



**Faculty of Engineering & Technology Electrical &  
Computer Engineering Department**

**ARTIFICIAL INTELLIGENCE - ENCS3340**

**#Porject2: Machine Learning for Classification**

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## **Introduction**

This report details the experiments and results from testing different machine learning algorithms for a classification task using the Early Stage Diabetes Risk Prediction Dataset. The objective is to compare the performance of three models: Decision Tree, Naive Bayes, and Multilayer Perceptron (MLP).

## Dataset Description

The Early Stage Diabetes Risk Prediction Dataset contains diagnostic measurements that are used to predict the onset of diabetes based on certain diagnostic measurements. The dataset comprises the following attributes:

- **Age:** Age in years.
- **Gender:** Male or Female.
- **Polyuria:** Yes or No.
- **Polydipsia:** Yes or No.
- **Sudden weight loss:** Yes or No.
- **Weakness:** Yes or No.
- **Polyphagia:** Yes or No.
- **Genital thrush:** Yes or No.
- **Visual blurring:** Yes or No.
- **Itching:** Yes or No.
- **Irritability:** Yes or No.
- **Delayed healing:** Yes or No.
- **Partial paresis:** Yes or No.
- **Muscle stiffness:** Yes or No.
- **Alopecia:** Yes or No.
- **Obesity:** Yes or No.
- **Class:** Positive or Negative.



## Second Run (Modified Settings):

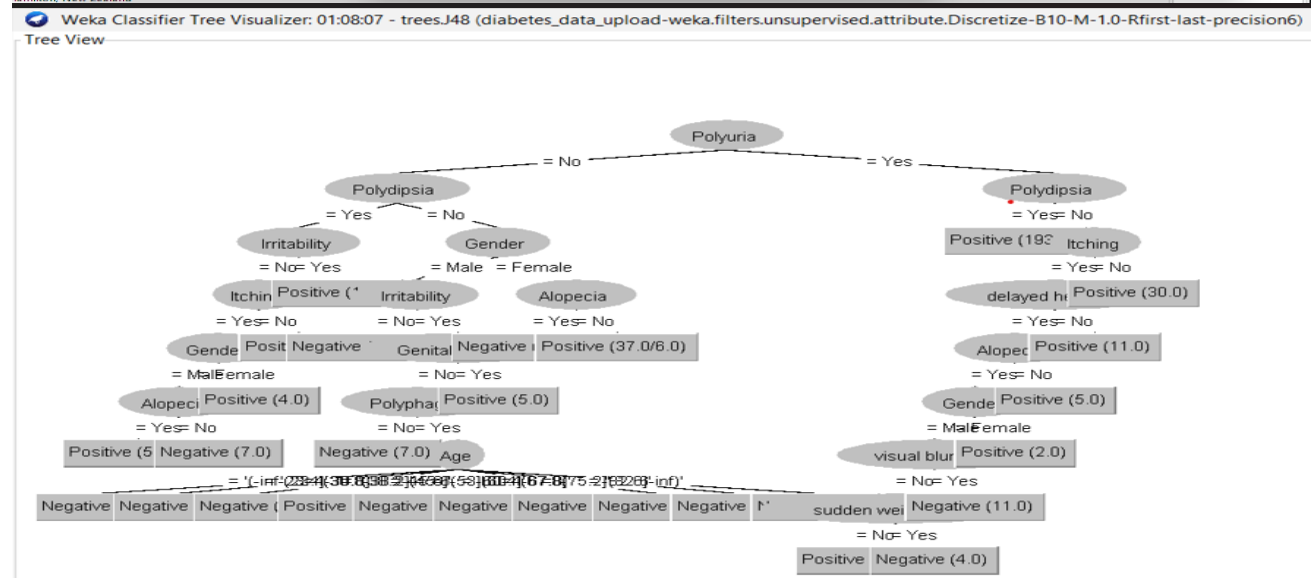
- **Confidence Factor:** 0.25
- **MinNumObj:** 2
- **Batch Size:** 50

## Results:

- Correctly Classified Instances: 488 (93.85%)
- Incorrectly Classified Instances: 32 (6.15%)
- Kappa Statistic: 0.8707
- Mean Absolute Error: 0.0876
- Root Mean Squared Error: 0.2427
- Relative Absolute Error: 18.4918%
- Root Relative Squared Error: 49.8807%
- Detailed Accuracy By Class:
  - Precision: Positive: 0.955, Negative: 0.908
  - Recall: Positive: 0.941, Negative: 0.935
  - F-Measure: Positive: 0.950, Negative: 0.921

Classifier	Correctly Classified Instances	Incorrectly Classified Instances	Kappa Statistic	Mean Absolute Error	Root Mean Squared Error	Relative Absolute Error	Root Relative Squared Error
weka.classifiers.trees.J48	488 (93.85%)	32 (6.15%)	0.8707	0.0876	0.2427	18.4918%	49.8807%

Weka GUI showing the 'weka.classifiers.trees.J48' classifier settings. The 'Batch Size' is set to 50, 'Confidence Factor' is 0.25, and 'MinNumObj' is 2. The 'Results' tab shows the performance metrics: Correctly Classified Instances: 488 (93.85%), Incorrectly Classified Instances: 32 (6.15%), Kappa Statistic: 0.8707, Mean Absolute Error: 0.0876, Root Mean Squared Error: 0.2427, Relative Absolute Error: 18.4918%, Root Relative Squared Error: 49.8807%.



## Naive Bayes

The Naive Bayes classifier was tested with the following settings:

### First Run (Default Settings):

- **Batch Size:** 100
- **Kernel Estimator:** False
- **Supervised Discretization:** False

### Results:

- Correctly Classified Instances: 456 (87.69%)
- Incorrectly Classified Instances: 64 (12.31%)
- Kappa Statistic: 0.7453
- Mean Absolute Error: 0.1507
- Root Mean Squared Error: 0.3203
- Relative Absolute Error: 31.8164%
- Root Relative Squared Error: 65.833%
- Detailed Accuracy By Class:
  - Precision: Positive: 0.930, Negative: 0.806
  - Recall: Positive: 0.866, Negative: 0.895
  - F-Measure: Positive: 0.896, Negative: 0.848

The screenshot displays the Weka Explorer interface with the Naive Bayes classifier selected. The 'Test options' section shows 'Cross-validation' with 'Folds' set to 5 and 'Percentage split' at 66%. The 'Classifier output' pane shows the following results:

```
Classifier output
Obesity
Yes      62.0    28.0
No      260.0   174.0
[total] 322.0   202.0

Time taken to build model: 0 seconds

=== Stratified cross-validation ===
=== Summary ===
Correctly Classified Instances      456           87.6923 %
Incorrectly Classified Instances     64           12.3077 %
Kappa statistic                     0.7453
Mean absolute error                  0.1507
Root mean squared error              0.3203
Relative absolute error              31.8164 %
Root relative squared error          65.833 %
Total Number of Instances           520

=== Detailed Accuracy By Class ===
               TP Rate  FP Rate  Precision  Recall   F-Measure  MDC     ROC Area  PRG Area  Class
0.866   0.105   0.930   0.866   0.896   0.748   0.946   0.968   Positive
0.895   0.134   0.806   0.895   0.848   0.748   0.946   0.915   Negative
Weighted Avg.   0.877   0.116   0.882   0.877   0.878   0.748   0.946   0.948

=== Confusion Matrix ===
  a  b  <-- classified as
277 43 | a = Positive
21 179 | b = Negative
```

The status bar at the bottom shows 'Status OK' and the system tray includes a weather widget (85°F Sunny), search bar, and system clock (1:21 AM 6/22/2024).

## Second Run (Modified Settings):

- **Batch Size:** 40
- **Kernel Estimator:** False
- **Supervised Discretization:** False

## Results:

- Correctly Classified Instances: 456 (87.69%)
- Incorrectly Classified Instances: 64 (12.31%)
- Kappa Statistic: 0.7453
- Mean Absolute Error: 0.1507
- Root Mean Squared Error: 0.3203
- Relative Absolute Error: 31.8164%
- Root Relative Squared Error: 65.833%
- Detailed Accuracy By Class:
  - Precision: Positive: 0.930, Negative: 0.806
  - Recall: Positive: 0.866, Negative: 0.895
  - F-Measure: Positive: 0.896, Negative: 0.848

The screenshot displays the Weka Explorer interface with the NaiveBayes classifier selected. The 'Classifier output' pane shows the following results:

```
==== Stratified cross-validation ====
==== Summary ====
Correctly Classified Instances      456      87.6923 %
Incorrectly Classified Instances    64      12.3077 %
Kappa statistic                    0.7453
Mean absolute error                 0.1507
Root mean squared error             0.3203
Relative absolute error             31.8164 %
Root relative squared error         65.833 %
Total Number of Instances          520

==== Detailed Accuracy By Class ====
          TP Rate  FP Rate  Precision  Recall  F-Measure  MDC      ROC Area  PRC Area  Class
0.866   0.105   0.930   0.866   0.896   0.748   0.946   0.968   Positive
0.895   0.134   0.806   0.895   0.848   0.748   0.946   0.915   Negative
Weighted Avg.   0.877   0.116   0.882   0.877   0.878   0.748   0.946   0.948

==== Confusion Matrix ====
  a  b  <-- classified as
277 43 | a = Positive
21 179 | b = Negative
```

A configuration dialog for the NaiveBayes classifier is open, showing the following settings:

- batchSize: 40
- debug: True
- displayModelInOldFormat: True
- doNotCheckCapabilities: False
- numDecimalPlaces: 2
- useKernelEstimator: False
- useSupervisedDiscretization: False

## Multilayer Perceptron (MLP)

The Multilayer Perceptron was tested with the following settings:

### First Run (Default Settings):

- **Learning Rate:** 0.3
- **Momentum:** 0.2
- **Training Time:** 50
- **Batch Size:** 100

### Results:

- Correctly Classified Instances: 489 (94.04%)
- Incorrectly Classified Instances: 31 (5.96%)
- Kappa Statistic: 0.8751
- Mean Absolute Error: 0.0732
- Root Mean Squared Error: 0.221
- Relative Absolute Error: 15.45%
- Root Relative Squared Error: 45.42%
- Detailed Accuracy By Class:
  - Precision: Positive: 0.965, Negative: 0.904
  - Recall: Positive: 0.938, Negative: 0.945
  - F-Measure: Positive: 0.951, Negative: 0.924

The screenshot displays the Weka Explorer interface with the MultilayerPerceptron classifier selected. The 'Test options' section shows 'Cross-validation' with 5 folds. The 'Classifier output' section displays the following results:

```
==== Stratified cross-validation ====
==== Summary ====

Correctly Classified Instances      489      94.6154 %
Incorrectly Classified Instances     31      5.3846 %
Kappa statistic                     0.8871
Mean absolute error                  0.0512
Root mean squared error              0.1953
Relative absolute error              10.8161 %
Root relative squared error          40.1462 %
Total Number of Instances           520

==== Detailed Accuracy By Class ====

      TP Rate  FP Rate  Precision  Recall  F-Measure  MCC  ROC Area  PRC Area  Class
      -----  -
      0.944    0.050    0.968    0.944    0.956    0.888    0.982    0.589    Positive
      0.950    0.056    0.913    0.950    0.931    0.888    0.982    0.958    Negative
Weighted Avg.   0.946    0.052    0.947    0.946    0.946    0.888    0.982    0.977

==== Confusion Matrix ====

  a  b  <-- classified as
302 18 |  a = Positive
 10 190 | b = Negative
```

The status bar at the bottom indicates 'Status OK' and the system clock shows 1:16 AM on 6/22/2024.



## Second Run (Modified Settings):

- **Learning Rate:** 0.3
- **Momentum:** 0.2
- **Training Time:** 50
- **Batch Size:** 40

## Results:

- Correctly Classified Instances: 492 (94.62%)
- Incorrectly Classified Instances: 28 (5.38%)
- Kappa Statistic: 0.8871
- Mean Absolute Error: 0.0512
- Root Mean Squared Error: 0.1953
- Relative Absolute Error: 10.8161%
- Root Relative Squared Error: 40.1462%
- Detailed Accuracy By Class:
  - Precision: Positive: 0.968, Negative: 0.913
  - Recall: Positive: 0.944, Negative: 0.950
  - F-Measure: Positive: 0.956, Negative: 0.931

The screenshot displays the Weka Explorer interface with the MultilayerPerceptron classifier selected. The 'Test options' section shows 'Cross-validation' with 'Folds' set to 5 and 'Percentage split' at 66%. The 'Classifier output' section shows the 'Stratified cross-validation' results, including a summary of performance metrics and a detailed accuracy by class table.

**Classifier output**

==== Stratified cross-validation ====

==== Summary ====

	Correctly Classified Instances	Incorrectly Classified Instances	Kappa statistic	Mean absolute error	Root mean squared error	Relative absolute error	Root relative squared error	Total Number of Instances
	489	31	0.8751	0.0732	0.221	15.4506 %	45.4163 %	520

==== Detailed Accuracy By Class ====

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
Weighted Avg.	0.938	0.055	0.965	0.938	0.951	0.876	0.975	0.984	Positive
	0.945	0.063	0.904	0.945	0.924	0.876	0.975	0.955	Negative

==== Confusion Matrix ====

```
a b <-- classified as
300 20 | a = Positive
11 189 | b = Negative
```

The 'GenericObjectEditor' window shows the configuration for the MultilayerPerceptron classifier. Key settings include: GUI (False), autoBuild (True), batchSize (40), debug (False), decay (False), doNotCheckCapabilities (False), hiddenLayers (a), learningRate (0.3), momentum (0.2), nominalToBinaryFilter (True), normalizeAttributes (True), normalizeNumericClass (True), numDecimalPlaces (2), reset (False), resume (False), seed (0), trainingTime (50), validationSetSize (0), and validationThreshold (10).

## **Conclusion**

From the results, it can be seen that the Multilayer Perceptron (MLP) performed the best in terms of accuracy (94.62%), followed by the Decision Tree (93.85%) and Naive Bayes (87.69%). The MLP also had the lowest mean absolute error and root mean squared error, indicating better overall performance. The Naive Bayes classifier, while simpler, had the lowest performance metrics among the three models. The Decision Tree provided a good balance of accuracy and interpretability.

The modifications to the hyper-parameters slightly improved the performance of the Decision Tree and MLP, but the Naive Bayes classifier's performance remained unchanged. This suggests that the Naive Bayes model might be less sensitive to changes in batch size compared to the other models.