Assignment 6: 100 Points
Cross-Validation, Random Search, Grid Search and Bayesian Optimization

Due Date: M 03/17

Part A: Cross-Validation (30 Points)

Cross-Validation on a Large Dataset

Q1. Consider a dataset with 1,500 samples and 25 features. You are performing 10-fold cross-validation to tune the hyperparameters of a model.

(a) How many samples will be used for training and testing in each fold?
In each fold, _____ samples will be used for training, and _____ samples will be used for testing (**7 points**).

Answers:

Total samples = 1500.
Using 10-fold cross-validation, the dataset is split into 10 equal parts.
Test samples per fold = $\frac{1500}{10} = 150$.
Training samples per fold = Total samples - Test samples = $1500 - 150 = 1350$.
Answer: 1,350 samples will be used for training, and 150 samples will be used for testing.

(b) Given that the model achieves an accuracy of 85% on each fold, what will be the overall accuracy after completing the 10-fold cross-validation?
The overall accuracy will be _____ % after completing the 10-fold cross-validation (**8 points**).

Answers:

Since each fold achieves 85% accuracy, the average accuracy over all folds remains 85%.
Answer: 85%

Stratified Cross-Validation

Q2. You are now performing stratified 5-fold cross-validation on a dataset with 2,000 samples where 60% of the samples belong to Class A, and 40% belong to Class B.

(a) How many samples from each class will be in each fold?
Class A samples in each fold = _____, Class B samples in each fold = _____ (**7 points**).

Answers:

Total samples = 2000.
Class A samples = $2000 \times 0.60 = 1200$.
Class B samples = $2000 \times 0.40 = 800$.
Since there are 5 folds, each fold gets:

Class A per fold = $\frac{1200}{5} = 240$.

Class B per fold = $\frac{800}{5} = 160$.

Answer: Class A: 240 samples, Class B: 160 samples.

(b) What is the proportion of Class A samples in each fold?
The proportion of Class A samples in each fold is _____ % (**8 points**).

Answers:

Total samples per fold = 240 (Class A) + 160 (Class B) = 400.
Proportion of Class A = $\frac{240}{400} \times 100 = 60\%$.
Answer: 60%

Part B: Grid Search and Random Search (40 Points)

Grid Search with Multiple Hyperparameters

Q3. You are tuning a machine learning model with the following hyperparameters:

- C: [0.01, 0.1, 1, 10, 100]
- ϵ: [0.01, 0.1, 0.5, 1]
- γ: ['scale', 'auto']

(a) How many total hyperparameter combinations are there in the grid?
The total number of hyperparameter combinations in the grid is _____
(**10 points**).

Answers:

Options for $C = 5$, for $\epsilon = 4$, for $\gamma = 2$.
Total combinations $= 5 \times 4 \times 2 = 40$.
Answer: 40

(b) If you perform 10-fold cross-validation for each hyperparameter combination, how many evaluations will be performed?
The total number of evaluations performed will be _____
(**10 points**).

Answers:

Each of the 40 combinations is evaluated using 10-fold cross-validation.
Total evaluations $= 40 \times 10 = 400$.
Answer: 400

Random Search with Multiple Iterations

Q4. You are now performing random search over the same hyperparameters, but you randomly select 12 combinations.

(a) How many different hyperparameter combinations will be selected in each iteration?
The number of hyperparameter combinations selected in each iteration is _____ (**10 points**).

Answers:

By the problem statement, 12 combinations are randomly selected per iteration.
Answer: 12

(b) If you perform 20 iterations of random search, how many total evaluations will be conducted?
The total number of evaluations conducted will be _____ (**10 points**).

Answers:

Total evaluations = Number of iterations $\times$ combinations per iteration = $20 \times 12 = 240$.
Answer: 240

Part C: Bayesian Optimization (30 Points)

Q5. You are tuning the hyperparameters of a model with the following hyperparameter ranges:

- C: [0.01, 0.1, 1, 10, 100]
- ϵ: [0.01, 0.1, 0.5, 1]
- γ: ['scale', 'auto']

Number of iterations in Bayesian optimization = 50.

(a) What is the total number of hyperparameter combinations in the search space?
The total number of hyperparameter combinations in the search space is _____ (**7 points**).

Answers:

The hyperparameter space is the same as in grid search: C has 5 options, ϵ has 4 options, and γ has 2 options.
Total combinations = $5 \times 4 \times 2 = 40$.
Answer: 40

(b) If Bayesian optimization selects 4 combinations per iteration, how many evaluations will be done in 50 iterations?
The total number of evaluations performed will be _____ (**7 points**).

Answers:

Evaluations per iteration = 4.
Total evaluations = $4 \times 50 = 200$.
Answer: 200

(c) What is the total number of evaluations that would be needed for grid search to explore all 40 combinations with 10-fold cross-validation?
The total number of evaluations for grid search would be _____ (**8 points**).

Answers:

Grid search evaluations = Total combinations $\times$ number of folds = $40 \times 10 = 400$.
Answer: 400

(d) How does the total number of evaluations compare between Grid Search and Bayesian Optimization?
The total evaluations for Grid Search are _____, and the total evaluations for Bayesian Optimization are _____ (**8 points**).

Answers:

From (c), Grid Search requires 400 evaluations.
From (b), Bayesian Optimization requires 200 evaluations.
Answer: Grid Search: 400, Bayesian Optimization: 200