In [ ]:

In [1]:

```
import math
import numpy as np
import pandas as pd
# import seaborn as sns
# import matplotlib.pyplot as plt

# from sklearn.preprocessing import LabelEncoder
# from sklearn.preprocessing import OneHotEncoder
from sklearn.preprocessing import LabelBinarizer
from sklearn import preprocessing
from scipy.special import expit
from sklearn.model_selection import train_test_split
from numpy.random import default_rng

from sklearn.metrics import classification_report
from sklearn.metrics import confusion_matrix
from sklearn.metrics import accuracy_score

import time

from wine_accffaAnn import *



class MultiLayerPerceptron():
    # ================== Activation Functions ================ #

    # accepts a vector or list and returns a list after performing corresponding functio

    @staticmethod
    def sigmoid(vectorSig):
        """returns 1/(1+exp(-x)), where the output values lies between zero and one"""
        sig = expit(vectorSig)
        return sig

    @staticmethod
    def binaryStep(x):
        """ It returns '0' is the input is less then zero otherwise it returns one """
        return np.heaviside(x, 1)

    @staticmethod
    def linear(x):
        """ y = f(x) It returns the input as it is"""
        return x

    @staticmethod
    def tanh(x):
        """ It returns the value (1-exp(-2x))/(1+exp(-2x)) and the value returned will b
        return np.tanh(x)

    @staticmethod
    def relu(x):  # Rectified Linear Unit
        """ It returns zero if the input is less than zero otherwise it returns the give
        x1 = []
        for i in x:
            if i < 0:
                x1.append(0)
            else:
                x1.append(i)

        return x1
```

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    @staticmethod
    def leakyRelu(x):
        """ It returns zero if the input is less than zero otherwise it returns the give
        x1 = []
        for i in x:
            if i < 0:
                x1.append((0.01 * i))
            else:
                x1.append(i)

        return x1

    @staticmethod
    def parametricRelu(self, a, x):
        """ It returns zero if the input is less than zero otherwise it returns the give
        x1 = []
        for i in x:
            if i < 0:
                x1.append((a * i))
            else:
                x1.append(i)

        return x1

    @staticmethod
    def softmax(self, x):
        """ Compute softmax values for each sets of scores in x"""
        return np.exp(x) / np.sum(np.exp(x), axis=0)

    # ============ Activation Functions Part Ends ============= #

    # ================= Distance Calculation ================== #

    @staticmethod
    def chebishev(self, cord1, cord2, exponent_h):
        dist = 0.0
        if ((type(cord1) == int and type(cord2) == int) or ((type(cord1) == float and ty
            dist = math.pow((cord1 - cord2), exponent_h)
        else:
            for i, j in zip(cord1, cord2):
                dist += math.pow((i - j), exponent_h)
        dist = math.pow(dist, (1.0 / exponent_h))
        return dist

    @staticmethod
    def minimum_distance(self, cord1, cord2):
        # min(|x1-y1|, |x2-y2|, |x3-y3|, ...)
        dist = float('inf')
        if ((type(cord1) == int and type(cord2) == int) or ((type(cord1) == float and ty
            dist = math.fabs(cord1 - cord2)
        else:
            for i, j in zip(cord1, cord2):
                temp_dist = math.fabs(i - j)
                if (temp_dist < dist):
                    dist = temp_dist
        return dist

    @staticmethod
    def maximum_distance(self, cord1, cord2):
        # max(|x1-y1|, |x2-y2|, |x3-y3|, ...)
        dist = float('-inf')
        if ((type(cord1) == int and type(cord2) == int) or ((type(cord1) == float and ty
            dist = math.fabs(cord1 - cord2)
        else:
            for i, j in zip(cord1, cord2):
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                temp_dist = math.fabs(i - j)
                if (temp_dist > dist):
                    dist = temp_dist
        return dist

    @staticmethod
    def manhattan(self, cord1, cord2):
        # |x1-y1| + |x2-y2| + |x3-y3| + ...
        dist = 0.0
        if ((type(cord1) == int and type(cord2) == int) or ((type(cord1) == float and ty
            dist = math.fabs(cord1 - cord2)
        else:
            for i, j in zip(cord1, cord2):
                dist += math.fabs(i - j)
        return dist

    @staticmethod
    def eucledian(self, cord1, cord2):
        dist = 0.0
        if ((type(cord1) == int and type(cord2) == int) or ((type(cord1) == float and ty
            dist = math.pow((cord1 - cord2), 2)
        else:
            for i, j in zip(cord1, cord2):
                dist += math.pow((i - j), 2)
        return math.pow(dist, 0.5)

    # =========== Distance Calculation Ends ============== #

    def __init__(self, dimensions=(8, 5), all_weights=(0.1, 0.2), fileName="iris", test

        """
        Args:
            dimensions : dimension of the neural network
            all_weights : the optimal weights we get from the bio-algoANN models
        """

        self.allPop_Weights = []
        self.allPopl_Chromosomes = []
        self.allPop_ReceivedOut = []
        self.allPop_ErrorVal = []

        self.all_weights = all_weights

        self.fitness = []

        # ================== Input dataset and corresponding output ====================

        self.fileName = fileName
        self.fileName += ".csv"
        data = pd.read_csv(self.fileName, sep=';')
        data = data.infer_objects()

        output_values_expected = []
        input_values = []

        # ~~~~ encoding ~~~~#

        # labelencoder = LabelEncoder()
        # data[data.columns[-1]] = labelencoder.fit_transform(data[data.columns[-1]])

        # one hot encoding - for multi-column
        # enc = OneHotEncoder(handle_unknown='ignore')
        # combinedData = np.vstack((data[data.columns[-2]], data[data.columns[-1]])).T
        # print(combinedData)
        # y = enc.fit_transform(combinedData).toarray()
        # y = OneHotEncoder().fit_transform(combinedData).toarray()
```

```python
        #
        y = LabelBinarizer().fit_transform(data[data.columns[-1]])
        # print(y)

        # ~~~~ encoding ends~~~~#

        for j in range(len(data)):
            output_values_expected.append(y[j])

        # print(output_values_expected)

        input_values = []
        for j in range(len(data)):
            b = []
            for i in range(len(data.columns) - 1):
                b.append(data[data.columns[i]][j])
            input_values.append(b)

        self.X = input_values[:]
        self.Y = output_values_expected[:]

        # input and output
        self.X = input_values[:]
        self.Y = output_values_expected[:]

        self.test = test
        X_train, X_test, Y_train, Y_test = train_test_split(X, y, test_size=0.33)
        if(self.test == True):
            self.X = X_test
            self.Y = Y_test
        else:
            self.X = X_train
            self.Y = Y_train

        self.dimension = dimensions
        # print(self.dimension)

        # ================ Finding Initial Weights ================ #

        self.pop = []  # weights
        reshaped_all_weights = []
        start = 0
        for i in range(len(self.dimension) - 1):
            end = start + self.dimension[i + 1] * self.dimension[i]
            temp_arr = self.all_weights[start:end]
            w = np.reshape(temp_arr[:], (self.dimension[i + 1], self.dimension[i]))
            reshaped_all_weights.append(w)
            start = end
        self.pop.append(reshaped_all_weights)

        self.init_pop = self.all_weights

    # ================ Initial Weights Part Ends ================ #


    def Predict(self, chromo):
        # X, Y and pop are used
        self.fitness = []
        total_error = 0
        m_arr = []
        k1 = 0
        for i in range(len(self.dimension) - 1):
            p = self.dimension[i]
            q = self.dimension[i + 1]
            k2 = k1 + p * q
```

```
            m_temp = chromo[k1:k2]
            m_arr.append(np.reshape(m_temp, (p, q)))
            k1 = k2

        y_predicted = []
        for x, y in zip(self.X, self.Y):

            yo = x

            for mCount in range(len(m_arr)):
                yo = np.dot(yo, m_arr[mCount])
                yo = self.sigmoid(yo)

            # converting to sklearn acceptable form
            max_yo = max(yo)
            for y_vals in range(len(yo)):
                if(yo[y_vals] == max_yo):
                    yo[y_vals] = 1
                else:
                    yo[y_vals] = 0
            y_predicted.append(yo)
        return (y_predicted, self.Y)

    def main(self):
        Y_PREDICT, Y_ACTUAL = self.Predict(self.init_pop)
        Y_PREDICT = np.array(Y_PREDICT)
        Y_ACTUAL = np.array(Y_ACTUAL)

        n_classes = 7

        label_binarizer = LabelBinarizer()
        label_binarizer.fit(range(n_classes))
        Y_PREDICT = label_binarizer.inverse_transform(np.array(Y_PREDICT))
        Y_ACTUAL = label_binarizer.inverse_transform(np.array(Y_ACTUAL))

        # find error
        if(self.test == True):
            print("\n Actual / Expected", Y_ACTUAL)
            print("\n Predictions", Y_PREDICT)
            print("\n\nConfusion Matrix")
            print(confusion_matrix(Y_ACTUAL, Y_PREDICT))

            print("\n\nClassification Report")
            target_names = []
            for i in range(7):
                k='class '+str(i)
                target_names.append(k)
            print(classification_report(Y_ACTUAL, Y_PREDICT, target_names=target_names))
            print("\n\n\n")
        return accuracy_score(Y_ACTUAL, Y_PREDICT)
```

In [2]:

```
start_time = time.time()
i = InputData(fileName="../ANN/winequality-white")
input_val, output_val = i.main()
end_time = time.time()
print("Time for inputting data : ", end_time - start_time)

print("============ Calling FFA to get best weights ===============")

start_time = time.time()
a = ffaAnn(initialPopSize=100, m=10, dimensions = [100,10], input_values=input_val, outp

fit, b, weights, dim, all_gen_best_weight = a.main()

end_time = time.time()
```

```
print("Time taken : ", end_time - start_time)

print("\n Fitness : ", fit, "\n Best Weights : ", weights, "\n Dimensions : ", dim)



import matplotlib.pyplot as plt
x=b[:]
z=[i for i in range(0,10)]
plt.plot(z,x)

plt.title("Firefly Algorithm")
plt.ylabel("Fitness")
plt.xlabel("Iterations")
end_time = time.time()
print("Time Taken : ", end_time - start_time)
```

```
Time for inputting data :  0.2642948627471924
============ Calling FFA to get best weights ================
--------------GENERATION 0-----------
Initial worst fitness =  173025.89881924863

 Initial best fitness =  34972.049987817154
--------------GENERATION 1-----------
--------------GENERATION 2-----------
--------------GENERATION 3-----------
--------------GENERATION 4-----------
--------------GENERATION 5-----------
--------------GENERATION 6-----------
--------------GENERATION 7-----------
--------------GENERATION 8-----------
--------------GENERATION 9-----------
Fitness :  34972.049987817154
Time taken :  797.5820610523224

 Fitness :  34972.049987817154
 Best Weights :  [-24, -12, -40, -50, 39, -12, 67, 36, 32, 64, 52, -11, -55, -70, 0, 80,
-27, -9, 76, -51, -82, 22, 84, -83, -21, -55, -57, -46, 36, 84, -61, 63, 33, -71, -73, -
78, 44, 60, -40, -13, 41, -13, 22, 33, 48, -73, -79, -39, 6, -35, 76, 74, -74, -6, 3, -4
9, 10, 12, -64, 56, 58, 2, -5, -17, -33, 24, -75, -22, 37, 58, -12, 61, 64, -82, 81, 21,
69, -84, 5, 19, -41, 29, 54, -88, -25, 8, 60, 32, 89, 86, 46, 48, -66, 46, -50, 16, 22,
89, 14, -90, -22, 46, 47, -35, 77, -90, -23, -89, -79, 35, 75, -77, 44, 73, -14, -10, 6
2, 38, 43, 79, -86, -84, 72, -14, 54, 52, 79, 16, -88, 68, 68, 0, 1, -58, -13, 29, 31, 6
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1, 88, -59, 51, -14, 30, -63, 62, -7, 45, 45, -80, 60, 86, -11, -3, -71, -84, -42, -54,
14, 51, -3, 40, 6, 10, 28, -45, 75, -61, 18, -44, -47, -82, -80, 83, -8, 13, 1, -83, 9,
-84, -37, 15, 17, -20, 7, 88, -85, -83, -6, 0, 0, 49, -44, -65, 35, 41, 80, -62, 28, 10,
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-70, 3, -76, 23, -43, 25, -33, 76, 8, -37, -31, 52, -50, -16, -65, 12, -15, -82, 17, 56,
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```

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-71, 70, 6, 21, -53, 80, 12, 65, -90, 3, -61, 85, -31, 7, 55, -76, -69, 89, 37, 8, 33, 1
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6, -83, -45, 21, 52, 75, 71, 61, -14, 76, 87, -22, 87, 33, -17, -49, 47, -77, 82, 57, -1
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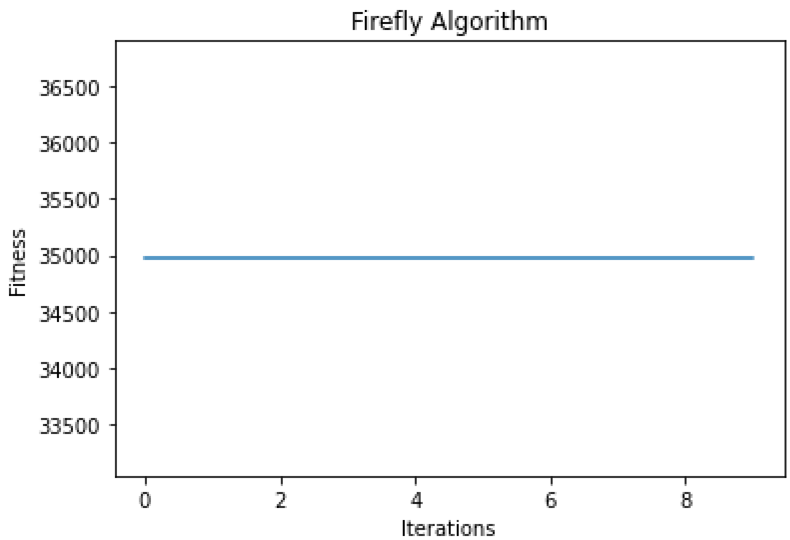
7, -38, 74, 51, 83, 70, 67, 39, -66, 6, -81, -49, -54, -25, 31, -12, 86, 61, 80, -61, -5
9, -90, 48, 37, 56, -26, 53, 41, -40, 18, 51, 20, -81, -40, 53, -49, 66, 83, -65, -70, 3
5, 85, -41, 38, -15, 29, 59, 60, 25, 86, 55, -15, 45, 80, -9, -56, -51, -2, 23, 55, 52,
25, -90, 35, 81, 22, -20, 68, -21, 59, -30, 9, 56, -74, -63, -48, 31, 34, 54, -11, 35, 1
8, 40, -17, 67, 16, 15, -10, 79, -28, -4, -15, 2, 22, -72, -89, -60, 60, -66, -27, 75, -
2, -52, -50, 52, 35, 53, 13, 52, -31, 70, -5, 55, 43, -26, -75, -50, -87, 23, -69, 39, -
34, -50, 37, -62, 68, 0, -24, 79, -19, 13, 86, -9, 33, 69, -86, -33, 12, -52, -76, -4, -

```
87, 40, -6, -48, 85, 50, -73, 42, -33, 65, 43, -51, 9, 51, 20, -12, -84, -31, 18, 33, -4
7, -59, 88, 70, 20, 39, 81, -16, 20, -78, -39, 29, 27, -85, 39, 87, 81, -20, 73, -53, 3
7, 83, 38, -11, 58, 30, -74, 19, -26, 85, -70, 51, -35, -1, 78, -7, 75, 80, -70, -50, -5
3, -48, -71, 22, 15, 26, 63, 72, 66, 21, 23, -38, -64, -72, -69, 54, -60, 16, -76, 35, 8
6, 86, -19, 36, 24, 63, 45, -72, -13, 86, -78, 82, 8, -56, -71, 28, -26, -61, -72, 67, -
69, 74, 28, 5, -41, -80, 1, 77, 38, 2, 3, -70, -89, 83, -78, 47, 76, 82, 42, -90, -3, 3
5, 68, -33, 46, 12, 22, -47, -1, -33, -69, 75, 11, 22, -35, -49, 65, -70, 4, 1, 17, -76,
15, -83, -22, -32, 65, 12, -36, -17, 71, -80, -49, -46, -46, -23, -31, -72, -56, 81, 28,
13, 43, 2, -13, -50, -75, -46, -12, -48, -42, -86, 10, -30, -26, -5, 68, -12, 5, 42, -6
6, 52, 7, 5, -66, 16, -17, 39, -23, -32, -60, -54, -52, -57, -38, 57, 3, -66, -68, -69,
46, -57, 15, 51, -38, -42, 6, 23, -26, 88, -68, 36, 49, 10, -89, -11, -90, -75, 77, -2,
-71, 58, -74, -81, -37, -27, 73, 89, 87, -4, -76, -23, -26, -56, 65, -2, 71, -82, 61, -
4]
 Dimensions :  [11, 100, 10, 7]
Time Taken :  797.6638431549072
```



In [3]:
```python
print("\n\n============= MLP Program Begins ============")

start_time = time.time()
print("Training")
m = MultiLayerPerceptron(fileName="../ANN/winequality-white", dimensions=dim, all_weight
m.main()
end_time = time.time()
print("Time taken = ", end_time - start_time)
```

```
============= MLP Program Begins ============
Training
Time taken =  0.49268388748168945
```

In [4]:
```python
start_time = time.time()
print("Testing")
m = MultiLayerPerceptron(fileName="../ANN/winequality-white", dimensions=dim, all_weight
m.main()

end_time = time.time()
print("Time taken = ", end_time - start_time)
```

```
Testing
Time taken =  0.5116314888000488
```

In [5]:
```python
all_accuracy = []
for weights in all_gen_best_weight:
    m = MultiLayerPerceptron(fileName="../ANN/winequality-white", dimensions=dim, all_we
    accuracy_val = m.main()
    print(accuracy_val)
    all_accuracy.append(accuracy_val)
```

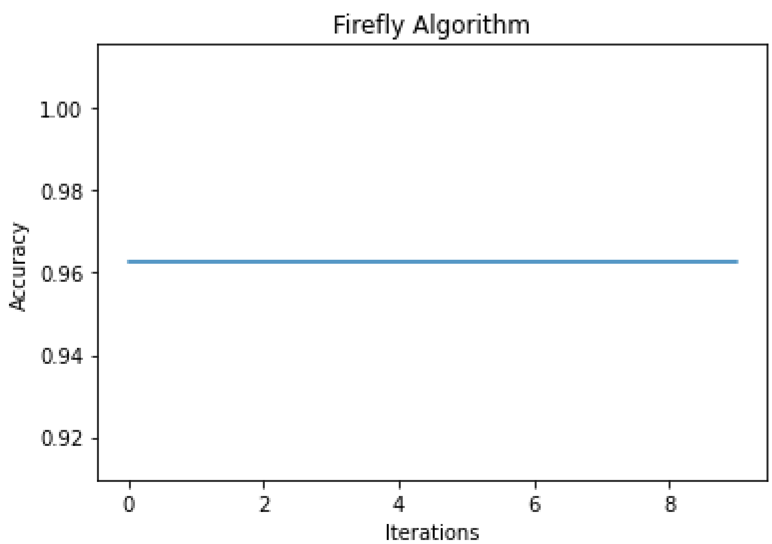
```
import matplotlib.pyplot as plt
x=all_accuracy[:]
z=[i for i in range(len(x))]
plt.plot(z,x)

plt.title("Firefly Algorithm")
plt.ylabel("Accuracy")
plt.xlabel("Iterations")
```

```
0.9626378113515721
0.9626378113515721
0.9626378113515721
0.9626378113515721
0.9626378113515721
0.9626378113515721
0.9626378113515721
0.9626378113515721
0.9626378113515721
0.9626378113515721
```

Out[5]:

```
Text(0.5, 0, 'Iterations')
```



In [ ]:

In [ ]:

In [ ]:

In [6]:

```
start_time = time.time()
i = InputData(fileName="../ANN/winequality-white")
input_val, output_val = i.main()
end_time = time.time()
print("Time for inputting data : ", end_time - start_time)

print("============ Calling FFA to get best weights ===============")

start_time = time.time()
a = ffaAnn(initialPopSize=100, m=10, dimensions = [100,10], input_values=input_val, outp

fit, b, weights, dim, all_gen_best_weight = a.main()

end_time = time.time()
print("Time taken : ", end_time - start_time)

print("\n Fitness : ", fit, "\n Best Weights : ", weights, "\n Dimensions : ", dim)
```

```
import matplotlib.pyplot as plt
x=b[:]
z=[i for i in range(0,100)]
plt.plot(z,x)

plt.title("Firefly Algorithm")
plt.ylabel("Fitness")
plt.xlabel("Iterations")
end_time = time.time()
print("Time Taken : ", end_time - start_time)
```

```
Time for inputting data :  0.35205578804016113
============ Calling FFA to get best weights ===============
--------------GENERATION 0-----------
Initial worst fitness =  200644.6410310447

 Initial best fitness =  34307.82335153011
--------------GENERATION 1-----------
--------------GENERATION 2-----------
--------------GENERATION 3-----------
--------------GENERATION 4-----------
--------------GENERATION 5-----------
--------------GENERATION 6-----------
--------------GENERATION 7-----------
--------------GENERATION 8-----------
--------------GENERATION 9-----------
--------------GENERATION 10-----------
--------------GENERATION 11-----------
--------------GENERATION 12-----------
--------------GENERATION 13-----------
--------------GENERATION 14-----------
--------------GENERATION 15-----------
--------------GENERATION 16-----------
--------------GENERATION 17-----------
--------------GENERATION 18-----------
--------------GENERATION 19-----------
--------------GENERATION 20-----------
--------------GENERATION 21-----------
--------------GENERATION 22-----------
--------------GENERATION 23-----------
--------------GENERATION 24-----------
--------------GENERATION 25-----------
--------------GENERATION 26-----------
--------------GENERATION 27-----------
--------------GENERATION 28-----------
--------------GENERATION 29-----------
--------------GENERATION 30-----------
--------------GENERATION 31-----------
--------------GENERATION 32-----------
--------------GENERATION 33-----------
--------------GENERATION 34-----------
--------------GENERATION 35-----------
--------------GENERATION 36-----------
--------------GENERATION 37-----------
--------------GENERATION 38-----------
--------------GENERATION 39-----------
--------------GENERATION 40-----------
--------------GENERATION 41-----------
--------------GENERATION 42-----------
--------------GENERATION 43-----------
--------------GENERATION 44-----------
--------------GENERATION 45-----------
--------------GENERATION 46-----------
--------------GENERATION 47-----------
--------------GENERATION 48-----------
```

```
---------------GENERATION 49-----------
---------------GENERATION 50-----------
---------------GENERATION 51-----------
---------------GENERATION 52-----------
---------------GENERATION 53-----------
---------------GENERATION 54-----------
---------------GENERATION 55-----------
---------------GENERATION 56-----------
---------------GENERATION 57-----------
---------------GENERATION 58-----------
---------------GENERATION 59-----------
---------------GENERATION 60-----------
---------------GENERATION 61-----------
---------------GENERATION 62-----------
---------------GENERATION 63-----------
---------------GENERATION 64-----------
---------------GENERATION 65-----------
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---------------GENERATION 83-----------
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---------------GENERATION 85-----------
---------------GENERATION 86-----------
---------------GENERATION 87-----------
---------------GENERATION 88-----------
---------------GENERATION 89-----------
---------------GENERATION 90-----------
---------------GENERATION 91-----------
---------------GENERATION 92-----------
---------------GENERATION 93-----------
---------------GENERATION 94-----------
---------------GENERATION 95-----------
---------------GENERATION 96-----------
---------------GENERATION 97-----------
---------------GENERATION 98-----------
---------------GENERATION 99-----------
Fitness :  23512.49667324166
Time taken :  8389.365004777908

 Fitness :  23512.49667324166
 Best Weights :  [0, 0, 0, 0, 8, -12, -1, 0, 0, -2, -1, -2, 0, 8, -15, -6, 0, 0, 1, -2,
0, 0, 0, -7, 0, 0, 4, 0, 0, 0, -2, -3, -1, -14, -2, 5, 0, 1, 8, -1, 0, 5, -4, 0, -2, -1,
0, -2, 0, 0, -5, 0, 0, -1, 2, 0, -2, 0, 0, 1, 2, 0, 0, 0, 7, 0, 0, 0, -2, 11, 0, 6, 0,
0, 0, 0, -1, -1, 0, 3, -1, -2, 4, 4, 0, 0, 0, -5, 0, -6, -3, 5, 0, 0, 6, 0, 0, -7, -4,
0, 0, -1, 7, 0, 0, 0, 0, 0, -1, -4, -1, 2, -1, 0, -4, 0, 0, -2, 0, 2, 0, 0, -2, 0, 0, 0,
0, 0, 6, -8, 0, -1, 0, 1, 0, 0, 0, 0, 3, -2, 0, -8, 0, -3, 0, -3, 0, 0, 0, 8, 0, 0, 0,
0, -2, 0, 0, 0, -11, 0, -1, -8, -4, 4, 0, -7, -10, 0, 0, 0, -1, 0, -3, 0, 0, 0, 0, 0, -
1, -3, -16, 3, 0, 4, -3, 0, 6, 0, 0, -8, 0, -2, -1, 0, 0, -6, -1, 0, -3, 0, -1, 0, 0, 0,
0, 0, -2, 0, 0, 0, 0, -2, -2, 0, 0, 0, 0, 0, 0, 0, 7, 1, 0, 7, -4, -1, 0, -6, 0, -5, 0,
-2, -8, -5, 15, -9, 0, 2, 11, -6, 0, 0, 0, 0, 5, 10, 0, -2, -2, 0, 0, -2, 0, -3, 0, 0,
0, 0, 0, 0, 0, 0, -4, 1, -1, 8, 7, 0, -2, 0, -1, 0, 0, 0, 0, 0, 0, -7, 0, -3, 0, 0, 0,
```

4, -1, -2, 0, 0, -1, 0, 1, 0, 0, 4, 0, 0, -4, 0, -1, -5, -1, -1, 0, 7, 4, -1, -1, -12,
0, -3, 0, 0, -7, 0, 0, 0, -2, 0, 0, 0, 0, 2, 0, -4, 0, 4, -2, 0, 0, -1, 0, 0, 13, 0,
0, 0, -2, 6, 0, -4, -1, 0, 9, -4, 0, -2, 0, 0, 6, 0, -12, -11, -10, -11, 0, 0, 0, 0, 0,
0, 0, -1, -1, -1, -7, -6, -3, 5, -1, 0, 0, 0, 0, -14, -11, 0, 0, 0, 3, -1, 8, -10, 0, 0,
0, 0, -1, 0, 0, -2, -15, 0, 2, -1, -1, 0, -1, 9, 0, 0, -3, 0, 0, 0, -5, 0, 0, 0, 0, -5,
0, 0, 0, 0, 0, 1, -5, 0, 0, -2, 0, -2, 0, -3, 0, 0, 0, 0, -7, -1, -2, 0, -5, -2, -4, 0,
0, 3, -6, 0, -8, 0, -4, -2, -2, -3, 12, 2, 0, 0, -5, -8, 0, 0, 0, 0, -1, 0, 0, 3, 0, 0,
0, 7, 0, 11, -14, 0, 0, 0, 0, 0, 0, 3, -2, 0, -1, 0, 6, -1, 3, 0, 4, 0, -8, 0, -8, -1,
0, 0, 0, -4, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, -6, -1, 0, 1, 0, -2, 9, -11, -5, -2, -
8, 3, -7, 0, 0, 0, 0, -1, 0, 13, 0, -1, -5, -4, -8, 0, 0, -2, 0, 0, 0, 0, 0, 0, 0, 0, -
2, -1, 0, 0, 0, 0, 3, 0, 0, 0, 0, -1, 0, 4, 0, -10, -2, 0, 0, 0, -2, -2, 0, 0, -1, 4, -2
0, -5, 0, 1, 0, 0, 7, 0, 0, 0, -1, 1, -1, -2, 0, 0, -5, 0, -2, -1, 0, 0, -2, -3, 6, -1,
0, 2, 3, 0, 0, -12, -1, -2, 0, -9, 0, 1, -6, -2, 0, 0, 0, 6, 0, 0, -6, 0, 0, 0, 0, -7,
0, 0, 0, 0, 0, -1, 0, -2, 0, 8, -3, -1, 0, -7, 0, 0, 0, -2, 0, 2, -2, 1, 0, -2, 7, 0, -
8, 0, 11, -1, -1, -1, 0, 0, 0, 0, 0, -5, -8, -2, 4, 0, -3, 9, 0, -2, 0, 0, 0, 0, 0, 0, -
3, -7, 0, 5, 0, 2, 0, 0, 0, 0, 0, 0, -1, -17, 0, 0, -1, -7, -2, 0, 2, 0, 9, 0, 0, -1, -
1, -2, 0, 6, 0, -19, 0, 12, -14, -2, -8, -1, -7, 4, 0, 0, 0, 0, 2, 0, 8, -1, 0, 0, 0, -
3, 0, -2, 0, 0, 0, 7, 3, 0, 6, -7, 0, -2, 0, -3, -10, 4, -2, 0, 2, -1, 0, -2, 6, 0, 0, -
6, -2, 2, -1, -3, 0, -6, 0, 0, 0, 0, 0, -11, 0, 1, 0, -1, 0, -5, 0, 0, -8, 0, 0, 0, -1,
-1, 0, -1, 0, -2, -1, 0, -4, 3, -1, 0, 0, 0, 0, 0, 0, 0, -1, -4, 2, 0, -5, 8, 6, 0, 0,
0, 0, 0, -1, -1, 4, -5, 1, 0, 0, 8, 5, -1, -9, -1, -1, 0, 0, 0, -1, 0, 4, 3, 10, 3, 6,
0, 8, -1, 0, -8, -12, 0, 13, 0, -6, -2, -1, 0, 0, 0, -1, 1, 0, 0, -2, -7, 1, 0, 0, -1, -
4, 0, -1, 0, 0, -1, 10, 0, 0, 0, 0, 0, 0, 3, 0, 0, 1, 0, 0, -1, 0, -9, 0, 0, -3, 0, 0, -
12, 0, 0, 0, 4, 4, 0, -1, 0, 0, 0, -1, 0, 0, 0, 0, 0, 4, -1, -1, 0, 0, 0, 0, 0, 11, -1,
4, -4, 0, 0, 0, 0, 1, 5, 0, 0, 0, -6, 0, 0, 0, 0, 0, 0, 0, 0, -1, -7, -2, 0, 0, 0, -16,
-5, -2, -2, -1, 11, 0, 0, -1, -1, -7, 0, 4, -1, -3, -1, -5, 0, 7, 0, 0, -2, 6, -2, 4, 0,
0, 1, -2, -3, 0, -7, -1, 0, 0, 0, 0, 0, -13, 5, 0, 12, 1, 0, 9, 0, -18, 0, -3, -4, 0, -
4, 0, 0, 4, 0, -1, 0, 0, -1, -2, -2, 0, 0, 0, 0, 3, -2, -10, 0, -8, -3, 0, 0, -7, 3, 5,
0, 1, -2, -2, 0, 0, -1, 1, -1, -3, 0, 0, 2, -4, -10, -4, -8, 0, 0, -1, -6, 0, 0, 0, 0,
7, -9, 0, 0, 0, 0, 5, 0, 0, 0, 0, 4, 0, 0, 0, 0, 0, 6, 1, 0, -3, 0, 0, 0, 0, -8, 0, -4,
0, -12, 0, 11, 0, 0, -1, 1, 0, -2, -15, -1, -2, -1, 0, 0, 0, 0, 0, -5, 0, 0, 0, 0, 0, -1
0, 6, -6, 0, 8, 0, -7, 0, -1, 0, 0, -6, 0, 0, 0, -3, -2, 0, 0, -2, 0, 0, 3, -7, -2, 0,
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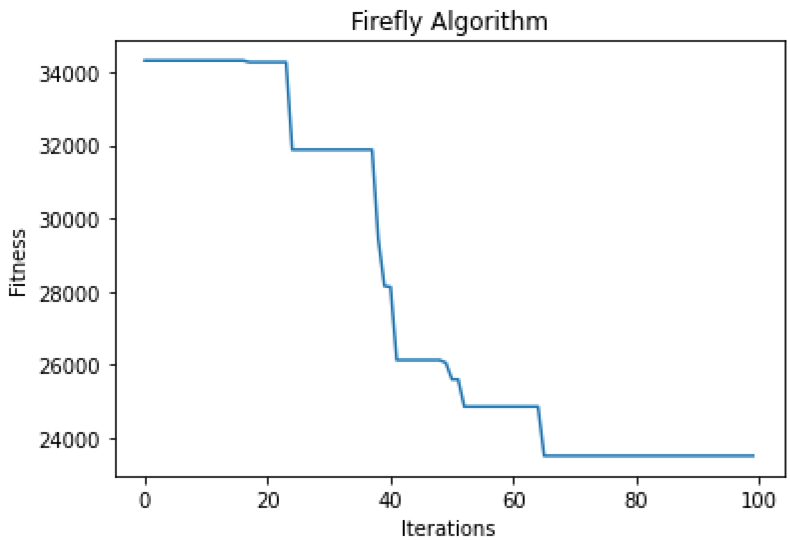
0, 0, 0, -4, 0, 0, 0, -1, 0, 0, 0, 0, 0, 11, 0, 0, 0, 0, -8, 0, 0, 9, -1, 0, 0, -2, 6,
0, 1, 0, -7, -9, 0, 0, 0, 0, 0, -2, 0, 0, 0, 4, -1, 0, 0, 0, 0, 4, 7, 0, 12, -1, 0, 0,
0, -6, -1, -1, -2, -3, -7, 0, 0, 1, 2, -2, -5, -7, 0, 0, 0, -2, -3, 0, -1, -2, 0, -2, 0,
0, -10, 0, -12, 0, -2, 0, -1, 0, 1, 0, 0, -2, 0, -1, 0, 0, 17, 4, -3, 0, 0, 4, -9, -2,
0, -3, 0, -8, 0, 0, 0, 0, -3, -5, 0, 0, 0, 0, -1, 0, 0, 0, 0, -1, 0, 2, -1, 0, -2, 9, -
5, 0, -1, -1, 0, 0, 0, -5, 0, 0, -6, -3, 0, 0, -3, 0, 0, -6, -1, 0, 0, 0, -1, -1, 0, 0,
0, 2, 0, 0, 7, -1, 9, 4, 0, 4, 0, -5, 13, 0, 0, 0, 0, 0, -2, 0, -2, 0, -2, 0, 3, 0, 0,
1, -7, -5, 4, 0, -5, 0, 0, 0, 0, 0, 0, -5, -1, 0, 0, 0, 0, -1, 8, -5, 0, -5, 1, 0, 0, 0,
11, 0, -4, 0, -2, 0, 0, 0, 0, -4, 1, -1, 0, 1, 0, 0, -6, 0, -10, 0, 0, -3, -5, 1, -8, 4,
-2, -2, 0, 0, 0, -1, -1, 0, -6, -4, 0, 0, 0, 0, 0, 0, -1, 4, 0, 1, 0, 0, 0, 0, 7, -9, 1,
0, 0, 0, -4, -6, 0, 0, -1, 0, 1, 0, 0, 1, 0, 13, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
-2, 0, 0, 0, 6, -1, 7, 0, 0, 0, 0, -9, -7, 5, -7, -2, -2, 0, 0, 4, 0, 11, 0, 4, -1, 0, -
1, -2, -1, -1, 0, 0, 0, 8, -2, 0, -4, 0, -10, 0, 0, 0, 0, 9, 0, 9, -8, 7, 0, 6, 0, -1,
0, 0, 0, 0, -1, 0, 0, 0, -2, -7, 14, -1, 0, 0, 10, -2, 0, -1, -2, 4, -1, 0, 0, 0, 0, -1,
0, 6, 12, 0, 0, 7, -2, -3, 3, 5, 0, 0, -5, 0, -8, -6, -18, -7, -5, 0, 2, 0, -7, -2, -5,
0, 0, 5, 0, -1, -13, 0, 0, -9, 0, 0, 0, -3, 2, 0, 0, 0, -1, -3, 0, 0, 0, 3, 0, 0, 0, -1
5, 3, 0, 0, -10, -6, 0, -4, -7, -3, 0, 1, -6, -1, -1, 0, 0, 0, 0, -2, -21, 0, 0, 0, 0, -
6, -2, 0, -7, 0, -9, 0, -9, -5, 0, -2, -2, 0, -2, -18, 0, -1, -10, 0, -2, -9, -5, -1, 0,
7, 0, 0, -1, -9, 0, 0, -2, 0, 13, 0, 0, -14, -7, 0, 0, -17, 0, 3, 0, -1, 0, -1, 1, -3, -
2, -9, 0, 0, -1, -9, 0, -2, 0, -9, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, -2, -6, 0, -2, 7, 1
3, -2, 0, 0, 0, -4, 0, -2, -6, 0, -12, 0, 0, 0, 0, -1, 0, 1, 0, -2, -6, 0, -1, -2, 2, 0,
-2, -2, 0, -2, 0, 0, -1, 0, 0, 0, -2, 9, 0, 0, 0, 0, 0, -2, 0, -1, 0, -3, 0, 0, 1, -1,
1, 0, -1, 0, 0, 0, -7, 0, 0, -5, 0, 0, -5, -2, -2, 0, 0, -11, -2, 0, 0, 0, 0, -2, 8, -1,
0, 0, 0, 15, 2, -1, -2, 0, 1, 0, 0, 0, 0, 5, 7, -3, -5, 0, -1, 0, -7, 0, -6, 0, 0, -2, -
4, -14, -1, 0, 0, 0, 0, 0, -2, 0, 0, 0, 4, 11, 0, 3, 1, -5, -1, 0, -1, -2, 0, -1, 5, 0,
8, 0, 0, 0, 0, -5, 0, 0, 0, 0, 0, 0, -3, -8, 0, -5, 0, 0, -2, 0, 0, 0, -10, 0, -3, -1,
0, 0, 0, 0, -3, 0, -1, 0, -7, -6, 0, -6, 0, -3, -3, -2, -7, 0, -2, 0, -3, 0, -14, 0, 0,
7, -13, -2, -2, 0, 3, -5, -2, 3, 0, 0, 1, 7, 0, 0, 3, 0, -2, 0, 0, -9, -1, -15, 7, 0, -
1, 0, 0, -5, -2, 0, -3, -3, 0, -2, 0, 0, -1, -1, -2, 0, -4, 0, 0, 0, 0, 0, -3, -1, 0, 0,
-3, 0, 0, 0, 0, 0, -6, -1, 11, 0, 0, 0, 0, 0, 0, 0, -3, -2, 0, -15, -6, -8, 0, 0, 0, 0,
0, 0, 2, 0, 0, -1, -6, 0, 0, 0, -2, 0, 4, 0, 0, 0, 0, 4, -1, 3, 6, 0, -11, -2, 0, 2, 0,
0, 0, 0, 0, 3, 0, 0, 0, 0, 0, -2, 0, 0, -7, -2, -1, -1, 0, 1, -3, 0, 0, 0, 2, 0, 0, 0,
0, 0, 7, -1, -2, -1, -2, -7, 0, 0, -2, -7, 5, -1, 0, -1, 0, 0, 0, 0, 0, 0, 0, 0, -11, 0,

```
0, 0, 0, 0, 0, 0, -1, 0, 6, -1, -10, 0, 9, 0, 0, 0, 0, 0, 0, 0, -13, 0, 7, 5, 3, 0, -1,
-7, 0, -4, 0, 0, -1, -2, 0, 0, 8, -19, 1, 0, 0, -3, 0, 0, -15, 0, 0, 0, 0, 3, 3, 0, 0,
1, -1, 0, -6, -4, -9, 0, 0, -1, 0, -11, 6, -1, -6, 0, -2, 0, -2, -2, 0, 0, 4, 0, -2, 0,
0, 0, 0, 10, 0, 0, 0, -10, 0, 0, 0, 7, 0, -2, 0, 0, -6, 0, 0, -5, 0, -4, 0, -6, -13, -1
2, 0, 0, -2, -6, -6, -2, 0, 0, 0, -11, 0, -2, 0, 0, -3, 0, -3, 2, 0, 0, 0, 7, -3, 10, 0,
-17, -10, -4, -1, -19, 0, 0, -2, 0, 0, 0, 5, 2, 0, 0, 0, -10, 0, 0, -5, 0, -2, 0, -2, -
1, 0, 0, 0, 0, 0, 0, 0, -1, -3, -1, -13, -2, 6, 0, 0, 0, 0, 7]
 Dimensions :  [11, 100, 10, 7]
Time Taken :  8389.378967523575
```



In [7]:
```
print("\n\n============= MLP Program Begins ============")

start_time = time.time()
print("Training")
m = MultiLayerPerceptron(fileName="../ANN/winequality-white", dimensions=dim, all_weight
m.main()
end_time = time.time()
print("Time taken = ", end_time - start_time)
```

```
============= MLP Program Begins ============
Training
Time taken =  0.4777228832244873
```

In [8]:
```
start_time = time.time()
print("Testing")
m = MultiLayerPerceptron(fileName="../ANN/winequality-white", dimensions=dim, all_weight
m.main()

end_time = time.time()
print("Time taken = ", end_time - start_time)
```

```
Testing
Time taken =  0.43782925605773926
```

In [9]:
```
all_accuracy = []
for weights in all_gen_best_weight:
    m = MultiLayerPerceptron(fileName="../ANN/winequality-white", dimensions=dim, all_we
    accuracy_val = m.main()
    print(accuracy_val)
    all_accuracy.append(accuracy_val)

import matplotlib.pyplot as plt
x=all_accuracy[:]
z=[i for i in range(len(x))]
plt.plot(z,x)

plt.title("Firefly Algorithm")
```

```python
plt.ylabel("Accuracy")
plt.xlabel("Iterations")
```

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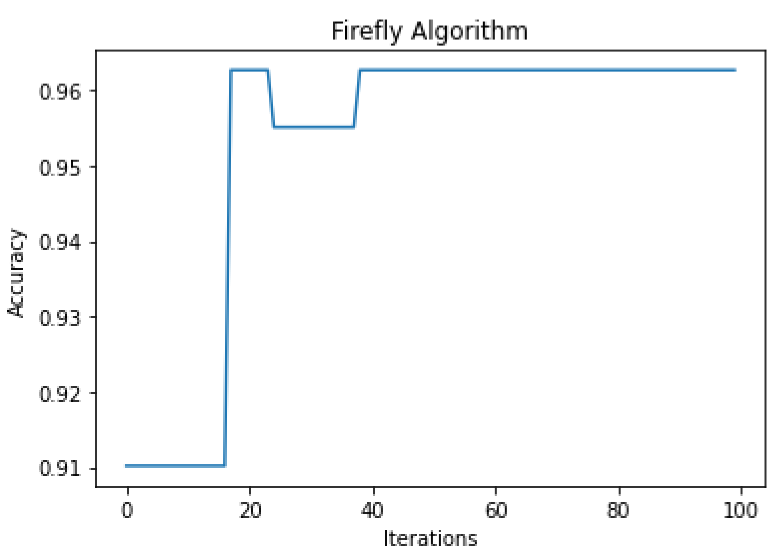
```

Out[9]:

```
Text(0.5, 0, 'Iterations')
```



In [ ]: