Tugas Besar 1C IF3270 - Machine Learning

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Nama file : Tubes1C_13517014.ipynb

Topik : Implementasi modul myMLP

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In [1]:
```
from Layer import Layer, ActivationFunction
from MLP import MLP
from sklearn.neural_network import MLPClassifier as skMLP
from sklearn import metrics

import matplotlib as plt
import numpy as np
import pandas as pd
import sklearn.datasets as dataset
import sklearn.preprocessing as preprocessing
import sklearn.tree as tree
```

A. Penjelasan Implementasi

Implementasi myMLP

Implementasi myMLP dari kelompok kami menggunakan proses yang digunakan pada MLP pada umumnya, yaitu melakukan feed forward feedforward untuk menentukan keputusan yang ada berdasarkan data training yang dilatih dan data test yang diuji dan memperbaiki hasilnya dengan backpropagation, yaitu algoritma neural network yang memperbaiki weight setiap node dalam layer.

Pada implementasi MLP kami , logika komputasi didalam layer dibuat didalam Layer.py, terdapat class Layer yang mengandung informasi intrinsik sebuah Layer, misalnya jumlah node pada layer tersebut, weight dari layer sebelumnya, delta dan sebagainya. Selain itu terdapat juga class ActivationFunction yang merupakan enumerasi dari berbagai jenis fungsi aktivasi seperti fungsi linear dan sigmoid.

Class Layer akan menerima inputan berupa jumlah node, lapisan layer ke-berapa, dan jumlah node pada layer sebelumnya. Kemudian, setiap input yang masuk akan dicek apakah itu adalah layer pertama atau bukan pertama. Jika bukan pertama, akan ditambahkan bias. Kemudian, setiap layer yang terbentuk akan diberi fungsi aktivasi sesuai jenis layernya. Bagi layer pertama, fungsi aktivasi yang digunakan adalah linear, hal ini disebabkan dalam implementasi MLP kami, input layer tidak melakukan komputasi melainkan hanya meneruskan input kepada hidden layer. Bagi layer kedua dan layer output, fungsi aktivasi yang digunakan adalah sigmoid

Kemudian, setiap layer yang terbentuk akan diolah di dalam class MLP di file MLP.py dimana data-data akan selalu direset dengan flush dan diisi dengan delta sesuai dengan layernya melalui flushDelta. Kemudian, data yang telah masuk akan di-feed forward untuk nambahkan nilai dari node awal ke nilai akhir. Setelah itu, baru dijalankan algoritma backpropagation, yaitu mencari nilai delta atribut, delta hidden unit, dan delta weight untuk diterapkan pada setiap layer. Itu dilakukan untuk setiap data yang ada.

Setiap data diperoleh dari dataset yang discan dan memiliki dikelompokkan ke dalam mini-batch yang setiapnya berisi 10 data. flushDelta akan dipanggil setiap 1 mini-batch selesai diproses untuk meng-update weight. Setelah semua mini-batch selesai diproses, maka 1 epoch selesai.

Setelah itu, akan dijalankan predictionValue dan melakukan fungsi pembelajaran (learn) yang terhenti ketika mencapai max iteration, mencapai error minimum, atau mulai diverge.

B. Hasil Eksekusi dan Perbandingan dengan hasil MLP sklearn

In [2]:
```
# Read data from csv
data = pd.read_csv("iris.csv")
predictData = data
dataHead = list(data.columns)

# Shuffle data
data = data.sample(frac=1).reset_index(drop=True)

# Creates data by 10 (indexes of data)
dataSplitCount = 10
dataDict = {n: data.iloc[n:n+dataSplitCount, :] for n in range(0, len(data), d
ataSplitCount)}
```

1. myMLP

In [3]:
```
'''
Model generator
Generates layer to be put in MLP class and return MLP Model

Current layer:
    x
        x   x
    x
GK      x   x
    x
        x   x
    x

Abaikan GK
Layer paling kiri adalah keempat input dari 4 atribut iris.csv
Layer tengah adalah hidden layer
Layer output berfungsi sebagai yang dijelaskan di fungsi outputCheck
'''
def generateModel(learningRate):
    layer0 = Layer(4, 0, 4, ActivationFunction.linear)
    layer1 = Layer(3, 1, 4, ActivationFunction.sigmoid)
    layer2 = Layer(3, 2, 3, ActivationFunction.sigmoid)
    layers = []
    layers.append(layer0)
    layers.append(layer1)
    layers.append(layer2)
    return MLP(layers, learningRate)

# Do data training
'''
Create a function that returns the tuple of output node
'''
def nodeOutputCheck(str):
    if (str == "Versicolor"):
        return [0, 0, 1]
    elif (str == "Virginica"):
        return [0, 1, 0]
    elif (str == "Setosa"):
        return [1, 0, 0]
    else:
        return [1, 1, 1]
```

In [4]:
```
model = generateModel(0.1)
model.learn(dataDict, dataSplitCount, nodeOutputCheck, maxIteration=1000, minE
rror=1, divergingMaxCount=10)
```

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Iteration: 72, Wrong Prediction: 7, Total Case: 150, Error: 3.91842, Accurac
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Iteration: 73, Wrong Prediction: 7, Total Case: 150, Error: 3.8838, Accuracy:
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Iteration: 75, Wrong Prediction: 7, Total Case: 150, Error: 3.8039, Accuracy:
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Iteration: 252, Wrong Prediction: 5, Total Case: 150, Error: 2.71599, Accurac
y: 96.67%
Iteration: 253, Wrong Prediction: 5, Total Case: 150, Error: 2.71447, Accurac
y: 96.67%
Iteration: 254, Wrong Prediction: 5, Total Case: 150, Error: 2.71306, Accurac
y: 96.67%
Iteration: 255, Wrong Prediction: 5, Total Case: 150, Error: 2.71175, Accurac
y: 96.67%
Iteration: 256, Wrong Prediction: 5, Total Case: 150, Error: 2.71056, Accurac
y: 96.67%
Iteration: 257, Wrong Prediction: 5, Total Case: 150, Error: 2.70946, Accurac
y: 96.67%
Iteration: 258, Wrong Prediction: 5, Total Case: 150, Error: 2.70846, Accurac
y: 96.67%
Iteration: 259, Wrong Prediction: 5, Total Case: 150, Error: 2.70754, Accurac
y: 96.67%
Iteration: 260, Wrong Prediction: 5, Total Case: 150, Error: 2.70668, Accurac
y: 96.67%
Iteration: 261, Wrong Prediction: 5, Total Case: 150, Error: 2.70589, Accurac
y: 96.67%
Iteration: 262, Wrong Prediction: 6, Total Case: 150, Error: 2.70512, Accurac
y: 96.0%
Iteration: 263, Wrong Prediction: 6, Total Case: 150, Error: 2.70435, Accurac
y: 96.0%
Iteration: 264, Wrong Prediction: 6, Total Case: 150, Error: 2.70354, Accurac
y: 96.0%
Iteration: 265, Wrong Prediction: 6, Total Case: 150, Error: 2.70267, Accurac
y: 96.0%
Iteration: 266, Wrong Prediction: 6, Total Case: 150, Error: 2.70166, Accurac
y: 96.0%
Iteration: 267, Wrong Prediction: 6, Total Case: 150, Error: 2.70048, Accurac
y: 96.0%
Iteration: 268, Wrong Prediction: 6, Total Case: 150, Error: 2.69905, Accurac
y: 96.0%
Iteration: 269, Wrong Prediction: 6, Total Case: 150, Error: 2.69729, Accurac
y: 96.0%
Iteration: 270, Wrong Prediction: 6, Total Case: 150, Error: 2.69511, Accurac
y: 96.0%
```

```
Iteration: 271, Wrong Prediction: 6, Total Case: 150, Error: 2.69243, Accurac
y: 96.0%
Iteration: 272, Wrong Prediction: 6, Total Case: 150, Error: 2.68911, Accurac
y: 96.0%
Iteration: 273, Wrong Prediction: 6, Total Case: 150, Error: 2.68504, Accurac
y: 96.0%
Iteration: 274, Wrong Prediction: 6, Total Case: 150, Error: 2.68008, Accurac
y: 96.0%
Iteration: 275, Wrong Prediction: 6, Total Case: 150, Error: 2.67408, Accurac
y: 96.0%
Iteration: 276, Wrong Prediction: 6, Total Case: 150, Error: 2.66684, Accurac
y: 96.0%
Iteration: 277, Wrong Prediction: 6, Total Case: 150, Error: 2.65819, Accurac
y: 96.0%
Iteration: 278, Wrong Prediction: 5, Total Case: 150, Error: 2.6479, Accurac
y: 96.67%
Iteration: 279, Wrong Prediction: 5, Total Case: 150, Error: 2.63571, Accurac
y: 96.67%
Iteration: 280, Wrong Prediction: 4, Total Case: 150, Error: 2.62129, Accurac
y: 97.33%
Iteration: 281, Wrong Prediction: 4, Total Case: 150, Error: 2.60418, Accurac
y: 97.33%
Iteration: 282, Wrong Prediction: 4, Total Case: 150, Error: 2.58344, Accurac
y: 97.33%
Iteration: 283, Wrong Prediction: 4, Total Case: 150, Error: 2.55667, Accurac
y: 97.33%
Iteration: 284, Wrong Prediction: 4, Total Case: 150, Error: 2.51776, Accurac
y: 97.33%
Iteration: 285, Wrong Prediction: 4, Total Case: 150, Error: 2.5588, Accurac
y: 97.33%
Iteration: 286, Wrong Prediction: 4, Total Case: 150, Error: 2.5445, Accurac
y: 97.33%
Iteration: 287, Wrong Prediction: 4, Total Case: 150, Error: 2.50846, Accurac
y: 97.33%
Iteration: 288, Wrong Prediction: 4, Total Case: 150, Error: 2.56285, Accurac
y: 97.33%
Iteration: 289, Wrong Prediction: 4, Total Case: 150, Error: 2.5624, Accurac
y: 97.33%
Iteration: 290, Wrong Prediction: 4, Total Case: 150, Error: 2.56437, Accurac
y: 97.33%
Iteration: 291, Wrong Prediction: 4, Total Case: 150, Error: 2.5099, Accurac
y: 97.33%
Iteration: 292, Wrong Prediction: 4, Total Case: 150, Error: 2.63166, Accurac
y: 97.33%
Iteration: 293, Wrong Prediction: 4, Total Case: 150, Error: 2.63812, Accurac
y: 97.33%
Iteration: 294, Wrong Prediction: 4, Total Case: 150, Error: 2.64053, Accurac
y: 97.33%
Iteration: 295, Wrong Prediction: 4, Total Case: 150, Error: 2.6424, Accurac
y: 97.33%
Iteration: 296, Wrong Prediction: 4, Total Case: 150, Error: 2.644, Accuracy:
97.33%
Iteration: 297, Wrong Prediction: 4, Total Case: 150, Error: 2.64548, Accurac
y: 97.33%
Iteration: 298, Wrong Prediction: 4, Total Case: 150, Error: 2.64687, Accurac
y: 97.33%
Iteration: 299, Wrong Prediction: 4, Total Case: 150, Error: 2.64819, Accurac
```

```
y: 97.33%
Iteration: 300, Wrong Prediction: 4, Total Case: 150, Error: 2.64945, Accurac
y: 97.33%
Iteration: 301, Wrong Prediction: 4, Total Case: 150, Error: 2.65065, Accurac
y: 97.33%
```

In [5]:
```
model.predict(predictData, nodeOutputCheck)
```

```
Test Prediction:
[1, 0, 0] [1, 0, 0] True
Test Prediction:
[1, 0, 0] [1, 0, 0] True
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[0, 1, 0] [0, 1, 0] True
Test Prediction:
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[0, 1, 0] [0, 1, 0] True
Test Prediction:
[0, 1, 0] [0, 1, 0] True
Test Prediction:
[0, 1, 0] [0, 1, 0] True
```

In [6]:

```
for i in range(len(model.layers)):
    print("Layer: {}".format(i))
    print(np.matrix(model.layers[i].weight))
```

```
Layer: 0
[[1]
 [1]
 [1]
 [1]]
Layer: 1
[[ 0.32148913  0.45764157  2.3153078  -3.28581657 -1.4545532 ]
 [-5.2479528  -4.92510752 -3.45121705  7.47247823  6.24807592]
 [ 1.95831773  0.77724573  1.46830511 -1.82105995 -1.81374146]]
Layer: 2
[[-3.67763966  6.58721345 -2.65448921  0.64507866]
 [-2.47828443 -2.17045227  5.52574239 -2.60876634]
 [ 2.86157331 -7.38211112 -5.57595907  1.05785671]]
```

2. MLP sklearn

In [7]:

```
df_norm = data[['sepal.length', 'sepal.width', 'petal.length', 'petal.width']]
.apply(lambda x: (x - x.min()) / (x.max() - x.min()))
target = data[['variety']].replace(['Setosa','Versicolor','Virginica'],[0,1,2
])
df = pd.concat([df_norm, target], axis=1)
testDf = df

df = df.sample(frac=1).reset_index(drop=True)

trainX = df[['sepal.length', 'sepal.width', 'petal.length', 'petal.width']]
trainY = df[['variety']]

testX = df_norm
testY = target
```

In [8]:
```
mlp = skMLP(solver='sgd', alpha=0.1, learning_rate_init=0.1, hidden_layer_size
s=(1,3), activation='logistic', max_iter=1000, random_state=1, verbose=True)

mlp.fit(trainX, trainY)
```

```
tion 17, loss = 1.09841908
Iteration 18, loss = 1.09773342
Iteration 19, loss = 1.09718462
Iteration 20, loss = 1.09680759
Iteration 21, loss = 1.09659550
Iteration 22, loss = 1.09651289
Iteration 23, loss = 1.09651077
Iteration 24, loss = 1.09653993
Iteration 25, loss = 1.09656033
Iteration 26, loss = 1.09654608
Iteration 27, loss = 1.09648620
Iteration 28, loss = 1.09638238
Iteration 29, loss = 1.09624497
Iteration 30, loss = 1.09608845
Iteration 31, loss = 1.09592734
Iteration 32, loss = 1.09577325
Iteration 33, loss = 1.09563329
Iteration 34, loss = 1.09550983
Iteration 35, loss = 1.09540116
Iteration 36, loss = 1.09530295
Iteration 37, loss = 1.09520970
Iteration 38, loss = 1.09511612
Iteration 39, loss = 1.09501810
Iteration 40, loss = 1.09491316
Iteration 41, loss = 1.09480043
Iteration 42, loss = 1.09468040
Iteration 43, loss = 1.09455434
Iteration 44, loss = 1.09442385
Iteration 45, loss = 1.09429036
Iteration 46, loss = 1.09415490
Iteration 47, loss = 1.09401794
Iteration 48, loss = 1.09387943
Iteration 49, loss = 1.09373891
Iteration 50, loss = 1.09359569
Iteration 51, loss = 1.09344901
Iteration 52, loss = 1.09329819
Iteration 53, loss = 1.09314268
Iteration 54, loss = 1.09298211
Iteration 55, loss = 1.09281627
Iteration 56, loss = 1.09264509
Iteration 57, loss = 1.09246854
Iteration 58, loss = 1.09228659
Iteration 59, loss = 1.09209919
Iteration 60, loss = 1.09190623
Iteration 61, loss = 1.09170751
Iteration 62, loss = 1.09150278
Iteration 63, loss = 1.09129174
Iteration 64, loss = 1.09107406
Iteration 65, loss = 1.09084941
Iteration 66, loss = 1.09061742
Iteration 67, loss = 1.09037777
Iteration 68, loss = 1.09013012
Iteration 69, loss = 1.08987414
Iteration 70, loss = 1.08960948
Iteration 71, loss = 1.08933581
Iteration 72, loss = 1.08905274
Iteration 73, loss = 1.08875991
```

```
Iteration 74, loss = 1.08845687
Iteration 75, loss = 1.08814320
Iteration 76, loss = 1.08781842
Iteration 77, loss = 1.08748203
Iteration 78, loss = 1.08713351
Iteration 79, loss = 1.08677231
Iteration 80, loss = 1.08639784
Iteration 81, loss = 1.08600951
Iteration 82, loss = 1.08560668
Iteration 83, loss = 1.08518870
Iteration 84, loss = 1.08475487
Iteration 85, loss = 1.08430445
Iteration 86, loss = 1.08383669
Iteration 87, loss = 1.08335076
Iteration 88, loss = 1.08284582
Iteration 89, loss = 1.08232096
Iteration 90, loss = 1.08177525
Iteration 91, loss = 1.08120768
Iteration 92, loss = 1.08061721
Iteration 93, loss = 1.08000274
Iteration 94, loss = 1.07936308
Iteration 95, loss = 1.07869704
Iteration 96, loss = 1.07800330
Iteration 97, loss = 1.07728052
Iteration 98, loss = 1.07652727
Iteration 99, loss = 1.07574202
Iteration 100, loss = 1.07492320
Iteration 101, loss = 1.07406913
Iteration 102, loss = 1.07317805
Iteration 103, loss = 1.07224809
Iteration 104, loss = 1.07127731
Iteration 105, loss = 1.07026364
Iteration 106, loss = 1.06920492
Iteration 107, loss = 1.06809885
Iteration 108, loss = 1.06694305
Iteration 109, loss = 1.06573499
Iteration 110, loss = 1.06447201
Iteration 111, loss = 1.06315133
Iteration 112, loss = 1.06177001
Iteration 113, loss = 1.06032498
Iteration 114, loss = 1.05881301
Iteration 115, loss = 1.05723072
Iteration 116, loss = 1.05557457
Iteration 117, loss = 1.05384084
Iteration 118, loss = 1.05202567
Iteration 119, loss = 1.05012499
Iteration 120, loss = 1.04813458
Iteration 121, loss = 1.04605002
Iteration 122, loss = 1.04386674
Iteration 123, loss = 1.04157996
Iteration 124, loss = 1.03918473
Iteration 125, loss = 1.03667593
Iteration 126, loss = 1.03404824
Iteration 127, loss = 1.03129620
Iteration 128, loss = 1.02841418
Iteration 129, loss = 1.02539638
Iteration 130, loss = 1.02223688
```

```
Iteration 131, loss = 1.01892963
Iteration 132, loss = 1.01546846
Iteration 133, loss = 1.01184713
Iteration 134, loss = 1.00805934
Iteration 135, loss = 1.00409874
Iteration 136, loss = 0.99995901
Iteration 137, loss = 0.99563387
Iteration 138, loss = 0.99111710
Iteration 139, loss = 0.98640266
Iteration 140, loss = 0.98148467
Iteration 141, loss = 0.97635754
Iteration 142, loss = 0.97101599
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Iteration 154, loss = 0.88910781
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Iteration 157, loss = 0.86363309
Iteration 158, loss = 0.85477008
Iteration 159, loss = 0.84574403
Iteration 160, loss = 0.83657109
Iteration 161, loss = 0.82726893
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Iteration 163, loss = 0.80835502
Iteration 164, loss = 0.79878540
Iteration 165, loss = 0.78917049
Iteration 166, loss = 0.77953358
Iteration 167, loss = 0.76989844
Iteration 168, loss = 0.76028898
Iteration 169, loss = 0.75072906
Iteration 170, loss = 0.74124212
Iteration 171, loss = 0.73185093
Iteration 172, loss = 0.72257737
Iteration 173, loss = 0.71344209
Iteration 174, loss = 0.70446439
Iteration 175, loss = 0.69566197
Iteration 176, loss = 0.68705078
Iteration 177, loss = 0.67864492
Iteration 178, loss = 0.67045658
Iteration 179, loss = 0.66249595
Iteration 180, loss = 0.65477125
Iteration 181, loss = 0.64728877
Iteration 182, loss = 0.64005291
Iteration 183, loss = 0.63306625
Iteration 184, loss = 0.62632973
Iteration 185, loss = 0.61984267
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Iteration 188, loss = 0.60185125
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Iteration 245, loss = 0.45349486
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Iteration 302, loss = 0.35810499
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Iteration 359, loss = 0.29628668
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Iteration 416, loss = 0.26076397
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Iteration 473, loss = 0.23983417
Iteration 474, loss = 0.23955222
Iteration 475, loss = 0.23927266
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Iteration 495, loss = 0.23414610
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Iteration 522, loss = 0.22842808
Iteration 523, loss = 0.22823896
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Iteration 525, loss = 0.22786510
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Iteration 530, loss = 0.22695550
Iteration 531, loss = 0.22677776
Iteration 532, loss = 0.22660138
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Iteration 536, loss = 0.22590926
Iteration 537, loss = 0.22573951
Iteration 538, loss = 0.22557105
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Iteration 558, loss = 0.22245473
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Iteration 560, loss = 0.22216776
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Iteration 562, loss = 0.22188495
Iteration 563, loss = 0.22174509
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Iteration 565, loss = 0.22146838
Iteration 566, loss = 0.22133152
Iteration 567, loss = 0.22119565
Iteration 568, loss = 0.22106075
Iteration 569, loss = 0.22092682
Iteration 570, loss = 0.22079384
Iteration 571, loss = 0.22066182
Iteration 572, loss = 0.22053073
Iteration 573, loss = 0.22040058
Iteration 574, loss = 0.22027135
Iteration 575, loss = 0.22014304
Iteration 576, loss = 0.22001563
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Iteration 578, loss = 0.21976350
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Iteration 580, loss = 0.21951491
Iteration 581, loss = 0.21939191
Iteration 582, loss = 0.21926978
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Iteration 587, loss = 0.21867173
Iteration 588, loss = 0.21855459
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Iteration 590, loss = 0.21832272
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Iteration 594, loss = 0.21786845
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Iteration 604, loss = 0.21678538
Iteration 605, loss = 0.21668103
Iteration 606, loss = 0.21657737
Iteration 607, loss = 0.21647440
Iteration 608, loss = 0.21637211
Iteration 609, loss = 0.21627050
Iteration 610, loss = 0.21616956
Iteration 611, loss = 0.21606928
Iteration 612, loss = 0.21596966
Iteration 613, loss = 0.21587070
Iteration 614, loss = 0.21577238
Iteration 615, loss = 0.21567470
Iteration 616, loss = 0.21557766
Iteration 617, loss = 0.21548125
Iteration 618, loss = 0.21538547
Iteration 619, loss = 0.21529030
Iteration 620, loss = 0.21519575
Iteration 621, loss = 0.21510181
Iteration 622, loss = 0.21500847
Training loss did not improve more than tol=0.000100 for 10 consecutive epoch
s. Stopping.
```

Out[8]:

```
MLPClassifier(activation='logistic', alpha=0.1, batch_size='auto', beta_1=0.
9,
              beta_2=0.999, early_stopping=False, epsilon=1e-08,
              hidden_layer_sizes=(1, 3), learning_rate='constant',
              learning_rate_init=0.1, max_fun=15000, max_iter=1000,
              momentum=0.9, n_iter_no_change=10, nesterovs_momentum=True,
              power_t=0.5, random_state=1, shuffle=True, solver='sgd',
              tol=0.0001, validation_fraction=0.1, verbose=True,
              warm_start=False)
```

```
In [9]: print('Training set total iterations:', mlp.n_iter_)
print('           Training set score: ' + '{:.2%}'.format(mlp.score(trainX, tr
ainY)))
print('            Training set loss: %.5f' % mlp.loss_)
print('             Number of output:', mlp.n_outputs_)
print('              Number of layer:', mlp.n_layers_)

print('\nLoss:')
print('Layer: 0\n', mlp.intercepts_[0])
print('Layer: 1\n', mlp.intercepts_[1])
print('Layer: 2\n', mlp.intercepts_[2])

print('\nWeight:')
print('Layer: 0\n', mlp.coefs_[0])
print('Layer: 1\n', mlp.coefs_[1])
print('Layer: 2\n', mlp.coefs_[2])

prediction = mlp.predict(testX)
print('\nTest accuracy: ' + '{:.2%}'.format(metrics.accuracy_score(prediction,
testY)))
```

```
Training set total iterations: 622
           Training set score: 96.00%
            Training set loss: 0.21501
             Number of output: 3
              Number of layer: 4

Loss:
Layer: 0
 [2.95321137]
Layer: 1
 [ 1.71625189  3.99231484 -1.563244  ]
Layer: 2
 [ 2.39546079  0.71942836 -2.44235655]

Weight:
Layer: 0
 [[ 0.50803757]
 [ 1.89315219]
 [-3.23071367]
 [-4.24337168]]
Layer: 1
 [[-5.8821578  -5.74953572  4.67013753]]
Layer: 2
 [[-3.58808463 -1.68534776  5.47831888]
 [-6.80100172  2.06963982  4.43691932]
 [ 3.75845381  0.7633835  -4.98305845]]

Test accuracy: 96.00%
```

C. Pembagian Tugas

NIM	Nama	Tugas
13517014	Yoel Susanto	Feed Forward, Backpropagation, Data Structure
13517065	Andrian Cedric	Feed Forward, Function, Documentation
13517131	Jan Meyer Saragih	Feed Forward, Backpropagation, Data Structure
13517137	Vincent Budianto	Feed Forward, Function, Documentation