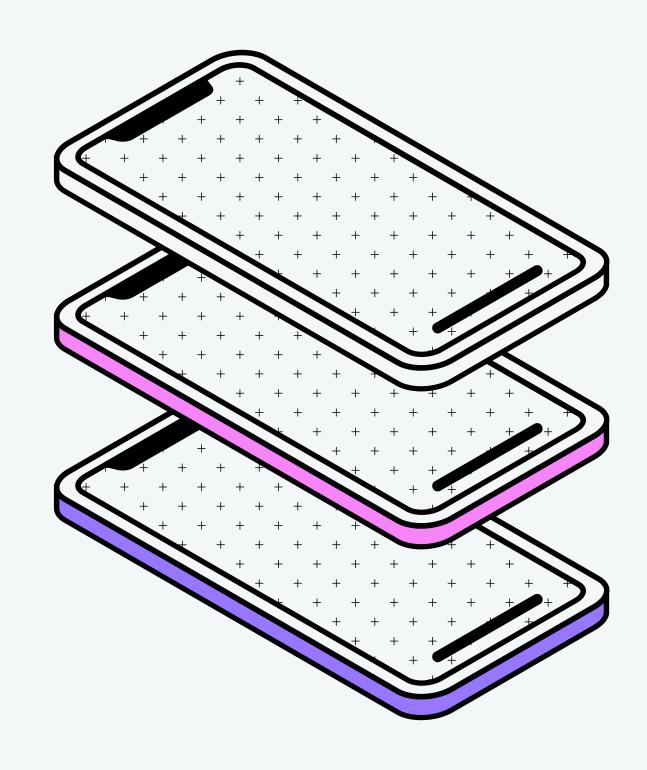
SC1015 Mini Project

Mobile Phone Price Range Based on Their Specifications

FCS7 Group 8

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- 2. Lam Wai Jun (U2321478F)



Source: Mobile Price Range from Kaggle

Introduction



Aligns with my budget while meeting the desired specification.

But, insufficient information about the price range of mobile phone!



Problem Definition

How do different mobile phone specifications affect its price?

<u>Aim</u>

To find the relationship between mobile phone specifications and their prices.

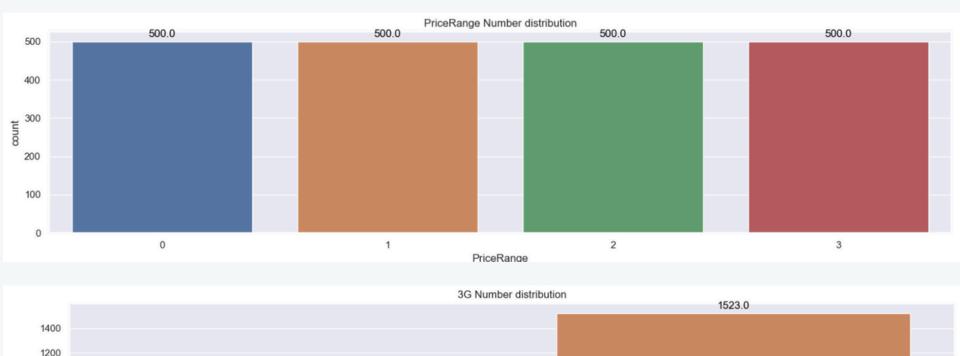


Data Preparation

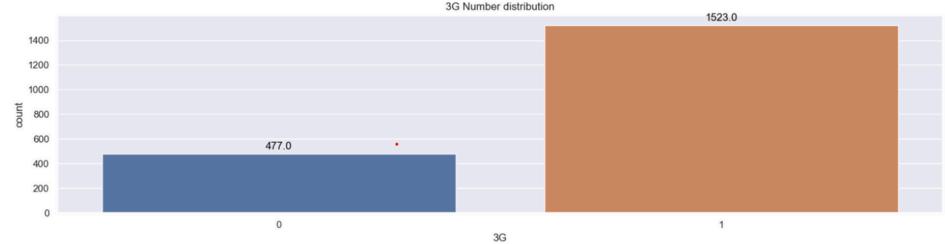
	BatteryPower	InternalMemory	ClockSpeed	NoOfCores I	RAM '	TalkTime	DualSim	3G 4	4G W	/iFi	Bluetooth	MobileDepth	MobileWeight	Touch Screen	ScreenHeight	ScreenWidth	FrontCameraPx	RearCameraPX	PriceRange	Total Resolution
0	842	7	2.2	2	2549	19	0	0	0	1	0	0.6	188	0	9	7	1	2	1	15120
1	1021	53	0.5	3 :	2631	7	1	1	1	0	1	0.7	136	1	17	3	0	6	2	1799140
2	563	41	0.5	5	2603	9	1	1	1	0	1	0.9	145	1	11	2	2	6	2	2167308
3	615	10	2.5	6	2769	11	0	1	0	0	1	0.8	131	0	16	8	0	9	2	2171776
4	1821	44	1.2	2	1411	15	0	1	1	0	1	0.6	141	1	8	2	13	14	1	1464096
1995	794	2	0.5	6	668	19	1	1	1	0	1	0.8	106	1	13	4	0	14	0	2309580
1996	1965	39	2.6	4	2032	16	1	1	0	1	1	0.2	187	1	11	10	0	3	2	1797975
1997	1911	36	0.9	8	3057	5	1	1	1	0	0	0.7	108	1	9	1	1	3	3	1416576
1998	1512	46	0.9	5	869	19	0	1	1	1	0	0.1	145	1	18	10	4	5	0	225120
1999	510	45	2.0	6	3919	2	1	1	1	1	1	0.9	168	1	19	4	5	16	3	364182

The remaining 20 variables
PriceRange as response variable
The other 19 are predictor variables

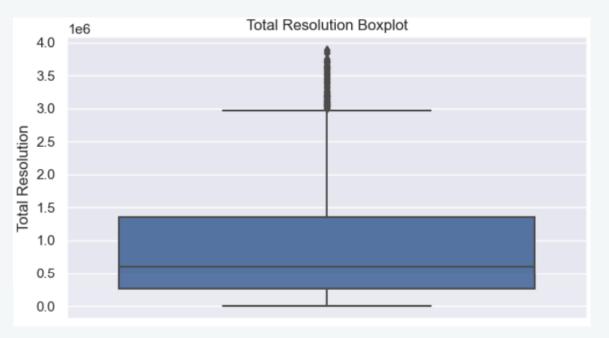
Exploratory Data Analysis



Response variable is balanced!

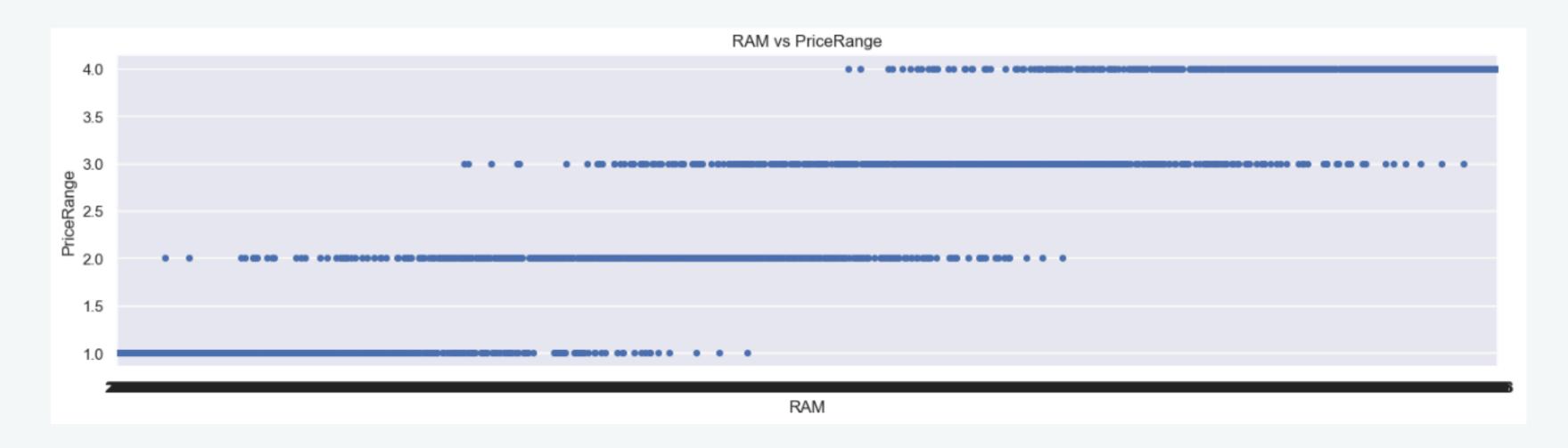


Variable 3G with ratio 3:1 approximately.



Variable Total Resolution has many outliers

Exploratory Data Analysis

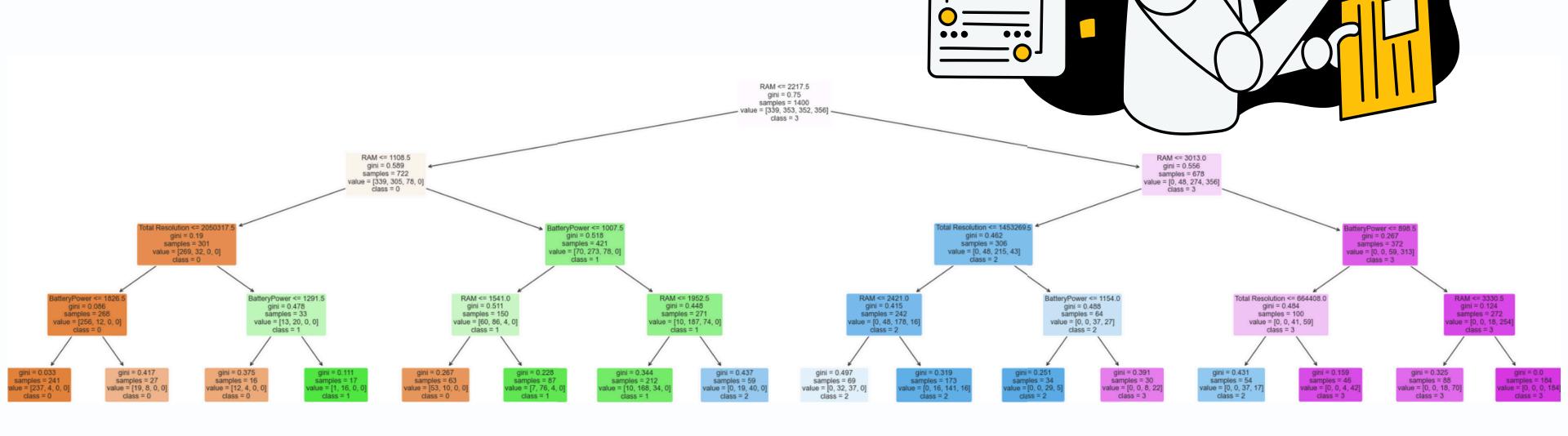


Datapoints for the variable RAM are clustered. RAM may be a significant factor.

Heatmap of Correlation 1.00 1.00 -0.00 | 0.01 -0.03 -0.00 | 0.05 -0.04 | 0.01 | 0.02 -0.01 | 0.03 | 0.00 -0.01 -0.03 -0.02 | 0.03 | 0.03 | 0.20 | 0.02 BatteryPower 0.00 | 1.00 | 0.01 |-0.03 | 0.03 |-0.00 |-0.02 |-0.01 | 0.01 | 0.01 | 0.04 | 0.01 |-0.03 |-0.03 | 0.04 | 0.01 |-0.03 |-0.03 | 0.04 | 0.02 InternalMemory 0.01 | 0.01 **| 1.00 |**-0.01 | 0.00 |-0.01 |-0.00 |-0.0**5 |-0.04 |**-0.02 | 0.02 |-0.01 | 0.02 |-0.03 |-0.01 |-0.00 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 |-0.01 ClockSpeed - 0.75 0.03-0.03-0.01 | 1.00 | 0.00 | 0.01 |-0.02-0.01-0.03-0.01 | 0.04 |-0.00|-0.02 | 0.02 |-0.00 | 0.03 |-0.01 |-0.00 | 0.00 | 0.00 NoOfCores 0.00|0.03|0.00|0.00|1.00|0.01|0.04|0.02|0.01|0.02|0.03|-0.01|-0.00|-0.03|0.02|0.04|0.02|0.03|0.92|-0.01 RAM - 0.50 0.05 | 0.00 | 0.01 | 0.01 | 0.01 | **1.00 | -**0.04 | -0.04 | -0.05 | -0.03 | 0.01 | 0.02 | 0.01 | 0.02 | -0.02 | -0.02 | -0.01 | 0.01 | 0.02 | -0.01 TalkTime -0.04-0.02-0.00-0.02 0.04 -0.04 1.00 -0.01 0.00 0.02 0.04 -0.02-0.01 -0.02-0.01 -0.02 -0.03 -0.02 0.02 -0.02 -0.02 -0.02 -0.03 -0.02 -0 0.01 | 0.01 | 0.05 | -0.01 | 0.02 | 0.04 | 0.01 | 1.00 | 0.58 | 0.00 | 0.03 | 0.01 | 0.00 | 0.01 | 0.01 | 0.03 | 0.00 | -0.00 | 0.02 | -0.03 - 0.25 0.02 | 0.01 | -0.04 | -0.03 | 0.01 | -0.05 | 0.00 | 0.58 | 1.00 | -0.02 | 0.01 | -0.00 | 0.02 | 0.03 | 0.04 | -0.02 | -0.01 | 0.01 | -0.01 0.01|0.01|+0.02|+0.01|0.02|+0.03|0.02|0.00|+0.02|1.00|+0.02|+0.03|+0.00|0.01|0.03|0.04|0.02|0.01|0.02|0.04 - 0.00 0.01 | 0.04 | 0.02 | 0.04 | 0.03 | 0.01 | 0.04 | -0.03 | 0.01 | -0.02 | 1.00 | 0.00 | -0.01 | 0.01 | -0.00 | 0.00 | 0.00 | -0.01 | 0.02 | -0.02 Bluetooth 0.03 | 0.01 | 0.01 | -0.00 | -0.01 | 0.02 | -0.02 | -0.01 | -0.00 | -0.03 | 0.00 | 1.00 | 0.02 | -0.00 | -0.03 | -0.02 | -0.00 | 0.03 | 0.00 | 0.03 MobileDepth 0.00 |-0.03|0.01|-0.02|-0.00|0.01 |-0.01|0.00|-0.02|-0.00|0.01|0.02| 1.00 |-0.01|-0.03|-0.02| 0.02|0.02|-0.03|-0.01 **MobileWeight -** −0.25 0.01|-0.03|0.02|0.02|-0.03|0.02|-0.02|0.01|0.02|0.01|0.01|-0.00|-0.01|1.00|-0.02|0.01|-0.01|-0.01|-0.01|-0.03|0.02 TouchScreen 0.03 | 0.04 | 0.03 | 0.00 | 0.02 | 0.02 | 0.01 | 0.01 | 0.03 | 0.03 | 0.00 | 0.03 | 0.03 | 0.02 | 1.00 | 0.51 | 0.01 | 0.00 | 0.02 | 0.06 ScreenHeight - -0.50 0.02|0.01|-0.01|0.03|0.04|-0.02|-0.02|0.03|0.04|0.04|0.00|-0.02|-0.02|0.01|0.51|1.00|-0.01|-0.02|0.04|0.05 ScreenWidth FrontCameraPx 0.03 | 0.03 | 0.01 | -0.00 | 0.03 | 0.01 | 0.02 | -0.00 | -0.01 | 0.01 | -0.01 | 0.03 | 0.02 | -0.01 | 0.00 | -0.02 | 0.64 | 1.00 | 0.03 | -0.02 | 0.03 | -0.02 | 0.04 | 1.00 | 0.03 | -0.02 | 0.03 | -0.02 | 0.03 | -0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | RearCameraPX - -0.75 0.20 | 0.04 | 0.01 | 0.00 | 0.92 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.00 | -0.03 | -0.03 | 0.02 | 0.04 | 0.02 | 0.03 | 1.00 | 0.18 PriceRange 0.02 | 0.02 | 0.01 | 0.00 | -0.01 | -0.01 | -0.02 | -0.03 | -0.01 | 0.04 | -0.02 | 0.03 | -0.01 | 0.02 | 0.06 | 0.05 | -0.01 | -0.02 | 0.18 | 1.00 Total Resolution − −1.00 MobileWeight ClockSpeed ScreenHeight ScreenWidth iternalMemory TouchScreen RearCameraPX NoOfCores BatteryPowe

Machine Learning

- Decision Tree
- Random Forest
- Random Forest with Gridsearch

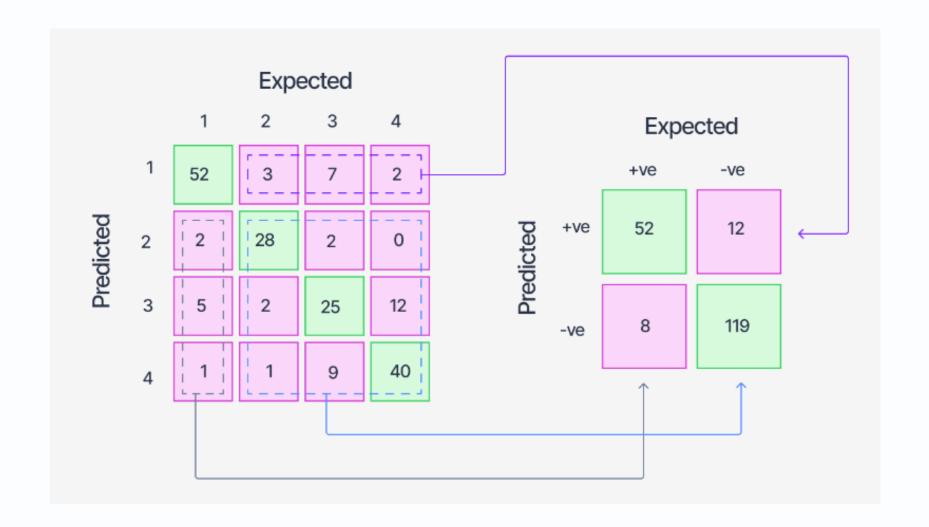


000

0 0 0

Interpret multiclass confusion matrix

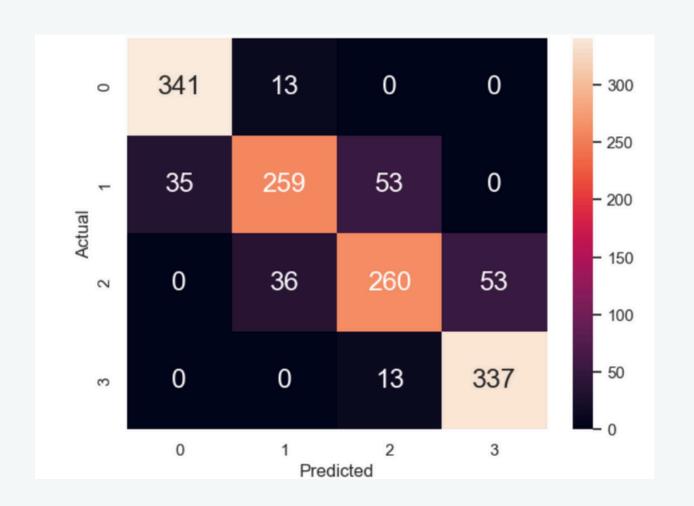
- The 4x4 confusion matrix is converted into a one-versus-all type matrix.
- Each class will have its performance metrics.
- Take average performance metrics.



Decision Tree Performance Metrics

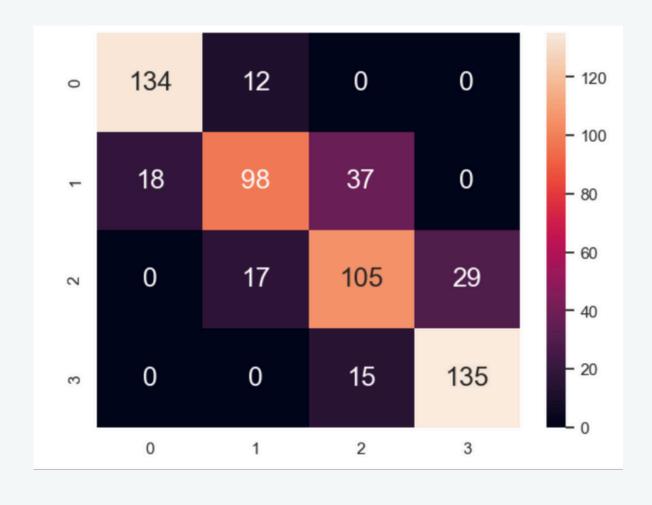
Train Data

Accuracy: 0.85500 Average TPR: 0.85437 Average TNR: 0.97190 Average FPR: 0.02809 Average FNR: 0.14562



Test Data

Accuracy: 0.78666 Average TPR: 0.78842 Average TNR: 0.94445 Average FPR: 0.05554 Average FNR: 0.21157



Second Attempt - Random Forest

Model 2: Random Forest

Train Data Trest Data

 Accuracy: 0.88357
 Accuracy: 0.79333

 Average TPR: 0.88416
 Average TPR: 0.79109

 Average TNR: 0.97266
 Average TNR: 0.95889

 Average FPR: 0.02733
 Average FPR: 0.04110

 Average FNR: 0.11583
 Average FNR: 0.20890

Model 2.1: Increased Trees

Train Data Test Data

Accuracy: 0.88071 Accuracy: 0.78166

Average TPR: 0.88135 Average TPR: 0.77857

Average TNR: 0.97028 Average TNR: 0.96054

Average FPR: 0.02971 Average FPR: 0.03945

Average FNR: 0.11864 Average FNR: 0.22142

Model 2.2: Increased Depth

Train Data Test Data

 Accuracy: 0.97
 0.82833

 Average TPR: 0.96976
 Average TPR: 0.82861

 Average TNR: 0.98431
 Average TNR: 0.96889

 Average FPR: 0.01568
 Average FPR: 0.03110

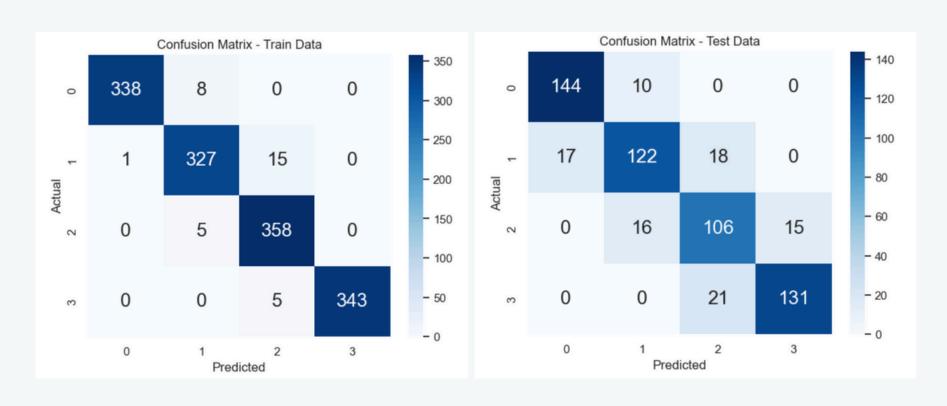
 Average FNR: 0.03023
 Average FNR: 0.17138

Model 2.3: Both Trees and Depth Increased

Train Data

Accuracy: 0.97571 Average TPR: 0.97552 Average TNR: 0.98597 Average FPR: 0.01402 Average FNR: 0.02447 Test Data

Accuracy: 0.83833 Average TPR: 0.83692 Average TNR: 0.97448 Average FPR: 0.02551 Average FNR: 0.16307



Third Attempt - Gridsearch

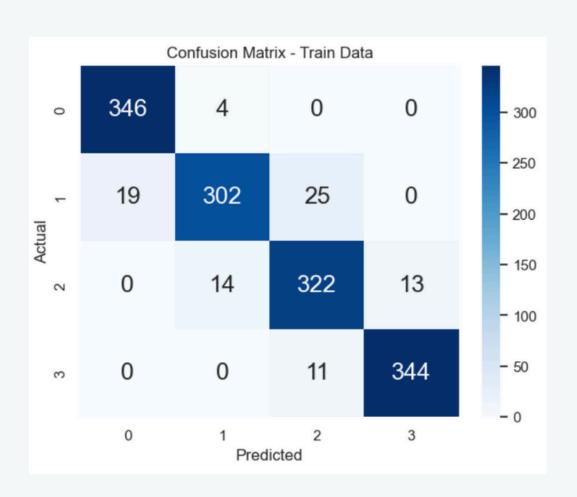
Train Data

Accuracy: 0.93857

Average TPR: 0.93826 Average TNR: 0.98566

Average FPR: 0.01433

Average FNR: 0.06173



Test Data

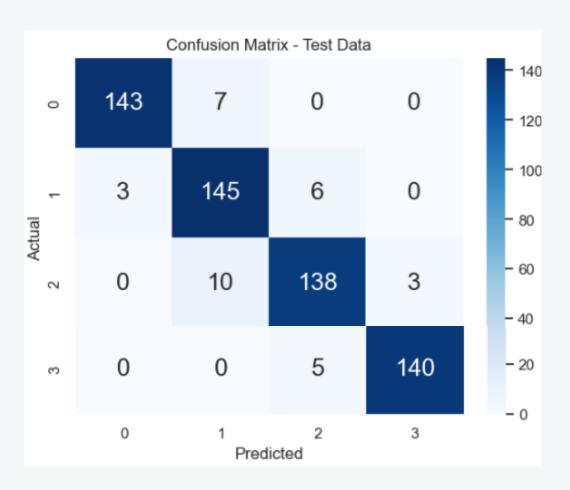
Accuracy: 0.94333

Average TPR: 0.94357

Average TNR: 0.98554

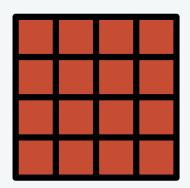
Average FPR: 0.01445

Average FNR: 0.05642



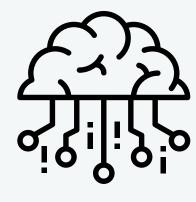
New Learnings





Multiclass confusion matrix

Unlike binary class confusion matrix, 4x4 confusion matrix need to be converted first before interpreting.



Random Forest

Very similar to the Decision Tree in principle, but with multiple decision trees for improved classification.



Overfitting

Able to give accurate predictions for training data but cannot perform well for test data.

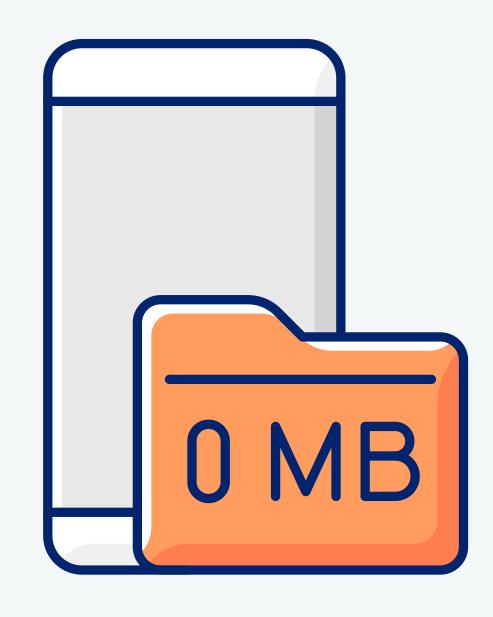


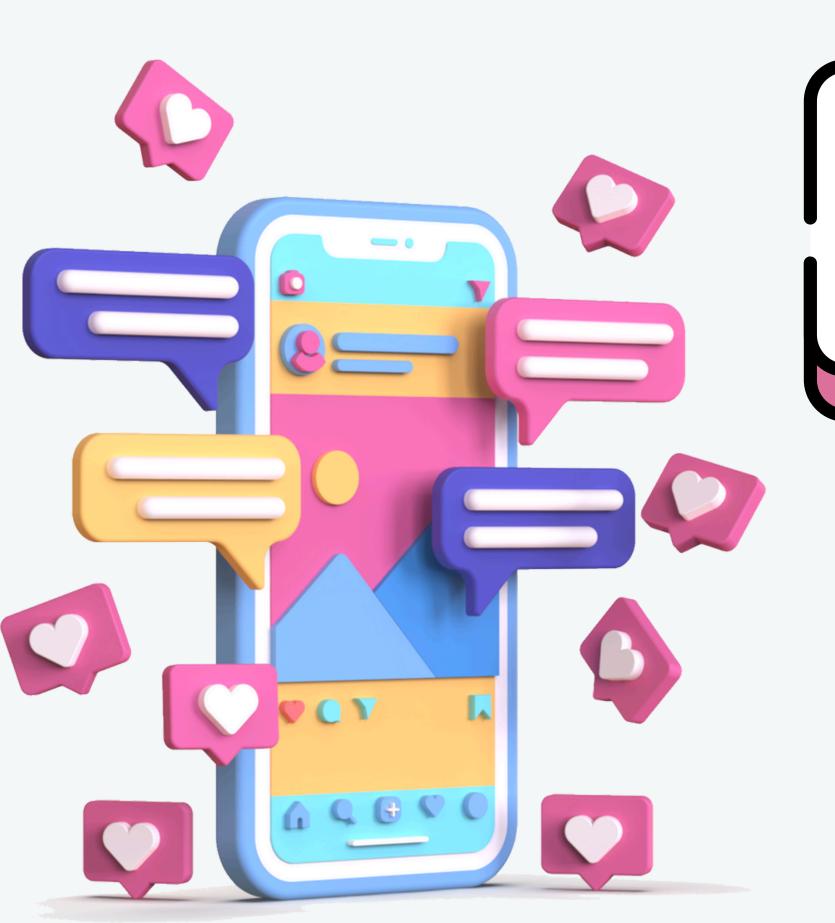
To optimize the hyperparameters of the machine learning model.

Outcome & Data-Driven Insights

RAM of a mobile phone is a key specification that influences the mobile price.

Decision-making is still an individual's choice, and no analysis can decide for you!





Thank You!