**Real-Time Example: Confusion Matrix in Credit Card Fraud Detection**

**Scenario**

A bank implements a machine learning model to detect fraudulent credit card transactions. The model classifies transactions as **Fraudulent (Positive)** or **Genuine (Negative)**.

After evaluating the model on **10,000 transactions**, the results are summarized in a **confusion matrix**.

**Confusion Matrix for Fraud Detection**

| **Actual \ Predicted** | **Fraud (Positive)** | **Genuine (Negative)** |
| --- | --- | --- |
| **Fraud (Positive)** | **120** (True Positive, TP) | **30** (False Negative, FN) |
| **Genuine (Negative)** | **50** (False Positive, FP) | **9,800** (True Negative, TN) |

**Explanation of the Values**

* **True Positive (TP) = 120**  
  → Fraudulent transactions correctly identified as fraud.
* **False Negative (FN) = 30**  
  → Fraudulent transactions wrongly classified as genuine (missed fraud).
* **False Positive (FP) = 50**  
  → Genuine transactions wrongly classified as fraud (false alarms).
* **True Negative (TN) = 9,800**  
  → Genuine transactions correctly classified as genuine.

**Key Performance Metrics**

Using the confusion matrix, we calculate important metrics:

**1. Accuracy = (TP + TN) / (Total Transactions)**

(120 + 9,800) / 10,000 = 0.992 \text{ (99.2% accurate)}

**2. Precision (Fraud Detection Accuracy) = TP / (TP + FP)**

120 / (120 + 50) = 0.706 \text{ (70.6%)}

→ Out of all flagged fraudulent transactions, 70.6% were actually fraud.

**3. Recall (Sensitivity or True Positive Rate) = TP / (TP + FN)**

120 / (120 + 30) = 0.8 \text{ (80%)}

→ The model correctly identified 80% of actual fraud cases.

**4. F1-Score (Harmonic Mean of Precision & Recall)**

2 \times \frac{0.706 \times 0.8}{0.706 + 0.8} = 0.75 \text{ (75%)}

**Insights and Business Impact**

* **High Accuracy (99.2%)** shows the model performs well overall.
* **Precision (70.6%) is moderate**, meaning some legitimate transactions were falsely flagged as fraud, causing customer inconvenience.
* **High Recall (80%)** means the bank catches most fraud cases, reducing financial losses.
* **False Negatives (30 missed fraud cases)** could result in significant monetary loss for customers.
* **False Positives (50 false fraud alerts)** could lead to blocked transactions, frustrating users.

**Conclusion**

The confusion matrix helps the bank **evaluate the trade-off between catching fraudulent transactions and minimizing false alarms**. The model might need improvements, such as adjusting thresholds or using additional fraud detection methods.