Subject Name Solutions

4341603 – Winter 2024

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Describe human learning in brief.

Solution

Human learning is the process by which humans acquire knowledge, skills, and behaviors through experience, practice, and instruction.

Table 1: Human Learning Process

Aspect	Description
Observation	Gathering information from environment
Experience	Learning through trial and error
Practice	Repetition to improve skills
Memory	Storing and retrieving information

- **Learning Types**: Visual, auditory, kinesthetic learning styles
- **Feedback Loop**: Humans learn from mistakes and successes
- **Adaptation**: Ability to apply knowledge to new situations

Mnemonic

"OEPMA" - Observe, Experience, Practice, Memory, Adapt

Question 1(b) [4 marks]

Differentiate: Supervised Learning v/s Unsupervised Learning

Solution

Comparison Table: Supervised vs Unsupervised Learning

Parameter	Supervised Learning	Unsupervised Learning
Training Data	Labeled data (input-output pairs)	Unlabeled data (only inputs)
Goal	Predict output for new inputs	Find hidden patterns
Examples	Classification, Regression	Clustering, Association
Feedback	Direct feedback available	No direct feedback

- **Supervised**: Teacher guides learning with correct answers
- **Unsupervised**: Self-discovery of patterns without guidance

Mnemonic

"SL-Labels, UL-Unknown" patterns

Question 1(c) [7 marks]

List out machine learning activities. Explain each in detail.

Solution

Table 2: Machine Learning Activities

Activity	Purpose	Description
Data Collection	Gather raw data	Collecting relevant data from various sources
Data Preprocessing	Clean and prepare data	Handling missing values, normalization
Feature Selection	Choose important features	Selecting relevant attributes for learning
Model Training	Build learning model	Training algorithm on prepared dataset
Model Evaluation	Assess performance	Testing model accuracy and effectiveness
Model Deployment	Put model to use	Implementing model in real-world applications

```
flowchart LR
    A[Data Collection] {-{-} B[Data Preprocessing]}
    B {-{-} C[Feature Selection]}
    C {-{-} D[Model Training]}
    D {-{-} E[Model Evaluation]}
    E {-{-} F[Model Deployment]}
    F {-{-} G[Model Monitoring]}
```

- **Iterative Process**: Activities repeat for model improvement
- **Quality Control**: Each step ensures better model performance

Mnemonic

"CPFTEDM" - Collect, Preprocess, Feature, Train, Evaluate, Deploy, Monitor

Question 1(c OR) [7 marks]

Find mean, median, and mode for the following data: 1, 1, 1, 2, 4, 5, 5, 6, 6, 7, 7, 7, 7, 8, 9, 10, 11

Solution

Data Analysis Table

Statistic	Formula	Calculation	Result
Mean	Sum/Count	(1+1+1+2+4+5+5+6+6+7+7+7+7+8+9+10+11)/17	5.88
Median	Middle value	7th position in sorted data	6
Mode	Most frequent	Value appearing 4 times	7

Step-by-step calculation:

- **Count**: 17 values
- **Sum**: 100
- **Mean**: 100/17 = 5.88
- **Median**: Middle position (9th) = 6
- **Mode**: 7 appears 4 times (highest frequency)

Mnemonic

"MMM" - Mean=Average, Median=Middle, Mode=Most frequent

Question 2(a) [3 marks]

Write down steps to use hold out method for model training.

Solution

Hold Out Method Steps

Step	Action	Purpose
1	Split dataset (70-80% training, 20-30% testing)	Separate data for training and evaluation
2	Train model on training set	Build learning algorithm
3	Test model on testing set	Evaluate model performance

- **Random Split**: Ensure representative distribution in both sets
- **No Overlap**: Testing data never used in training
- **Single Split**: One-time division of data

Mnemonic

"STT" - Split, Train, Test

Question 2(b) [4 marks]

Explain structure of confusion matrix.

Solution

Confusion Matrix Structure

	Predicted Positive	Predicted Negative
Actual Positive	True Positive (TP)	False Negative (FN)
Actual Negative	False Positive (FP)	True Negative (TN)

Components Explanation:

- **TP**: Correctly predicted positive cases
- **TN**: Correctly predicted negative cases

- **FP**: Incorrectly predicted as positive (Type I error)
- **FN**: Incorrectly predicted as negative (Type II error)

Performance Metrics:

- **Accuracy** = (TP+TN)/(TP+TN+FP+FN)
- **Precision** = TP/(TP+FP)

Mnemonic

"TPFN-FPTN" for matrix positions

Question 2(c) [7 marks]

Define data pre-processing. Explain various methods used in data pre-processing.

Solution

Data pre-processing is the technique of preparing raw data by cleaning, transforming, and organizing it for machine learning algorithms.

Data Pre-processing Methods Table

Method	Purpose	Techniques
Data Cleaning	Remove noise and inconsistencies	Handle missing values, remove duplicates
Data Transformation	Convert data format	Normalization, standardization
Data Reduction	Reduce dataset size	Feature selection, dimensionality reduction

Data Integration	Combine multiple sources	Merge datasets, resolve conflicts

```
flowchart LR
    A[Raw Data] {-{-} B[Data Cleaning]}
    B {-{-} C[Data Transformation]}
    C {-{-} D[Data Reduction]}
    D {-{-} E[Clean Data]}
```

- **Missing Values**: Use mean, median, or mode for imputation
- **Outliers**: Detect and handle extreme values
- **Feature Scaling**: Normalize data to same scale

Mnemonic

"CTRI" - Clean, Transform, Reduce, Integrate

Question 2(a OR) [3 marks]

Explain histogram with suitable example.

Solution

A histogram is a graphical representation showing the frequency distribution of numerical data by dividing it into bins.

Histogram Components Table

Component	Description
X-axis	Data ranges (bins)
Y-axis	Frequency of occurrence
Bars	Height represents frequency

Example: Student marks distribution:

- Bins: 0-20, 21-40, 41-60, 61-80, 81-100
- Heights show number of students in each range

Mnemonic

"BAR" - Bins, Axes, Range

Question 2(b OR) [4 marks]

Relate the appropriate data type of following examples: i) Gender of a person ii) Rank of students iii) Price of a home iv) Color of a flower

Solution

Data Types Classification Table

Example	Data Type	Characteristics
Gender of person	Nominal Categorical	No natural order (Male/Female)
Rank of students	Ordinal Categorical	Has meaningful order (1st, 2nd, 3rd)
Price of home	Continuous Numerical	Can take any value within range
Color of flower	Nominal Categorical	No natural order (Red, Blue, Yellow)

- **Categorical Data**: Limited set of distinct categories
- **Numerical Data**: Mathematical operations possible
- **Ordinal**: Categories with meaningful sequence

Mnemonic

"NOCO" - Nominal, Ordinal, Continuous

Question 2(c OR) [7 marks]

Describe K-fold cross validation in details.

Solution

K-fold cross validation is a model evaluation technique that divides dataset into K equal parts for robust performance assessment.

K-fold Process Table

Step	Action	Purpose
1	Divide data into K equal folds	Create K subsets
2	Use K-1 folds for training	Train model
3	Use 1 fold for testing	Evaluate performance
4	Repeat K times	Each fold serves as test set once
5	Average all results	Get final performance metric

```
flowchart LR
    A[Original Dataset] {-{-} B[Divide into K folds]}
    B {-{-} C[Iteration 1: Train on folds 2{-}K, Test on fold 1]}
    C {-{-} D[Iteration 2: Train on folds 1,3{-}K, Test on fold 2]}
    D {-{-} E[... Continue for K iterations]}
    E {-{-} F[Average all K results]}
```

Advantages:

- **Robust Evaluation**: Every data point used for both training and testing
- **Reduced Overfitting**: Multiple validation rounds
- **Better Generalization**: More reliable performance estimate

Common Values: K=5 or K=10 typically used

Mnemonic

"DURAT" - Divide, Use, Repeat, Average, Test

Question 3(a) [3 marks]

List out applications of regression.

Solution

Regression Applications Table

Domain	Application	Purpose
Finance	Stock price prediction	Forecast market trends
Healthcare	Drug dosage calculation	Determine optimal treatment
Marketing	Sales forecasting	Predict revenue
Real Estate	Property valuation	Estimate house prices

- **Predictive Modeling**: Forecasting continuous values
- **Trend Analysis**: Understanding relationships between variables
- **Risk Assessment**: Evaluating future outcomes

Mnemonic

"FHMR" - Finance, Healthcare, Marketing, Real estate

Question 3(b) [4 marks]

Write a short note on single linear regression.

Solution

Single linear regression models the relationship between one independent variable (X) and one dependent variable (Y) using a straight line.

Linear Regression Components

Component	Formula	Description
Equation	Y = a + bX	Linear relationship
Slope (b)	Change in Y / Change in X	Rate of change
Intercept (a)	Y-value when X=0	Starting point
Error	Actual - Predicted	Difference from line

- **Goal**: Find best-fit line minimizing errors
- **Method**: Least squares optimization
- **Assumption**: Linear relationship exists between variables

Mnemonic

"YABX" - Y equals a plus b times X

Question 3(c) [7 marks]

Write and discuss K-NN algorithm.

Solution

K-Nearest Neighbors (K-NN) is a lazy learning algorithm that classifies data points based on the majority class of their K nearest neighbors.

K-NN Algorithm Steps

Step	Action	Description
1	Choose K value	Select number of neighbors
2	Calculate distances	Find distance to all training points
3	Sort distances	Arrange in ascending order
4	Select K nearest	Choose K closest points
5	Majority voting	Assign most common class

```
flowchart LR
    A[New Data Point] {-{-} B[Calculate Distance to All Training Points]}
    B {-{-} C[Sort Distances]}
    C {-{-} D[Select K Nearest Neighbors]}
    D {-{-} E[Majority Vote]}
    E {-{-} F[Assign Class Label]}
```

Distance Metrics:

- **Euclidean**: Most common distance measure
- **Manhattan**: Sum of absolute differences
- **Minkowski**: Generalized distance metric

Advantages:

- **Simple**: Easy to understand and implement
- **No Training**: Stores all data, no model building

Disadvantages:

- **Computationally Expensive**: Must check all points
- **Sensitive to K**: Performance depends on K value

Mnemonic

"CCSM" - Choose, Calculate, Sort, Majority vote

Question 3(a OR) [3 marks]

Write any three examples of supervised learning in the field of healthcare

Solution

Healthcare Supervised Learning Examples

Application	Input	Output	Purpose
Disease Diagnosis	Symptoms, test results	Disease type	Identify medical conditions
Drug Response Prediction	Patient data, genetics	Drug effectiveness	Personalized medicine
Medical Image Analysis	X-rays, MRI scans	Tumor detection	Early disease detection

- **Pattern Recognition**: Learning from labeled medical data
- **Clinical Decision Support**: Assisting doctors in diagnosis
- **Predictive Medicine**: Forecasting health outcomes

Mnemonic

"DDM" - Diagnosis, Drug response, Medical imaging

Question 3(b OR) [4 marks]

Differentiate: Classification v/s Regression.

Solution

Classification vs Regression Comparison

Aspect	Classification	Regression
Output Type	Discrete categories/classes	Continuous numerical values
Goal	Predict class labels	Predict numerical values
Examples	Email spam/not spam	House price prediction
Evaluation	Accuracy, Precision, Recall	MAE, MSE, R-squared

- **Classification**: Predicts categories (Yes/No, Red/Blue/Green)
- **Regression**: Predicts quantities (Price, Temperature, Weight)
- **Algorithms**: Some work for both, others specialized

Mnemonic

"CLASS-Categories, REG-Real numbers"

Question 3(c OR) [7 marks]

Explain classification learning steps in details.

Solution

Classification learning involves training a model to assign input data to predefined categories or classes.
Classification Learning Steps

Step	Process	Description
1	Data Collection	Gather labeled training examples
2	Data Preprocessing	Clean and prepare data
3	Feature Selection	Choose relevant attributes
4	Model Selection**	Choose classification algorithm
5	Training	Learn from labeled data
6	Evaluation	Test model performance
7	Deployment	Use model for predictions

```
flowchart LR
    A[Labeled Training Data] {-{-} B[Preprocessing]}
    B {-{-} C[Feature Selection]}
    C {-{-} D[Choose Algorithm]}
    D {-{-} E[Train Model]}
    E {-{-} F[Evaluate Performance]}
    F {-{-} G\{Good Performance?\}}
    G {-{-}|No| D}
    G {-{-}|Yes| H[Deploy Model]}
```

Key Concepts:

- **Supervised Learning**: Requires labeled training data
- **Feature Engineering**: Transform raw data into useful features
- **Cross-validation**: Ensure model generalizes well
- **Performance Metrics**: Accuracy, precision, recall, F1-score

Common Algorithms:

- **Decision Trees**: Easy to interpret rules
- **SVM**: Effective for high-dimensional data
- **Neural Networks**: Handle complex patterns

Mnemonic

"DCFMTED" - Data, Clean, Features, Model, Train, Evaluate, Deploy

Question 4(a) [3 marks]

Differentiate: Clustering v/s Classification.

Solution

Clustering vs Classification Comparison

Aspect	Clustering	Classification
Learning Type	Unsupervised	Supervised
Training Data	Unlabeled data	Labeled data
Goal	Find hidden groups	Predict known classes
Output	Group assignments	Class predictions

- **Clustering**: Discovers unknown patterns in data
- **Classification**: Learns from known examples to predict new ones
- **Evaluation**: Clustering harder to evaluate than classification

Mnemonic

"CL-Unknown groups, CLASS-Known categories"

Question 4(b) [4 marks]

List out advantages and disadvantages of apriori algorithm.

Solution

Apriori Algorithm Pros and Cons

Advantages	Disadvantages
Easy to understand	**Computationally expensive**
Finds all frequent itemsets	**Multiple database scans**
Well-established algorithm	**Large memory requirements**
Generates association rules	**Poor scalability**

Advantages Details:

- **Simplicity**: Straightforward logic and implementation
- **Completeness**: Finds all frequent patterns
- **Rule Generation**: Creates meaningful association rules

Disadvantages Details:

- **Performance**: Slow on large datasets
- **Memory**: Stores many candidate itemsets
- **Scalability**: Performance degrades with data size

Mnemonic

"EASY-SLOW" - Easy to use but slow performance

Question 4(c) [7 marks]

Write and explain applications of unsupervised learning.

Solution

Unsupervised learning discovers hidden patterns in data without labeled examples.

Unsupervised Learning Applications

Domain	Application	Technique	Purpose
Marketing	Customer segmentation	Clustering	Group similar customers
Retail	Market basket analysis	Association rules	Find buying patterns
Anomaly Detection	Fraud detection	Outlier detection	Identify unusual behavior
Data Compression	Dimensionality reduction	PCA	Reduce data size
Recommendation	Content filtering	Clustering	Suggest similar items

```
mindmap
  root((Unsupervised Learning))
    Clustering
      Customer Segmentation
      Image Segmentation
      Gene Sequencing
    Association Rules
      Market Basket Analysis
      Web Usage Mining
      Protein Sequences
    Anomaly Detection
      Fraud Detection
      Network Security
      Quality Control
    Dimensionality Reduction
      Data Visualization
      Feature Extraction
      Data Compression
```

Key Benefits:

- **Pattern Discovery**: Reveals hidden structures
- **No Labels Required**: Works with raw data
- **Exploratory Analysis**: Understand data characteristics

Common Techniques:

- **K-means**: Partition data into clusters
- **Hierarchical Clustering**: Create cluster hierarchies
- **Apriori**: Find association rules

Mnemonic

"MRAD" - Marketing, Retail, Anomaly, Dimensionality

Question 4(a OR) [3 marks]

List out applications of apriori algorithm.

Solution

Apriori Algorithm Applications

Domain	Application	Purpose
Retail	Market basket analysis	Find items bought together
Web Mining	Website usage patterns	Discover page visit sequences
Bioinformatics	Gene pattern analysis	Identify gene associations

- **Association Rules**: "If A then B" relationships
- **Frequent Patterns**: Items appearing together often
- **Cross-selling**: Recommend related products

Mnemonic

"RWB" - Retail, Web, Bioinformatics

Question 4(b OR) [4 marks]

Define: Support and Confidence.

Solution

Association Rule Metrics

Metric	Formula	Description	Range
Support	Support(A) = Count(A) / Total transactions	How often itemset appears	0 to 1
Confidence	Confidence(A) = Support(A) / Support(A)	How often rule is true	0 to 1

Support Example:

- If itemset {Bread, Milk} appears in 3 out of 10 transactions
- Support = 3/10 = 0.3 (30%)

Confidence Example:

- Rule: "Bread $\rightarrow Milk''$
- If {Bread, Milk} appears 3 times, Bread alone appears 5 times
- Confidence = 3/5 = 0.6 (60%)

Mnemonic

"SUP-How often, CONF-How reliable"

Question 4(c OR) [7 marks]

Write and explain K-means clustering approach in detail.

Solution

K-means clustering partitions data into K clusters by minimizing within-cluster sum of squares.

K-means Algorithm Steps

Step	Action	Description
1	Choose K	Select number of clusters
2	Initialize centroids	Place K points randomly
3	Assign points	Each point to nearest centroid
4	Update centroids	Calculate mean of assigned points
5	Repeat 3-4	Until convergence

```
flowchart LR
    A[Choose K value] {-{-} B[Initialize K centroids randomly]}
    B {-{-} C[Assign each point to nearest centroid]}
    C {-{-} D[Update centroids to cluster means]}
    D {-{-} E\{Centroids changed?\}}
    E {-{-}|Yes| C}
    E {-{-}|No| F[Final clusters]}
```

Algorithm Details:

- **Distance Metric**: Usually Euclidean distance
- **Convergence**: When centroids stop moving significantly
- **Objective**: Minimize within-cluster sum of squares (WCSS)

Advantages:

- **Simple**: Easy to understand and implement
- **Efficient**: Linear time complexity
- **Scalable**: Works well with large datasets

Disadvantages:

- **K Selection**: Must choose K beforehand
- **Sensitive to Initialization**: Different starting points give different results
- **Assumes Spherical Clusters**: May not work with irregular shapes

Choosing K:

- **Elbow Method**: Plot WCSS vs K, look for "elbow"
- **Silhouette Analysis**: Measure cluster quality

Mnemonic

"CIAUR" - Choose K, Initialize, Assign, Update, Repeat

Question 5(a) [3 marks]

Give the difference between predictive model and descriptive model.

Solution

Predictive vs Descriptive Models

Aspect	Predictive Model	Descriptive Model
Purpose	Forecast future outcomes	Explain current patterns
Output	Predictions/classifications	Insights/summaries
Examples	Sales forecasting, spam detection	Customer segmentation, trend analysis

- **Predictive**: Uses historical data to predict future
- **Descriptive**: Analyzes existing data to understand patterns
- **Goal**: Prediction vs Understanding

Mnemonic

"PRED-Future, DESC-Present"

Question 5(b) [4 marks]

List out application of scikit-learn.

Solution

Scikit-learn Applications

Category	Applications	Algorithms
Classification	Email filtering, image recognition	SVM, Random Forest, Naive Bayes

Regression	Price prediction, risk assessment	Linear Regression, Decision Trees
Clustering	Customer segmentation, data exploration	K-means, DBSCAN
Preprocessing	Data cleaning, feature scaling	StandardScaler, LabelEncoder

- **Machine Learning Library**: Comprehensive Python toolkit
- **Easy Integration**: Works with NumPy, Pandas
- **Well-documented**: Extensive examples and tutorials

Mnemonic

"CRCP" - Classification, Regression, Clustering, Preprocessing

Question 5(c) [7 marks]

Explain features and applications of Numpy.

Solution

NumPy (Numerical Python) is the fundamental library for scientific computing in Python, providing support for large multi-dimensional arrays and mathematical functions.

NumPy Features Table

Feature	Description	Benefit
N-dimensional Arrays	Powerful array objects	Efficient data storage
Broadcasting	Operations on different shaped arrays	Flexible computations
Mathematical Functions	Trigonometric, logarithmic, statistical	Complete math toolkit
Performance	Implemented in C/Fortran	Fast execution
Memory Efficiency	Contiguous memory layout	Reduced memory usage

NumPy Applications

Domain	Application	Purpose
Machine Learning	Data preprocessing, feature engineering	Handle numerical data
Image Processing	Image manipulation, filtering	Process pixel arrays
Scientific Computing	Numerical simulations, modeling	Mathematical computations
Financial Analysis	Portfolio optimization, risk modeling	Quantitative analysis

```
mindmap
  root((NumPy))
    Core Features
      N{-dimensional Arrays}
      Broadcasting
      Mathematical Functions
      Fast Performance
    Applications
      Machine Learning
      Image Processing
      Scientific Computing
      Financial Analysis
    Benefits
      Memory Efficient
      Easy to Use
      Integrates Well
      Industry Standard
```

Key Capabilities:

- **Array Operations**: Element-wise operations, slicing, indexing
- **Linear Algebra**: Matrix operations, eigenvalues, decompositions
- **Random Number Generation**: Statistical distributions, sampling
- **Fourier Transforms**: Signal processing, frequency analysis

Integration:

- **Pandas**: DataFrames built on NumPy arrays
- **Matplotlib**: Plotting NumPy arrays
- **Scikit-learn**: ML algorithms use NumPy arrays

Mnemonic

"NFAMS" - N-dimensional, Fast, Arrays, Math, Scientific

Question 5(a OR) [3 marks]

Write a short note on bagging

Solution

Bagging (Bootstrap Aggregating) is an ensemble method that improves model performance by training multiple models on different subsets of data.

Bagging Process Table

Step	Process	Purpose
Bootstrap Sampling	Create multiple training sets	Generate diverse datasets
Train Models	Build model on each subset	Create multiple predictors
Aggregate Results	Combine predictions (voting/averaging)	Reduce overfitting

- **Variance Reduction**: Reduces model variance through averaging
- **Parallel Training**: Models trained independently
- **Example**: Random Forest uses bagging with decision trees

Mnemonic

"BTA" - Bootstrap, Train, Aggregate

Question 5(b OR) [4 marks]

List out features of Pandas.

Solution

Pandas Features

Feature	Description	Benefit
DataFrame/Series	Structured data containers	Easy data manipulation
File I/O	Read/write CSV, Excel, JSON	Handle various formats
Data Cleaning	Handle missing values, duplicates	Prepare clean data
Grouping/Aggregation	Group by operations, statistics	Analyze data patterns

Data Operations:

- **Indexing**: Flexible data selection and filtering
- **Merging**: Combine datasets with joins
- **Reshaping**: Pivot tables and data transformation

Mnemonic

"DFIG" - DataFrame, File I/O, Indexing, Grouping

Question 5(c OR) [7 marks]

Explain features and applications of Matplotlib.

Solution

Matplotlib is a comprehensive 2D plotting library for Python that produces publication-quality figures in various formats and interactive environments.

Matplotlib Features

Feature	Description	Capability
Plot Types	Line, bar, scatter, histogram, pie	Diverse visualization options
Customization	Colors, fonts, styles, layouts	Professional appearance
Interactive Features	Zoom, pan, widgets	Dynamic exploration
Multiple Backends	GUI, web, file output	Flexible deployment
3D Plotting	Surface, wireframe, scatter plots	Three-dimensional visualization

Matplotlib Applications

Domain	Application	Visualization Type
Data Science	Exploratory data analysis	Histograms, scatter plots
Scientific Research	Publication figures	Line plots, error bars
Business Intelligence	Dashboard creation	Bar charts, trend lines
Machine Learning	Model performance visualization	Confusion matrices, ROC curves
Engineering	Signal analysis	Time series, frequency plots

```
flowchart LR
    A[Raw Data] {-{-} B[Matplotlib Processing]}
    B {-{-} C[Static Plots]}
    B {-{-} D[Interactive Plots]}
    B {-{-} E[Publication Figures]}
    C {-{-} F[PNG/PDF Output]}
    D {-{-} G[Web Applications]}
    E {-{-} H[Research Papers]}
```

Key Components:

- **Figure**: Top-level container for all plot elements
- **Axes**: Individual plots within a figure
- **Artist**: Everything drawn on figure (lines, text, etc.)
- **Backend**: Handles rendering to different outputs

Plot Customization:

- **Colors/Styles**: Wide range of visual options
- **Annotations**: Text labels, arrows, legends
- **Subplots**: Multiple plots in single figure
- **Layouts**: Grid arrangements, spacing control

Integration Benefits:

- **NumPy Arrays**: Direct plotting of numerical data
- **Pandas**: Built-in plotting methods
- **Jupyter Notebooks**: Inline plot display
- **Web Frameworks**: Embed plots in applications

Output Formats:

- **Raster**: PNG, JPEG for web use
- **Vector**: PDF, SVG for publications
- **Interactive**: HTML for web deployment

Mnemonic

“MVICS” - Multiple plots, Visualization, Interactive, Customizable, Scientific