Machine Learning Notes

# Multiclass Classification

In machine learning, multiclass classification is a problem where there are more than two categories or classes. The goal is to classify an input into one of these multiple classes. Common examples include predicting the type of animal (cat, dog, bird), the type of fruit (apple, banana, orange), or the digit in handwritten digit recognition (0-9).

# One-vs-All (OvA) or One-vs-Rest (OvR)

One-vs-All (OvA) or One-vs-Rest (OvR) is a technique used for solving multiclass classification problems. It works by breaking down the multiclass problem into multiple binary classification problems. For each class, a binary classifier is created, where the class is compared to all other classes (hence the name 'One vs All').

For example, if you're classifying animals into cats, dogs, and birds, three binary classifiers are created:  
- A classifier to distinguish cats vs non-cats.  
- A classifier to distinguish dogs vs non-dogs.  
- A classifier to distinguish birds vs non-birds.  
During prediction, the classifier with the highest score is selected as the predicted class.

Formula: Each binary classifier calculates a score for the probability of its class:  
P(class | input) = output of binary classifier  
The class with the highest probability is chosen.

# One-vs-One (OvO)

In One-vs-One (OvO), instead of comparing each class against all other classes, a separate binary classifier is created for each pair of classes. If there are N classes, the number of classifiers created is N(N-1)/2.

For example, for the animal classification task (cats, dogs, birds):  
- A classifier to distinguish cats vs dogs.  
- A classifier to distinguish cats vs birds.  
- A classifier to distinguish dogs vs birds.  
During prediction, each classifier votes for one of the two classes it was trained on, and the class with the most votes is chosen.

Formula: Each classifier is trained to predict between two classes (class A vs class B), and during prediction, a majority vote across all classifiers determines the final class.