

# Machine Learning Unit III

## PYQ-Based Important Questions – Detailed Exam

### Answers

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## Q1. Explain Ensemble Learning

### Definition

Ensemble Learning is a machine learning technique in which multiple models are combined together to produce better and more accurate results than a single model.

### Easy Explanation

In real life, one person may make a wrong decision, but if many experts give opinions together, the final decision is usually better.

Similarly, in ensemble learning:

Multiple Models → Combined Decision → Better Prediction

### Working of Ensemble Learning

Training Data

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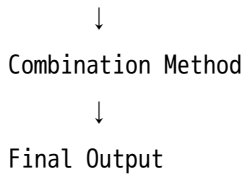
Model 1    Model 2    Model 3

↓

↓

↓

Predictions from all models



## Types of Ensemble Learning

Type	Meaning
Voting	Majority decision is selected
Bagging	Models are trained parallelly
Boosting	Models are trained sequentially
Stacking	A meta-model combines predictions

## Advantages

- Improves prediction accuracy
- Reduces overfitting
- Reduces errors of individual models
- Works well on complex datasets
- Gives stable results

## Disadvantages

- More computation required
- Difficult to understand compared to single model
- Training time may increase
- Requires more memory

## Applications

- Medical diagnosis
- Fraud detection
- Stock market prediction

- Recommendation systems
- Image classification

## **Conclusion**

Ensemble Learning improves machine learning performance by combining multiple weak or strong models to produce a more accurate final prediction.

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## **Q2. Explain Random Forest Trees**

### **Definition**

Random Forest is an ensemble learning algorithm that combines multiple decision trees to improve accuracy and reduce overfitting.

### **Easy Explanation**

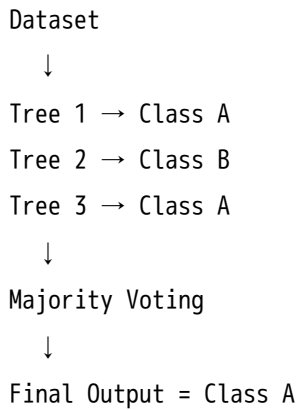
A single decision tree may give wrong output. Random Forest creates many decision trees and takes majority voting from them.

Many Decision Trees → Voting → Final Prediction

### **Working of Random Forest**

1. Random samples are selected from the dataset.
2. Multiple decision trees are created.
3. Each tree gives its own prediction.
4. Final result is selected using majority voting for classification.
5. For regression, average of outputs is taken.

# Diagram



## Features of Random Forest

Feature	Explanation
Based on Bagging	Uses random samples
Multiple Trees	Creates many decision trees
Voting	Final class by majority
Reduces Overfitting	More stable than one tree

## Advantages

- High accuracy
- Reduces overfitting
- Handles large datasets
- Works for classification and regression
- Handles missing data better than single tree

## Disadvantages

- Slower than single decision tree
- Requires more memory

- Less interpretable than one decision tree

## Applications

- Disease prediction
- Loan approval
- Fraud detection
- Stock prediction
- Customer behavior analysis

## Conclusion

Random Forest is a powerful ensemble method that uses multiple decision trees and majority voting to provide accurate and reliable predictions.

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## Q3. Explain AdaBoost Algorithm

### Full Form

AdaBoost means **Adaptive Boosting**.

### Definition

AdaBoost is a boosting algorithm that combines multiple weak learners to create one strong classifier.

### Easy Explanation

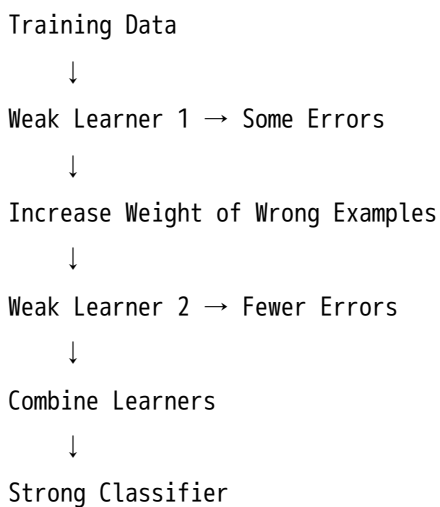
AdaBoost trains models one by one. Each next model focuses more on the examples that were wrongly classified by the previous model.

Weak Classifier + Weak Classifier + Weak Classifier = Strong Classifier

## Working of AdaBoost

1. Initially, all training examples are given equal weight.
2. A weak classifier is trained.
3. Misclassified examples are identified.
4. Weights of wrongly classified examples are increased.
5. Next classifier focuses more on difficult examples.
6. Final output is produced by combining all weak classifiers.

## Diagram



## Important Points

- AdaBoost works sequentially.
- It focuses on mistakes.
- It converts weak learners into strong learners.
- It is commonly used for classification.

## Advantages

- Improves accuracy
- Simple and effective
- Reduces bias
- Works well with weak learners

## **Disadvantages**

- Sensitive to noisy data
- Outliers can affect performance
- Training may take more time

## **Applications**

- Face detection
- Spam detection
- Text classification
- Medical diagnosis
- Fraud detection

## **Conclusion**

AdaBoost is an important boosting technique that improves classification accuracy by giving more attention to wrongly classified examples.

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# **Q4. Differentiate Bagging and Boosting**

## **Definition of Bagging**

Bagging stands for Bootstrap Aggregating. It trains multiple models independently on random subsets of data and combines their outputs.

## **Definition of Boosting**

Boosting trains models sequentially, where each new model improves the mistakes of the previous model.

## Difference Table

<b>Bagging</b>	<b>Boosting</b>
Full form is Bootstrap Aggregating	Means improving weak learners
Models are trained independently	Models are trained sequentially
Works parallelly	Works step by step
Reduces variance	Reduces bias
Less sensitive to noise	More sensitive to noise
Example: Random Forest	Example: AdaBoost
Uses random subsets of data	Focuses on wrongly classified data
Final output by voting/averaging	Final output by weighted voting

## Bagging Working

Dataset

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Random Sample 1 → Model 1

Random Sample 2 → Model 2

Random Sample 3 → Model 3

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Voting / Averaging

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Final Output

## Boosting Working

Model 1 → Errors

Model 2 → Corrects Errors

Model 3 → Further Improves

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Final Strong Model

## Advantages of Bagging

- Reduces overfitting
- Improves model stability
- Works well with high variance models

## Advantages of Boosting

- High accuracy
- Converts weak learners into strong learners
- Useful for difficult classification problems

## Conclusion

Bagging trains models independently to reduce variance, while Boosting trains models sequentially to reduce bias and improve weak learners.

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## Q5. Explain Voting

### Definition

Voting is an ensemble learning technique where multiple classifiers vote for the final prediction.

### Easy Explanation

Voting works like an election. The class that gets the maximum votes becomes the final output.

## Example

Classifier 1 → Cat

Classifier 2 → Dog

Classifier 3 → Cat

Final Output → Cat

## Types of Voting

Type	Explanation
Hard Voting	Final class is selected by majority vote
Soft Voting	Final class is selected based on average probability

## Hard Voting Example

Model 1 → Yes

Model 2 → Yes

Model 3 → No

Final Output → Yes

## Soft Voting Example

If models give probabilities:

Class A probability = 0.70

Class B probability = 0.30

Final output will be Class A.

## **Advantages**

- Simple to understand
- Improves accuracy
- Combines multiple classifiers
- Reduces individual model error

## **Disadvantages**

- Poor models can reduce accuracy
- All models should be reasonably good
- Soft voting requires probability outputs

## **Applications**

- Spam detection
- Image classification
- Medical prediction
- Sentiment analysis

## **Conclusion**

Voting is a simple ensemble method that combines predictions of multiple classifiers and selects the final output based on majority or probability.

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## **Q6. Explain Stacking**

### **Definition**

Stacking is an ensemble learning technique in which predictions of multiple base models are combined using another model called a meta-learner.

## Easy Explanation

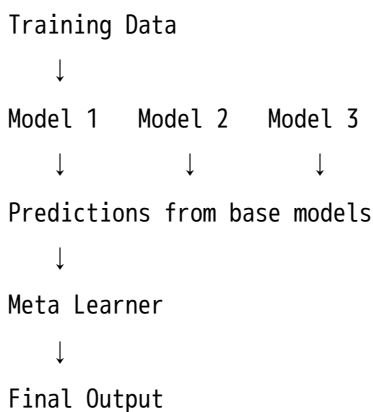
In stacking, first-level models make predictions. Then a second-level model studies those predictions and gives the final output.

Base Models → Meta Learner → Final Prediction

## Working of Stacking

1. Train multiple base models on training data.
2. Each model gives predictions.
3. These predictions are used as input for a meta-model.
4. Meta-model learns how to combine predictions.
5. Final prediction is generated.

## Diagram



## Example

Suppose three models predict student result:

Decision Tree → Pass

SVM → Pass

KNN → Fail

Meta-learner analyzes all predictions and gives final output:

Final Output → Pass

## Advantages

- Improves accuracy
- Combines strengths of different models
- More flexible than simple voting
- Useful for complex problems

## Disadvantages

- Complex to implement
- More training time
- Requires careful model selection
- Can overfit if not handled properly

## Applications

- Recommendation systems
- Forecasting

- Image recognition
- Competition-level ML models

## Conclusion

Stacking is a powerful ensemble method that uses a meta-learner to combine predictions from multiple models and improve final accuracy.

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## Q7. Explain ECOC

### Full Form

ECOC stands for **Error Correcting Output Codes**.

### Definition

ECOC is a technique used for multi-class classification by converting a multi-class problem into multiple binary classification problems.

### Easy Explanation

When there are many classes, classification becomes difficult. ECOC solves this by breaking the problem into several yes/no classification tasks.

### Working of ECOC

Multi-Class Problem

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Multiple Binary Classifiers

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Codeword Matching



Final Class

## Example

Suppose there are three classes:

Class A, Class B, Class C

Each class is represented using a binary code pattern.

Class	Code
A	1 0 1
B	0 1 1
C	1 1 0

The classifier output is compared with these codes, and the nearest matching class is selected.

## Why ECOC is Useful

It can correct some classification errors, similar to error correction in digital communication.

## Advantages

- Useful for multi-class classification
- Improves accuracy
- Can correct some errors
- Converts complex problem into simpler binary problems

## Disadvantages

- Requires many binary classifiers
- Implementation is complex
- More computation needed

## Applications

- Handwriting recognition
- Image classification
- Speech recognition
- Text classification

## Conclusion

ECOC is an effective method for solving multi-class classification problems using several binary classifiers and error-correcting code patterns.

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# Q8. Explain Model Combination Schemes

## Definition

Model Combination Schemes are methods used to combine outputs of multiple machine learning models to produce one final prediction.

## Easy Explanation

Different models may give different results. Model combination schemes combine these results to improve accuracy.

## Common Model Combination Schemes

Scheme	Meaning
Voting	Majority class is selected

<b>Scheme</b>	<b>Meaning</b>
Averaging	Average of predictions is taken
Weighted Voting	More important model gets more weight
Bagging	Independent models are combined
Boosting	Sequential models are combined
Stacking	Meta-model combines predictions

## Example

Model 1 → Yes

Model 2 → Yes

Model 3 → No

Final Output → Yes

## Weighted Voting Example

Model 1 weight = 0.5

Model 2 weight = 0.3

Model 3 weight = 0.2

The model with more weight has more effect on final output.

## Advantages

- Improves prediction accuracy
- Reduces individual model errors
- Makes prediction more reliable
- Useful for complex datasets

## **Disadvantages**

- More computational cost
- Difficult to interpret
- Requires proper model selection

## **Applications**

- Medical diagnosis
- Fraud detection
- Stock prediction
- Recommendation systems
- Image classification

## **Conclusion**

Model Combination Schemes improve machine learning performance by combining predictions of multiple models using methods like voting, averaging, bagging, boosting and stacking.