

Step 5 – Artificial Neural Network (Feedforward)

1. Create and train a **fully connected feedforward Artificial Neural Network (ANN)** to classify the two true classes.
 2. Plot the **decision boundary** of the ANN and compare it with the one obtained using Logistic Regression.
 3. Compute the performance metrics: **accuracy, precision, recall, F1-score**.
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When to Use an Artificial Neural Network (ANN)

-  Use it when:
 - The decision boundary is **non-linear/complex** and simpler linear models underfit.
 - You need **flexibility** and universal function approximation.
 - Inputs are **numeric and standardized**, and you can tune hyperparameters.
 -  Avoid it when:
 - The dataset is **small** and nearly **linearly separable** (Logistic Regression is simpler and more interpretable).
 - You need **strong explainability** or have tight compute constraints.
 - Features are **not scaled** or mostly **categorical** without proper encoding.
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Model Hyperparameters

- **Preprocessing:** `StandardScaler()` — input normalization
 - `hidden_layer_sizes = (8, 4, 4)` — number of neurons per hidden layer
 - `activation = "relu"` — activation function in hidden layers
 - `solver = "adam"` — optimizer for weight updates
 - `alpha = 0.001` — L2 regularization term
 - `learning_rate_init = 0.0001` — initial learning rate
 - `max_iter = 1000` — maximum training iterations
 - `random_state = 42` — reproducibility of initialization
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```
%run 00-setup.py
```

```
from tasks.ann import run_ann

from ml.data import load_dataset
from ml.viz import plt_dboundary, plt_cmatrix

from sklearn.model_selection import train_test_split
```

```
X, y, _ = load_dataset("../data/data_bivariate_gaussian.npz")

X_train, X_test, y_train, y_test = train_test_split(
    X, y, test_size=0.2, random_state=42, stratify=y
)
```

```
res = run_ann(
    X_train, y_train, X_test, y_test,
    params={
        "hidden_layers": (8, 4, 4),
        "activation": "relu",
        "alpha": 0.001,
        "learning_rate_init": 0.0001,
        "max_iter": 1000,
        "seed": 42
    }
)
```

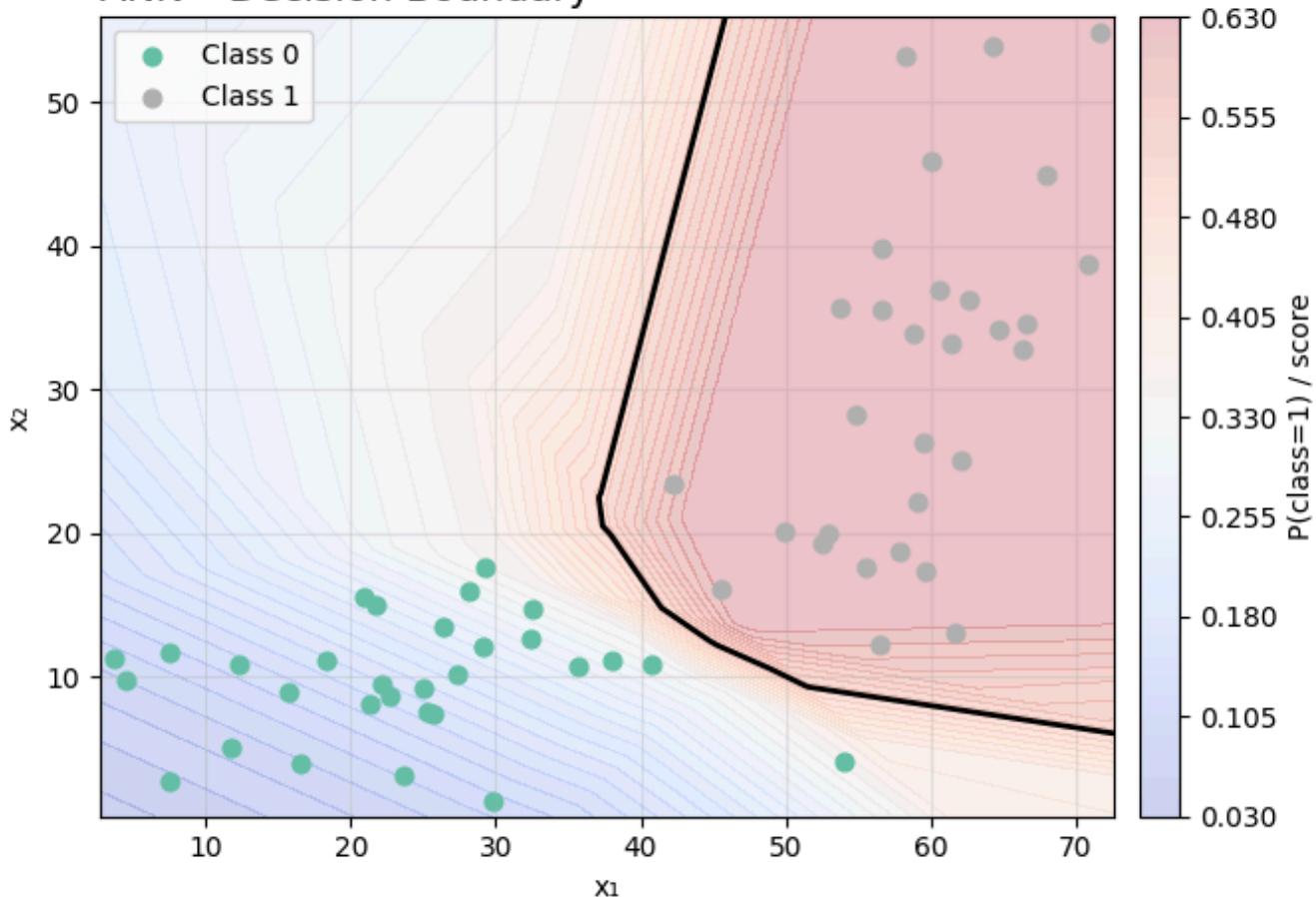
```
c:\Users\lgdan\Documents\MASTER\ML\.venv\Lib\site-packages\sklearn\neural_network\_multilayer_perceptron.py:781: ConvergenceWarning: Stochastic Optimizer: Maximum iterations (1000) reached and the optimization hasn't converged yet.
  warnings.warn(
```

```
print("Test:", res["test"]["metrics"])
```

```
Test: {'accuracy': 1.0, 'precision': 1.0, 'recall': 1.0, 'f1': 1.0}
```

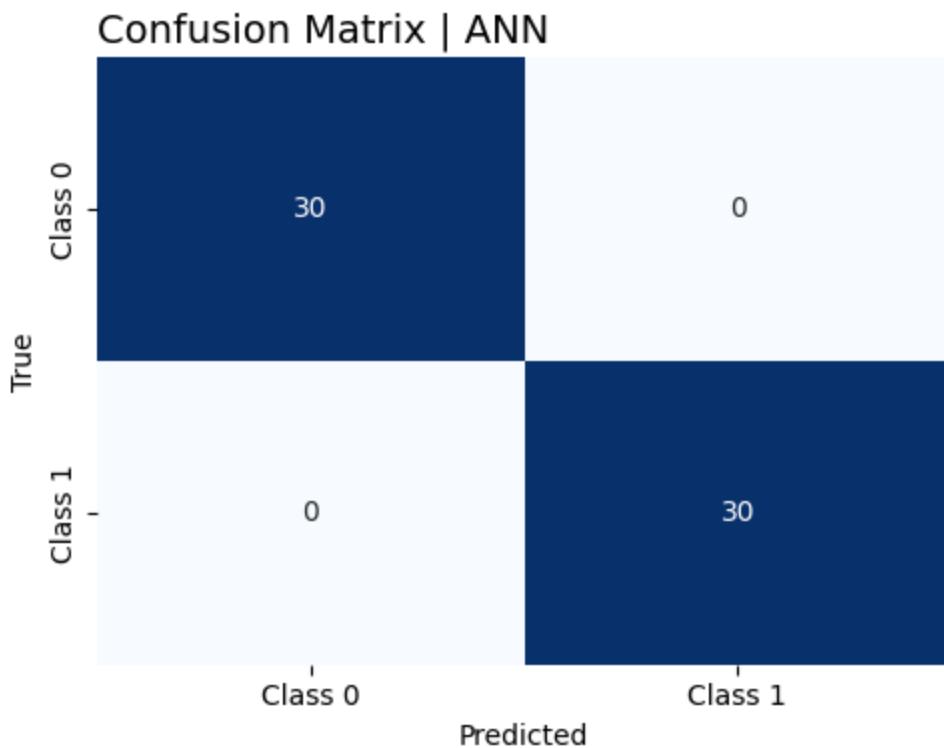
```
plt_dboundary(
    res["model"],
    X_test,
    y_test,
    title="ANN - Decision Boundary"
)
```

ANN - Decision Boundary



```
(<Figure size 700x500 with 2 Axes>,
<Axes: title={'left': 'ANN - Decision Boundary'}, xlabel='x1', ylabel='x2'>)
```

```
plt_cmatrix(
    y_true=y_test,
    y_pred=res["test"]["y_pred"],
    title="Confusion Matrix | ANN"
)
```



```
(<Figure size 500x400 with 1 Axes>,
<Axes: title={'left': 'Confusion Matrix | ANN'}, xlabel='Predicted', ylabel='True'>)
```

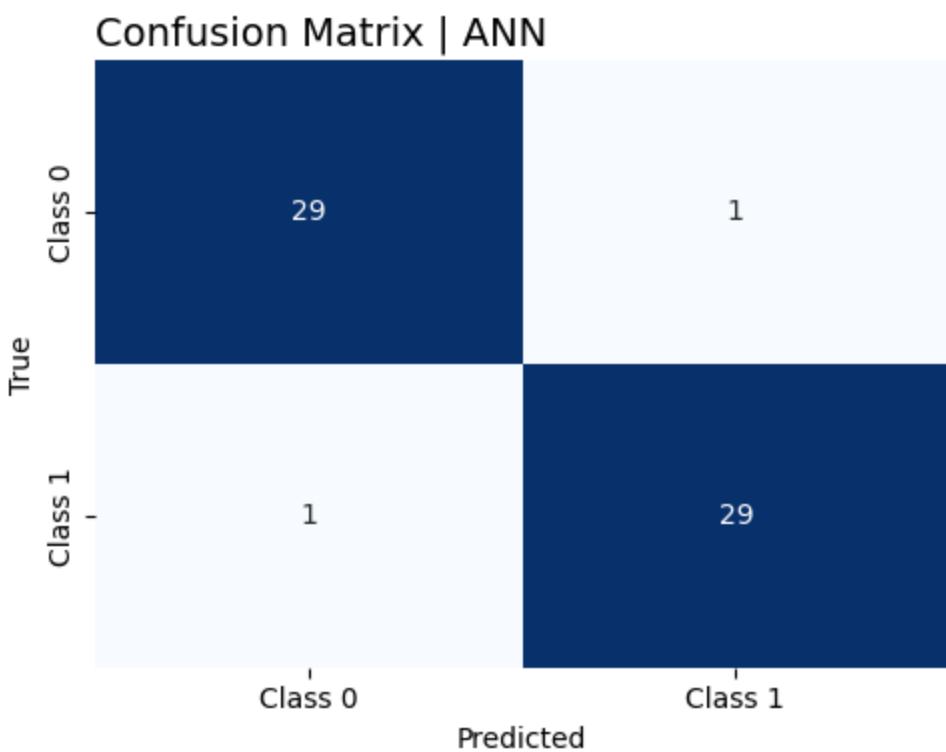
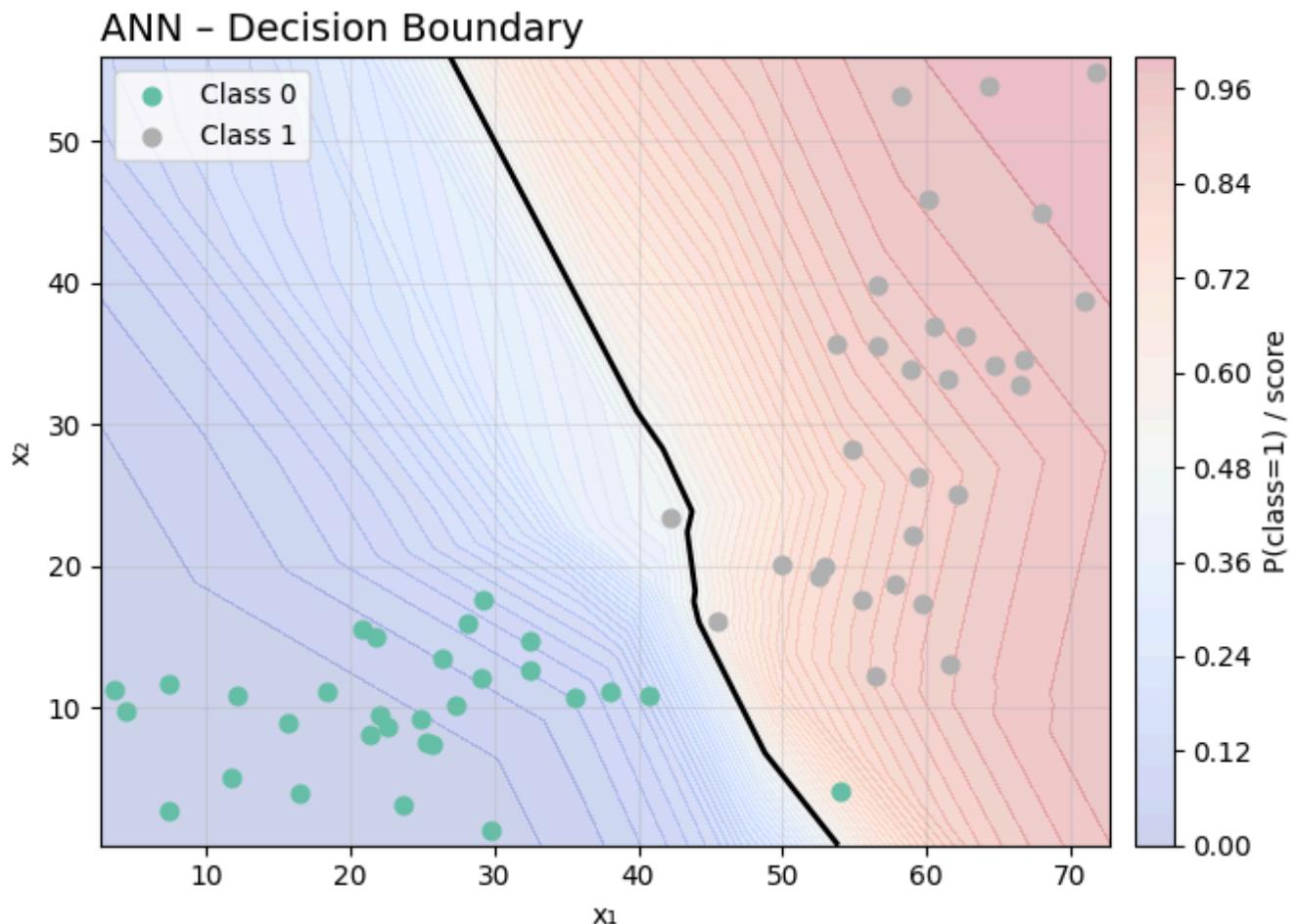
2 Layers, 8 and 4 neurons

```
res = run_ann(
    X_train, y_train, X_test, y_test,
    params={
        "hidden_layers": (8, 4),
        "activation": "relu",
        "alpha": 0.001,
        "learning_rate_init": 0.0001,
        "max_iter": 2000,
        "seed": 42
    }
)

plt_dboundary(
    res["model"],
    X_test,
    y_test,
    title="ANN - Decision Boundary"
)

plt_cmatrix(
    y_true=y_test,
    y_pred=res["test"]["y_pred"],
```

```
title="Confusion Matrix | ANN"
)
```



```
(<Figure size 500x400 with 1 Axes>,
<Axes: title={'left': 'Confusion Matrix | ANN'}, xlabel='Predicted', ylabel='True'>)
```