### Projet de traitement de données massives

Équipe no 14

Maxime Mainardi (536942625)

Cédric Fontaine (536983535)

Kenza Bellebouir (537198197)

Techniques avancées en intelligence artificielle IFT-4102/IFT-7025

Travail présenté à Brahim Chaib-draa



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# Techniques d’apprentissage automatique à développer

## Précision

La précision est une mesure de la qualité des prédictions positives. Elle représente la proportion des prédictions positives qui sont effectivement correctes. Par exemple, si un modèle prédit qu'un certain nombre d'instances appartiennent à une classe donnée, la précision correspond au pourcentage des prédictions correctes parmi celles-ci.

### Formule :

## Rappel

Vrai Positifs (VP)

𝑃𝑟é𝑐𝑖𝑠𝑖𝑜𝑛 = Vrai Positifs (VP) + Faux Positifs (FP)

Le rappel est une mesure de la capacité du modèle à détecter toutes les instances positives. Il représente la proportion des vrais positifs qui ont été correctement identifiés par rapport au nombre total de vrais positifs dans l'ensemble des données.

### Formule :

## F1-Score

Vrai Positifs (VP)

𝑅𝑎𝑝𝑝𝑒𝑙 = Vrai Positifs (VP) + Faux Négatifs (FN)

Le F1-score est une mesure qui combine la précision et le rappel. Il s'agit de la moyenne harmonique de ces deux métriques, et il est utile lorsque l'on souhaite équilibrer la capacité d'un modèle à identifier correctement les exemples positifs (rappel) et à minimiser les fausses alertes (précision).

### Formule :

𝐹1 − 𝑆𝑐𝑜𝑟𝑒 = 2 ×

Précision × Rappel Précision + Rappel

## Matrice de Confusion (Confusion Matrix)

La matrice de confusion est un tableau qui résume les performances d'un modèle de classification. Elle permet de voir comment les prédictions sont réparties entre les vraies classes et les classes prédites. Dans une classification binaire, elle contient quatre éléments :

* + **Vrai Positifs (VP)**: Nombre de prédictions positives correctes.
  + **Faux Positifs (FP)**: Nombre de prédictions positives incorrectes.
  + **Faux Négatifs (FN)**: Nombre de prédictions négatives incorrectes.
  + **Vrai Négatifs (VN)**: Nombre de prédictions négatives correctes. À partir de cette matrice, on peut extraire les différentes métriques :
  + **Exactitude** : Mesure de la proportion d'exemples bien classifiés sur le total.

VP + VN

𝐸𝑥𝑎𝑐𝑡𝑖𝑡𝑢𝑑𝑒 =

VP + FP + FN + VN

* + **Précision** et **Rappel** sont extraits respectivement en utilisant les vrais positifs, faux positifs et faux négatifs.
  + **F1-Score** est ensuite calculé en fonction de la précision et du rappel.

Dans le cas où la classification n'est pas binaire, les métriques sont généralement calculées pour chaque classe en utilisant une approche "un-contre-tous", puis moyennées pour obtenir une vue globale des performances.

# Arbre de décision

## Évaluation des performances sur l’ensemble de test

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Jeu de données** | **Classe** | **Exactitude** | **Précision** | **Rappel** | **F1-score** | **Matrice de confusion** |
| **Iris** | Classe 0 |  |  |  |  | [[15, 0, 0],  [0, 16, 0],  [0, 0, 14]] |
| Classe 1 |  |  |  |  |
| Classe 2 |  |  |  |  |
| **Abalone** | Classe 0 |  |  |  |  | [[117, 22, 1],  [67, 835, 49],  [0, 71, 92]] |
| Classe 1 |  |  |  |  |
| Classe 2 |  |  |  |  |
| **Wine** | Classe 0 |  |  |  |  | [[431, 48],  [107, 225]] |
| Classe 1 |  |  |  |  |

## Comparaison avec l'implémentation Scikit-learn

Réseau de neurones

## Évaluation des performances sur l’ensemble de test

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Jeu de données** | **Classe** | **Exactitude** | **Précision** | **Rappel** | **F1-score** | **Matrice de confusion** |
| **Iris** | Classe 0 |  |  |  |  | [[15, 0, 0],  [0, 15, 1],  [0, 1, 13]] |
| Classe 1 |  |  |  |  |
| Classe 2 |  |  |  |  |
| **Abalone** | Classe 0 |  |  |  |  | [[121, 19, 0], [141,  490, 320], [1, 60,  102]] |
| Classe 1 |  |  |  |  |
| Classe 2 |  |  |  |  |
| **Wine** | Classe 0 |  |  |  |  | [[366, 113],  [64, 268]] |
| Classe 1 |  |  |  |  |

## Comparaison avec l'implémentation Scikit-learn

# Discussion

### Analyse par jeu de données Iris

* + **Caractéristiques des données** : Ce jeu de donnée est composé de 150 instances réparties uniformément entre trois classes (Iris-setosa, Iris-versicolour, Iris-virginica) et présente à la fois des classes linéairement séparables et non séparables.

### Résultats Arbre de décision :

### Résultats Réseau de neurones :

### Abalone

* + **Caractéristiques des données** : Ce jeu de donnée, avec 4177 instances et 3 classes représentant des intervalles d’âges d’ormeaux, est très déséquilibré, avec une majorité d’exemples pour la classe intermédiaire.

### Résultats Arbre de décision :

### Résultats Réseau de neurones :

### Wine

* + **Caractéristiques des données** : Avec 2700 instances et deux classes binaires (bon ou mauvais vin), ce jeu de donnée présente des caractéristiques fortement corrélées (ex. : acidité, densité).

### Résultats Arbre de décision :

### Résultats Réseau de neurones :

# Comparaison entre les quatres techniques sur l’ensemble de test des jeux de données

### Résultat KNN :

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Jeu de données** | **Exactitude** | **Précision** | **Rappel** | **Temps\* (ms)** | **Best K**  **(2, 3, 5, 7, 9)** | **Métrique (euclidean, manhattan,**  **chebyshev, minkowski (p=3))** |
| **Iris** | - | - | - | 1.002 | 3 | chebyshev |
| **Classe 0** | 1.0 | 1.0 | 1.0 |  |  |  |
| **Classe 1** | 0.9333 | 0.9444 | 0.8947 |  |  |  |
| **Classe 2** | 0.9333 | 0.8571 | 0.9231 |  |  |  |
| **Wine** | - | - | - | 79.9994 | 2 | manhattan |
| **Classe 0** | 0.8089 | 0.8011 | 0.8998 |  |  |  |
| **Classe 1** | 0.8089 | 0.8242 | 0.6777 |  |  |  |
| **Abalones** | - | - | - | 174.0124 | 2 | manhattan |
| **Classe 0** | 0.9282 | 0.6359 | 0.8357 |  |  |  |
| **Classe 1** | 0.8333 | 0.8998 | 0.8780 |  |  |  |
| **Classe 2** | 0.9035 | 0.6479 | 0.5644 |  |  |  |

### Résultat Naïve Bayes :

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Jeu de données** | **Exactitude** | **Précision** | **Rappel** | **Temps\***  **(ms)** |
| **Iris** | - | - | - | 1.9996 |
| **Classe 0** | 1.0 | 1.0 | 1.0 |  |
| **Classe 1** | 0.9333 | 0.9444 | 0.8947 |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Jeu de données** | **Exactitude** | **Précision** | **Rappel** | **Temps\***  **(ms)** |
| **Classe 2** | 0.9333 | 0.8571 | 0.9231 |  |
| **Wine** | - | - | - | 16.0007 |
| **Classe 0** | 0.7817 | 0.8512 | 0.7641 |  |
| **Classe 1** | 0.7817 | 0.7034 | 0.8072 |  |
| **Abalone** | - | - | - | 34.9994 |
| **Classe 0** | 0.8716 | 0.4601 | 0.8643 |  |
| **Classe 1** | 0.5694 | 0.8612 | 0.5152 |  |
| **Classe 2** | 0.6962 | 0.2417 | 0.6258 |  |

### Temps d'exécution :

### Exactitude (Accuracy) :

### Précision (Precision) :

### Rappel (Recall) :

# Conclusion

# ANNEXE

PS C:\Users\User\Documents\AI\_avance\_tp4\_equipe14> & C:/Users/User/AppData/Local/Programs/Python/Python310/python.exe c:/Users/User/Documents/AI\_avance\_tp4\_equipe14/entrainer\_tester.py

Train Decision Tree:

Iris:

Confusion matrix:

[[33. 0. 0.]

[ 0. 37. 0.]

[ 0. 0. 35.]]

Class 0

Accuracy: 59.74285714285714

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Class 1

Accuracy: 57.076190476190476

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Class 2

Accuracy: 58.333333333333336

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Wine:

Confusion matrix:

[[1187. 0.]

[ 0. 702.]]

Class 0

Accuracy: 1006.7617787188989

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Class 1

Accuracy: 1006.7617787188989

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Abalones:

Confusion matrix:

[[ 366. 0. 0.]

[ 0. 2044. 0.]

[ 0. 0. 513.]]

Class 0

Accuracy: 2282.6565172767705

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Class 1

Accuracy: 1693.6630174478275

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Class 2

Accuracy: 2077.0677386247007

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Train Scikit-learn Decision Tree:

Iris:

Confusion matrix:

[[33. 0. 0.]

[ 0. 35. 2.]

[ 0. 0. 35.]]

Class 0

Accuracy: 1.0

Precision: 1.0

Recall: 1.0

F1-score: 1.0

Class 1

Accuracy: 0.9809523809523809

Precision: 0.9857142857142858

Recall: 0.972972972972973

F1-score: 0.9793021880544058

Class 2

Accuracy: 0.9809523809523809

Precision: 0.972972972972973

Recall: 0.9857142857142858

F1-score: 0.9793021880544058

Wine:

Confusion matrix:

[[1035. 152.]

[ 130. 572.]]

Class 0

Accuracy: 0.8507146638433033

Precision: 0.8392336328930832

Recall: 0.8433804486879466

F1-score: 0.8413019308602507

Class 1

Accuracy: 0.8507146638433033

Precision: 0.8392336328930832

Recall: 0.8433804486879466

F1-score: 0.8413019308602507

Abalones:

Confusion matrix:

[[ 188. 178. 0.]

[ 8. 2022. 14.]

[ 0. 450. 63.]]

Class 0

Accuracy: 0.9363667464933287

Precision: 0.9469552397416612

Recall: 0.755266267889924

F1-score: 0.8403176044621866

Class 1

Accuracy: 0.7776257269928156

Precision: 0.8412163936692238

Recall: 0.6373942769870583

F1-score: 0.7252571967365402

Class 2

Accuracy: 0.8412589804994868

Precision: 0.8300325816137482

Recall: 0.5584989444565771

F1-score: 0.6677159459357748

Train Decision Tree with Pruning:

Iris:

Confusion matrix:

[[33. 0. 0.]

[ 0. 37. 0.]

[ 0. 0. 35.]]

Class 0

Accuracy: 59.74285714285714

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Class 1

Accuracy: 57.076190476190476

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Class 2

Accuracy: 58.333333333333336

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Wine:

Confusion matrix:

[[1187. 0.]

[ 0. 702.]]

Class 0

Accuracy: 1006.7617787188989

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Class 1

Accuracy: 1006.7617787188989

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Abalones:

Confusion matrix:

[[ 366. 0. 0.]

[ 0. 2044. 0.]

[ 0. 0. 513.]]

Class 0

Accuracy: 2282.6565172767705

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Class 1

Accuracy: 1693.6630174478275

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Class 2

Accuracy: 2077.0677386247007

Precision: 0.5

Recall: 0.5

F1-score: 0.5

Test Decision Tree:

Iris:

Confusion matrix:

[[17. 0. 0.]

[ 0. 12. 1.]

[ 0. 0. 15.]]

Class 0

Accuracy: 1.0

Precision: 1.0

Recall: 1.0

F1-score: 1.0

Class 1

Accuracy: 0.9777777777777777

Precision: 0.9848484848484849

Recall: 0.9615384615384616

F1-score: 0.9730538922155688

Class 2

Accuracy: 0.9777777777777777

Precision: 0.96875

Recall: 0.9833333333333334

F1-score: 0.9759871931696905

Wine:

Confusion matrix:

[[410. 69.]

[ 27. 305.]]

Class 0

Accuracy: 0.8816276202219482

Precision: 0.8768615621826014

Recall: 0.8873122972055236

F1-score: 0.8820559753008947

Class 1

Accuracy: 0.8816276202219482

Precision: 0.8768615621826014

Recall: 0.8873122972055236

F1-score: 0.8820559753008947

Abalones:

Confusion matrix:

[[108. 32. 0.]

[ 44. 836. 71.]

[ 0. 57. 106.]]

Class 0

Accuracy: 0.9393939393939394

Precision: 0.8407441016333939

Recall: 0.8659656322133881

F1-score: 0.8531685067028502

Class 1

Accuracy: 0.8373205741626795

Precision: 0.7771198554177278

Recall: 0.7926726426585876

F1-score: 0.784819204081179

Class 2

Accuracy: 0.89792663476874

Precision: 0.772972632705412

Recall: 0.7926144191460527

F1-score: 0.7826703134304185

Test Decision Tree Pruning:

Iris:

Confusion matrix:

[[17. 0. 0.]

[ 0. 12. 1.]

[ 0. 0. 15.]]

Class 0

Accuracy: 1.0

Precision: 1.0

Recall: 1.0

F1-score: 1.0

Class 1

Accuracy: 0.9777777777777777

Precision: 0.9848484848484849

Recall: 0.9615384615384616

F1-score: 0.9730538922155688

Class 2

Accuracy: 0.9777777777777777

Precision: 0.96875

Recall: 0.9833333333333334

F1-score: 0.9759871931696905

Wine:

Confusion matrix:

[[410. 69.]

[ 27. 305.]]

Class 0

Accuracy: 0.8816276202219482

Precision: 0.8768615621826014

Recall: 0.8873122972055236

F1-score: 0.8820559753008947

Class 1

Accuracy: 0.8816276202219482

Precision: 0.8768615621826014

Recall: 0.8873122972055236

F1-score: 0.8820559753008947

Abalones:

Confusion matrix:

[[108. 32. 0.]

[ 44. 836. 71.]

[ 0. 57. 106.]]

Class 0

Accuracy: 0.9393939393939394

Precision: 0.8407441016333939

Recall: 0.8659656322133881

F1-score: 0.8531685067028502

Class 1

Accuracy: 0.8373205741626795

Precision: 0.7771198554177278

Recall: 0.7926726426585876

F1-score: 0.784819204081179

Class 2

Accuracy: 0.89792663476874

Precision: 0.772972632705412

Recall: 0.7926144191460527

F1-score: 0.7826703134304185

Optimizing Neural Network:

Neural Network layer size for iris:

Hidden layers: (10,), Accuracy: 0.9714285714285713

Hidden layers: (30,), Accuracy: 0.9619047619047618

Hidden layers: (50,), Accuracy: 0.9714285714285713

Hidden layers: (100,), Accuracy: 0.9714285714285713

Hidden layers: (150,), Accuracy: 0.9714285714285713

Hidden layers: (200,), Accuracy: 0.9714285714285713

Hidden layers: (250,), Accuracy: 0.9714285714285713

Hidden layers: (300,), Accuracy: 0.9714285714285713

Neural Network layer size for wine:

Hidden layers: (10,), Accuracy: 0.8206896551724137

Hidden layers: (30,), Accuracy: 0.7639257294429709

Hidden layers: (50,), Accuracy: 0.8143236074270558

Hidden layers: (100,), Accuracy: 0.8068965517241381

Hidden layers: (150,), Accuracy: 0.7946949602122018

Hidden layers: (200,), Accuracy: 0.8026525198938991

Hidden layers: (250,), Accuracy: 0.803183023872679

Hidden layers: (300,), Accuracy: 0.813262599469496

Neural Network layer size for abalones:

Hidden layers: (10,), Accuracy: 0.7856164383561643

Hidden layers: (30,), Accuracy: 0.7890410958904109

Hidden layers: (50,), Accuracy: 0.7842465753424658

Hidden layers: (100,), Accuracy: 0.7931506849315069

Hidden layers: (150,), Accuracy: 0.7928082191780822

Hidden layers: (200,), Accuracy: 0.7934931506849314

Hidden layers: (250,), Accuracy: 0.7914383561643835

Hidden layers: (300,), Accuracy: 0.7845890410958904

Best hidden layers for iris: 10, Accuracy: 0.9714285714285713

Best hidden layers for wine: 10, Accuracy: 0.8206896551724137

Best hidden layers for abalones: 200, Accuracy: 0.7934931506849314

Neural Network depth for iris:

Hidden layers: (10,), Accuracy: 0.8476190476190476

Hidden layers: (10, 10), Accuracy: 0.9619047619047618

Hidden layers: (10, 10, 10), Accuracy: 0.9714285714285713

Hidden layers: (10, 10, 10, 10), Accuracy: 0.9619047619047618

Hidden layers: (10, 10, 10, 10, 10), Accuracy: 0.9619047619047618

Neural Network depth for wine:

Hidden layers: (10,), Accuracy: 0.8015915119363395

Hidden layers: (10, 10), Accuracy: 0.8212201591511936

Hidden layers: (10, 10, 10), Accuracy: 0.826525198938992

Hidden layers: (10, 10, 10, 10), Accuracy: 0.7883289124668434

Hidden layers: (10, 10, 10, 10, 10), Accuracy: 0.7904509283819628

Neural Network depth for abalones:

Hidden layers: (200,), Accuracy: 0.7917808219178082

Hidden layers: (200, 200), Accuracy: 0.7962328767123288

Hidden layers: (200, 200, 200), Accuracy: 0.7852739726027397

Hidden layers: (200, 200, 200, 200), Accuracy: 0.7955479452054794

Hidden layers: (200, 200, 200, 200, 200), Accuracy: 0.795890410958904

Best hidden layers for iris: (10, 10, 10), Accuracy: 0.9714285714285713

Best hidden layers for wine: (10, 10, 10), Accuracy: 0.826525198938992

Best hidden layers for abalones: (200, 200), Accuracy: 0.7962328767123288

Train Neural Network:

Iris:

Epoch 0/1000, Loss: 0.6366449909560851

Epoch 100/1000, Loss: 0.6242921306249035

Epoch 200/1000, Loss: 0.3349718200270826

Epoch 300/1000, Loss: 0.17359454964290022

Epoch 400/1000, Loss: 0.10445798302468928

Epoch 500/1000, Loss: 0.14763031611466815

Epoch 600/1000, Loss: 0.17886051277741755

Epoch 700/1000, Loss: 0.11396894480369114

Epoch 800/1000, Loss: 0.06930160112873757

Epoch 900/1000, Loss: 0.11953509502650819

Confusion matrix:

[[33. 0. 0.]

[ 0. 37. 0.]

[ 0. 16. 19.]]

Class 0

Accuracy: 1.0

Precision: 1.0

Recall: 1.0

F1-score: 1.0

Class 1

Accuracy: 0.8476190476190476

Precision: 0.8490566037735849

Recall: 0.8823529411764706

F1-score: 0.8653846153846154

Class 2

Accuracy: 0.8476190476190476

Precision: 0.9069767441860466

Recall: 0.7714285714285714

F1-score: 0.833729216152019

Wine:

Epoch 0/3000, Loss: 0.6803209041281557

Epoch 100/3000, Loss: 0.6379271304499511

Epoch 200/3000, Loss: 0.6343182918628211

Epoch 300/3000, Loss: 0.6302122077644479

Epoch 400/3000, Loss: 0.6248300279226648

Epoch 500/3000, Loss: 0.6166606815159975

Epoch 600/3000, Loss: 0.6074474812595269

Epoch 700/3000, Loss: 0.5972211489977526

Epoch 800/3000, Loss: 0.5871876906745322

Epoch 900/3000, Loss: 0.5898607616267946

Epoch 1000/3000, Loss: 0.58427253564048

Epoch 1100/3000, Loss: 0.5811651474489867

Epoch 1200/3000, Loss: 0.5776149637908486

Epoch 1300/3000, Loss: 0.5738499741198899

Epoch 1400/3000, Loss: 0.5728900690233233

Epoch 1500/3000, Loss: 0.5695497247324239

Epoch 1600/3000, Loss: 0.5696438286209061

Epoch 1700/3000, Loss: 0.5682398390060136

Epoch 1800/3000, Loss: 0.5661799352438649

Epoch 1900/3000, Loss: 0.5648082320555222

Epoch 2000/3000, Loss: 0.5607813103005027

Epoch 2100/3000, Loss: 0.5476187820101589

Epoch 2200/3000, Loss: 0.5441434660138389

Epoch 2300/3000, Loss: 0.5458813363218507

Epoch 2400/3000, Loss: 0.5430560854065228

Epoch 2500/3000, Loss: 0.5328527083419539

Epoch 2600/3000, Loss: 0.5539049441332577

Epoch 2700/3000, Loss: 0.5419851680482202

Epoch 2800/3000, Loss: 0.5273636000093469

Epoch 2900/3000, Loss: 0.5301069861929153

Confusion matrix:

[[872. 315.]

[164. 538.]]

Class 0

Accuracy: 0.7464266807834833

Precision: 0.7362069823969003

Recall: 0.7505034358446321

F1-score: 0.7432864705894842

Class 1

Accuracy: 0.7464266807834833

Precision: 0.7362069823969003

Recall: 0.7505034358446321

F1-score: 0.7432864705894842

Abalones:

Epoch 0/8000, Loss: 0.7065455261564267

Epoch 100/8000, Loss: 0.4596140854354567

Epoch 200/8000, Loss: 0.43490665566350906

Epoch 300/8000, Loss: 0.4174202843917101

Epoch 400/8000, Loss: 0.4049641473392451

Epoch 500/8000, Loss: 0.3953429542400048

Epoch 600/8000, Loss: 0.3881597978911409

Epoch 700/8000, Loss: 0.38264027065786527

Epoch 800/8000, Loss: 0.37825934587510496

Epoch 900/8000, Loss: 0.3747540510883087

Epoch 1000/8000, Loss: 0.37179941223132257

Epoch 1100/8000, Loss: 0.36925702558071855

Epoch 1200/8000, Loss: 0.36698237250106513

Epoch 1300/8000, Loss: 0.36488512866530576

Epoch 1400/8000, Loss: 0.36299147195243625

Epoch 1500/8000, Loss: 0.36123713908108457

Epoch 1600/8000, Loss: 0.3596198631738905

Epoch 1700/8000, Loss: 0.35811489186152645

Epoch 1800/8000, Loss: 0.356683254875989

Epoch 1900/8000, Loss: 0.35532069260245824

Epoch 2000/8000, Loss: 0.35400852290213153

Epoch 2100/8000, Loss: 0.3527295839494072

Epoch 2200/8000, Loss: 0.35146121802387736

Epoch 2300/8000, Loss: 0.35023715916255044

Epoch 2400/8000, Loss: 0.349072245475741

Epoch 2500/8000, Loss: 0.34794826856790656

Epoch 2600/8000, Loss: 0.34685537538664396

Epoch 2700/8000, Loss: 0.3457775123098192

Epoch 2800/8000, Loss: 0.3447073675016398

Epoch 2900/8000, Loss: 0.3436665592282964

Epoch 3000/8000, Loss: 0.3426616871788033

Epoch 3100/8000, Loss: 0.3416747692840615

Epoch 3200/8000, Loss: 0.3407042409087679

Epoch 3300/8000, Loss: 0.33974883742803397

Epoch 3400/8000, Loss: 0.33880426491677784

Epoch 3500/8000, Loss: 0.3378688610430805

Epoch 3600/8000, Loss: 0.3369413155856828

Epoch 3700/8000, Loss: 0.3360162866981201

Epoch 3800/8000, Loss: 0.33509590295437836

Epoch 3900/8000, Loss: 0.33418787977817643

Epoch 4000/8000, Loss: 0.33332078172320695

Epoch 4100/8000, Loss: 0.33247224527905117

Epoch 4200/8000, Loss: 0.33164705376952586

Epoch 4300/8000, Loss: 0.3308359113653215

Epoch 4400/8000, Loss: 0.3300350897006269

Epoch 4500/8000, Loss: 0.3292552752237167

Epoch 4600/8000, Loss: 0.32849953678919547

Epoch 4700/8000, Loss: 0.32776502187932177

Epoch 4800/8000, Loss: 0.32705401720875876

Epoch 4900/8000, Loss: 0.3263617363541099

Epoch 5000/8000, Loss: 0.32569087072889913

Epoch 5100/8000, Loss: 0.3250400952598364

Epoch 5200/8000, Loss: 0.3244148450404902

Epoch 5300/8000, Loss: 0.3238148610196225

Epoch 5400/8000, Loss: 0.3232357350797553

Epoch 5500/8000, Loss: 0.32267567052855406

Epoch 5600/8000, Loss: 0.3221355586337692

Epoch 5700/8000, Loss: 0.3216207606765619

Epoch 5800/8000, Loss: 0.32112883781918694

Epoch 5900/8000, Loss: 0.3206569781638001

Epoch 6000/8000, Loss: 0.3202004035602835

Epoch 6100/8000, Loss: 0.31975699539188146

Epoch 6200/8000, Loss: 0.3193224829270624

Epoch 6300/8000, Loss: 0.31890835773729637

Epoch 6400/8000, Loss: 0.318519937367081

Epoch 6500/8000, Loss: 0.318151625181283

Epoch 6600/8000, Loss: 0.3178073440745092

Epoch 6700/8000, Loss: 0.3174815572283346

Epoch 6800/8000, Loss: 0.317169675611612

Epoch 6900/8000, Loss: 0.3168598452452422

Epoch 7000/8000, Loss: 0.3165573017671789

Epoch 7100/8000, Loss: 0.31625519466422136

Epoch 7200/8000, Loss: 0.315959128581129

Epoch 7300/8000, Loss: 0.3156978839870801

Epoch 7400/8000, Loss: 0.3154526281545026

Epoch 7500/8000, Loss: 0.3152200495992243

Epoch 7600/8000, Loss: 0.31498894017099227

Epoch 7700/8000, Loss: 0.3147608123830432

Epoch 7800/8000, Loss: 0.314544870648457

Epoch 7900/8000, Loss: 0.3143383298822741

Confusion matrix:

[[ 235. 131. 0.]

[ 83. 1888. 73.]

[ 0. 332. 181.]]

Class 0

Accuracy: 0.9267875470407116

Precision: 0.844352901411171

Recall: 0.8048082943852833

F1-score: 0.82410648537702

Class 1

Accuracy: 0.7882312692439275

Precision: 0.7651676269285796

Recall: 0.6984720673065149

F1-score: 0.7303002457802712

Class 2

Accuracy: 0.8614437222032159

Precision: 0.7941036337299351

Recall: 0.6612680271448561

F1-score: 0.7216237025111792

Test Neural Network:

Iris:

Confusion matrix:

[[17. 0. 0.]

[ 0. 13. 0.]

[ 0. 10. 5.]]

Class 0

Accuracy: 1.0

Precision: 1.0

Recall: 1.0

F1-score: 1.0

Class 1

Accuracy: 0.7777777777777778

Precision: 0.7826086956521738

Recall: 0.84375

F1-score: 0.81203007518797

Class 2

Accuracy: 0.7777777777777778

Precision: 0.875

Recall: 0.6666666666666666

F1-score: 0.7567567567567567

Wine:

Confusion matrix:

[[354. 125.]

[ 85. 247.]]

Class 0

Accuracy: 0.7410604192355117

Precision: 0.7351783133710534

Recall: 0.7415077847926151

F1-score: 0.7383294841784583

Class 1

Accuracy: 0.7410604192355117

Precision: 0.7351783133710534

Recall: 0.7415077847926151

F1-score: 0.7383294841784583

Abalones:

Confusion matrix:

[[ 79. 61. 0.]

[ 25. 896. 30.]

[ 0. 110. 53.]]

Class 0

Accuracy: 0.9314194577352473

Precision: 0.8532859531772575

Recall: 0.7709220312900744

F1-score: 0.8100156465003877

Class 1

Accuracy: 0.8197767145135566

Precision: 0.7728099674733999

Recall: 0.6889048526303735

F1-score: 0.7284492562177749

Class 2

Accuracy: 0.8883572567783095

Precision: 0.7723087053594395

Recall: 0.6488278328544196

F1-score: 0.7052037156440495

Comparison of the 4 models:

Iris:

Training time:

Knn: 0.0

Naive Bayes: 0.0

Decision Tree: 0.012295722961425781

Neural Network: 0.12752819061279297

Prediction time:

Knn: 0.0

Naive Bayes: 0.0

Decision Tree: 0.0

Neural Network: 0.0

Accuracy:

Knn: 0.9777777777777777

Naive Bayes: 0.9555555555555556

Decision Tree: 0.9777777777777777

Neural Network: 0.7777777777777778

Wine:

Training time:

Knn: 0.0

Naive Bayes: 0.0

Decision Tree: 0.9375135898590088

Neural Network: 1.4912514686584473

Prediction time:

Knn: 0.0

Naive Bayes: 0.0

Decision Tree: 0.0

Neural Network: 0.0

Accuracy:

Knn: 0.8088779284833539

Naive Bayes: 0.781750924784217

Decision Tree: 0.8816276202219482

Neural Network: 0.7410604192355117

Abalones:

Training time:

Knn: 0.0

Naive Bayes: 0.0

Decision Tree: 1.894421100616455

Neural Network: 212.9279477596283

Prediction time:

Knn: 0.0

Naive Bayes: 0.0

Decision Tree: 0.0

Neural Network: 0.0

Accuracy:

Knn: 0.8325358851674641

Naive Bayes: 0.5685805422647527

Decision Tree: 0.8373205741626795  
 Neural Network: 0.8197767145135566