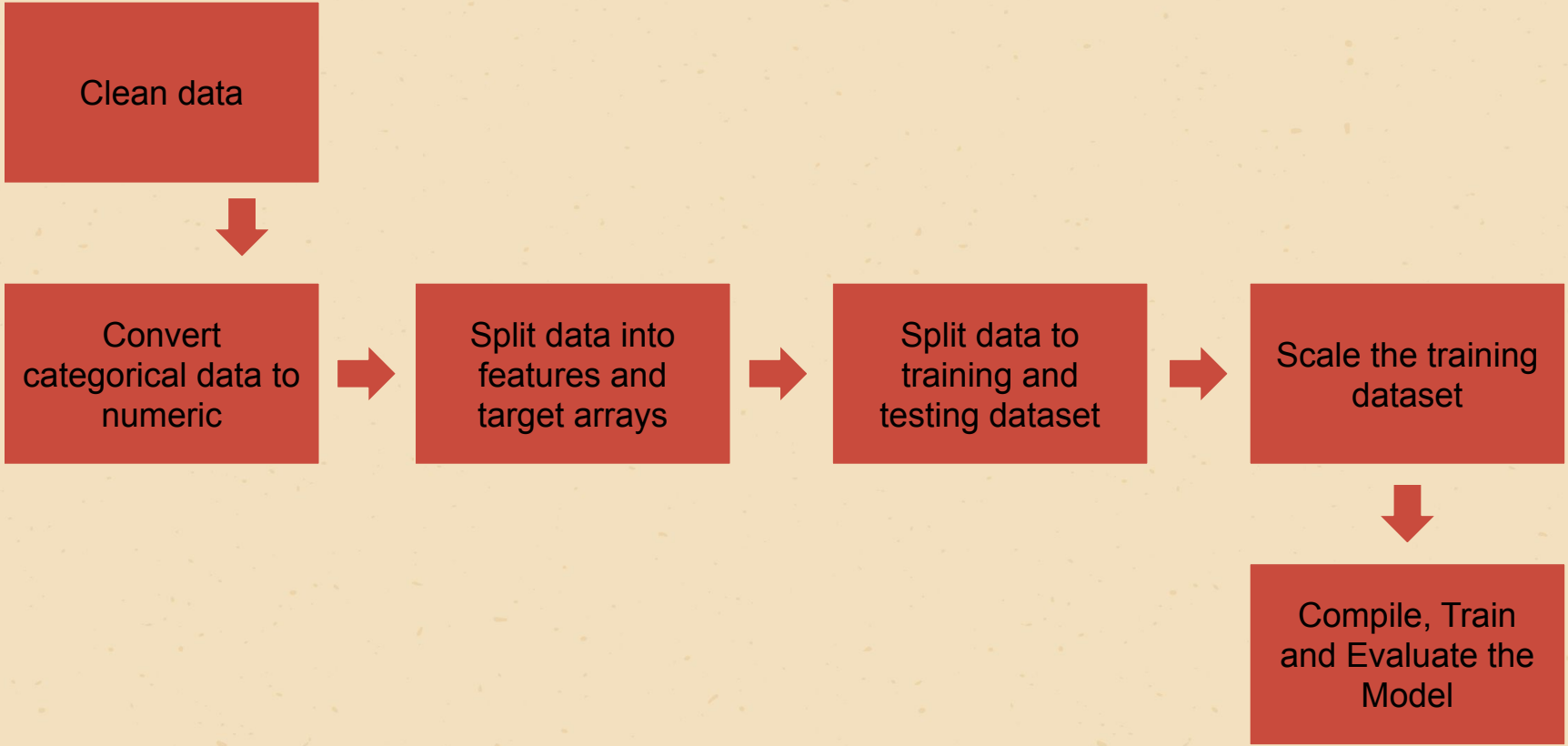
	gender	age	hypertension	heart_disease	ever_married	avg_glucose_level
0	1	67	0	1	1	228.69
1	0	61	0	0	1	202.21
2	1	80	0	1	1	105.92
3	0	49	0	0	1	171.23
4	0	79	1	0	1	174.12

```
Feature Importances:
gender: 0.0021709465205578316
age: 0.07153149848800829
hypertension: 0.008266308556091801
heart_disease: 0.008543232209240057
avg_glucose_level: -0.004505799643233578
bmi: 0.004575498287225877
```

```
print(f"Training Data Score: {classifier.score(X_train, y_train)}")
print(f"Testing Data Score: {classifier.score(X_test, y_test)}")
```

```
Training Data Score: 0.9511876794570608
Testing Data Score: 0.9514866979655712
```

Neural network - Keras model



Neural network - Keras model - 1st attempt

Model structure

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense (Dense)               (None, 4)                 84

 dense_1 (Dense)             (None, 4)                 20

 dense_2 (Dense)             (None, 1)                 5

=================================================================
Total params: 109 (436.00 Byte)
Trainable params: 109 (436.00 Byte)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

Model evaluation on test dataset

```
39/39 - 0s - loss: 0.1421 - accuracy: 0.9617 - 220ms/epoch - 6ms/step
Loss: 0.14209918677806854, Accuracy: 0.9616951942443848
```

Neural network - Keras model - 2nd attempt

Model structure

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_3 (Dense)             (None, 4)                 84

 dense_4 (Dense)             (None, 6)                 30

 dense_5 (Dense)             (None, 8)                 56

 dense_6 (Dense)             (None, 1)                 9

=================================================================
Total params: 179 (716.00 Byte)
Trainable params: 179 (716.00 Byte)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

- Loss and accuracy is pretty good!
- Changing hyperparameters seem to not further improve the model.

Model evaluation on test dataset

```
39/39 - 0s - loss: 0.1464 - accuracy: 0.9617 - 192ms/epoch - 5ms/step
Loss: 0.14636258780956268, Accuracy: 0.9616951942443848
```

Conclusion

- More data on people with strokes required to increases support / balance of result
- Best model (Highest accuracy score) -> Neural network

What we learnt from this data

- BMI, Age & Glucose levels are the main features contributing to strokes
- Not all the features are useful for analysis

Questions