Problem Statement: - Social Network Ad

How to develop an AI solution to personalize advertisements for users based on historical data, and predict whether a user is likely to purchase the advertised product. The AI system should display advertisements only to users with a high probability of making a purchase, in order to target the right customers effectively.

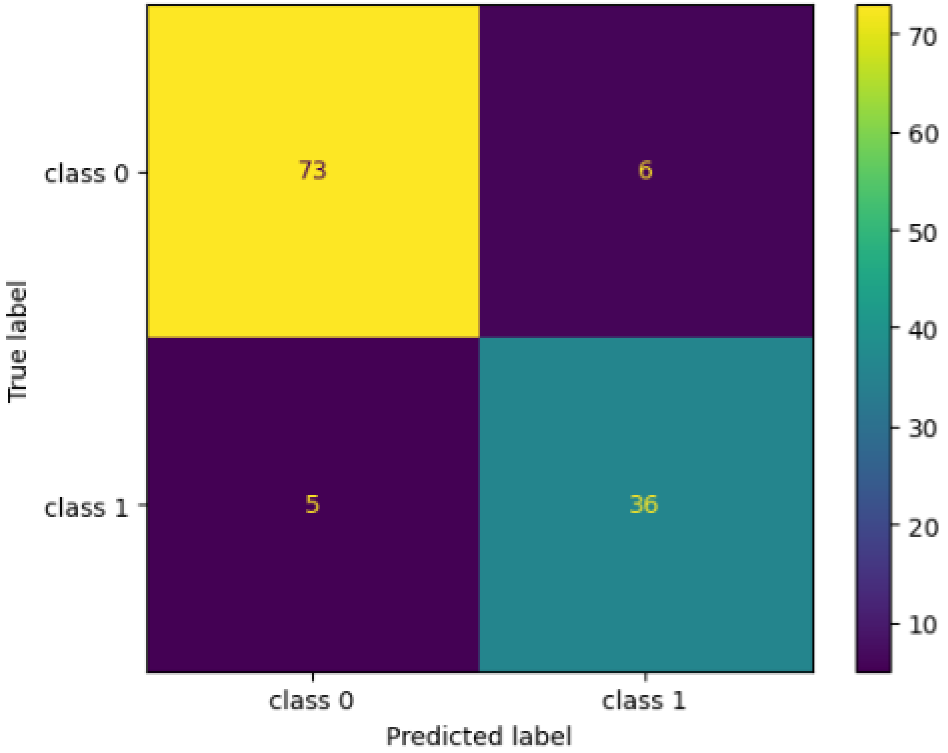
Class 0 – User purchased

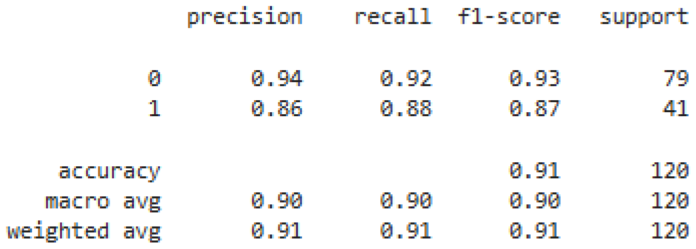
Class 1 – User did not purchase

Support – Actual No. of. Samples in Each class

Random Forest Classifier

Code link: https://github.com/krthiksha/Machine-Learning-Classification_module/blob/main/1.RandomForest_classification.ipynb





```
              precision    recall  f1-score   support

           0       0.94      0.92      0.93        79
           1       0.86      0.88      0.87        41

    accuracy                           0.91       120
   macro avg       0.90      0.90      0.90       120
weighted avg       0.91      0.91      0.91       120
```

Classification report for random forest classifier

1) What is the overall performance of the model?

   Accuracy : 0.91

2) What is the percentage of correctly classified class 0?

   Recall of class 0 : 0.92

3) What is the percentage of correctly classified class 1?

   Recall of class 1 : 0.88

4) What is the percentage of correctly and wrongly classified class 0?

   Precision of class 0 : 0.94

5) What is the percentage of correctly and wrongly classified class 1?

   Precision of class 1 : 0.86

6) Measure the balance between precision and recall for class 0?

   F1 score of class 0 : 0.93

7) Measure the balance between precision and recall for class 1?

   F1 score of class 1 : 0.87

8) What is the macro average of precision?

   macro average of precision : 0.90

9) What is the macro average of recall?

   macro average of recall : 0.90

10) What is the macro average of f1 score?

    macro average of f1 score : 0.90

11) What is the weighted average of precision?

    weighted average of precision : 0.91

12) What is the weighted average of recall?

    weighted average of recall : 0.91

13) What is the weighted average of f1 score?

    weighted average of f1 score : 0.91

Algorithm : RandomForestClassifier

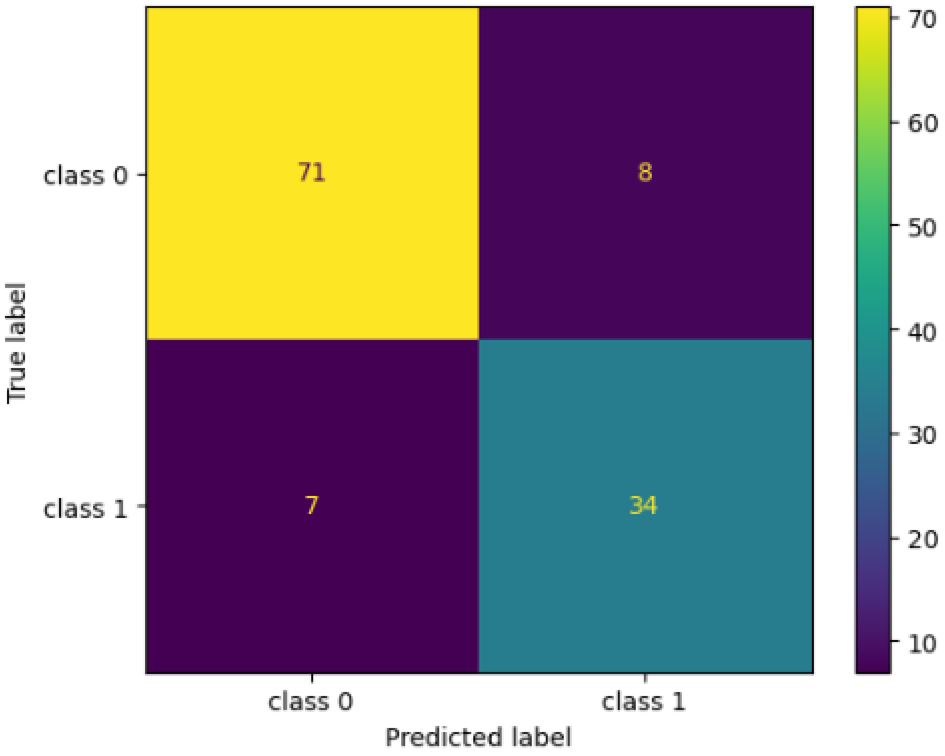
Accuracy (overall performance of the model) = 0.91

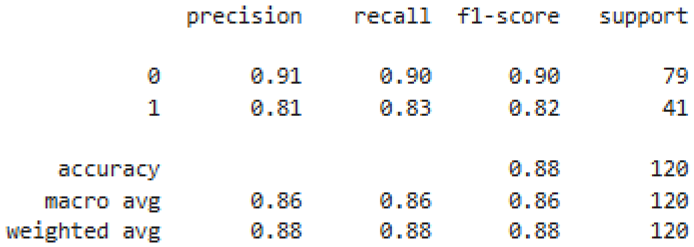
overall metrics performance (precision,recall,f1-score) = good

Result : **Good Model**

Decision Tree Classifier

Code link: https://github.com/krthiksha/Machine-Learning-Classification_module/blob/main/2.DecisionTree_classification.ipynb





```
              precision    recall  f1-score   support

           0       0.91      0.90      0.90        79
           1       0.81      0.83      0.82        41

    accuracy                           0.88       120
   macro avg       0.86      0.86      0.86       120
weighted avg       0.88      0.88      0.88       120
```

Classification report for random forest classifier

1) What is the percentage of correct classification of both the classes?

   Accuracy : 0.88

2) How many actual positives did I find for class 0?

   Recall of class 0 : 0.90

3) How many actual positives did I find class 1?

   Recall of class 1 : 0.85

4) How correct my positive predictions for class 0?

   Precision of class 0 : 0.92

5) How correct my positive predictions for class 1?

   Precision of class 1 : 0.81

6) What is the overall performance of class 0?

   F1 score of class 0 : 0.93

7) What is the overall performance of class 1?

   F1 score of class 1 : 0.87

8) What is the macro precision?

   macro average of precision : 0.87

9) What is the macro recall?

   macro average of recall : 0.88

10) What is the macro f1 measure?

    macro average of f1 score : 0.87

11) What is the weighted precision?

    weighted average of precision : 0.89

12) What is the weighted recall?

    weighted average of recall : 0.88

13) What is the weighted f1 score?

    weighted average of f1 score : 0.88

Algorithm : DecisionTreeClassifier

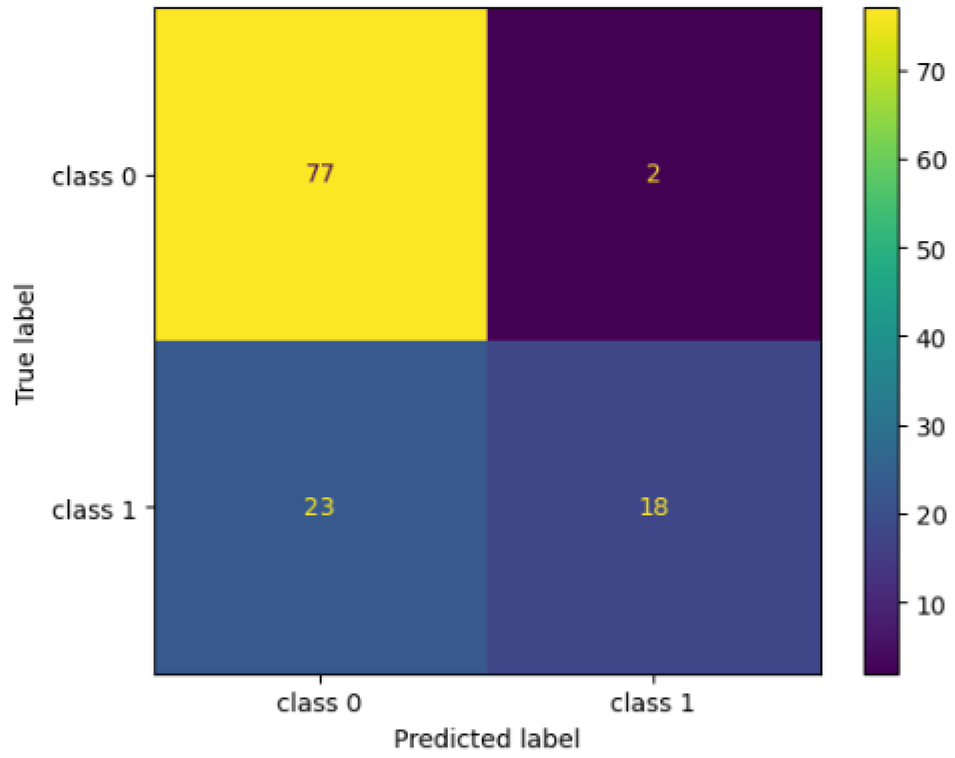
Accuracy (overall performance of the model) = 0.88

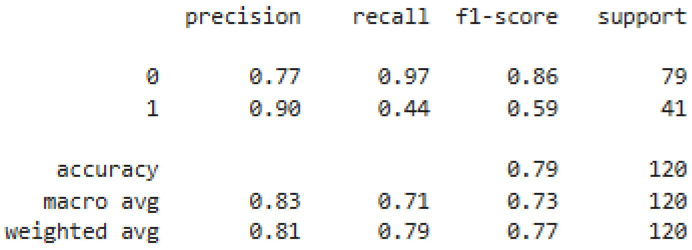
overall metrics performance (precision,recall,f1-score) = good

Result **: Good Model but not better than Randomforestclassifier**

SVC (support vector classifier)

Code: https://github.com/krthiksha/Machine-Learning-Classification_module/blob/main/3.SVM_classification.ipynb





```
              precision    recall  f1-score   support

           0       0.77      0.97      0.86        79
           1       0.90      0.44      0.59        41

    accuracy                           0.79       120
   macro avg       0.83      0.71      0.73       120
weighted avg       0.81      0.79      0.77       120
```

Classification report for random forest classifier

1) Overall how many predictions where correct?

   Accuracy : 0.79

2) Of all actual users for class 0 (Not purchases), How many did the model correctly Identified?

   Recall of class 0 : 0.97

3) Of all actual users for class 1 (purchased), how many did model correctly identified?

   Recall of class 1 : 0.44

4) Of all actual users for class 0 (not purchased), how many were actually correct?

   Precision of class 0 : 0.77

5) Of all actual users for class 1 (purchased), how many were actually correct?

Precision of class 1 : 0.90

6) What is F1 measure of class 0?

   F1 score of class 0 : 0.86

7) What is F1 measure of class 1?

   F1 score of class 1 : 0.59

8) What is the average performance of precision for the model?

   macro average of precision : 0.83

9) What is the average performance of recall for the model?

   macro average of recall : 0.71

10) What is the average performance of f1 score for the model?

    macro average of f1 score : 0.73

11) What is the sum of product of proportion rate of each class in precision?

    weighted average of precision : 0.81

12) What is the sum of product of proportion rate of each class in recall?

    weighted average of recall : 0.79

13) What is the sum of product of proportion rate of each class in f1 score?

    weighted average of f1 score : 0.77

Algorithm : SVC

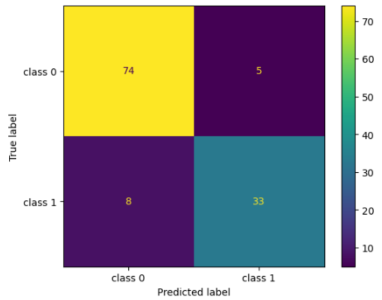
Accuracy (overall performance of the model) = 0.79

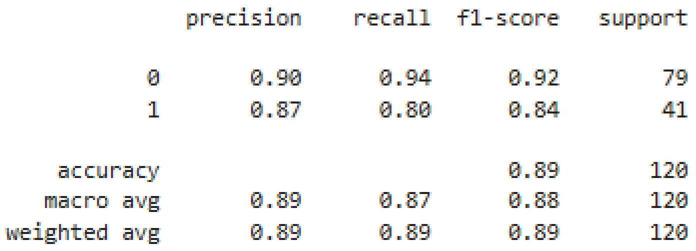
overall metrics performance (precision,recall,f1-score) = poor

Result : **poor model**

LOGISTIC REGRESSION (CLASSIFICATION ALGORITHM)

Code: https://github.com/krthiksha/Machine-Learning-Classification_module/blob/main/4.Logistic_Regression_classification.ipynb





```
              precision    recall  f1-score   support

           0       0.90      0.94      0.92        79
           1       0.87      0.80      0.84        41

    accuracy                           0.89       120
   macro avg       0.89      0.87      0.88       120
weighted avg       0.89      0.89      0.89       120
```

Algorithm : Logistic Regression

Accuracy (overall performance of the model) = 0.89

overall metrics performance (precision,recall,f1-score) = good

Result : **good model but not better than Randomforestclassifier**

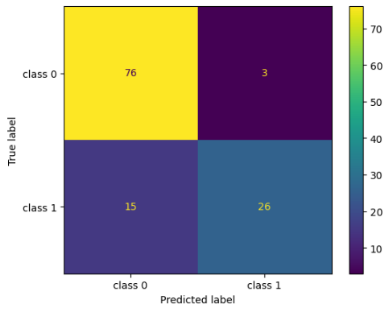
PROBLEM STATEMENT:-   Social network Ad (User Purchase Prediciton)

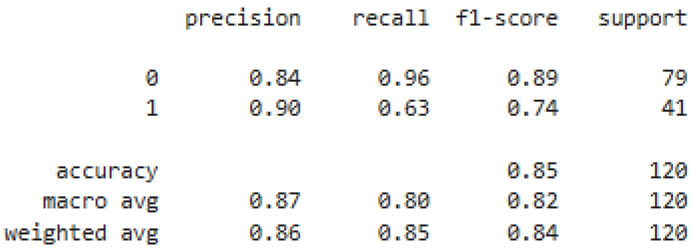
Algorithm: Logistic regression

SL.NO	solver	max_iter	C	Confusion matrix	model accuracy	Remark
1	lbfgs	100	1.0	[[74 5] [8 33]]	0.89 (ConvergenceWarning)	Warning
2	lbfgs	120	1.0	[[74 5] [8 33]]	0.89	Good Model
3	lbfgs	200	1.0	[[74 5] [8 33]]	0.89	Good Model
4	liblinear	120	1.0	[[79 0] [41 0]]	0.66	poor
5	newton-cg	120	1.0	[[74 5] [8 33]]	0.89	Good Model
6	newton-cholesky	120	1.0	[[74 5] [8 33]]	0.89	Good Model
7	sag	120	1.0	[[79 0] [41 0]]	0.66	poor
8	saga	120	1.0	[[79 0] [41 0]]	0.66	poor
9	lbfgs	120	0.01	[[74 5] [11 30]]	0.87	Good Model

KNN classifier:

Code: https://github.com/krthiksha/Machine-Learning-Classification_module/blob/main/4.KNN_classification.ipynb





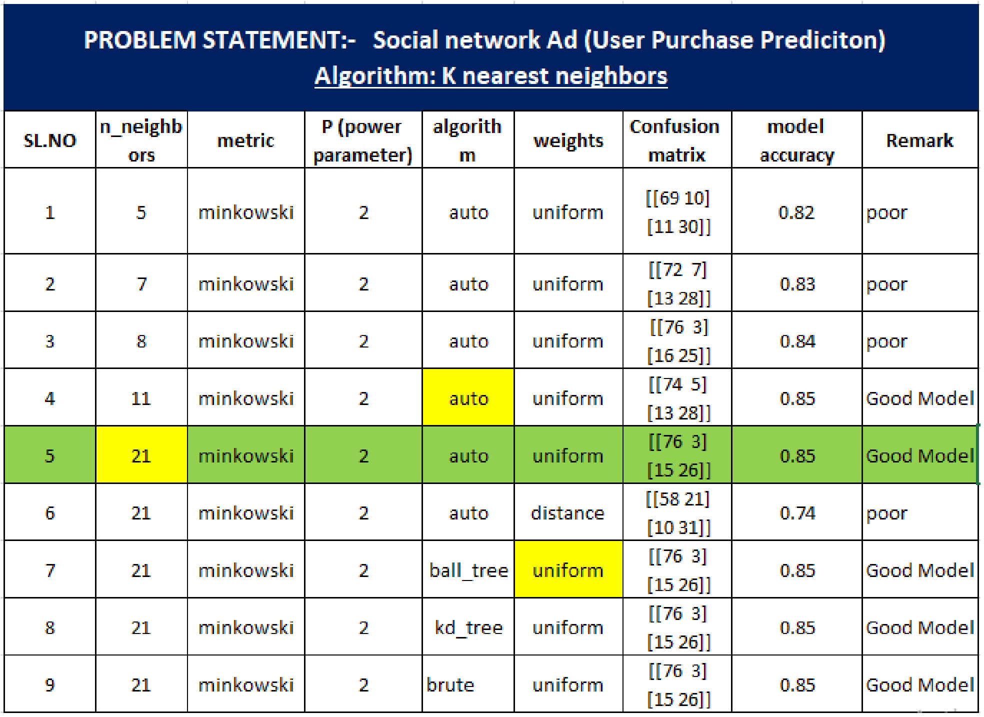
```
              precision    recall  f1-score   support

           0       0.84      0.96      0.89        79
           1       0.90      0.63      0.74        41

    accuracy                           0.85       120
   macro avg       0.87      0.80      0.82       120
weighted avg       0.86      0.85      0.84       120
```

Algorithm : K nearest neighbors classifier

Accuracy (overall performance of the model) = 0.85

overall metrics performance (precision,recall,f1-score) = good

Result**: good model but not better than Randomforestclassifier for the problem statement (social network ad)**



PROBLEM STATEMENT:- Social network Ad (User Purchase Prediciton)

Algorithm: K nearest neighbors

SL.NO	n_neighbors	metric	P (power parameter)	algorithm	weights	Confusion matrix	model accuracy	Remark
1	5	minkowski	2	auto	uniform	[[69 10] [11 30]]	0.82	poor
2	7	minkowski	2	auto	uniform	[[72 7] [13 28]]	0.83	poor
3	8	minkowski	2	auto	uniform	[[76 3] [16 25]]	0.84	poor
4	11	minkowski	2	auto	uniform	[[74 5] [13 28]]	0.85	Good Model
5	21	minkowski	2	auto	uniform	[[76 3] [15 26]]	0.85	Good Model
6	21	minkowski	2	auto	distance	[[58 21] [10 31]]	0.74	poor
7	21	minkowski	2	ball_tree	uniform	[[76 3] [15 26]]	0.85	Good Model
8	21	minkowski	2	kd_tree	uniform	[[76 3] [15 26]]	0.85	Good Model
9	21	minkowski	2	brute	uniform	[[76 3] [15 26]]	0.85	Good Model

Naïve Bayes

Code: https://github.com/krthiksha/Machine-Learning-Classification_module/blob/main/4.NB_classification.ipynb

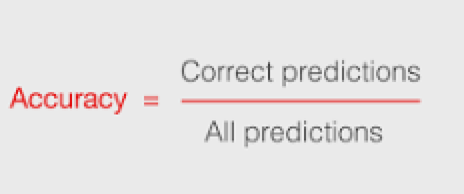
PROBLEM STATEMENT:- Social network Ad (User Purchase Prediciton)

Algorithm: Naïve Bayes

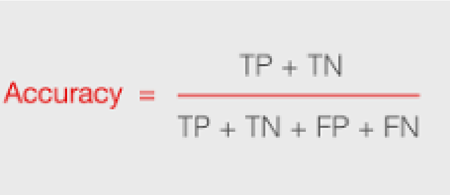
SL.NO	NB types	Confusion matrix	model accuracy	Remark
1	**GaussianNB**	[[74 5] [8 33]]	0.89	Good Model
2	MultinomialNB	[[68 11] [28 13]]	0.68	poor
3	ComplementNB	[[42 37] [20 21]]	0.53	poor
4	BernoulliNB	[[79 0] [41 0]]	0.66	poor
5	**CategoricalNB**	[[76 3] [9 32]]	0.90	Good Model

Evaluation Metrics using Confusion Matrix

Accuracy



$$\text{Accuracy} = \frac{\text{Correct predictions}}{\text{All predictions}}$$



$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

Accuracy Scenarios:

- Overall performance of the model?
- What is the Percentage of correct classification of both the classes?
- Overall how many predictions were correct?

Calculation of Random Forest classifier:

Accuracy = (73+36) / (73+36+5+6)

=109/120

=0.90833 ~ 0.91

Recall

$$\text{Recall (or Sensitivity)} = \frac{\text{True Positives (TP)}}{\text{True Positives (TP)} + \text{False Negatives (FN)}}$$

Recall Scenarios:

- Percentage of correctly classified of a specific class?
- How many actual positives did I find?
- Of all actual users for a specific class, how many did the model correctly identified?

Calculation of Random Forest classifier:

Recall (class 0) = 73 / (73+6)

= 73/79 = 0.92

Precision

$$\text{Precision} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$$

Precision Scenarios:

- Percentage of correctly and wrongly classified of a specific class?
- How correct my positive predictions for a specific class?
- Of all users for a specific class, how many were actually correct?

Calculation of Random Forest classifier:

Precision (class 0) = 73 / (73+5) = 73/78

= 0.9358 ~ 0.94

F1 score / F1 measure

$$F1\ score\ =\ \frac{2}{\frac{1}{Precision}+\frac{1}{Recall}} = 2 \cdot \frac{Precision * Recall}{Precision + Recall}$$

$$\Rightarrow F1\ score\ =\ 2 \cdot \frac{Precision * Recall}{Precision + Recall}$$

Scenarios:

- Balance between precision and recall for classes?
- Overall performance of a specific class?
- What is F1 measure of a specific class?

Calculation of Random Forest classifier:

F1 score (class 0) = 2 ((0.94 * 0.92) / (0.94 + 0.92))

= 2(0.8648/1.86)

= 2(0.464)

=0.9298 ~ 0.93

Macro average

Macro precision = (precision1 + precision2) / 2

Macro recall = (recall1 + recall2) / 2

Macro f1score = (f1score 1 + f1score 2) / 2

Calculation of Random Forest classifier:

Macro precision = (0.94 + 0.86) / 2 = 1.8/2 =0.90

Scenarios:

Metrics – (precision, recall, f1 score)

- Macro average of metrics
- Macro metrics
- Average performance for the metrics for the model

Weighted average

Weighted average = Sum (metrics * proportion rate)

Scenarios:

Metrics – (precision, recall, f1 score)

- Weighted average of metrics
- Weighted metrics
- Sum of product of proportional rate of each classes in metrics

Calculation of Random Forest classifier:

Weighted precision = (0.94 * (79/120)) + (0.86 * (41/120))

= (0.94 * (0.658)) + (0.86 * (0.34))

= 0.618 + 0.29

= 0.9085 ~ 0.91