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**Roll number: 2012076**

**Subject: MLDL**

**Practical 10**

**Deep-Learning on pima-indians-diabetes**

**Importing The Libraries**

from numpy import loadtxt

from keras.models import Sequential

from keras.layers import Dense

# load the dataset

dataset = loadtxt('pima-indians-diabetes.csv', delimiter=',')

# split into input (X) and output (y) variables

X = dataset[:,0:8]

y = dataset[:,8]

**define the keras model**

* create model

model = Sequential()

model.add(Dense(12, input\_dim=8, activation='relu'))

model.add(Dense(8, activation='relu'))

model.add(Dense(1, activation='sigmoid'))

* compile the keras model

model.compile(loss='binary\_crossentropy', optimizer='adam', metrics=['accuracy'])

# fit the keras model on the dataset

model.fit(X, y, epochs=150, batch\_size=10)

Epoch 1/150

77/77 [==============================] - 1s 978us/step - loss: 16.3494 - accuracy: 0.6458

Epoch 2/150

77/77 [==============================] - 0s 945us/step - loss: 4.1753 - accuracy: 0.5638

Epoch 3/150

77/77 [==============================] - 0s 936us/step - loss: 1.9131 - accuracy: 0.6159

Epoch 4/150

77/77 [==============================] - 0s 834us/step - loss: 1.2107 - accuracy: 0.6107

Epoch 5/150

77/77 [==============================] - 0s 841us/step - loss: 0.9360 - accuracy: 0.6172

Epoch 6/150

77/77 [==============================] - 0s 1ms/step - loss: 0.8656 - accuracy: 0.6107

Epoch 7/150

77/77 [==============================] - 0s 958us/step - loss: 0.8161 - accuracy: 0.6367

Epoch 8/150

77/77 [==============================] - 0s 888us/step - loss: 0.7775 - accuracy: 0.6159

Epoch 9/150

77/77 [==============================] - 0s 994us/step - loss: 0.7544 - accuracy: 0.6133

Epoch 10/150

77/77 [==============================] - 0s 996us/step - loss: 0.7299 - accuracy: 0.6497

Epoch 11/150

77/77 [==============================] - 0s 985us/step - loss: 0.7134 - accuracy: 0.6497

Epoch 12/150

77/77 [==============================] - 0s 1ms/step - loss: 0.7217 - accuracy: 0.6302

Epoch 13/150

77/77 [==============================] - 0s 913us/step - loss: 0.6779 - accuracy: 0.6354

Epoch 14/150

77/77 [==============================] - 0s 823us/step - loss: 0.6885 - accuracy: 0.6576

Epoch 15/150

77/77 [==============================] - 0s 987us/step - loss: 0.6749 - accuracy: 0.6445

Epoch 16/150

77/77 [==============================] - 0s 819us/step - loss: 0.6645 - accuracy: 0.6471

Epoch 17/150

77/77 [==============================] - 0s 947us/step - loss: 0.6525 - accuracy: 0.6549

Epoch 18/150

77/77 [==============================] - 0s 987us/step - loss: 0.6391 - accuracy: 0.6745

Epoch 19/150

77/77 [==============================] - 0s 1ms/step - loss: 0.6379 - accuracy: 0.6680

Epoch 20/150

77/77 [==============================] - 0s 951us/step - loss: 0.6281 - accuracy: 0.6497

Epoch 21/150

77/77 [==============================] - 0s 950us/step - loss: 0.6199 - accuracy: 0.6758

Epoch 22/150

77/77 [==============================] - 0s 855us/step - loss: 0.6226 - accuracy: 0.6589

Epoch 23/150

77/77 [==============================] - 0s 948us/step - loss: 0.6031 - accuracy: 0.6784

Epoch 24/150

77/77 [==============================] - 0s 946us/step - loss: 0.5955 - accuracy: 0.6888

Epoch 25/150

77/77 [==============================] - 0s 998us/step - loss: 0.6011 - accuracy: 0.6914

Epoch 26/150

77/77 [==============================] - 0s 932us/step - loss: 0.5907 - accuracy: 0.6901

Epoch 27/150

77/77 [==============================] - 0s 951us/step - loss: 0.6284 - accuracy: 0.6836

Epoch 28/150

77/77 [==============================] - 0s 911us/step - loss: 0.5931 - accuracy: 0.6966

Epoch 29/150

77/77 [==============================] - 0s 964us/step - loss: 0.5841 - accuracy: 0.7005

Epoch 30/150

77/77 [==============================] - 0s 988us/step - loss: 0.6045 - accuracy: 0.6927

Epoch 31/150

77/77 [==============================] - 0s 985us/step - loss: 0.5866 - accuracy: 0.6966

Epoch 32/150

77/77 [==============================] - 0s 947us/step - loss: 0.5929 - accuracy: 0.6953

Epoch 33/150

77/77 [==============================] - 0s 850us/step - loss: 0.5802 - accuracy: 0.7096

Epoch 34/150

77/77 [==============================] - 0s 929us/step - loss: 0.5673 - accuracy: 0.7031

Epoch 35/150

77/77 [==============================] - 0s 948us/step - loss: 0.5765 - accuracy: 0.7018

Epoch 36/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5772 - accuracy: 0.7070

Epoch 37/150

77/77 [==============================] - 0s 933us/step - loss: 0.5903 - accuracy: 0.7083

Epoch 38/150

77/77 [==============================] - 0s 823us/step - loss: 0.5652 - accuracy: 0.7031

Epoch 39/150

77/77 [==============================] - 0s 859us/step - loss: 0.5815 - accuracy: 0.6979

Epoch 40/150

77/77 [==============================] - 0s 844us/step - loss: 0.5706 - accuracy: 0.7083

Epoch 41/150

77/77 [==============================] - 0s 842us/step - loss: 0.5606 - accuracy: 0.7135

Epoch 42/150

77/77 [==============================] - 0s 885us/step - loss: 0.5687 - accuracy: 0.7005

Epoch 43/150

77/77 [==============================] - 0s 917us/step - loss: 0.5615 - accuracy: 0.7044

Epoch 44/150

77/77 [==============================] - 0s 964us/step - loss: 0.5584 - accuracy: 0.7161

Epoch 45/150

77/77 [==============================] - 0s 985us/step - loss: 0.5612 - accuracy: 0.7161

Epoch 46/150

77/77 [==============================] - 0s 860us/step - loss: 0.5654 - accuracy: 0.7083

Epoch 47/150

77/77 [==============================] - 0s 862us/step - loss: 0.5463 - accuracy: 0.7253

Epoch 48/150

77/77 [==============================] - 0s 863us/step - loss: 0.5462 - accuracy: 0.7318

Epoch 49/150

77/77 [==============================] - 0s 865us/step - loss: 0.5660 - accuracy: 0.7148

Epoch 50/150

77/77 [==============================] - 0s 860us/step - loss: 0.5463 - accuracy: 0.7240

Epoch 51/150

77/77 [==============================] - 0s 909us/step - loss: 0.5527 - accuracy: 0.7383

Epoch 52/150

77/77 [==============================] - 0s 962us/step - loss: 0.5552 - accuracy: 0.7357

Epoch 53/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5538 - accuracy: 0.7214

Epoch 54/150

77/77 [==============================] - 0s 944us/step - loss: 0.5563 - accuracy: 0.7122

Epoch 55/150

77/77 [==============================] - 0s 954us/step - loss: 0.5448 - accuracy: 0.7318

Epoch 56/150

77/77 [==============================] - 0s 920us/step - loss: 0.5625 - accuracy: 0.7161

Epoch 57/150

77/77 [==============================] - 0s 979us/step - loss: 0.5550 - accuracy: 0.7344

Epoch 58/150

77/77 [==============================] - 0s 947us/step - loss: 0.5494 - accuracy: 0.7227

Epoch 59/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5482 - accuracy: 0.7292

Epoch 60/150

77/77 [==============================] - 0s 895us/step - loss: 0.5384 - accuracy: 0.7396

Epoch 61/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5448 - accuracy: 0.7396

Epoch 62/150

77/77 [==============================] - 0s 978us/step - loss: 0.5330 - accuracy: 0.7461

Epoch 63/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5343 - accuracy: 0.7292

Epoch 64/150

77/77 [==============================] - 0s 948us/step - loss: 0.5525 - accuracy: 0.7344

Epoch 65/150

77/77 [==============================] - 0s 845us/step - loss: 0.5592 - accuracy: 0.7305

Epoch 66/150

77/77 [==============================] - 0s 948us/step - loss: 0.5452 - accuracy: 0.7383

Epoch 67/150

77/77 [==============================] - 0s 947us/step - loss: 0.5556 - accuracy: 0.7148

Epoch 68/150

77/77 [==============================] - 0s 992us/step - loss: 0.5592 - accuracy: 0.7161

Epoch 69/150

77/77 [==============================] - 0s 960us/step - loss: 0.5337 - accuracy: 0.7370

Epoch 70/150

77/77 [==============================] - 0s 989us/step - loss: 0.5446 - accuracy: 0.7240

Epoch 71/150

77/77 [==============================] - 0s 965us/step - loss: 0.5286 - accuracy: 0.7539

Epoch 72/150

77/77 [==============================] - 0s 841us/step - loss: 0.5360 - accuracy: 0.7344

Epoch 73/150

77/77 [==============================] - 0s 866us/step - loss: 0.5325 - accuracy: 0.7435

Epoch 74/150

77/77 [==============================] - 0s 958us/step - loss: 0.5283 - accuracy: 0.7370

Epoch 75/150

77/77 [==============================] - 0s 982us/step - loss: 0.5372 - accuracy: 0.7422

Epoch 76/150

77/77 [==============================] - 0s 884us/step - loss: 0.5328 - accuracy: 0.7422

Epoch 77/150

77/77 [==============================] - 0s 882us/step - loss: 0.5347 - accuracy: 0.7396

Epoch 78/150

77/77 [==============================] - 0s 849us/step - loss: 0.5376 - accuracy: 0.7227

Epoch 79/150

77/77 [==============================] - 0s 974us/step - loss: 0.5263 - accuracy: 0.7422

Epoch 80/150

77/77 [==============================] - 0s 984us/step - loss: 0.5429 - accuracy: 0.7318

Epoch 81/150

77/77 [==============================] - 0s 863us/step - loss: 0.5296 - accuracy: 0.7344

Epoch 82/150

77/77 [==============================] - 0s 865us/step - loss: 0.5436 - accuracy: 0.7201

Epoch 83/150

77/77 [==============================] - 0s 854us/step - loss: 0.5806 - accuracy: 0.7214

Epoch 84/150

77/77 [==============================] - 0s 863us/step - loss: 0.5375 - accuracy: 0.7448

Epoch 85/150

77/77 [==============================] - 0s 978us/step - loss: 0.5294 - accuracy: 0.7292

Epoch 86/150

77/77 [==============================] - 0s 967us/step - loss: 0.5229 - accuracy: 0.7370

Epoch 87/150

77/77 [==============================] - 0s 912us/step - loss: 0.5337 - accuracy: 0.7292

Epoch 88/150

77/77 [==============================] - 0s 942us/step - loss: 0.5432 - accuracy: 0.7305

Epoch 89/150

77/77 [==============================] - 0s 977us/step - loss: 0.5237 - accuracy: 0.7474

Epoch 90/150

77/77 [==============================] - 0s 952us/step - loss: 0.5139 - accuracy: 0.7487

Epoch 91/150

77/77 [==============================] - 0s 863us/step - loss: 0.5393 - accuracy: 0.7474

Epoch 92/150

77/77 [==============================] - 0s 991us/step - loss: 0.5286 - accuracy: 0.7396

Epoch 93/150

77/77 [==============================] - 0s 948us/step - loss: 0.5534 - accuracy: 0.7318

Epoch 94/150

77/77 [==============================] - 0s 842us/step - loss: 0.5242 - accuracy: 0.7461

Epoch 95/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5183 - accuracy: 0.7591

Epoch 96/150

77/77 [==============================] - 0s 994us/step - loss: 0.5185 - accuracy: 0.7643

Epoch 97/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5201 - accuracy: 0.7500

Epoch 98/150

77/77 [==============================] - 0s 866us/step - loss: 0.5118 - accuracy: 0.7500

Epoch 99/150

77/77 [==============================] - 0s 857us/step - loss: 0.5211 - accuracy: 0.7279

Epoch 100/150

77/77 [==============================] - 0s 864us/step - loss: 0.5121 - accuracy: 0.7578

Epoch 101/150

77/77 [==============================] - 0s 866us/step - loss: 0.5231 - accuracy: 0.7318

Epoch 102/150

77/77 [==============================] - 0s 961us/step - loss: 0.5235 - accuracy: 0.7435

Epoch 103/150

77/77 [==============================] - 0s 879us/step - loss: 0.5123 - accuracy: 0.7513

Epoch 104/150

77/77 [==============================] - 0s 865us/step - loss: 0.5108 - accuracy: 0.7526

Epoch 105/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5127 - accuracy: 0.7526

Epoch 106/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5129 - accuracy: 0.7539

Epoch 107/150

77/77 [==============================] - 0s 838us/step - loss: 0.5197 - accuracy: 0.7630

Epoch 108/150

77/77 [==============================] - 0s 860us/step - loss: 0.5295 - accuracy: 0.7318

Epoch 109/150

77/77 [==============================] - 0s 872us/step - loss: 0.5125 - accuracy: 0.7474

Epoch 110/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5142 - accuracy: 0.7435

Epoch 111/150

77/77 [==============================] - 0s 945us/step - loss: 0.5074 - accuracy: 0.7552

Epoch 112/150

77/77 [==============================] - 0s 956us/step - loss: 0.5037 - accuracy: 0.7526

Epoch 113/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5088 - accuracy: 0.7630

Epoch 114/150

77/77 [==============================] - 0s 949us/step - loss: 0.5053 - accuracy: 0.7448

Epoch 115/150

77/77 [==============================] - 0s 968us/step - loss: 0.5026 - accuracy: 0.7669

Epoch 116/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5082 - accuracy: 0.7487

Epoch 117/150

77/77 [==============================] - 0s 979us/step - loss: 0.5035 - accuracy: 0.7461

Epoch 118/150

77/77 [==============================] - 0s 945us/step - loss: 0.5167 - accuracy: 0.7487

Epoch 119/150

77/77 [==============================] - 0s 1ms/step - loss: 0.4996 - accuracy: 0.7669

Epoch 120/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5039 - accuracy: 0.7513

Epoch 121/150

77/77 [==============================] - 0s 1ms/step - loss: 0.4949 - accuracy: 0.7721

Epoch 122/150

77/77 [==============================] - 0s 855us/step - loss: 0.5183 - accuracy: 0.7370

Epoch 123/150

77/77 [==============================] - 0s 842us/step - loss: 0.5108 - accuracy: 0.7526

Epoch 124/150

77/77 [==============================] - 0s 841us/step - loss: 0.4958 - accuracy: 0.7565

Epoch 125/150

77/77 [==============================] - 0s 854us/step - loss: 0.5199 - accuracy: 0.7539

Epoch 126/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5067 - accuracy: 0.7474

Epoch 127/150

77/77 [==============================] - 0s 988us/step - loss: 0.5090 - accuracy: 0.7591

Epoch 128/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5221 - accuracy: 0.7578

Epoch 129/150

77/77 [==============================] - 0s 847us/step - loss: 0.4966 - accuracy: 0.7604

Epoch 130/150

77/77 [==============================] - 0s 898us/step - loss: 0.4928 - accuracy: 0.7591

Epoch 131/150

77/77 [==============================] - 0s 845us/step - loss: 0.4991 - accuracy: 0.7630

Epoch 132/150

77/77 [==============================] - 0s 842us/step - loss: 0.5063 - accuracy: 0.7500

Epoch 133/150

77/77 [==============================] - 0s 1ms/step - loss: 0.4970 - accuracy: 0.7643

Epoch 134/150

77/77 [==============================] - 0s 944us/step - loss: 0.4957 - accuracy: 0.7630

Epoch 135/150

77/77 [==============================] - 0s 949us/step - loss: 0.4999 - accuracy: 0.7643

Epoch 136/150

77/77 [==============================] - 0s 984us/step - loss: 0.5052 - accuracy: 0.7565

Epoch 137/150

77/77 [==============================] - 0s 980us/step - loss: 0.4962 - accuracy: 0.7578

Epoch 138/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5105 - accuracy: 0.7422

Epoch 139/150

77/77 [==============================] - 0s 922us/step - loss: 0.4947 - accuracy: 0.7721

Epoch 140/150

77/77 [==============================] - 0s 931us/step - loss: 0.5092 - accuracy: 0.7500

Epoch 141/150

77/77 [==============================] - 0s 957us/step - loss: 0.5018 - accuracy: 0.7656

Epoch 142/150

77/77 [==============================] - 0s 986us/step - loss: 0.5033 - accuracy: 0.7578

Epoch 143/150

77/77 [==============================] - 0s 932us/step - loss: 0.4926 - accuracy: 0.7656

Epoch 144/150

77/77 [==============================] - 0s 979us/step - loss: 0.5043 - accuracy: 0.7422

Epoch 145/150

77/77 [==============================] - 0s 977us/step - loss: 0.4942 - accuracy: 0.7669

Epoch 146/150

77/77 [==============================] - 0s 899us/step - loss: 0.4869 - accuracy: 0.7617

Epoch 147/150

77/77 [==============================] - 0s 956us/step - loss: 0.4951 - accuracy: 0.7591

Epoch 148/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5024 - accuracy: 0.7565

Epoch 149/150

77/77 [==============================] - 0s 1ms/step - loss: 0.4965 - accuracy: 0.7812

Epoch 150/150

77/77 [==============================] - 0s 928us/step - loss: 0.4878 - accuracy: 0.7669

Out[6]:

<keras.callbacks.History at 0x1dc1e60ed30>

# evaluate the keras model

\_, accuracy = model.evaluate(X, y)

print('Accuracy: %.2f' % (accuracy\*100))

24/24 [==============================] - 0s 1ms/step - loss: 0.4737 - accuracy: 0.7734

Accuracy: 77.34

model.summary()

Model: "sequential"

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Layer (type) Output Shape Param #

=================================================================

dense (Dense) (None, 12) 108

dense\_1 (Dense) (None, 8) 104

dense\_2 (Dense) (None, 1) 9

=================================================================

Total params: 221

Trainable params: 221

Non-trainable params: 0

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**Deep-Learning on diabetes**

# Import Libraries

import pandas as pd

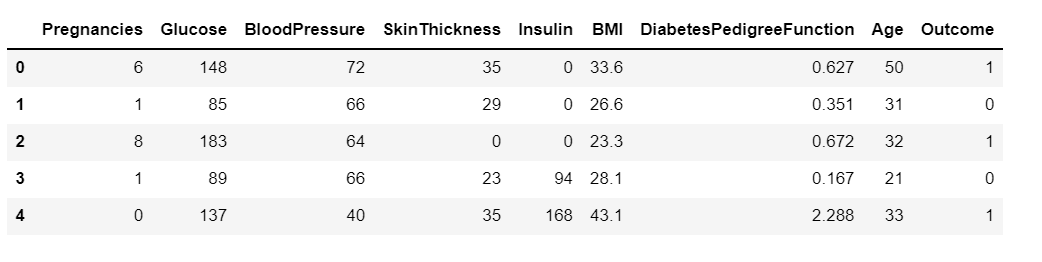
from keras.layers import Dense

from keras.models import Sequential

# Loading The DataSets

df = pd.read\_csv('diabetes.csv')

df.head()



# Spliting The DataSet

x = df.drop('Outcome',axis=1)

y = df['Outcome']

# Building The Keras Model

model = Sequential()

model.add(Dense(12,input\_dim=8,activation='relu'))

model.add(Dense(12,activation='relu'))

model.add(Dense(1,activation='sigmoid'))

model.compile(loss='binary\_crossentropy',optimizer='adam',metrics=['accuracy'])

# Fitting The Model

model.fit(x,y,epochs=150,batch\_size=10)

Epoch 1/150

77/77 [==============================] - 0s 1ms/step - loss: 2.6825 - accuracy: 0.5547

Epoch 2/150

77/77 [==============================] - 0s 974us/step - loss: 0.9222 - accuracy: 0.6081

Epoch 3/150

77/77 [==============================] - 0s 992us/step - loss: 0.8049 - accuracy: 0.6042

Epoch 4/150

77/77 [==============================] - 0s 1ms/step - loss: 0.7640 - accuracy: 0.6211

Epoch 5/150

77/77 [==============================] - 0s 985us/step - loss: 0.7790 - accuracy: 0.6211

Epoch 6/150

77/77 [==============================] - 0s 1ms/step - loss: 0.6984 - accuracy: 0.6589

Epoch 7/150

77/77 [==============================] - 0s 1ms/step - loss: 0.6998 - accuracy: 0.6471

Epoch 8/150

77/77 [==============================] - 0s 933us/step - loss: 0.6799 - accuracy: 0.6680

Epoch 9/150

77/77 [==============================] - 0s 1ms/step - loss: 0.6899 - accuracy: 0.6523

Epoch 10/150

77/77 [==============================] - 0s 1ms/step - loss: 0.6741 - accuracy: 0.6706

Epoch 11/150

77/77 [==============================] - 0s 935us/step - loss: 0.6625 - accuracy: 0.6680

Epoch 12/150

77/77 [==============================] - 0s 963us/step - loss: 0.6468 - accuracy: 0.6810

Epoch 13/150

77/77 [==============================] - 0s 974us/step - loss: 0.6691 - accuracy: 0.6784

Epoch 14/150

77/77 [==============================] - 0s 897us/step - loss: 0.6295 - accuracy: 0.6823

Epoch 15/150

77/77 [==============================] - 0s 1000us/step - loss: 0.6320 - accuracy: 0.6771

Epoch 16/150

77/77 [==============================] - 0s 986us/step - loss: 0.6310 - accuracy: 0.6797

Epoch 17/150

77/77 [==============================] - 0s 947us/step - loss: 0.6297 - accuracy: 0.6940

Epoch 18/150

77/77 [==============================] - 0s 912us/step - loss: 0.6160 - accuracy: 0.6888

Epoch 19/150

77/77 [==============================] - 0s 919us/step - loss: 0.6017 - accuracy: 0.7005

Epoch 20/150

77/77 [==============================] - 0s 958us/step - loss: 0.6082 - accuracy: 0.6914

Epoch 21/150

77/77 [==============================] - 0s 986us/step - loss: 0.5828 - accuracy: 0.7135

Epoch 22/150

77/77 [==============================] - 0s 880us/step - loss: 0.5933 - accuracy: 0.6927

Epoch 23/150

77/77 [==============================] - 0s 868us/step - loss: 0.5969 - accuracy: 0.7057

Epoch 24/150

77/77 [==============================] - 0s 870us/step - loss: 0.5843 - accuracy: 0.7018

Epoch 25/150

77/77 [==============================] - 0s 951us/step - loss: 0.5985 - accuracy: 0.6849

Epoch 26/150

77/77 [==============================] - 0s 982us/step - loss: 0.5884 - accuracy: 0.7070

Epoch 27/150

77/77 [==============================] - 0s 987us/step - loss: 0.5929 - accuracy: 0.6953

Epoch 28/150

77/77 [==============================] - 0s 843us/step - loss: 0.5968 - accuracy: 0.7305

Epoch 29/150

77/77 [==============================] - 0s 805us/step - loss: 0.6265 - accuracy: 0.6940

Epoch 30/150

77/77 [==============================] - 0s 780us/step - loss: 0.5870 - accuracy: 0.6875

Epoch 31/150

77/77 [==============================] - 0s 837us/step - loss: 0.5821 - accuracy: 0.6979

Epoch 32/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5960 - accuracy: 0.7070

Epoch 33/150

77/77 [==============================] - 0s 880us/step - loss: 0.5827 - accuracy: 0.7135

Epoch 34/150

77/77 [==============================] - 0s 835us/step - loss: 0.5767 - accuracy: 0.7031

Epoch 35/150

77/77 [==============================] - 0s 824us/step - loss: 0.5661 - accuracy: 0.7188

Epoch 36/150

77/77 [==============================] - 0s 837us/step - loss: 0.5722 - accuracy: 0.7135

Epoch 37/150

77/77 [==============================] - 0s 824us/step - loss: 0.5604 - accuracy: 0.7096

Epoch 38/150

77/77 [==============================] - 0s 759us/step - loss: 0.5637 - accuracy: 0.7174

Epoch 39/150

77/77 [==============================] - 0s 801us/step - loss: 0.5523 - accuracy: 0.7266

Epoch 40/150

77/77 [==============================] - 0s 798us/step - loss: 0.5606 - accuracy: 0.7409

Epoch 41/150

77/77 [==============================] - 0s 812us/step - loss: 0.5540 - accuracy: 0.7318

Epoch 42/150

77/77 [==============================] - 0s 843us/step - loss: 0.5651 - accuracy: 0.7279

Epoch 43/150

77/77 [==============================] - 0s 836us/step - loss: 0.5714 - accuracy: 0.7031

Epoch 44/150

77/77 [==============================] - 0s 845us/step - loss: 0.5517 - accuracy: 0.7240

Epoch 45/150

77/77 [==============================] - 0s 855us/step - loss: 0.5664 - accuracy: 0.7383

Epoch 46/150

77/77 [==============================] - 0s 832us/step - loss: 0.5615 - accuracy: 0.7305

Epoch 47/150

77/77 [==============================] - 0s 837us/step - loss: 0.5571 - accuracy: 0.7148

Epoch 48/150

77/77 [==============================] - 0s 831us/step - loss: 0.5522 - accuracy: 0.7174

Epoch 49/150

77/77 [==============================] - 0s 854us/step - loss: 0.5585 - accuracy: 0.7253

Epoch 50/150

77/77 [==============================] - 0s 845us/step - loss: 0.5475 - accuracy: 0.7448

Epoch 51/150

77/77 [==============================] - 0s 839us/step - loss: 0.5490 - accuracy: 0.7357

Epoch 52/150

77/77 [==============================] - 0s 847us/step - loss: 0.5557 - accuracy: 0.7174

Epoch 53/150

77/77 [==============================] - 0s 807us/step - loss: 0.5386 - accuracy: 0.7396

Epoch 54/150

77/77 [==============================] - 0s 743us/step - loss: 0.5655 - accuracy: 0.7292

Epoch 55/150

77/77 [==============================] - 0s 840us/step - loss: 0.5452 - accuracy: 0.7344

Epoch 56/150

77/77 [==============================] - 0s 813us/step - loss: 0.5596 - accuracy: 0.7214

Epoch 57/150

77/77 [==============================] - 0s 739us/step - loss: 0.5517 - accuracy: 0.7253

Epoch 58/150

77/77 [==============================] - 0s 844us/step - loss: 0.5419 - accuracy: 0.7331

Epoch 59/150

77/77 [==============================] - 0s 960us/step - loss: 0.5458 - accuracy: 0.7240

Epoch 60/150

77/77 [==============================] - 0s 937us/step - loss: 0.5457 - accuracy: 0.7409

Epoch 61/150

77/77 [==============================] - 0s 911us/step - loss: 0.5382 - accuracy: 0.7201

Epoch 62/150

77/77 [==============================] - 0s 862us/step - loss: 0.5477 - accuracy: 0.7344

Epoch 63/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5238 - accuracy: 0.7461

Epoch 64/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5489 - accuracy: 0.7253

Epoch 65/150

77/77 [==============================] - 0s 841us/step - loss: 0.5394 - accuracy: 0.7266

Epoch 66/150

77/77 [==============================] - 0s 980us/step - loss: 0.5295 - accuracy: 0.7513

Epoch 67/150

77/77 [==============================] - 0s 960us/step - loss: 0.5479 - accuracy: 0.7461

Epoch 68/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5361 - accuracy: 0.7318

Epoch 69/150

77/77 [==============================] - 0s 948us/step - loss: 0.5587 - accuracy: 0.7174

Epoch 70/150

77/77 [==============================] - 0s 840us/step - loss: 0.5468 - accuracy: 0.7331

Epoch 71/150

77/77 [==============================] - 0s 809us/step - loss: 0.5281 - accuracy: 0.7461

Epoch 72/150

77/77 [==============================] - 0s 981us/step - loss: 0.5325 - accuracy: 0.7396

Epoch 73/150

77/77 [==============================] - 0s 965us/step - loss: 0.5451 - accuracy: 0.7331

Epoch 74/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5382 - accuracy: 0.7396

Epoch 75/150

77/77 [==============================] - 0s 979us/step - loss: 0.5529 - accuracy: 0.7461

Epoch 76/150

77/77 [==============================] - 0s 962us/step - loss: 0.5384 - accuracy: 0.7448

Epoch 77/150

77/77 [==============================] - 0s 895us/step - loss: 0.5279 - accuracy: 0.7396

Epoch 78/150

77/77 [==============================] - 0s 984us/step - loss: 0.5308 - accuracy: 0.7539

Epoch 79/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5179 - accuracy: 0.7448

Epoch 80/150

77/77 [==============================] - 0s 895us/step - loss: 0.5189 - accuracy: 0.7487

Epoch 81/150

77/77 [==============================] - 0s 996us/step - loss: 0.5163 - accuracy: 0.7409

Epoch 82/150

77/77 [==============================] - 0s 908us/step - loss: 0.5323 - accuracy: 0.7292

Epoch 83/150

77/77 [==============================] - 0s 919us/step - loss: 0.5258 - accuracy: 0.7539

Epoch 84/150

77/77 [==============================] - 0s 966us/step - loss: 0.5264 - accuracy: 0.7357

Epoch 85/150

77/77 [==============================] - 0s 883us/step - loss: 0.5242 - accuracy: 0.7539

Epoch 86/150

77/77 [==============================] - 0s 858us/step - loss: 0.5165 - accuracy: 0.7513

Epoch 87/150

77/77 [==============================] - 0s 930us/step - loss: 0.5079 - accuracy: 0.7487

Epoch 88/150

77/77 [==============================] - 0s 857us/step - loss: 0.5467 - accuracy: 0.7292

Epoch 89/150

77/77 [==============================] - 0s 923us/step - loss: 0.5172 - accuracy: 0.7357

Epoch 90/150

77/77 [==============================] - 0s 920us/step - loss: 0.5318 - accuracy: 0.7513

Epoch 91/150

77/77 [==============================] - 0s 960us/step - loss: 0.5202 - accuracy: 0.7552

Epoch 92/150

77/77 [==============================] - 0s 985us/step - loss: 0.5312 - accuracy: 0.7396

Epoch 93/150

77/77 [==============================] - 0s 964us/step - loss: 0.5193 - accuracy: 0.7383

Epoch 94/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5270 - accuracy: 0.7461

Epoch 95/150

77/77 [==============================] - 0s 986us/step - loss: 0.5008 - accuracy: 0.7539

Epoch 96/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5327 - accuracy: 0.7539

Epoch 97/150

77/77 [==============================] - 0s 874us/step - loss: 0.5426 - accuracy: 0.7539

Epoch 98/150

77/77 [==============================] - 0s 848us/step - loss: 0.5154 - accuracy: 0.7474

Epoch 99/150

77/77 [==============================] - 0s 842us/step - loss: 0.5108 - accuracy: 0.7435

Epoch 100/150

77/77 [==============================] - 0s 860us/step - loss: 0.5105 - accuracy: 0.7604

Epoch 101/150

77/77 [==============================] - 0s 844us/step - loss: 0.5483 - accuracy: 0.7487

Epoch 102/150

77/77 [==============================] - 0s 842us/step - loss: 0.4933 - accuracy: 0.7617

Epoch 103/150

77/77 [==============================] - 0s 840us/step - loss: 0.5038 - accuracy: 0.7591

Epoch 104/150

77/77 [==============================] - 0s 794us/step - loss: 0.5139 - accuracy: 0.7461

Epoch 105/150

77/77 [==============================] - 0s 820us/step - loss: 0.5128 - accuracy: 0.7552

Epoch 106/150

77/77 [==============================] - 0s 934us/step - loss: 0.5144 - accuracy: 0.7409

Epoch 107/150

77/77 [==============================] - 0s 968us/step - loss: 0.5027 - accuracy: 0.7539

Epoch 108/150

77/77 [==============================] - 0s 947us/step - loss: 0.5409 - accuracy: 0.7383

Epoch 109/150

77/77 [==============================] - 0s 928us/step - loss: 0.5137 - accuracy: 0.7604

Epoch 110/150

77/77 [==============================] - 0s 964us/step - loss: 0.5287 - accuracy: 0.7526

Epoch 111/150

77/77 [==============================] - 0s 981us/step - loss: 0.5069 - accuracy: 0.7578

Epoch 112/150

77/77 [==============================] - 0s 982us/step - loss: 0.5070 - accuracy: 0.7604

Epoch 113/150

77/77 [==============================] - 0s 951us/step - loss: 0.5052 - accuracy: 0.7487

Epoch 114/150

77/77 [==============================] - 0s 893us/step - loss: 0.5125 - accuracy: 0.7396

Epoch 115/150

77/77 [==============================] - 0s 866us/step - loss: 0.4955 - accuracy: 0.7695

Epoch 116/150

77/77 [==============================] - 0s 859us/step - loss: 0.5204 - accuracy: 0.7318

Epoch 117/150

77/77 [==============================] - 0s 863us/step - loss: 0.5034 - accuracy: 0.7630

Epoch 118/150

77/77 [==============================] - 0s 874us/step - loss: 0.5104 - accuracy: 0.7539

Epoch 119/150

77/77 [==============================] - 0s 999us/step - loss: 0.5043 - accuracy: 0.7552

Epoch 120/150

77/77 [==============================] - 0s 944us/step - loss: 0.4900 - accuracy: 0.7565

Epoch 121/150

77/77 [==============================] - 0s 976us/step - loss: 0.5044 - accuracy: 0.7617

Epoch 122/150

77/77 [==============================] - 0s 897us/step - loss: 0.5015 - accuracy: 0.7604

Epoch 123/150

77/77 [==============================] - 0s 1ms/step - loss: 0.5006 - accuracy: 0.7578

Epoch 124/150

77/77 [==============================] - 0s 926us/step - loss: 0.4846 - accuracy: 0.7513

Epoch 125/150

77/77 [==============================] - 0s 874us/step - loss: 0.4957 - accuracy: 0.7773

Epoch 126/150

77/77 [==============================] - 0s 980us/step - loss: 0.4955 - accuracy: 0.7656

Epoch 127/150

77/77 [==============================] - 0s 757us/step - loss: 0.4934 - accuracy: 0.7578

Epoch 128/150

77/77 [==============================] - 0s 816us/step - loss: 0.4901 - accuracy: 0.7591

Epoch 129/150

77/77 [==============================] - 0s 942us/step - loss: 0.4840 - accuracy: 0.7539

Epoch 130/150

77/77 [==============================] - 0s 836us/step - loss: 0.4954 - accuracy: 0.7669

Epoch 131/150

77/77 [==============================] - 0s 842us/step - loss: 0.4801 - accuracy: 0.7826

Epoch 132/150

77/77 [==============================] - 0s 862us/step - loss: 0.5015 - accuracy: 0.7591

Epoch 133/150

77/77 [==============================] - 0s 998us/step - loss: 0.4860 - accuracy: 0.7812

Epoch 134/150

77/77 [==============================] - 0s 824us/step - loss: 0.4888 - accuracy: 0.7617

Epoch 135/150

77/77 [==============================] - 0s 850us/step - loss: 0.4972 - accuracy: 0.7630

Epoch 136/150

77/77 [==============================] - 0s 842us/step - loss: 0.4969 - accuracy: 0.7604

Epoch 137/150

77/77 [==============================] - 0s 712us/step - loss: 0.4947 - accuracy: 0.7656

Epoch 138/150

77/77 [==============================] - 0s 843us/step - loss: 0.4831 - accuracy: 0.7695

Epoch 139/150

77/77 [==============================] - 0s 841us/step - loss: 0.4873 - accuracy: 0.7760

Epoch 140/150

77/77 [==============================] - 0s 807us/step - loss: 0.4784 - accuracy: 0.7852

Epoch 141/150

77/77 [==============================] - 0s 844us/step - loss: 0.4855 - accuracy: 0.7604

Epoch 142/150

77/77 [==============================] - 0s 853us/step - loss: 0.4801 - accuracy: 0.7734

Epoch 143/150

77/77 [==============================] - 0s 743us/step - loss: 0.5038 - accuracy: 0.7643

Epoch 144/150

77/77 [==============================] - 0s 849us/step - loss: 0.4900 - accuracy: 0.7682

Epoch 145/150

77/77 [==============================] - 0s 827us/step - loss: 0.4738 - accuracy: 0.7695

Epoch 146/150

77/77 [==============================] - 0s 874us/step - loss: 0.4955 - accuracy: 0.7630

Epoch 147/150

77/77 [==============================] - 0s 839us/step - loss: 0.5015 - accuracy: 0.7695

Epoch 148/150

77/77 [==============================] - 0s 849us/step - loss: 0.4881 - accuracy: 0.7630

Epoch 149/150

77/77 [==============================] - 0s 825us/step - loss: 0.4868 - accuracy: 0.7643

Epoch 150/150

77/77 [==============================] - 0s 789us/step - loss: 0.4866 - accuracy: 0.7565

Out[6]:

<keras.callbacks.History at 0x1d179d32160>

# evaluate the keras model

# \_,accuracy = model.evaluate(x,y)

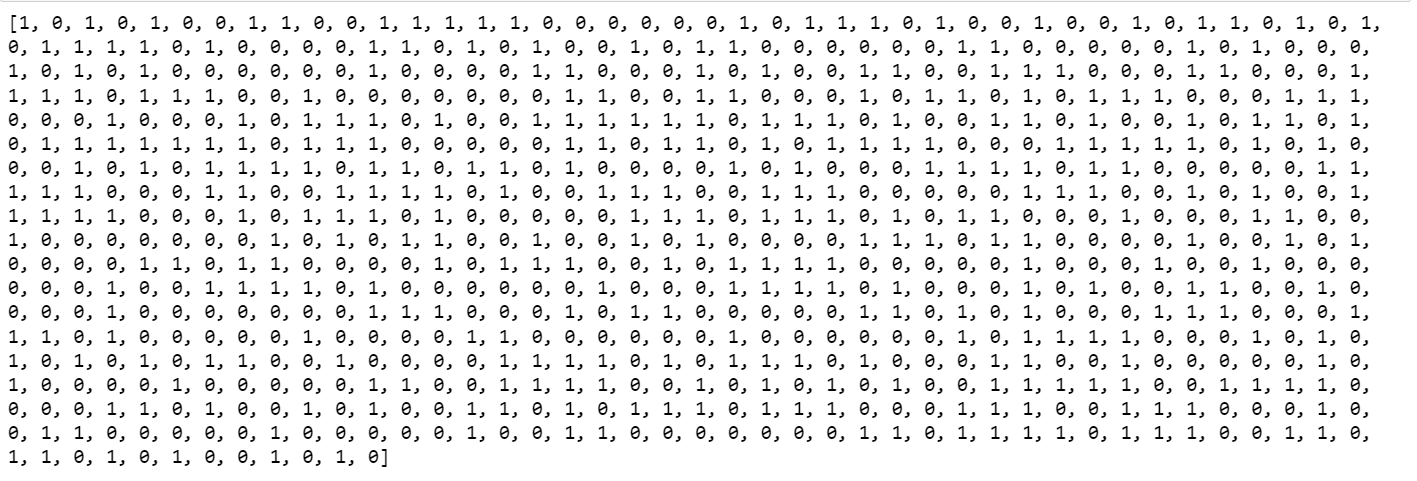
# print('Model Accuracy: %.2f'%(accuracy\*100))

24/24 [==============================] - 0s 870us/step - loss: 0.5013 - accuracy: 0.7643

Model Accuracy: 76.43

predictions = model.predict(x)

print([round(x[0]) for x in predictions])



model.summary()

Model: "sequential"

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Layer (type) Output Shape Param #

=================================================================

dense (Dense) (None, 12) 108

dense\_1 (Dense) (None, 12) 156

dense\_2 (Dense) (None, 1) 13

=================================================================

Total params: 277

Trainable params: 277

Non-trainable params: 0

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**Deep learning on ionosphere**

# pytorch mlp for binary classification

from numpy import vstack

from pandas import read\_csv

from sklearn.preprocessing import LabelEncoder

from sklearn.metrics import accuracy\_score

from torch.utils.data import Dataset

from torch.utils.data import DataLoader

from torch.utils.data import random\_split

from torch import Tensor

from torch.nn import Linear

from torch.nn import ReLU

from torch.nn import Sigmoid

from torch.nn import Module

from torch.optim import SGD

from torch.nn import BCELoss

from torch.nn.init import kaiming\_uniform\_

from torch.nn.init import xavier\_uniform\_

# dataset definition

class CSVDataset(Dataset):

# load the dataset

def \_\_init\_\_(self, path):

# load the csv file as a dataframe

df = read\_csv(path, header=None)

# store the inputs and outputs

self.X = df.values[:, :-1]

self.y = df.values[:, -1]

# ensure input data is floats

self.X = self.X.astype('float32')

# label encode target and ensure the values are floats

self.y = LabelEncoder().fit\_transform(self.y)

self.y = self.y.astype('float32')

self.y = self.y.reshape((len(self.y), 1))

# number of rows in the dataset

def \_\_len\_\_(self):

return len(self.X)

# get a row at an index

def \_\_getitem\_\_(self, idx):

return [self.X[idx], self.y[idx]]

# get indexes for train and test rows

def get\_splits(self, n\_test=0.33):

# determine sizes

test\_size = round(n\_test \* len(self.X))

train\_size = len(self.X) - test\_size

# calculate the split

return random\_split(self, [train\_size, test\_size])

# model definition

class MLP(Module):

# define model elements

def \_\_init\_\_(self, n\_inputs):

super(MLP, self).\_\_init\_\_()

# input to first hidden layer

self.hidden1 = Linear(n\_inputs, 10)

kaiming\_uniform\_(self.hidden1.weight, nonlinearity='relu')

self.act1 = ReLU()

# second hidden layer

self.hidden2 = Linear(10, 8)

kaiming\_uniform\_(self.hidden2.weight, nonlinearity='relu')

self.act2 = ReLU()

# third hidden layer and output

self.hidden3 = Linear(8, 1)

xavier\_uniform\_(self.hidden3.weight)

self.act3 = Sigmoid()

# forward propagate input

def forward(self, X):

# input to first hidden layer

X = self.hidden1(X)

X = self.act1(X)

# second hidden layer

X = self.hidden2(X)

X = self.act2(X)

# third hidden layer and output

X = self.hidden3(X)

X = self.act3(X)

return X

# prepare the dataset

def prepare\_data(path):

# load the dataset

dataset = CSVDataset(path)

# calculate split

train, test = dataset.get\_splits()

# prepare data loaders

train\_dl = DataLoader(train, batch\_size=32, shuffle=True)

test\_dl = DataLoader(test, batch\_size=1024, shuffle=False)

return train\_dl, test\_dl

# train the model

def train\_model(train\_dl, model):

# define the optimization

criterion = BCELoss()

optimizer = SGD(model.parameters(), lr=0.01, momentum=0.9)

# enumerate epochs

for epoch in range(100):

# enumerate mini batches

for i, (inputs, targets) in enumerate(train\_dl):

# clear the gradients

optimizer.zero\_grad()

# compute the model output

yhat = model(inputs)

# calculate loss

loss = criterion(yhat, targets)

# credit assignment

loss.backward()

# update model weights

optimizer.step()

# evaluate the model

def evaluate\_model(test\_dl, model):

predictions, actuals = list(), list()

for i, (inputs, targets) in enumerate(test\_dl):

# evaluate the model on the test set

yhat = model(inputs)

# retrieve numpy array

yhat = yhat.detach().numpy()

actual = targets.numpy()

actual = actual.reshape((len(actual), 1))

# round to class values

yhat = yhat.round()

# store

predictions.append(yhat)

actuals.append(actual)

predictions, actuals = vstack(predictions), vstack(actuals)

# calculate accuracy

acc = accuracy\_score(actuals, predictions)

return acc

# make a class prediction for one row of data

def predict(row, model):

# convert row to data

row = Tensor([row])

# make prediction

yhat = model(row)

# retrieve numpy array

yhat = yhat.detach().numpy()

return yhat

# prepare the data

path = 'https://raw.githubusercontent.com/jbrownlee/Datasets/master/ionosphere.csv'

train\_dl, test\_dl = prepare\_data(path)

print(len(train\_dl.dataset), len(test\_dl.dataset))

# define the network

model = MLP(34)

# train the model

train\_model(train\_dl, model)

# evaluate the model

acc = evaluate\_model(test\_dl, model)

print('Accuracy: %.3f' % acc)

# make a single prediction (expect class=1)

row = [1,0,0.99539,-0.05889,0.85243,0.02306,0.83398,-0.37708,1,0.03760,0.85243,-0.17755,0.59755,-0.44945,0.60536,-0.38223,0.84356,-0.38542,0.58212,-0.32192,0.56971,-0.29674,0.36946,-0.47357,0.56811,-0.51171,0.41078,-0.46168,0.21266,-0.34090,0.42267,-0.54487,0.18641,-0.45300]

yhat = predict(row, model)

print('Predicted: %.3f (class=%d)' % (yhat, yhat.round()))

235 116

Accuracy: 0.888

Predicted: 0.966 (class=1)