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118CS0597
Soft Computing Lab – VIII
14th March 2022

Code:

```
import random
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import tensorflow as tf
from tensorflow.keras import datasets, layers, models
from tensorflow.keras.optimizers import Adam

X1, Y1, X2, Y2, X3, Y3, X4, Y4 = [], [], [], [], [], [], [], []
for _ in range(100):
# Negative Samples
  X1.append([1, random.uniform(0, 2), random.uniform(0, 2)])
  Y1.append(-1)
  X2.append([1, random.uniform(0, 2), random.uniform(0, 2)])
  Y2.append(-1)
  X3.append([1, random.uniform(0, 2), random.uniform(0, 2)])
  Y3.append(-1)
  X4.append([1, random.uniform(0, 2), random.uniform(0, 2)])
  Y4.append(-1)
  # Positive Samples
  X1.append([1, random.uniform(3, 5), random.uniform(3, 5)])
  Y1.append(1)
  X2.append([1, random.uniform(2, 4), random.uniform(2, 4)])
  Y2.append(1)
  X3.append([1, random.uniform(0, 2), random.uniform(2, 4)])
  Y3.append(1)
  X4.append([1, random.uniform(1, 3), random.uniform(1, 3)])
  Y4.append(1)

X1, Y1 = np.array(X1), np.array(Y1)
X2, Y2 = np.array(X2), np.array(Y2)
X3, Y3 = np.array(X3), np.array(Y3)
X4, Y4 = np.array(X4), np.array(Y4)

fig, ((ax1, ax2), (ax3, ax4)) = plt.subplots(nrows = 2, ncols = 2, figsize = (12, 10))
sns.scatterplot(x=X1[Y1==-1].T[1], y=X1[Y1==-1].T[2], ax=ax1)
sns.scatterplot(x=X1[Y1==1].T[1], y=X1[Y1==1].T[2], ax=ax1)
ax1.legend([-1, 1])
ax1.set_title("Scatter Plot of X1")
ax1.set_xlabel("Var-1")
ax1.set_ylabel("Var-2")
sns.scatterplot(x=X2[Y2==-1].T[1], y=X2[Y2==-1].T[2], ax=ax2)
sns.scatterplot(x=X2[Y2==1].T[1], y=X2[Y2==1].T[2], ax=ax2)
ax2.legend([-1, 1])
ax2.set_title("Scatter Plot of X2")
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ax2.set_xlabel("Var-1")
ax2.set_ylabel("Var-2")
ax2.set_xlim([0, 5])
ax2.set_ylim([0, 5])
sns.scatterplot(x=X3[Y3==-1].T[1], y=X3[Y3==-1].T[2], ax=ax3)
sns.scatterplot(x=X3[Y3==1].T[1], y=X3[Y3==1].T[2], ax=ax3)
ax3.legend([-1, 1])
ax3.set_title("Scatter Plot of X3")
ax3.set_xlabel("Var-1")
ax3.set_ylabel("Var-2")
ax3.set_xlim([0, 5])
ax3.set_ylim([0, 5])
sns.scatterplot(x=X4[Y4==-1].T[1], y=X4[Y4==-1].T[2], ax=ax4)
sns.scatterplot(x=X4[Y4==1].T[1], y=X4[Y4==1].T[2], ax=ax4)
ax4.legend([-1, 1])
ax4.set_title("Scatter Plot of X4")
ax4.set_xlabel("Var-1")
ax4.set_ylabel("Var-2")
ax4.set_xlim([0, 5])
ax4.set_ylim([0, 5])

def accuracy(Y, y_pred):
  count = 0
  for val in Y == y_pred:
    if val:
      count += 1
  return count/Y.shape[0]
def thresh(x):
  val = []
  for i in x:
    if i > 0:
      val.append(1)
    else:
      val.append(-1)
  return np.array(val)
def perceptron(X, Y, W, learning_rate, iterations=100):
  while(iterations):
    y_pred = thresh(X@W)
    D = 0.5*(Y1[Y1 != y_pred] - y_pred[Y1 != y_pred])
    for x, d in zip(X1[Y1 != y_pred], D):
      W += learning_rate*d*x
    iterations -= 1
  y_pred = thresh(X@W)
  acc = accuracy(Y1, y_pred)
  return W, acc

W = np.array([1, 1, -0.5])
learning_rate = [0.01, 0.05]
Final_Weights, Accuracy = perceptron(X1, Y1, W, learning_rate[0])
print("\nLearning Rate -> 0.01\nFinal Weights: ", Final_Weights)
print(f"Accuracy : {Accuracy*100}%")
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Final_Weights, Accuracy = perceptron(X1, Y1, W, learning_rate[1])
print("\nLearning Rate -> 0.05\nFinal Weights: ", Final_Weights)
print(f"Accuracy : {Accuracy*100}%")

W = np.array([1, 1, -0.5])
learning_rate = [0.01, 0.05]
Final_Weights, Accuracy = perceptron(X2, Y2, W, learning_rate[0])
print("\nLearning Rate -> 0.01\nFinal Weights: ", Final_Weights)
print(f"Accuracy : {Accuracy*100}%")
Final_Weights, Accuracy = perceptron(X2, Y2, W, learning_rate[1])
print("\nLearning Rate -> 0.05\nFinal Weights: ", Final_Weights)
print(f"Accuracy : {Accuracy*100}%")

W = np.array([1, 1, -0.5])
learning_rate = [0.01, 0.05]
Final_Weights, Accuracy = perceptron(X3, Y3, W, learning_rate[0])
print("\nLearning Rate -> 0.01\nFinal Weights: ", Final_Weights)
print(f"Accuracy : {Accuracy*100}%")
Final_Weights, Accuracy = perceptron(X3, Y3, W, learning_rate[1])
print("\nLearning Rate -> 0.05\nFinal Weights: ", Final_Weights)
print(f"Accuracy : {Accuracy*100}%")

W = np.array([1, 1, -0.5])
learning_rate = [0.01, 0.05]
Final_Weights, Accuracy = perceptron(X4, Y4, W, learning_rate[0])
print("\nLearning Rate -> 0.01\nFinal Weights: ", Final_Weights)
print(f"Accuracy : {Accuracy*100}%")
Final_Weights, Accuracy = perceptron(X4, Y4, W, learning_rate[1])
print("\nLearning Rate -> 0.05\nFinal Weights: ", Final_Weights)
print(f"Accuracy : {Accuracy*100}%")

W = np.array([1, 1, 0.5])
learning_rate = 0.05
Final_Weights, Accuracy = perceptron(X3, Y3, W, learning_rate)
print("Final Weights: ", Final_Weights)
print(f"Accuracy : {Accuracy*100}%")

x = list(np.random.normal(-5, size=20)) + list(np.random.normal(5, size=20)) + list(np.r
andom.normal(10, size=20)) + \
list(np.random.normal(-5, size=20)) + list(np.random.normal(0, size=20)) + list(np.rando
m.normal(5, size=20)) + list(np.random.normal(15, size=20))
y = list(np.random.normal(5, size=20)) + list(np.random.normal(-5, size=20)) + list(np.
random.normal(0, size=20)) + \
list(np.random.normal(-5, size=20)) + list(np.random.normal(0, size=20)) + list(np.rando
m.normal(5, size=20)) + list(np.random.normal(-5, size=20))
# Training Data
X1 = np.array([x, y]).T
Y1 = np.array([1]*60 + [0]*80)

x = list(np.random.normal(-5, size=20)) + list(np.random.normal(5, size=20)) + list(np.r
andom.normal(10, size=20)) + \
```

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list(np.random.normal(-5, size=20)) + list(np.random.normal(0, size=20)) + list(np.rando
m.normal(5, size=20)) + list(np.random.normal(15, size=20))
y = list(np.random.normal(5, size=20)) + list(np.random.normal(-5, size=20)) + list(np.
random.normal(0, size=20)) + \
list(np.random.normal(-5, size=20)) + list(np.random.normal(0, size=20)) + list(np.rando
m.normal(5, size=20)) + list(np.random.normal(-5, size=20))
# Training Data
X2 = np.array([x, y]).T
Y2 = np.array([1]*60 + [0]*80)

plt.figure(figsize=(7, 5))
sns.scatterplot(x=X1[Y1==0].T[0], y=X1[Y1==0].T[1])
sns.scatterplot(x=X1[Y1==1].T[0], y=X1[Y1==1].T[1])
plt.legend([-1, 1])
plt.title("Scatter Plot For Training Data")
plt.xlabel("Var-1")
plt.ylabel("Var-2")

def plot_decision_boundary(X, y, model, steps=1000):
  # Define region of interest by data limits
  xmin, xmax = X[:,0].min() - 1, X[:,0].max() + 1
  ymin, ymax = X[:,1].min() - 1, X[:,1].max() + 1
  steps = 1000
  x_span = np.linspace(xmin, xmax, steps)
  y_span = np.linspace(ymin, ymax, steps)
  xx, yy = np.meshgrid(x_span, y_span)
  # Make predictions across region of interest
  labels = model.predict(np.c_[xx.ravel(), yy.ravel()])
  # Plot decision boundary in region of interest
  z = labels.reshape(xx.shape)
  fig, ax = plt.subplots()
  ax.contourf(xx, yy, z, alpha=0.5)
  train_labels = model.predict(X)
  ax.scatter(X[:,0], X[:,1], c=y, lw=0)
  ax.set_title("Decision Boundary and Test Data Points")

def plot_acc_loss(history):
  plt.figure(figsize = (12, 4))
  plt.subplot(1, 2, 1)
  plt.plot(history.history['accuracy'], 'g')
  Out[4]:
  Text(0, 0.5, 'Var-2')
  plt.title('Training Accuracy vs Epochs')
  plt.ylabel('Accuracy')
  plt.xlabel('Epochs')
  plt.subplot(1, 2, 2)
  plt.plot(history.history['loss'], 'r')
  plt.title('Training Loss vs Epochs')
  plt.ylabel('Loss')
  plt.xlabel('Epochs')
  plt.show()
```

```
ann = models.Sequential([
layers.Dense(2, activation='tanh'),
layers.Dense(1, activation='relu')])
ann.compile(optimizer=Adam(0.01),
loss='binary_crossentropy',
metrics=['accuracy'])
history = ann.fit(X1, Y1, epochs=900, shuffle=True, verbose=0)
plot_decision_boundary(X2, Y2, ann)

ann.evaluate(X2, Y2)
plot_acc_loss(history)

ann = models.Sequential([
layers.Dense(4, activation='tanh'),
layers.Dense(1, activation='relu')])
ann.compile(optimizer=Adam(0.01),
loss='binary_crossentropy',
metrics=['accuracy'])
history = ann.fit(X1, Y1, epochs=900, shuffle=True, verbose=0)
plot_decision_boundary(X2, Y2, ann)


ann.evaluate(X2, Y2)
plot_acc_loss(history)

ann = models.Sequential([
layers.Dense(4, activation='tanh'),
layers.Dense(1, activation='relu')])
ann.compile(optimizer=Adam(0.0001),
loss='binary_crossentropy',
metrics=['accuracy'])
history = ann.fit(X1, Y1, epochs=900, shuffle=True, verbose=0)
plot_decision_boundary(X2, Y2, ann)

ann.evaluate(X2, Y2)
plot_acc_loss(history)

ann = models.Sequential([
layers.Dense(2, activation='tanh'),
layers.Dense(1, activation='relu')])
ann.compile(optimizer=Adam(0.0001, 1.05, 0.7),
loss='binary_crossentropy',
metrics=['accuracy'])
history = ann.fit(X1, Y1, epochs=900, shuffle=True, verbose=0)
plot_decision_boundary(X2, Y2, ann)

ann.evaluate(X2, Y2)
plot_acc_loss(history)

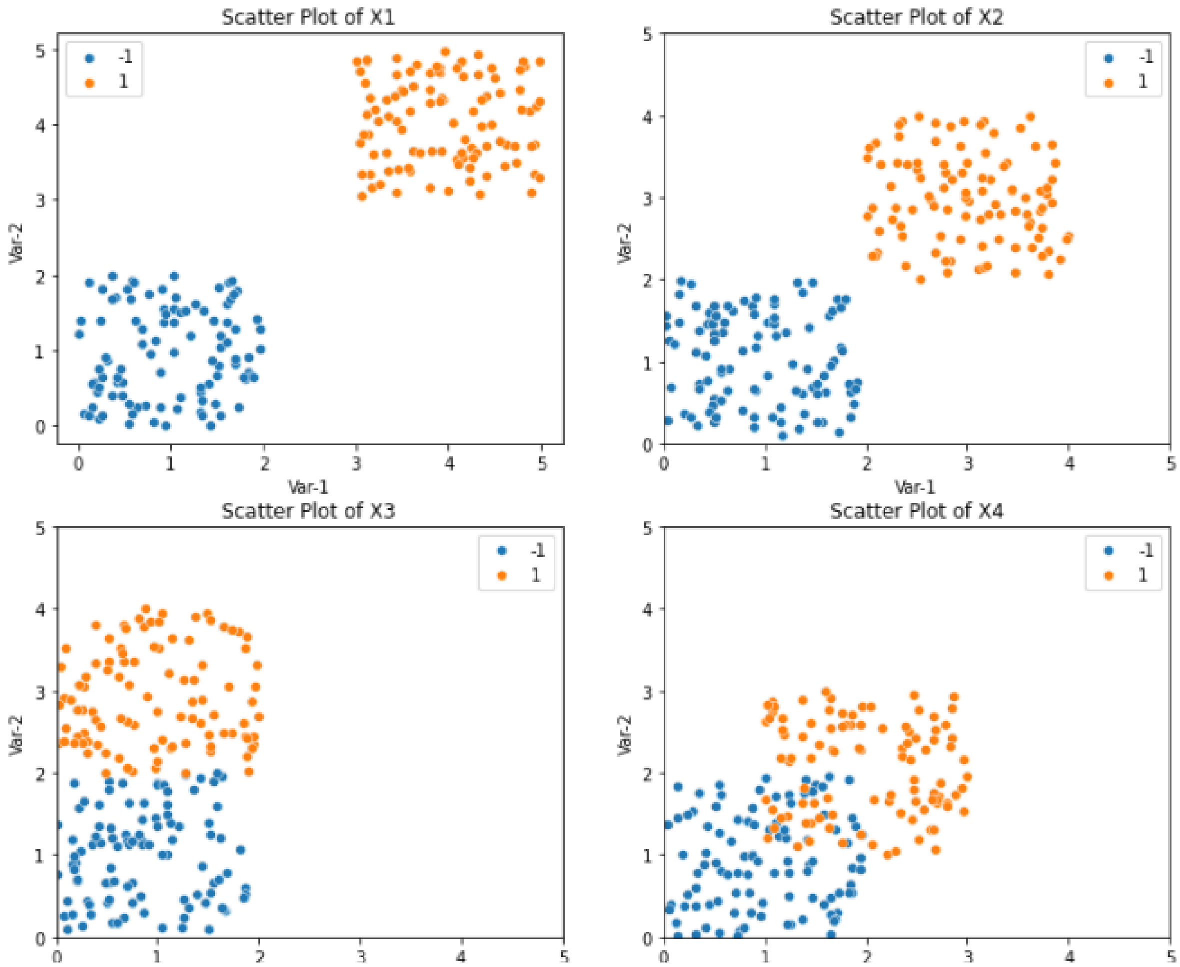
ann = models.Sequential([
```

```
layers.Dense(4, activation='tanh'),
layers.Dense(1, activation='relu')])
ann.compile(optimizer=Adam(0.0001, 1.05, 0.7),
loss='binary_crossentropy',
metrics=['accuracy'])
history = ann.fit(X1, Y1, epochs=900, shuffle=True, verbose=0)
plot_decision_boundary(X2, Y2, ann)

ann.evaluate(X2, Y2)
plot_acc_loss(history)
```

Output:

```
(0.0, 5.0)
```




```
Learning Rate -> 0.01
Final Weights:  [-1.88         1.04683176 -0.23842361]
Accuracy      :  100.0%

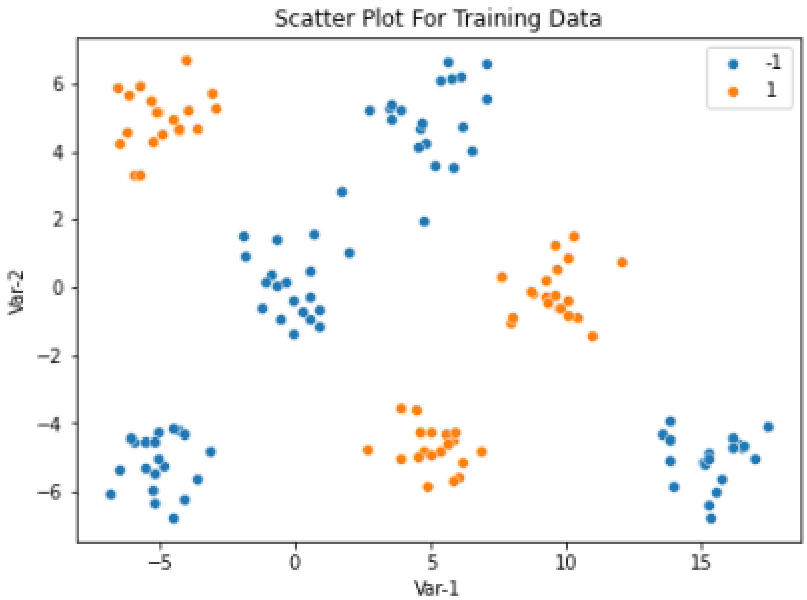
Learning Rate -> 0.05
Final Weights:  [-1.88         1.04683176 -0.23842361]
Accuracy      :  100.0%
```

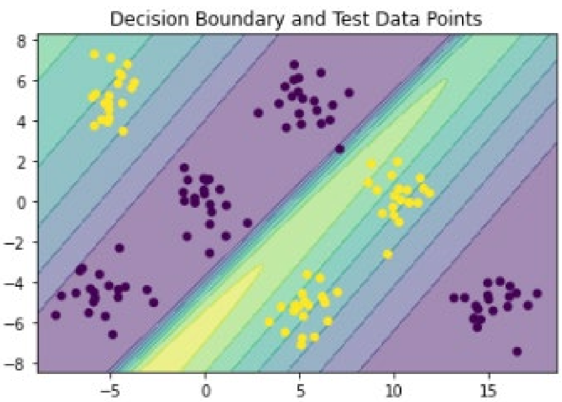
```
Learning Rate -> 0.01
Final Weights:  [-2.93        1.38323636  0.14824331]
Accuracy      :  100.0%

Learning Rate -> 0.05
Final Weights:  [-2.93        1.38323636  0.14824331]
Accuracy      :  100.0%
Learning Rate -> 0.01
Final Weights:  [-20.32        9.27715619   7.54016986]
Accuracy      :  85.0%

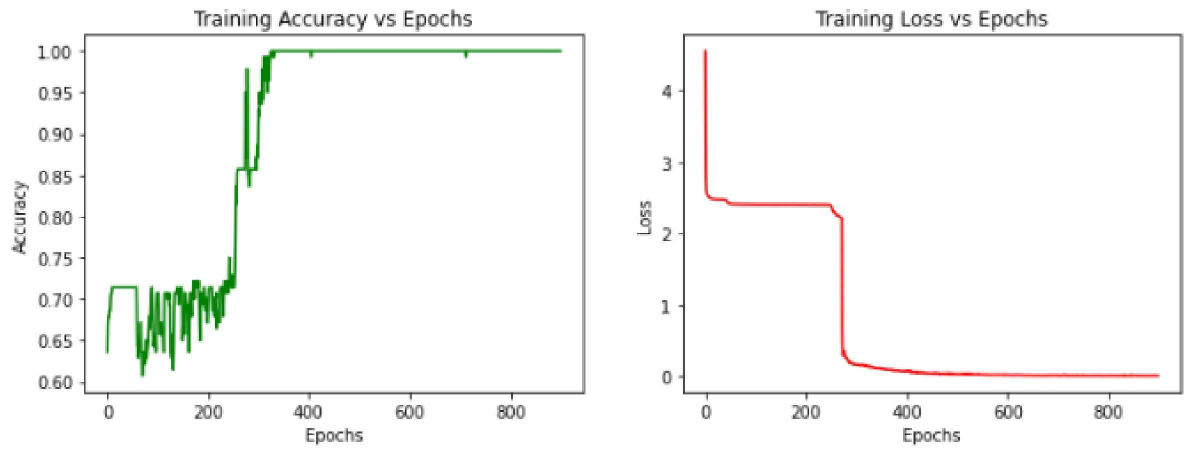
Learning Rate -> 0.05
Final Weights:  [-105.37        48.13024897   39.1560897 ]
Accuracy      :  84.5%
Final Weights:  [-16.8          6.49229892   6.08345077]
Accuracy      :  86.0%

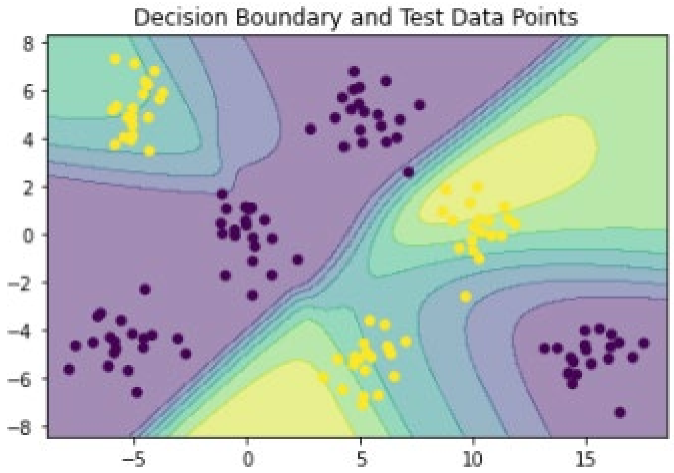
Learning Rate -> 0.05
Final Weights:  [-88.55        33.5145557   32.60395737]
Accuracy      :  86.5%
Final Weights:  [-91.45        41.79845313  33.94028943]
Accuracy      :  84.5%
Text(0, 0.5, 'Var-2')
```



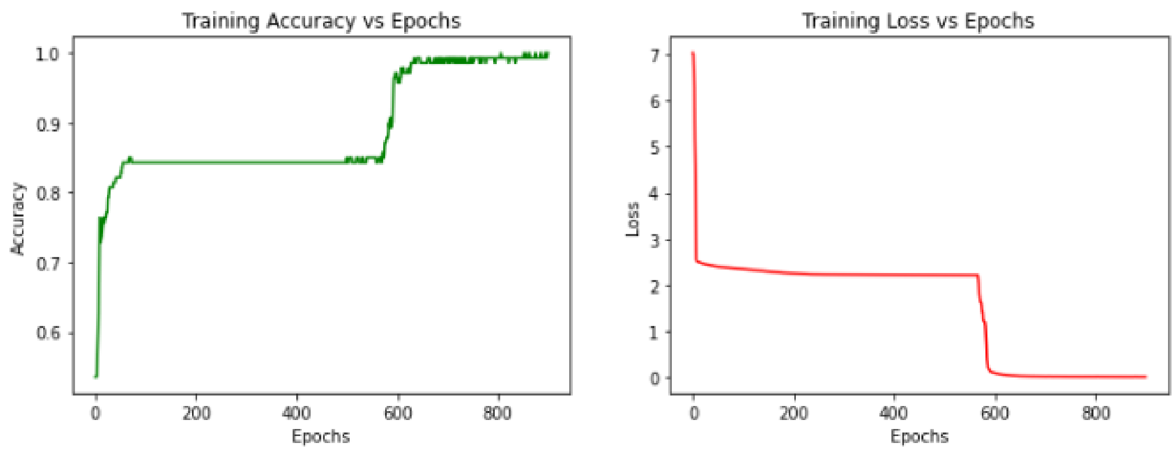


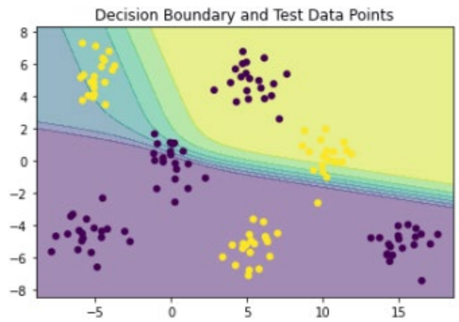
```
5/5 [==============================] - 0s 2ms/step - loss: 0.0206 - accuracy: 0.9929
```



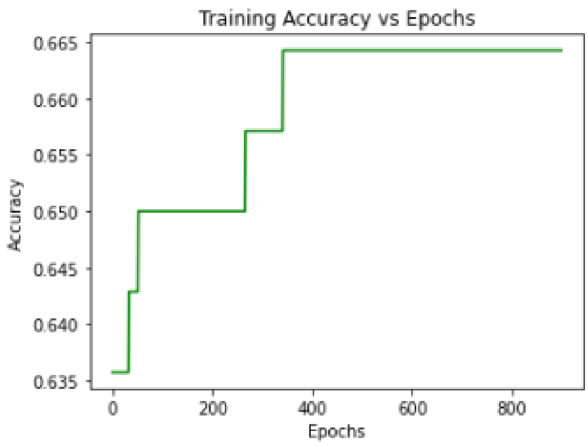


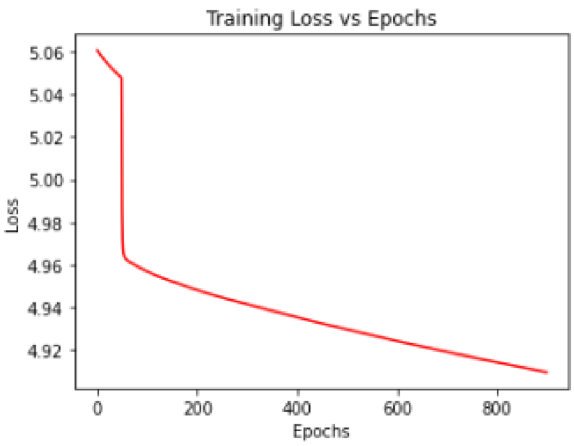

```
5/5 [==============================] - 0s 2ms/step - loss: 0.0150 - accuracy: 0.9929
```

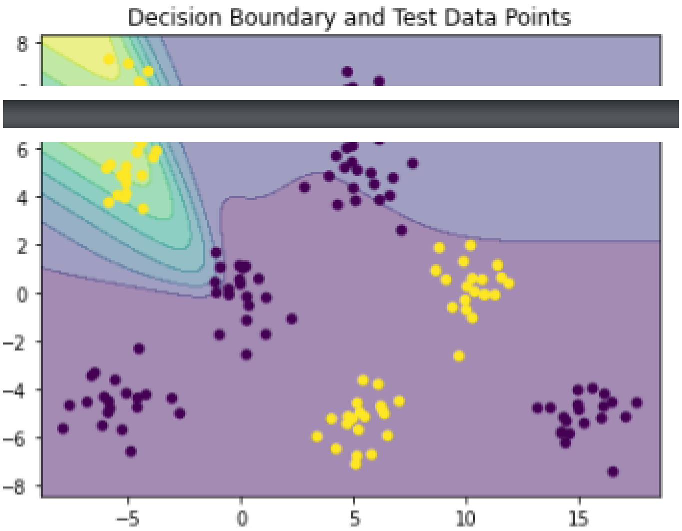




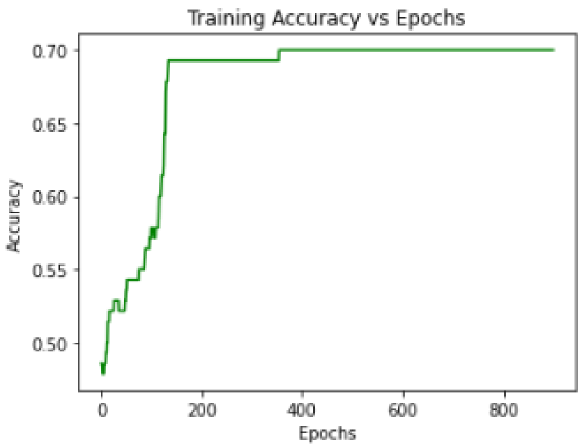
```
5/5 [==============================] - 0s 4ms/step - loss: 4.7271 - accuracy: 0.6571
```

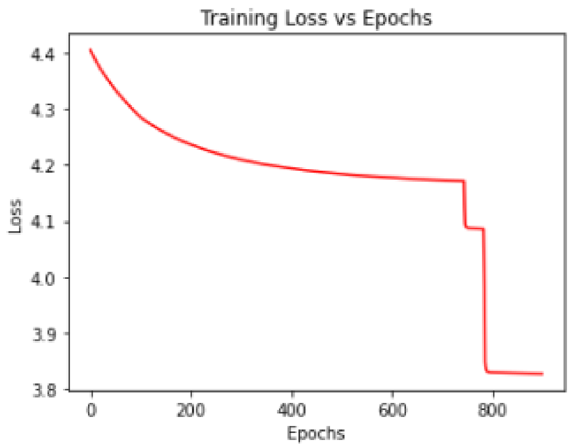




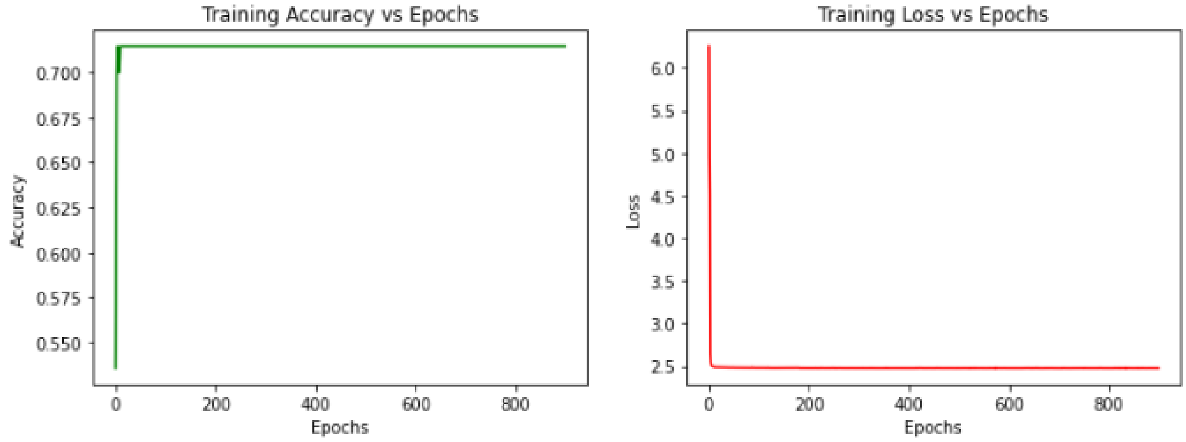


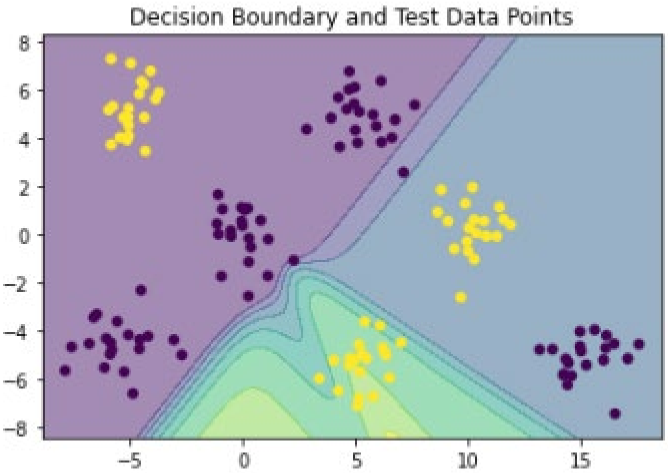

```
5/5 [==============================] - 0s 1ms/step - loss: 3.8171 - accuracy: 0.7143
```





```
5/5 [==============================] - 0s 0s/step - loss: 2.4831 - accuracy: 0.7071
```






```
5/5 [==============================] - 0s 3ms/step - loss: 2.4103 - accuracy: 0.7143
```