

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.

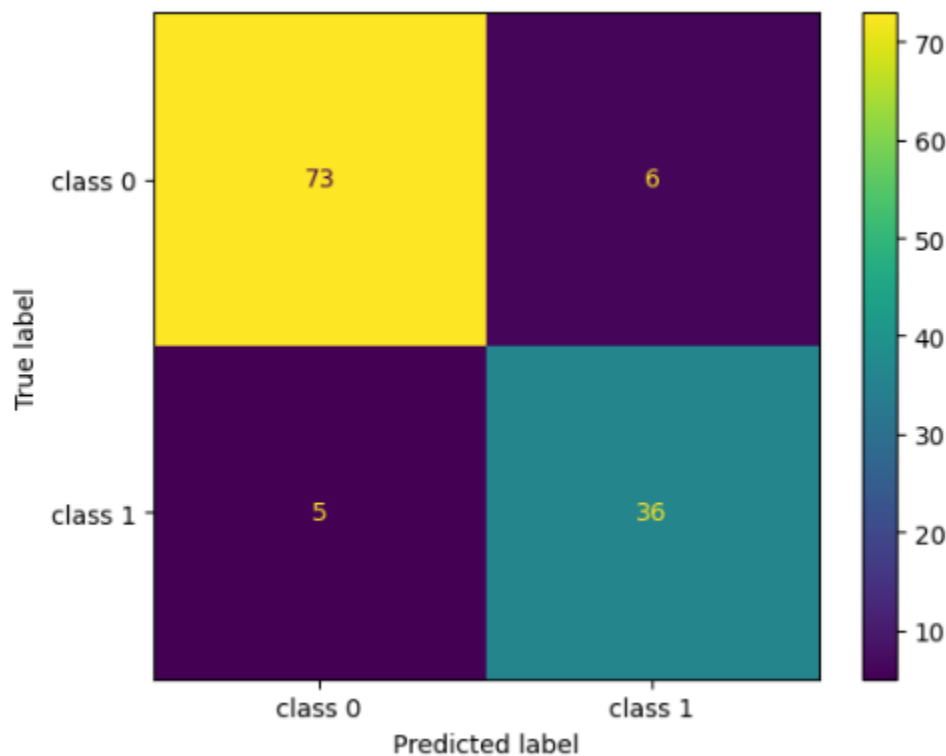
Class 0 – User purchased

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

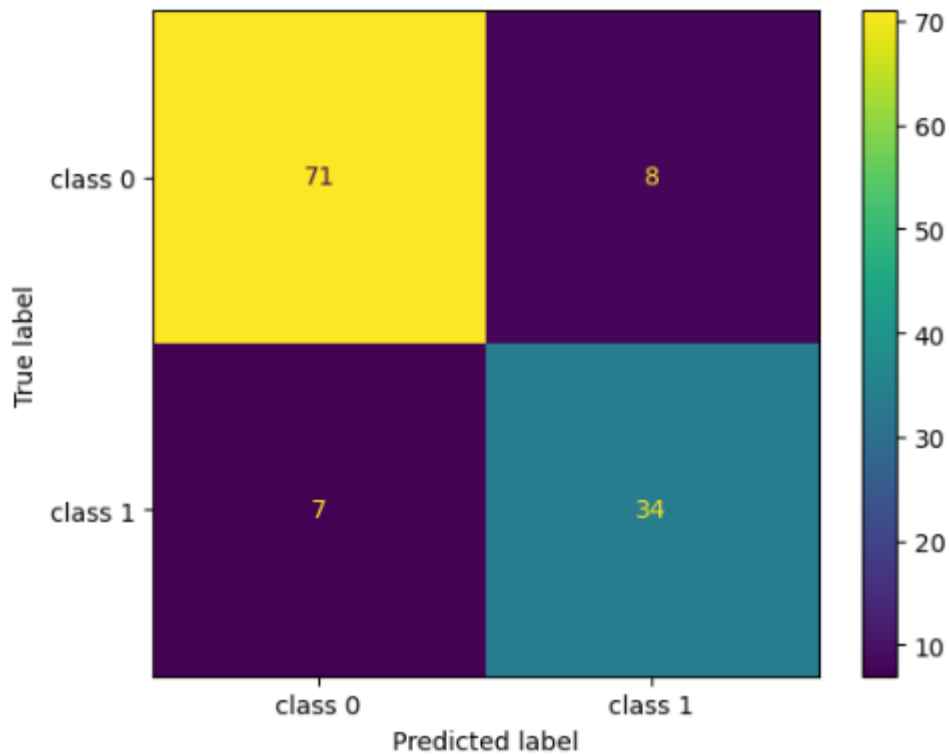
Accuracy (overall performance of the model) = 0.91

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

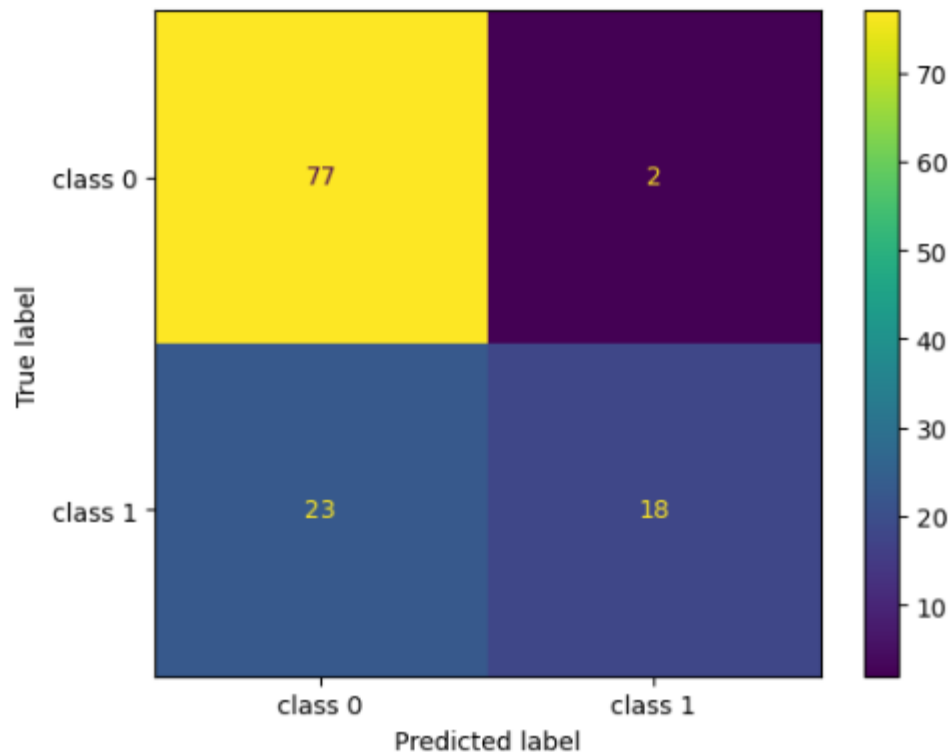
Accuracy (overall performance of the model) = 0.88

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 were 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

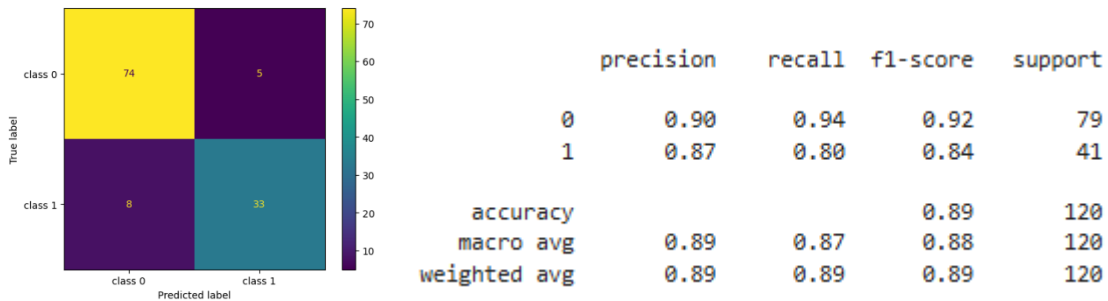
Accuracy (overall performance of the model) = 0.79

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



Algorithm : Logistic Regression

Accuracy (overall performance of the model) = 0.89

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

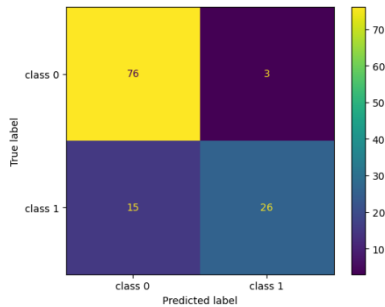
Result : **good model but not better than Randomforestclassifier**

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 Prediction)								
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 Prediction) Algorithm: Naïve Bayes

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

Algorithm : Naïve bayes - GaussianNB

Accuracy (overall performance of the model) = 0.89

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

Result: **good model but the Randomforestclassifier model performance (0.91) for the problem statement (social network ad)**

Best Model for social network ad problem is Random forest classifier with accuracy => 0.91

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:

$$\text{Accuracy} = (73+36) / (73+36+5+6)$$

$$= 109/120$$

$$= 0.90833 \sim 0.91$$

Recall

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

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:

$$\text{Recall (class 0)} = 73 / (73+6)$$

$$= 73/79 = 0.92$$

Precision

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

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 = $(0.94 * (79/120)) + (0.86 * (41/120))$

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

$$= 0.618 + 0.29$$

$$= 0.9085 \sim 0.91$$