PERFORMANCE METRICS

PRECAP

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PERFORMANCE METRICS

02

ACCURACY

03

PRECISION, RECALL, F1 SCORE

04

MACRO, WEIGHTED, MICRO AVERAGE

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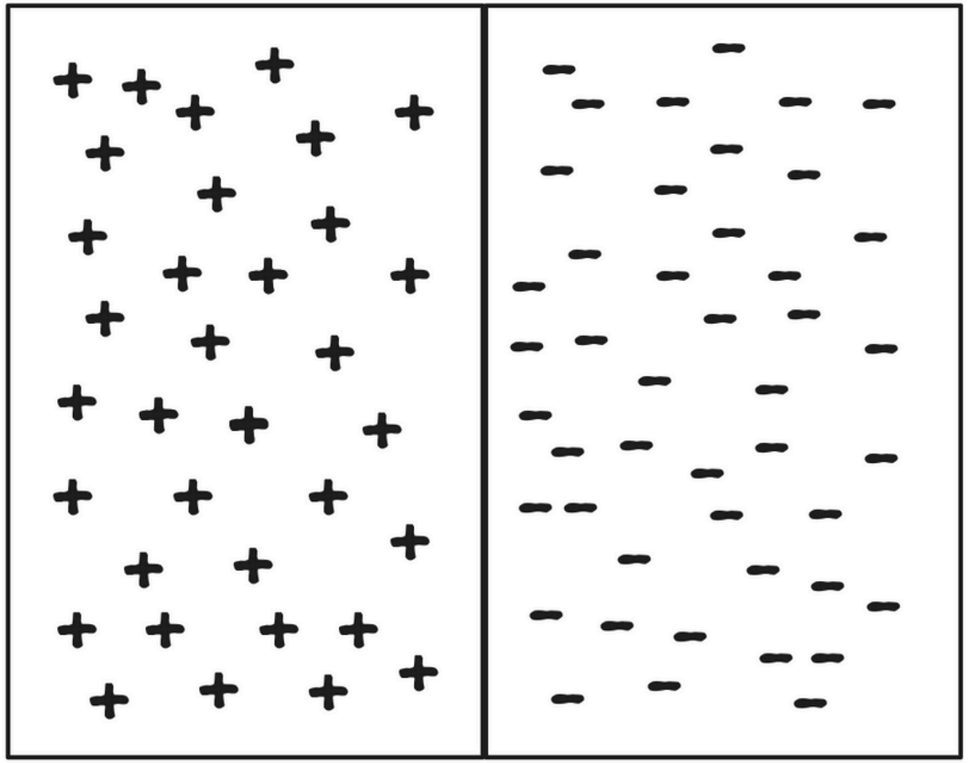
Binary Classification



Binary classification in machine learning refers to the task of categorizing data into one of two classes or categories.

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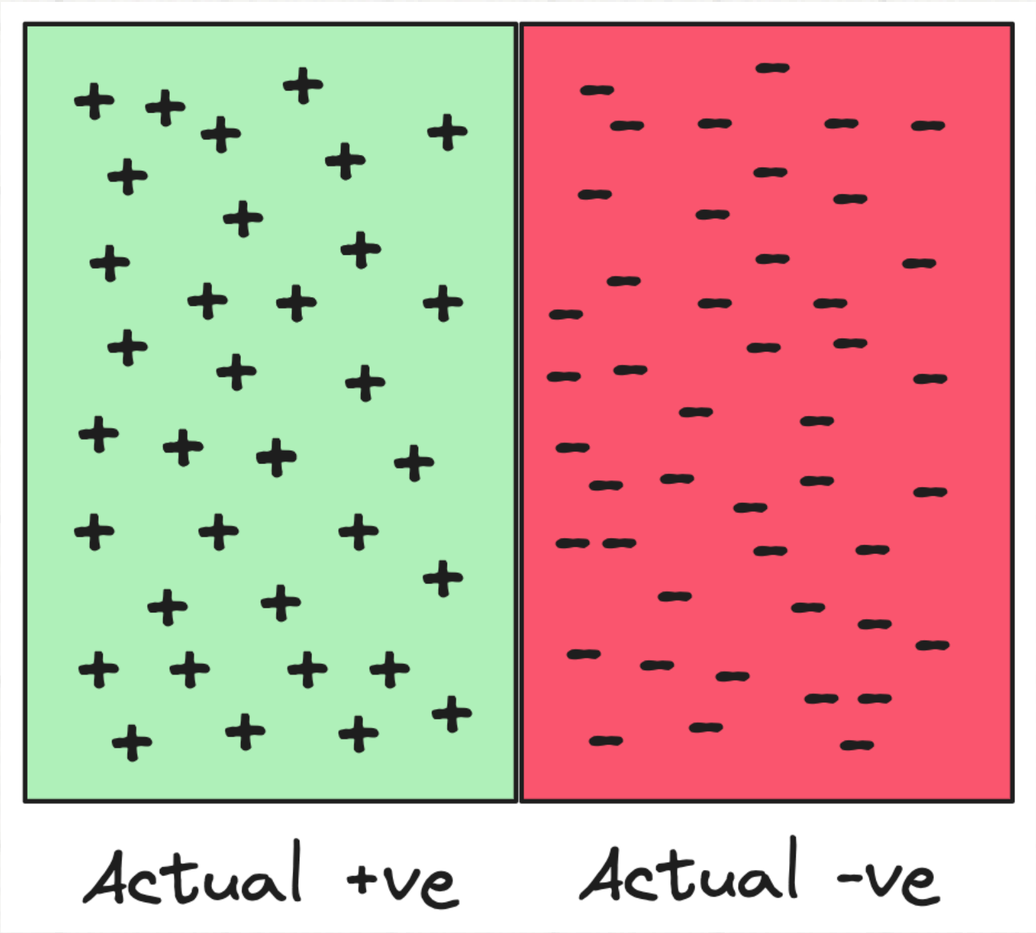

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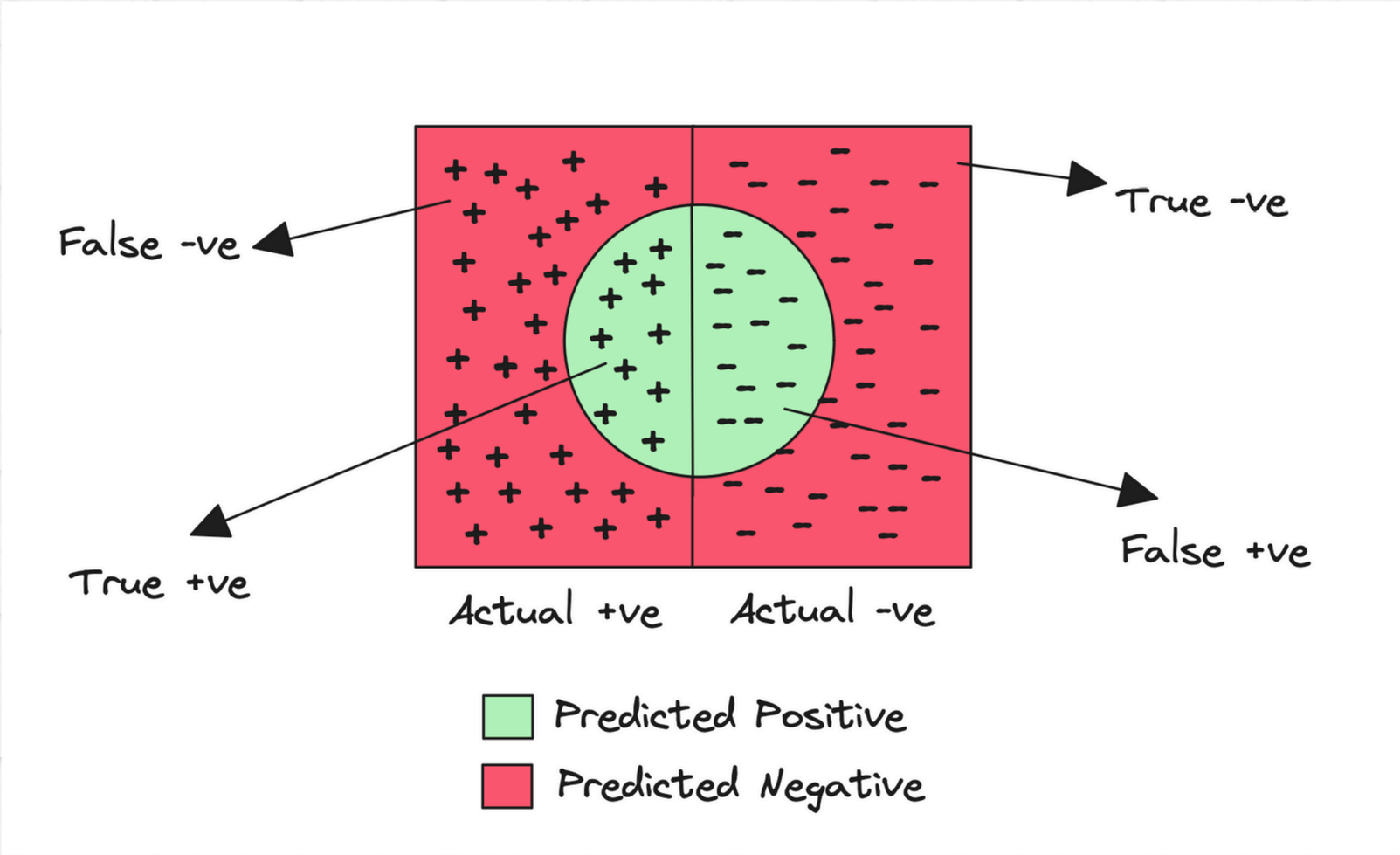
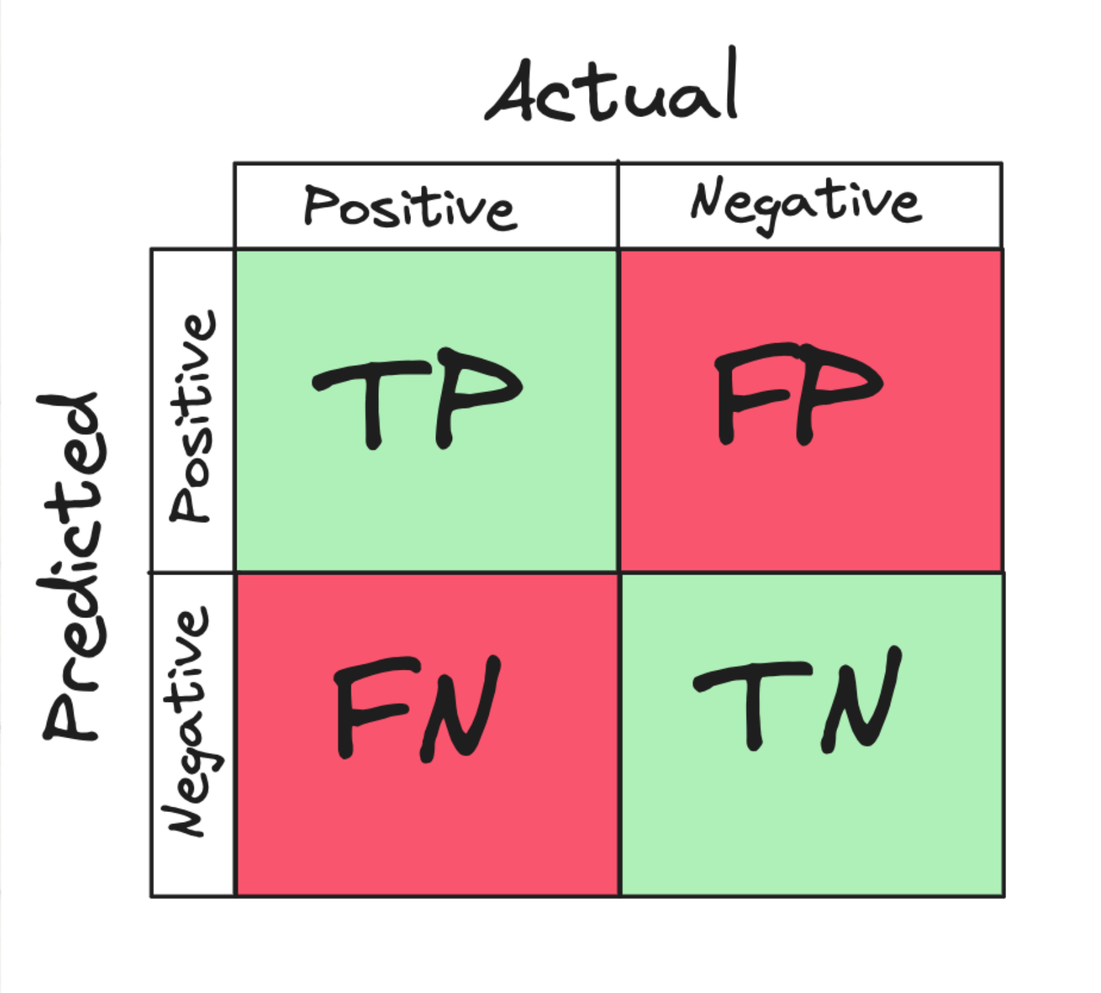


Confusion Matrix



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Accuracy

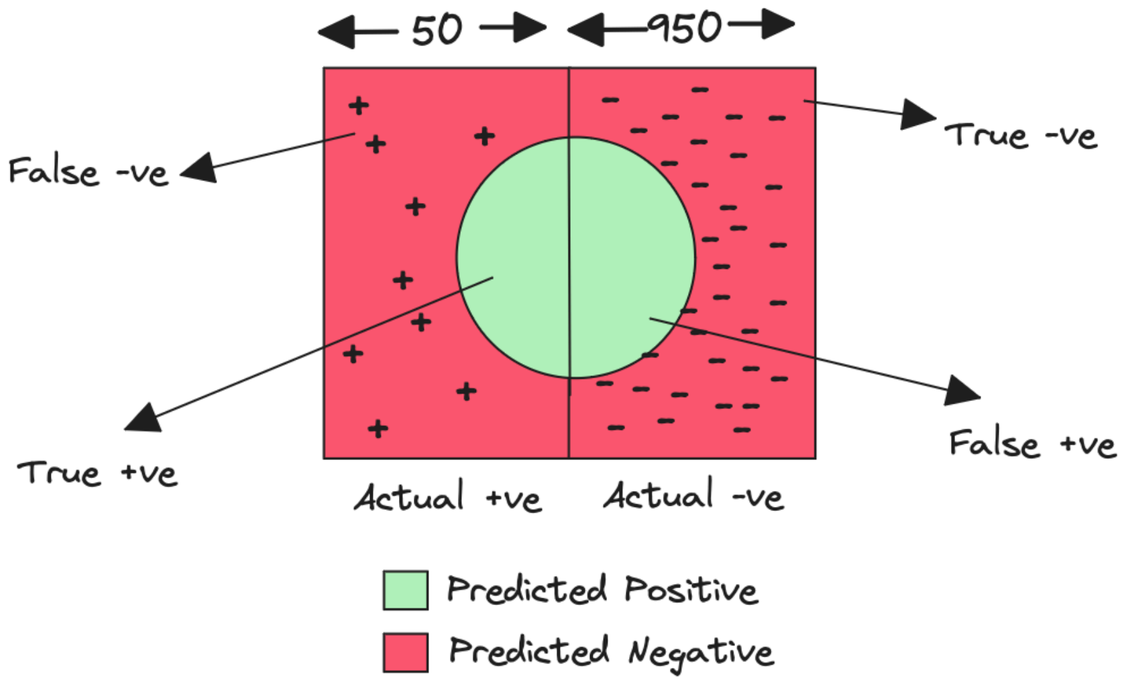
Accuracy is a commonly used metric to evaluate the performance of a classification model, including binary classification. It measures the proportion of correctly classified data points out of the total number of data points.

$$\text{Accuracy} = \frac{\text{Number of Correct Predictions}}{\text{Total Number of Predictions}}$$

Accuracy

$$\frac{TP + TN}{TP + TN + FP + FN}$$

Cancer Diagnosis Case - 1



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

$$= \frac{0 + 950}{0 + 950 + 0 + 50}$$

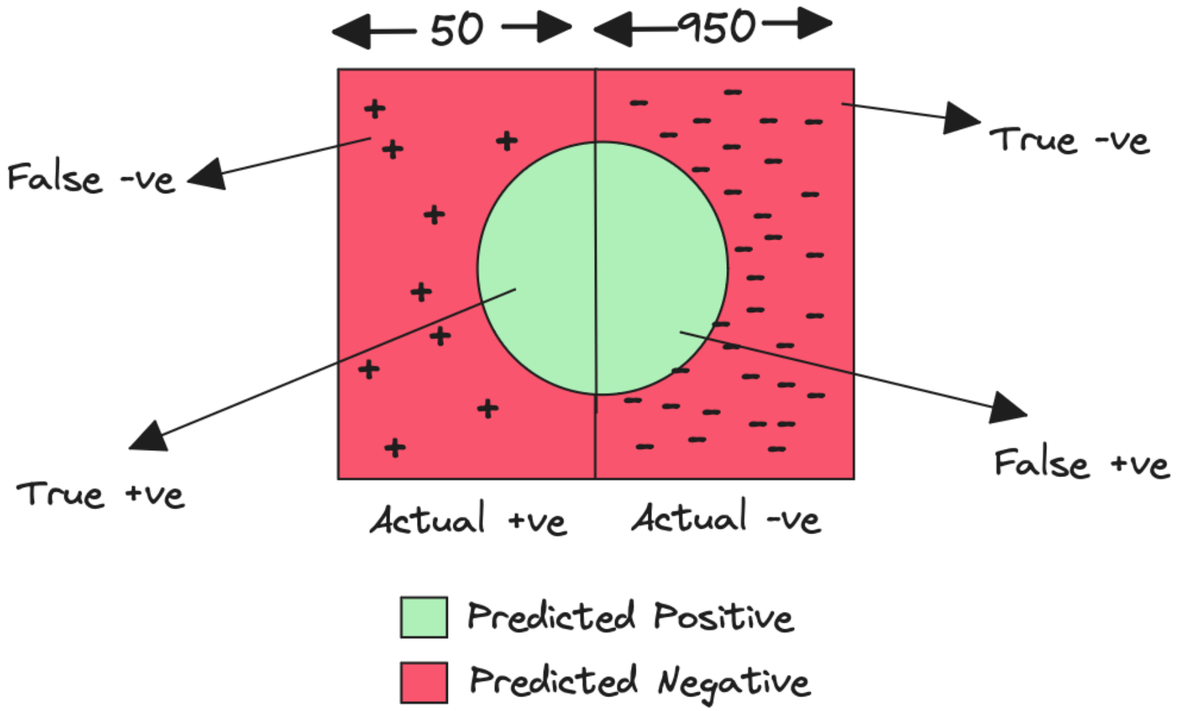
$$= 95\%$$

Recall

Recall is a metric used to evaluate the performance of a classification model, particularly in scenarios where the identification of all positive instances (true positives) is important. Recall, also known as sensitivity or true positive rate, measures the ability of a model to correctly identify all relevant instances from the total number of actual positive instances in the dataset.

$$\text{Recall} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}}$$

Cancer Diagnosis Case - 1



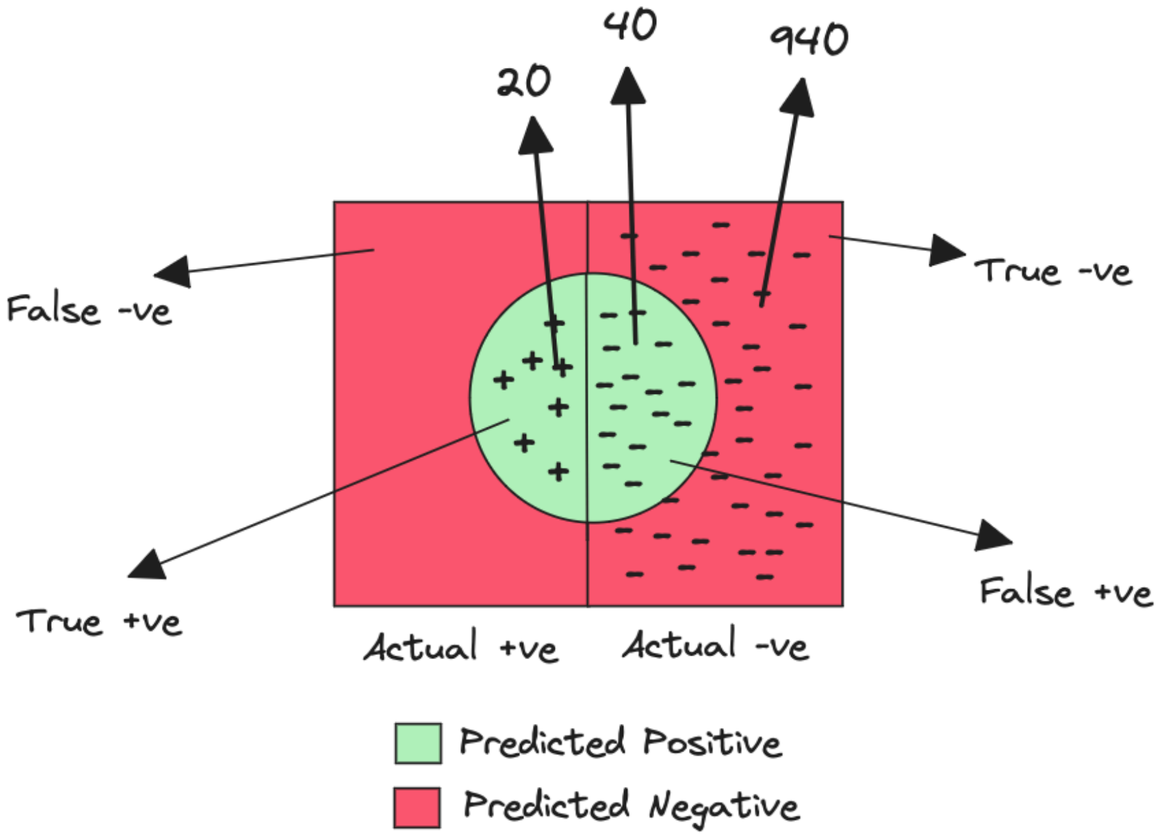
$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

$$= \frac{0 + 950}{0 + 950 + 0 + 50} = 95\%$$

$$\text{Recall} = \frac{TP}{TP + FN}$$

$$= \frac{0}{0 + 50} = 0\%$$

Cancer Diagnosis Case - 2



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

$$= \frac{20 + 940}{20 + 940 + 40 + 0} = 96\%$$

$$\text{Recall} = \frac{TP}{TP + FN}$$

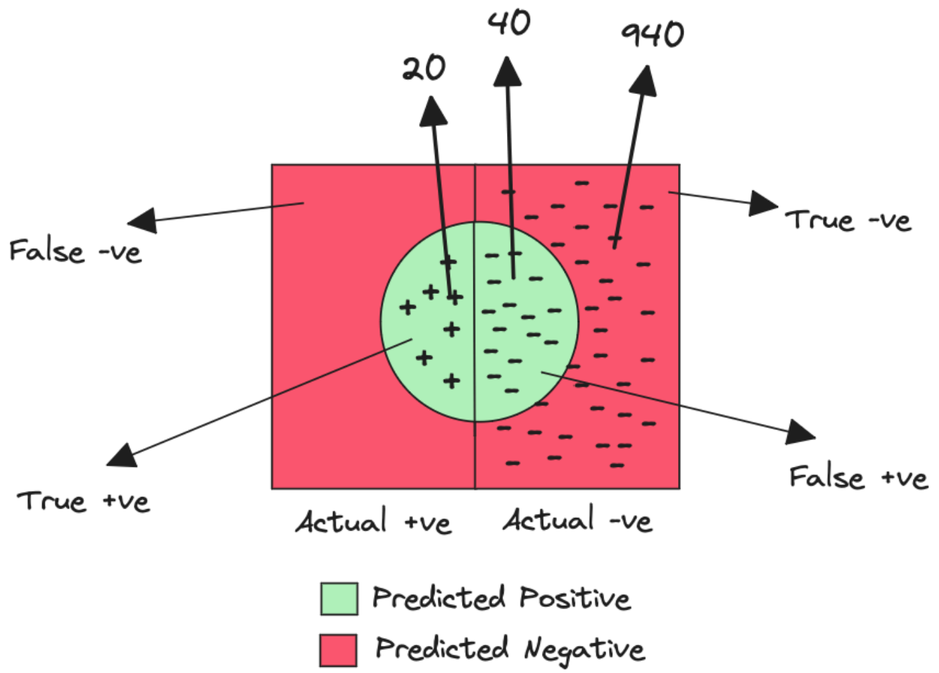
$$= \frac{20}{20 + 0} = 100\%$$

Precision

Precision is a metric used to evaluate the performance of a classification model, particularly in scenarios where the goal is to minimize false positives. Precision measures the proportion of true positive predictions (correctly identified positive instances) out of all instances predicted as positive by the model.

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

Credit Card Fraud Detection Case - 1



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

$$= \frac{20 + 940}{20 + 940 + 40 + 0} = 96\%$$

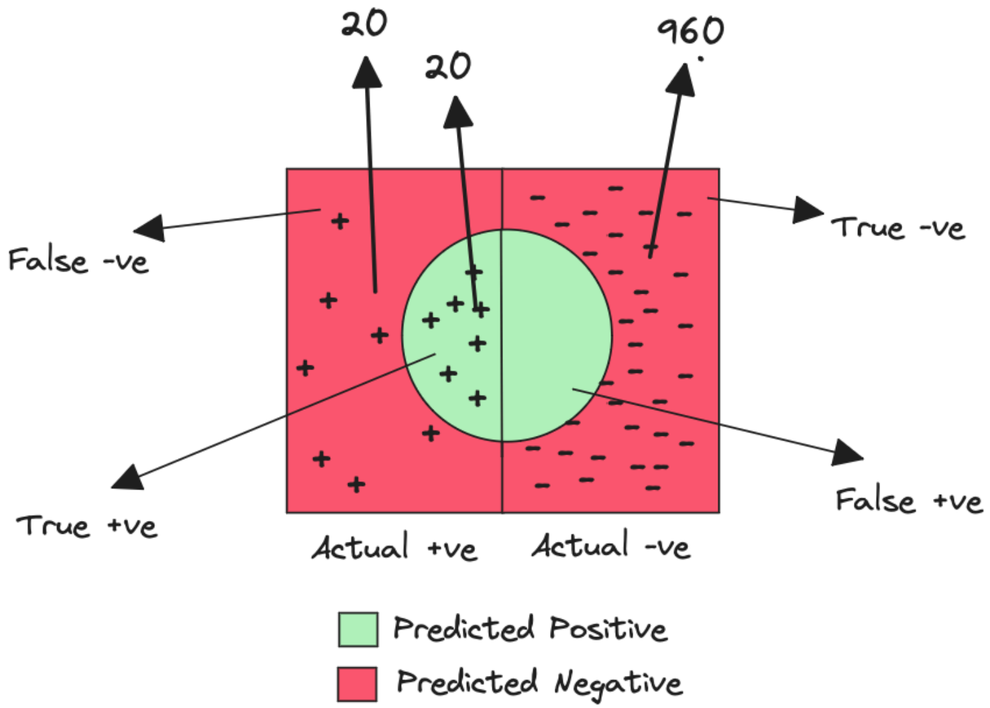
$$\text{Recall} = \frac{TP}{TP + FN}$$

$$= \frac{20}{20 + 0} = 100\%$$

$$\text{Precision} = \frac{TP}{TP + FP}$$

$$= \frac{20}{20 + 40} = 33.33\%$$

Credit Card Fraud Detection Case - 2



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

$$= \frac{20 + 960}{20 + 960 + 0 + 20} = 98\%$$

$$\text{Recall} = \frac{TP}{TP + FN}$$

$$= \frac{20}{20 + 20} = 50\%$$

$$\text{Precision} = \frac{TP}{TP + FP}$$

$$= \frac{20}{20 + 0} = 100\%$$

Recall and Precision ni Average chesi chuddam

Recall	Precision	Average
95%	2%	48.5%
5%	98%	51.5%

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Precision	Recall	Arithmetic Mean	Geometric Mean	Harmonic Mean
2	100	51.0	14.14	3.92
100	2	51.0	14.14	3.92
20	80	50	40	32
80	10	45.0	28.28	17.78
30	100	65.0	54.77	46.15
50	50	50	50	50
80	100	90	89.44	88.89
90	90	90	90	90
100	100	100	100	100

1. **Arithmetic Mean (AM):**

$$\text{AM} = \frac{a+b}{2}$$

2. **Geometric Mean (GM):**

$$\text{GM} = \sqrt{a \times b}$$

3. **Harmonic Mean (HM):**

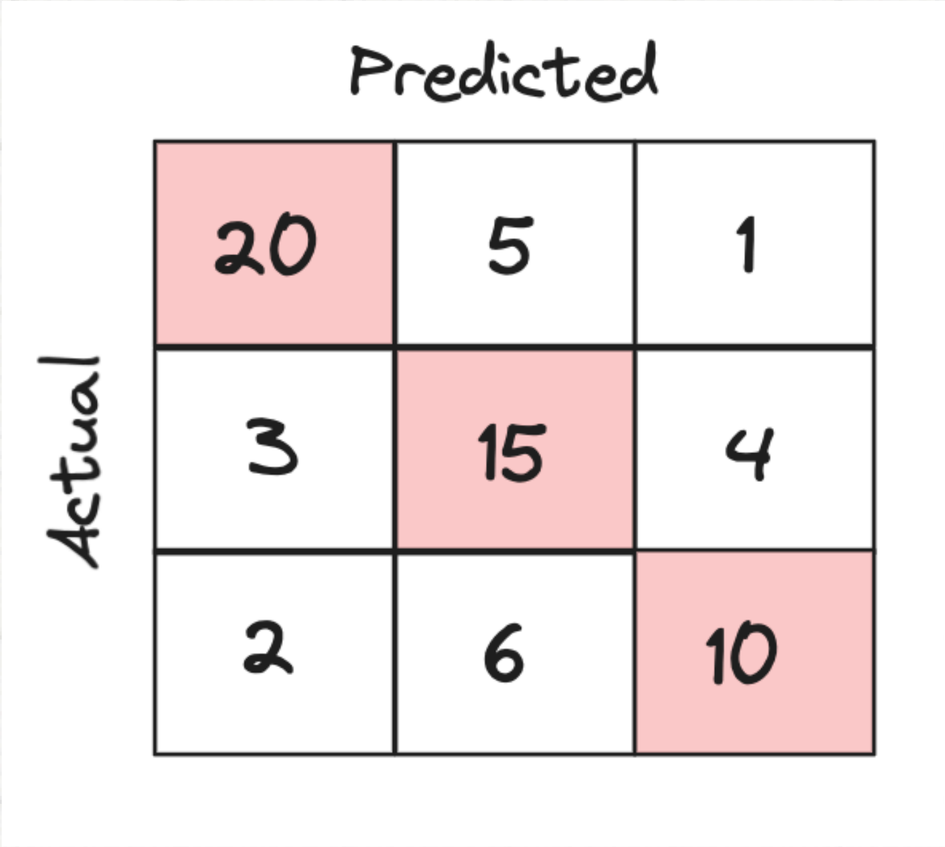
$$\text{HM} = \frac{2}{\left(\frac{1}{a}+\frac{1}{b}\right)}$$

F1 Score

The F1 score is a metric used in machine learning to evaluate the performance of a classification model, particularly when dealing with imbalanced classes. It combines both precision and recall into a single metric, providing a balanced assessment of the model's performance. It is the harmonic mean of precision and recall.

$$F1 = \frac{2 \times \text{precision} \times \text{recall}}{\text{precision} + \text{recall}}$$

Multi - Class Metrics



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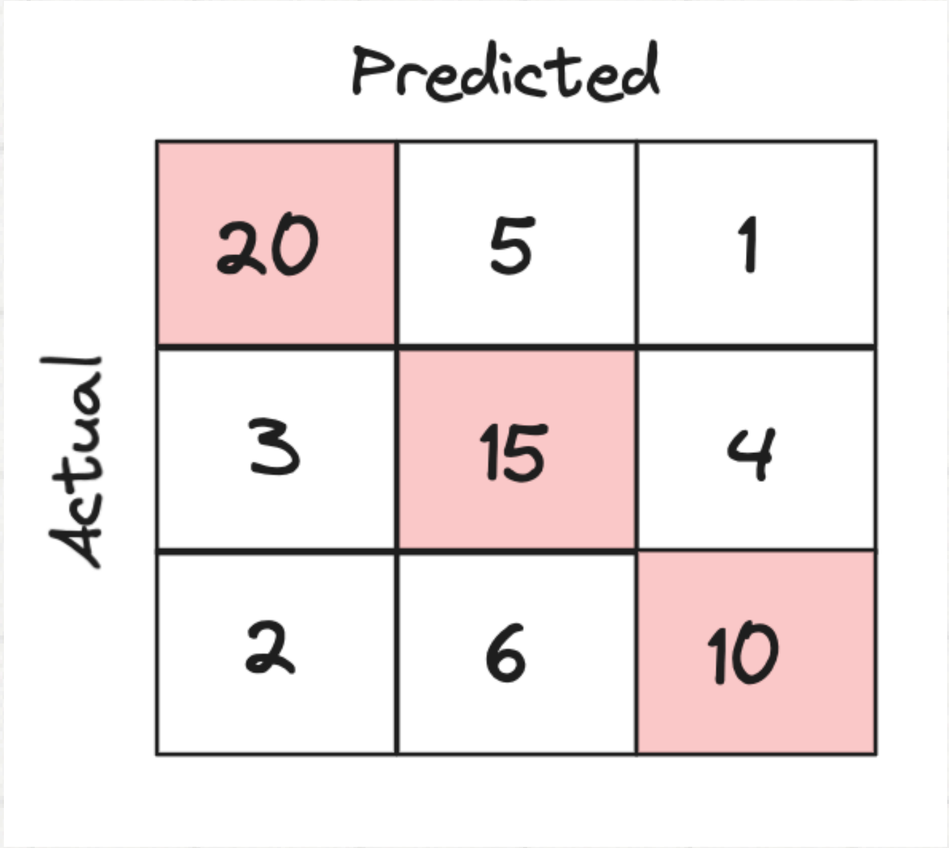
Multi - Class Metrics



Class A:

- True Positives (TP_A) = 20
- False Positives (FP_A) = 3 + 2 = 5
- False Negatives (FN_A) = 5 + 1 = 6

$$Precision_A = \frac{TP_A}{TP_A+FP_A} = \frac{20}{20+5} = \frac{20}{25} = 0.8$$

$$Recall_A = \frac{TP_A}{TP_A+FN_A} = \frac{20}{20+6} = \frac{20}{26} \approx 0.769$$

$$F1_A = \frac{2\times Precision_A \times Recall_A}{Precision_A+Recall_A} = \frac{2\times 0.8\times 0.769}{0.8+0.769} \approx 0.784$$

Class B:

- True Positives (TP_B) = 15
- False Positives (FP_B) = 5 + 6 = 11
- False Negatives (FN_B) = 3 + 4 = 7

$$Precision_B = \frac{TP_B}{TP_B+FP_B} = \frac{15}{15+11} \approx 0.577$$

$$Recall_B = \frac{TP_B}{TP_B+FN_B} = \frac{15}{15+7} \approx 0.682$$

$$F1_B = \frac{2\times Precision_B \times Recall_B}{Precision_B+Recall_B} = \frac{2\times 0.577\times 0.682}{0.577+0.682} \approx 0.625$$

Class C:

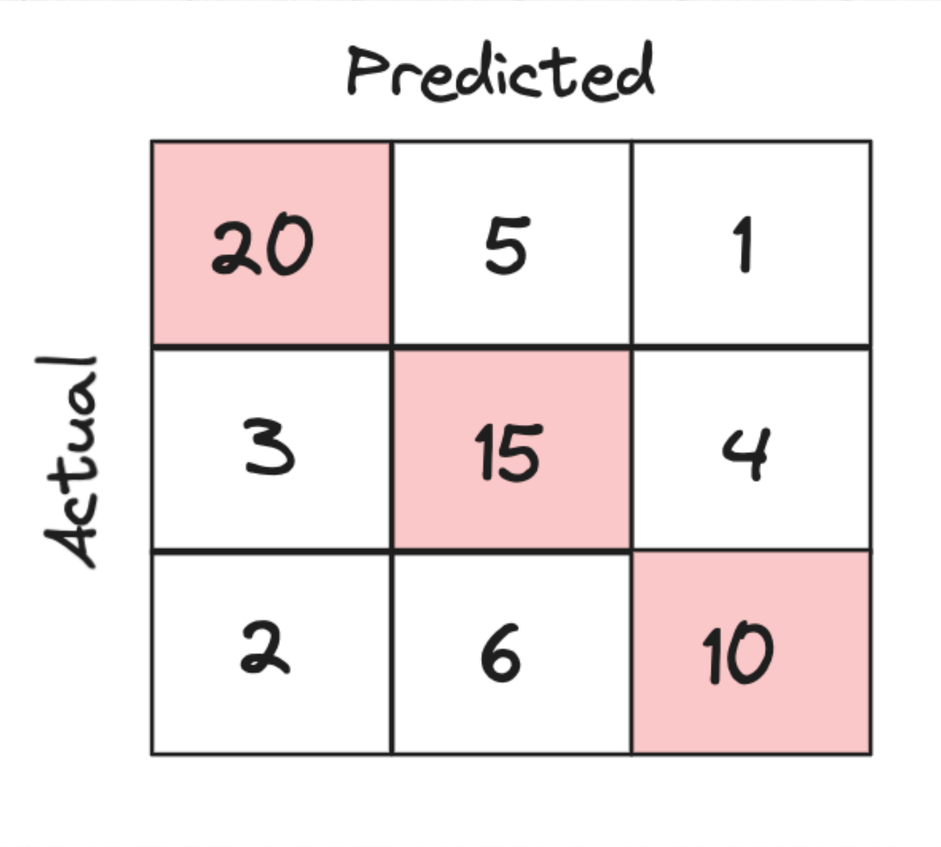
- True Positives (TP_C) = 10
- False Positives (FP_C) = 1 + 4 = 5
- False Negatives (FN_C) = 2 + 6 = 8

$$Precision_C = \frac{TP_C}{TP_C+FP_C} = \frac{10}{10+5} = \frac{10}{15} \approx 0.667$$

$$Recall_C = \frac{TP_C}{TP_C+FN_C} = \frac{10}{10+8} = \frac{10}{18} \approx 0.556$$

$$F1_C = \frac{2\times Precision_C \times Recall_C}{Precision_C+Recall_C} = \frac{2\times 0.667\times 0.556}{0.667+0.556} \approx 0.606$$

Multi - Class Metrics



Class	A	B	C
Precision	20/25	15/26	10/15
Recall	20/26	15/22	10/18
F1 Score	0.784	0.625	0.606

Macro Average

For precision:

$$Precision_{\text{macro}} = \frac{Precision_A + Precision_B + Precision_C}{3}$$

For recall:

$$Recall_{\text{macro}} = \frac{Recall_A + Recall_B + Recall_C}{3}$$

For F1 score:

$$F1_{\text{macro}} = \frac{F1_A + F1_B + F1_C}{3}$$

Let's calculate:

$$Precision_{\text{macro}} = \frac{0.8 + 0.577 + 0.667}{3} \approx 0.681$$

$$Recall_{\text{macro}} = \frac{0.769 + 0.682 + 0.556}{3} \approx 0.669$$

$$F1_{\text{macro}} = \frac{0.784 + 0.625 + 0.606}{3} \approx 0.672$$

Class	A	B	C	Macro Average
Precision	20/25	15/26	10/15	0.681
Recall	20/26	15/22	10/18	0.669
F1 Score	0.784	0.625	0.606	0.672

Macro Average

Macro-average calculates the F1 score for each class individually and then takes the average across all classes, giving equal weight to each class regardless of its size.

To calculate macro-average F1 score:

$$\text{Macro-average Precision} = \frac{\text{Precision}_A + \text{Precision}_B + \text{Precision}_C + \text{Precision}_D}{4}$$

$$\text{Macro-average Recall} = \frac{\text{Recall}_A + \text{Recall}_B + \text{Recall}_C + \text{Recall}_D}{4}$$

$$\text{Macro-average F1} = \frac{2 \times \text{Macro-average Precision} \times \text{Macro-average Recall}}{\text{Macro-average Precision} + \text{Macro-average Recall}}$$

Weighted Average

Class	A	B	C	Macro Average
Precision	20/25	15/26	10/15	0.681
Recall	20/26	15/22	10/18	0.669
F1 Score	0.784	0.625	0.606	0.672

$$\text{Weighted Precision} = \frac{\sum(\text{support}_i \times \text{precision}_i)}{\text{total instances}}$$

$$= \frac{(26 \times 0.8) + (22 \times 0.577) + (18 \times 0.667)}{26 + 22 + 18}$$

$$= \frac{20.8 + 12.694 + 12.006}{66}$$

$$= \frac{45.5}{66} \approx 0.689$$

$$\text{Weighted Recall} = \frac{\sum(\text{support}_i \times \text{recall}_i)}{\text{total instances}}$$

$$= \frac{(26 \times 0.769) + (22 \times 0.682) + (18 \times 0.556)}{66}$$

$$= \frac{19.994 + 15.004 + 10.008}{66} \approx 0.682$$

$$\text{Weighted F1-score} = \frac{\sum(\text{support}_i \times \text{F1-score}_i)}{\text{total instances}}$$

$$= \frac{(26 \times 0.784) + (22 \times 0.625) + (18 \times 0.607)}{66}$$

$$= \frac{20.384 + 13.75 + 10.926}{66} \approx 0.677$$

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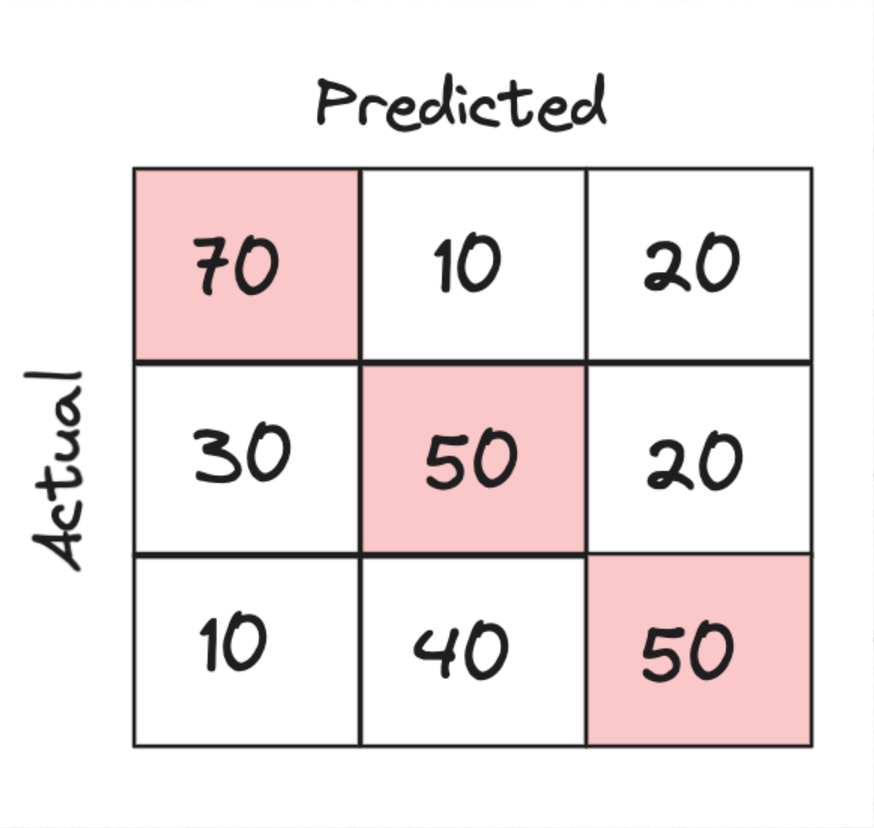
Weighted Average

Class	A	B	C	Macro Average	Weighted Average
Precision	20/25	15/26	10/15	0.681	0.689
Recall	20/26	15/22	10/18	0.669	0.682
F1 Score	0.784	0.625	0.606	0.672	0.677

Micro Average

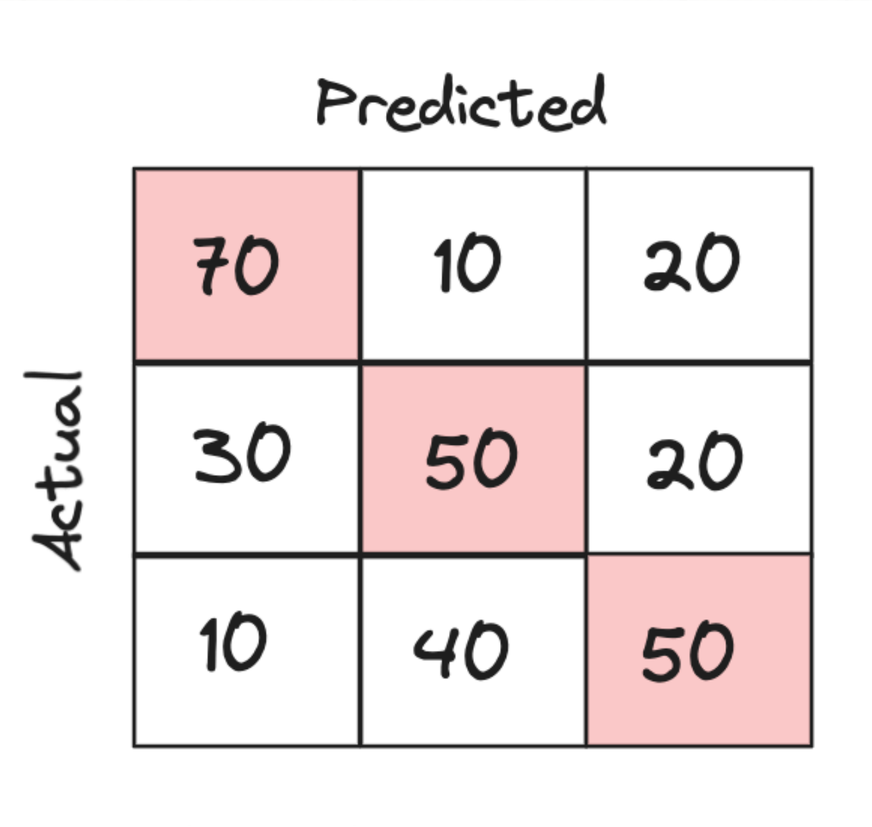


$$\text{Recall} = \frac{170}{170+130} = 0.567$$

$$\text{Precision} = \frac{170}{170+130} = 0.567$$

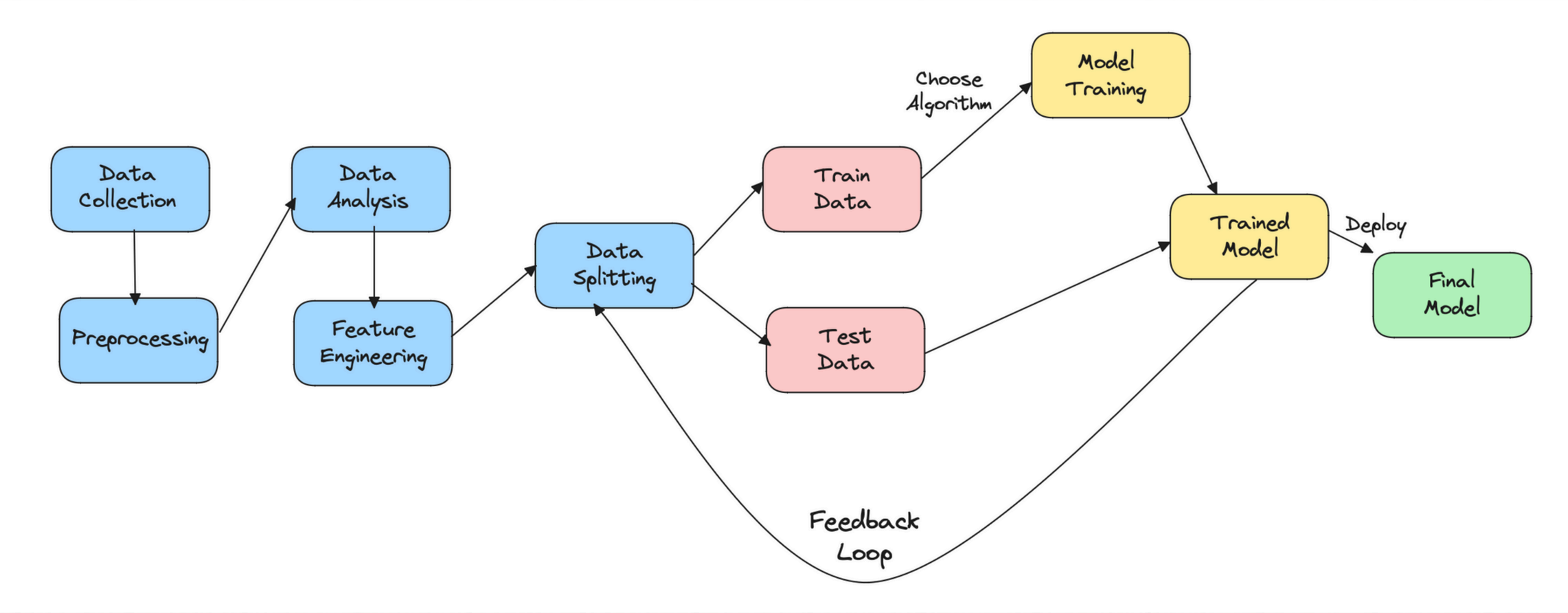
F1 Score = 0.567

Micro Average



Precision	Recall	F1 Score
0.567	0.567	0.567

ML in Short



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