In [1]:
```
import sklearn as sk
from sklearn import datasets
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
import tensorflow as tf
from tensorflow.python.keras.callbacks import TensorBoard
from time import time
from sklearn.metrics import classification_report,confusion_matrix
from sklearn import preprocessing
from sklearn.preprocessing import LabelEncoder
from keras.utils import np_utils
from keras.utils.np_utils import to_categorical
import torch
import torch.nn as nn #PyTorch's module wrapper
import torch.optim as optim #PyTorch's optimiser
from torch.autograd import Variable #
import numpy as np
```

```
/anaconda3/lib/python3.6/site-packages/h5py/__init__.py:36: FutureWarning: Conve
rsion of the second argument of issubdtype from `float` to `np.floating` is depr
ecated. In future, it will be treated as `np.float64 == np.dtype(float).type`.
  from ._conv import register_converters as _register_converters
Using TensorFlow backend.
```

In [2]:
```
iris = datasets.load_iris()
print(iris.DESCR)
```

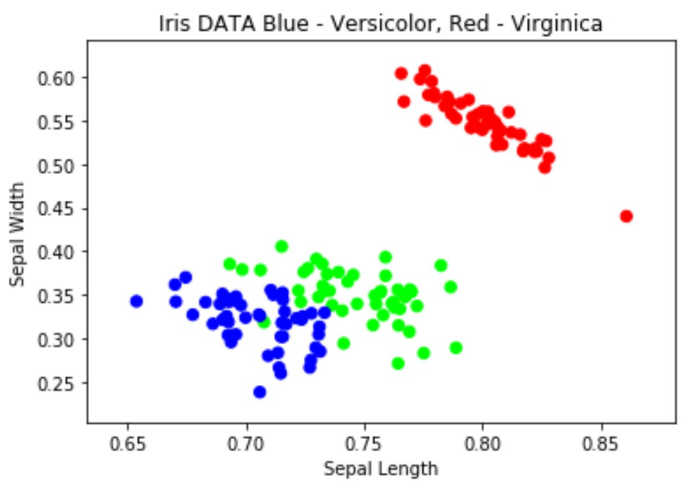
```
.. _iris_dataset:

Iris plants dataset
--------------------

**Data Set Characteristics:**

    :Number of Instances: 150 (50 in each of three classes)
    :Number of Attributes: 4 numeric, predictive attributes and the class
    :Attribute Information:
        - sepal length in cm
        - sepal width in cm
        - petal length in cm
        - petal width in cm
        - class:
                - Iris-Setosa
                - Iris-Versicolour
                - Iris-Virginica

    :Summary Statistics:

    ============== ==== ==== ======= ===== ====================
                    Min  Max   Mean    SD   Class Correlation
    ============== ==== ==== ======= ===== ====================
    sepal length:   4.3  7.9   5.84   0.83    0.7826
    sepal width:    2.0  4.4   3.05   0.43   -0.4194
    petal length:   1.0  6.9   3.76   1.76    0.9490  (high!)
    petal width:    0.1  2.5   1.20   0.76    0.9565  (high!)
    ============== ==== ==== ======= ===== ====================

    :Missing Attribute Values: None
    :Class Distribution: 33.3% for each of 3 classes.
    :Creator: R.A. Fisher
    :Donor: Michael Marshall (MARSHALL%PLU@io.arc.nasa.gov)
    :Date: July, 1988

The famous Iris database, first used by Sir R.A. Fisher. The dataset is taken
from Fisher's paper. Note that it's the same as in R, but not as in the UCI
Machine Learning Repository, which has two wrong data points.

This is perhaps the best known database to be found in the
pattern recognition literature.  Fisher's paper is a classic in the field and
is referenced frequently to this day.  (See Duda & Hart, for example.)  The
data set contains 3 classes of 50 instances each, where each class refers to a
type of iris plant.  One class is linearly separable from the other 2; the
latter are NOT linearly separable from each other.

.. topic:: References

   - Fisher, R.A. "The use of multiple measurements in taxonomic problems"
     Annual Eugenics, 7, Part II, 179-188 (1936); also in "Contributions to
     Mathematical Statistics" (John Wiley, NY, 1950).
   - Duda, R.O., & Hart, P.E. (1973) Pattern Classification and Scene Analysis.
     (Q327.D83) John Wiley & Sons.  ISBN 0-471-22361-1.  See page 218.
   - Dasarathy, B.V. (1980) "Nosing Around the Neighborhood: A New System
     Structure and Classification Rule for Recognition in Partially Exposed
     Environments".  IEEE Transactions on Pattern Analysis and Machine
     Intelligence, Vol. PAMI-2, No. 1, 67-71.
   - Gates, G.W. (1972) "The Reduced Nearest Neighbor Rule".  IEEE Transactions
     on Information Theory, May 1972, 431-433.
   - See also: 1988 MLC Proceedings, 54-64.  Cheeseman et al"s AUTOCLASS II
     conceptual clustering system finds 3 classes in the data.
   - Many, many more ...
```

In [3]:
```
X = iris.data # We take the first two features
X = preprocessing.normalize(X)
Y = iris.target
print(X.shape)
```

```
(150, 4)
```

In [4]:
```
encoder = LabelEncoder()
encoder.fit(Y)
Y = encoder.transform(Y)
Y = np_utils.to_categorical(Y)
```

In [5]:
```
plt.scatter(X[:,0], X[:,1], c=Y, s=40, cmap=plt.cm.Spectral)
plt.title('Iris DATA Blue - Versicolor, Red - Virginica')
plt.xlabel('Sepal Length')
plt.ylabel('Sepal Width')
plt.show()
```



In [6]:
```
X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size = 0.2)
```

In [7]:
```
print(X_train.shape)
print(X_test.shape)
print(y_train.shape)
print(y_test.shape)
```

```
(120, 4)
(30, 4)
(120, 3)
(30, 3)
```

TensorFlow - Keras Neural Networks

model2 = tf.keras.models.Sequential([tf.keras.layers.Flatten(), tf.keras.layers.Dense(4,input_shape=(4,),activation='relu'), tf.keras.layers.Dropout(0), tf.keras.layers.Dense(5, activation="relu"), tf.keras.layers.Dense(3, activation="softmax")]) adam = tf.keras.optimizers.Adam() model2.compile(optimizer=adam, loss='categorical_crossentropy', # Sparse as the classification is numerical metrics=['accuracy']) tensorboard = TensorBoard(log_dir="logs/".format(time)) y_pred = model2.predict_classes(x=X_test) history = model2.fit(X_train, y_train, epochs=10, batch_size = 2, shuffle=True, callbacks=[tensorboard]) print(model2.evaluate(X_test, y_test)) print(y_pred2)

In [8]:
```
input_dim = 4 # The four features of the dataset

model = tf.keras.models.Sequential([
    tf.keras.layers.Dense(4, input_dim = input_dim), # no activation function for i
nput
    tf.keras.layers.Dense(10, activation = 'relu'),
    tf.keras.layers.Dense(3, activation = 'softmax')
])

model.compile(optimizer = 'adam', loss = 'categorical_crossentropy',  metrics = ['a
ccuracy'] )
tensorboard = TensorBoard(log_dir="/Users/jon/Documents/LSBU/2\ Statistical\ Analys
is\ and\ Modeling/Paper\ 6\ January/logs/".format(time))
model.fit(X_train, y_train, epochs = 100, batch_size = 10, callbacks=[tensorboard])

scores = model.evaluate(X_test, y_test)
print("\n%s: %.2f%%" % (model.metrics_names[1], scores[1]*100))
```

```
Epoch 1/100
120/120 [==============================] - 0s 2ms/step - loss: 1.1534 - acc: 0.3
417
Epoch 2/100
120/120 [==============================] - 0s 361us/step - loss: 1.1413 - acc: 0
.3417
Epoch 3/100
120/120 [==============================] - 0s 395us/step - loss: 1.1317 - acc: 0
.3417
Epoch 4/100
120/120 [==============================] - 0s 360us/step - loss: 1.1255 - acc: 0
.3417
Epoch 5/100
120/120 [==============================] - 0s 318us/step - loss: 1.1194 - acc: 0
.3417
Epoch 6/100
120/120 [==============================] - 0s 308us/step - loss: 1.1144 - acc: 0
.3417
Epoch 7/100
120/120 [==============================] - 0s 386us/step - loss: 1.1097 - acc: 0
.3417
Epoch 8/100
120/120 [==============================] - 0s 335us/step - loss: 1.1060 - acc: 0
.3417
Epoch 9/100
120/120 [==============================] - 0s 363us/step - loss: 1.1023 - acc: 0
.3417
Epoch 10/100
120/120 [==============================] - 0s 370us/step - loss: 1.0993 - acc: 0
.3417
Epoch 11/100
120/120 [==============================] - 0s 356us/step - loss: 1.0965 - acc: 0
.3417
Epoch 12/100
120/120 [==============================] - 0s 363us/step - loss: 1.0932 - acc: 0
.3417
Epoch 13/100
120/120 [==============================] - 0s 337us/step - loss: 1.0901 - acc: 0
.3417
Epoch 14/100
120/120 [==============================] - 0s 332us/step - loss: 1.0871 - acc: 0
.3417
Epoch 15/100
120/120 [==============================] - 0s 370us/step - loss: 1.0842 - acc: 0
.3417
Epoch 16/100
120/120 [==============================] - 0s 326us/step - loss: 1.0809 - acc: 0
.3417
Epoch 17/100
120/120 [==============================] - 0s 355us/step - loss: 1.0775 - acc: 0
.3417
Epoch 18/100
120/120 [==============================] - 0s 343us/step - loss: 1.0734 - acc: 0
.3417
Epoch 19/100
120/120 [==============================] - 0s 332us/step - loss: 1.0695 - acc: 0
.3500
Epoch 20/100
120/120 [==============================] - 0s 455us/step - loss: 1.0655 - acc: 0
.3667
Epoch 21/100
120/120 [==============================] - 0s 325us/step - loss: 1.0608 - acc: 0
.4333
Epoch 22/100
```

Accuracy of the neural network

In [9]:
```
prediction_tf = model.predict(X_test)

predicted_values = []
for num in range(len(prediction_tf)):
    predicted_values.append(np.argmax(prediction_tf[num]))

test_values = []
for item in y_test:
    test_values.append(np.argmax(item))
correct = 0

for prediction, test in zip(predicted_values, test_values):
    if prediction == test:
        correct = correct+1

accuracy = correct/len(predicted_values)

print("The accuracy of the model is: "+str(accuracy*100)+"%")
```

```
The accuracy of the model is: 96.66666666666667%
```

In [10]:
```
confusion_matrix(y_true=test_values, y_pred=predicted_values)
```

Out[10]:
```
array([[ 8,  0,  0],
       [ 0, 12,  1],
       [ 0,  0,  9]])
```

Pytorch

In [11]:
```
X_train_tensor = Variable(torch.FloatTensor(X_train), requires_grad = False)
y_train_tensor = Variable(torch.FloatTensor(y_train), requires_grad = False)
X_test_tensor = Variable(torch.FloatTensor(X_test), requires_grad = False)
y_test_tensor = Variable(torch.FloatTensor(y_test), requires_grad = False)
```

In [12]:
```
print(X_train_tensor[0])
```

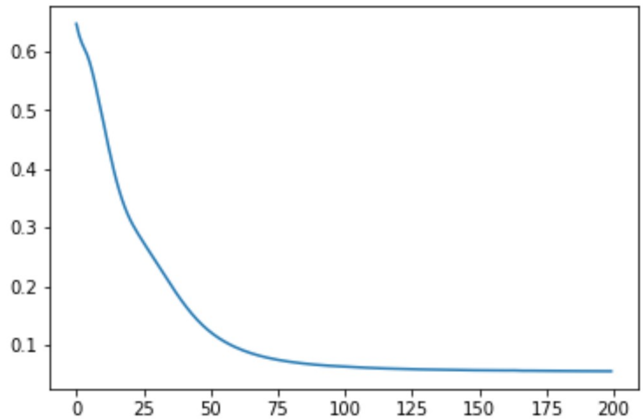
```
tensor([0.7692, 0.3077, 0.5385, 0.1538])
```

In [13]:
```
class LinearClassifier(nn.Module):
    def __init__(self):
        super(LinearClassifier, self).__init__()
        self.h_layer = nn.Linear(4, 10)
        self.act_h = nn.ReLU()
        self.i_layer = nn.Linear(10, 3)
        self.s_layer = nn.Softmax()
    def forward(self,x):
        y = self.h_layer(x)
        a = self.act_h(y)
        q = self.i_layer(a)
        p = self.s_layer(q)
        return q
model_pytorch = LinearClassifier()
loss_fn = nn.BCELoss() # calculates the loss
optim = torch.optim.Adam(model_pytorch.parameters(), lr = 0.04)
```

In [14]:
```
all_losses = []
for num in range(200):
    pred = model_pytorch(X_train_tensor) # this predicts the class of training data
    loss = loss_fn(pred, y_train_tensor) # calculates loss based on real values
    all_losses.append(loss.data)
    optim.zero_grad()
    loss.backward() # updates the weights based on loss
    optim.step() # update optimiser for next iteration
```

```
/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:12: UserWarning: Im
plicit dimension choice for softmax has been deprecated. Change the call to incl
ude dim=X as an argument.
  if sys.path[0] == '':
```

In [15]:
```
%matplotlib inline
all_losses = np.array(all_losses, dtype = np.float)
plt.plot(all_losses)
plt.show()
print(pred[3])
print(y_train_tensor[3])
print(all_losses[-1])
```




```
tensor([1.5540e-04, 9.2472e-01, 7.5129e-02], grad_fn=<SelectBackward>)
tensor([0., 1., 0.])
0.055241093039512634
```

In [16]:
```
from sklearn.metrics import accuracy_score
predicted_values_pytorch_tensor = []
for num in range(len(X_test_tensor)):
    predicted_values_pytorch_tensor.append(model_pytorch(X_test_tensor[num]))
```

```
/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:12: UserWarning: Im
plicit dimension choice for softmax has been deprecated. Change the call to incl
ude dim=X as an argument.
  if sys.path[0] == '':
```

In [17]:
```
predicted_values_pytorch = []
for item in predicted_values_pytorch_tensor:
    predicted_values_pytorch.append(np.argmax(item.data.numpy()))

print(predicted_values_pytorch)

test_values_pytorch = []
for item in y_test:
    test_values_pytorch.append(np.argmax(item))

correct_pytorch = 0
for prediction_pytorch, test_pytorch in zip(predicted_values_pytorch, test_values_p
ytorch):
    if prediction_pytorch == test_pytorch:
        correct_pytorch = correct_pytorch+1

accuracy_pytorch = correct_pytorch/len(predicted_values_pytorch)

print("The accuracy of the model using pytorch is: "+str(accuracy_pytorch*100)+"%")
```

```
[2, 0, 1, 1, 2, 0, 0, 1, 2, 0, 1, 1, 0, 2, 1, 2, 1, 1, 2, 1, 1, 0, 0, 2, 2, 1, 1
, 2, 2, 0]
The accuracy of the model using pytorch is: 96.66666666666667%
```

In [18]:
```
print(predicted_values_pytorch)
```

```
[2, 0, 1, 1, 2, 0, 0, 1, 2, 0, 1, 1, 0, 2, 1, 2, 1, 1, 2, 1, 1, 0, 0, 2, 2, 1, 1
, 2, 2, 0]
```

In [19]:
```
y_test_tensor
```

Out[19]:
```
tensor([[0., 0., 1.],
        [1., 0., 0.],
        [0., 1., 0.],
        [0., 1., 0.],
        [0., 0., 1.],
        [1., 0., 0.],
        [1., 0., 0.],
        [0., 1., 0.],
        [0., 0., 1.],
        [1., 0., 0.],
        [0., 1., 0.],
        [0., 1., 0.],
        [1., 0., 0.],
        [0., 1., 0.],
        [0., 1., 0.],
        [0., 0., 1.],
        [0., 1., 0.],
        [0., 1., 0.],
        [0., 0., 1.],
        [0., 1., 0.],
        [0., 1., 0.],
        [1., 0., 0.],
        [1., 0., 0.],
        [0., 0., 1.],
        [0., 0., 1.],
        [0., 1., 0.],
        [0., 1., 0.],
        [0., 0., 1.],
        [0., 0., 1.],
        [1., 0., 0.]])
```

```
In [ ]:
```