In [1]:

```
from sklearn.datasets import make_gaussian_quantiles
import numpy as np
import matplotlib.pyplot as plt
from sklearn.neighbors import KDTree
from matplotlib.colors import ListedColormap
import numpy as np
import matplotlib.pyplot as plt
from matplotlib.colors import ListedColormap
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.datasets import make_moons, make_circles, make_classificati
on
from sklearn.neural_network import MLPClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC
from sklearn.gaussian_process import GaussianProcessClassifier
from sklearn.gaussian_process.kernels import RBF
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier, AdaBoostClassifier
from sklearn.naive_bayes import GaussianNB
from sklearn.discriminant_analysis import QuadraticDiscriminantAnalysis
from sklearn.cluster import KMeans

%matplotlib inline
```

In [2]:

```
from sklearn.datasets import make_gaussian_quantiles,make_moons,make_cla
ssification,make_circles
# Construct dataset
# X1, y1 = make_gaussian_quantiles(cov=3.,
#                                  n_samples=10000, n_features=2,
#                                  n_classes=2, random_state=1)
X, y = make_classification(n_features=2, n_redundant=0, n_informative=2,
                           random_state=1, n_clusters_per_class=1,n_samp
les=1000)
rng = np.random.RandomState(2)
X += 2 * rng.uniform(size=X.shape)
linearly_separable = (X, y)

datasets = [make_moons(noise=0.3, random_state=0,n_samples=1000),
            make_circles(noise=0.2, factor=0.5, random_state=1,n_samples
=1000),
            linearly_separable
            ]
```

In [3]:

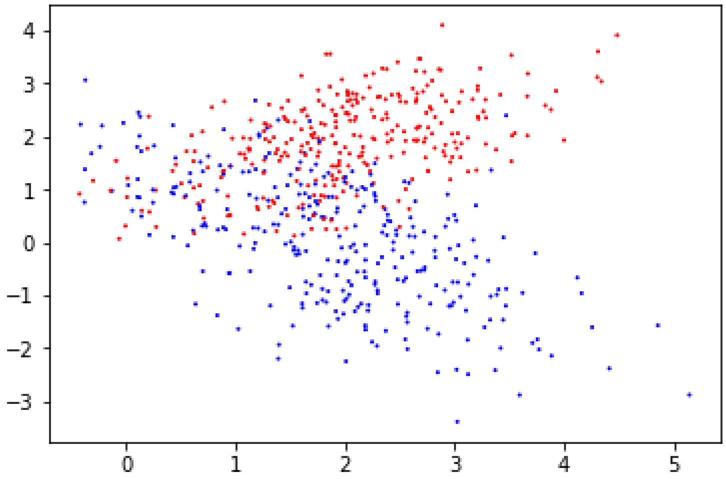
```
X, y = datasets[2]
```

In [4]:

```
x_train, x_test, y_train, y_test = \
        train_test_split(X, y, test_size=.4, random_state=42)
```

In [5]:

```
cm_bright = ListedColormap(['#FF0000', '#0000FF'])
plt.scatter(x_train[:, 0], x_train[:, 1], c=y_train,
            s=1, cmap=cm_bright);
```



In [6]:

```
var = np.var(x_train,axis = 0)
mean = np.mean(x_train,axis = 0)
```

In [7]:

```
C = 32 # partition sum
classes = 2

M = np.random.multivariate_normal(mean,[[var[0],0],[0,var[1]]],(C))

x_train.max()

# M[:,1] = (M[:,1] -0.5) * 4 + 2

PI = np.random.rand(C,classes)
k = 10
# PI = np.ones((C,classes))*0.5
```

In [8]:

```
def dist_softmax_forward(M,x, beta = 10):#M shape (C,2) x (2)
    x_as_M = np.tile(np.expand_dims(x,axis = 0),(C,1))
    ex = np.exp(-beta * np.sum((M - x_as_M)**2,axis = 1)/2)
    W = ex/np.sum(ex)
    return W
```

In [9]:

```
def find_knn(X,k = 10):
    tree = KDTree(x_train, leaf_size=2)
    dist, ind = tree.query(x_train, k=k)
    return dist, ind
```

In [10]:

```
dist, ind = find_knn(x_train)
```

In [11]:

```
Px = np.zeros((len(x_train),classes))

for m in range(len(x_train)):
    for n in range(k):
        Px[m][y_train[ind[m]][n]] += 1.

Px = Px/k
```

In [12]:

```
W_set = []
for i in range(len(x_train)):
    W_set.append (dist_softmax_forward(M,x_train[i]))
```

In [13]:

```
def empirical_info_loss(M,PI,X,Y,k = 10):

    L = 0

    for i in range(len(X)):


        for k in range(C):

            m = Px[i]/PI[k]




            Div = np.sum(Px[i] * np.where(m != 0, np.log2(m), 0))
            L += W_set[i][k] * Div

    return L
```

In [14]:

```
def update_m(M,PI,X,Y,alpha = 0.01,beta = 10,k = 10):

    D = np.zeros(M.shape)

    for i in range(len(X)):

        for j in range(C):
            PxPI = Px[i]/PI[j]

            Div = np.sum(Px[i] * np.where(PxPI != 0, np.log2(PxPI), 0))


            x_as_M = np.tile(np.expand_dims(X[i],axis = 0),(C,1))


            dwj_dmk = beta * np.tile(np.expand_dims(- W_set[i] * W_set[i
][j],axis = 1),(1,2)) * (x_as_M - M)


            dwj_dmk[j] += beta * W_set[i][j]* (x_as_M - M)[j]



            D = D + Div * dwj_dmk
    M[:] = M - alpha * D
```

In [15]:

```
def update_pi(M,PI,X,Y,k = 10):

    U = np.zeros((C,classes))

    for k in range(C):
        for i in range(len(X)):
            U[k] = U[k] + W_set[i][k] * Px[i]
#             print(W[k]*Px[i])

    L = np.tile(np.expand_dims(np.sum(U,axis = 1),axis = 1),(1,classes))
    PI[:] = (U/L)[:]
```

In [16]:

```
W_set = []
loss = []
for i in range(len(x_train)):
    W_set.append (dist_softmax_forward(M,x_train[i]))

for i in range(0,100):

    update_pi(M,PI,x_train,y_train)
    update_m(M,PI,x_train,y_train)
    L = empirical_info_loss(M,PI,x_train,y_train)

    print(i,L)
    loss.append(L)
    W_set = []
    for i in range(len(x_train)):
        W_set.append (dist_softmax_forward(M,x_train[i]))
```

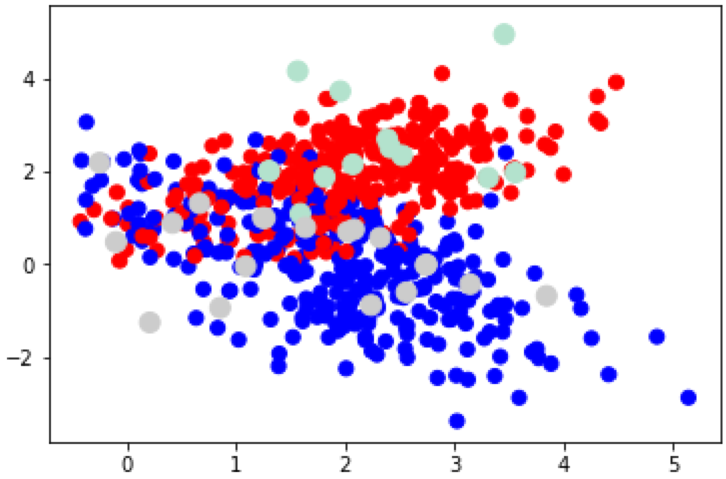
```
/home/leeyh/anaconda2/envs/py36/lib/python3.6/site-packages/ipykernel_l
auncher.py:10: RuntimeWarning: divide by zero encountered in log2
  # Remove the CWD from sys.path while we load stuff.
/home/leeyh/anaconda2/envs/py36/lib/python3.6/site-packages/ipykernel_l
auncher.py:15: RuntimeWarning: divide by zero encountered in log2
  from ipykernel import kernelapp as app
```

```
0 54.450079429523534
1 52.1038453753654
2 49.97263092822772
3 48.44009783641379
4 47.27077769132966
5 46.32251128071526
6 45.53990129032479
7 44.88615007685071
8 44.33446207266498
9 43.86497686760983
10 43.46253521062253
11 43.11517599313998
12 42.81324204642127
13 42.548858237802726
14 42.31559040268097
15 42.10818322953529
16 41.92234230308493
17 41.75455478081589
18 41.60194717244182
19 41.46217448823866
20 41.333332334863044
21 41.213884275982906
22 41.10259926409593
23 40.99849637810815
24 40.90079569739012
25 40.8088749392312
26 40.722231787625695
27 40.640451905930576
28 40.563182586711584
29 40.490111892852255
30 40.42095299726373
31 40.35543325227764
32 40.293287346217156
33 40.23425377161562
34 40.178073766443624
35 40.124491907723026
36 40.07325762754347
37 40.02412706205476
38 39.97686480613946
39 39.93124530445293
40 39.88705374499555
41 39.844086425033744
42 39.8021506295105
43 39.76106410303717
44 39.72065421465647
45 39.68075691718659
46 39.64121559639226
47 39.6018798946887
48 39.56260458298641
49 39.52324854492888
50 39.48367393126479
51 39.44374553885773
52 39.40333046870139
53 39.3622981196062
54 39.32052057786597
55 39.27787346647965
56 39.23423731810777
```

```
57 39.18949953087161
58 39.14355695180417
59 39.09631910539208
60 39.04771204084558
61 38.99768270937926
62 38.94620370240211
63 38.89327808711255
64 38.83894397610844
65 38.78327837520941
66 38.72639978610981
67 38.66846901842537
68 38.60968771220751
69 38.55029420923031
70 38.49055665335353
71 38.430763540012045
72 38.371212328433344
73 38.31219708933459
74 38.25399636972019
75 38.19686241867561
76 38.1410126172791
77 38.086623487693274
78 38.033827197078246
79 37.98271018712144
80 37.93331351274812
81 37.88563459502708
82 37.839630238815246
83 37.795220813759755
84 37.75229541893402
85 37.710717707870955
86 37.67033193617802
87 37.630968772840646
88 37.59245049746618
89 37.554595354232696
90 37.51722100080318
91 37.480147139422854
92 37.44319753016913
93 37.40620166237557
94 37.368996407684335
95 37.33142800524173
96 37.293354738530354
97 37.254650645795465
98 37.21521054076392
99 37.17495647366496
```

In [17]:

```
plt.scatter(x_train[:, 0], x_train[:, 1], c=y_train,
            s=50, cmap=cm_bright);
plt.scatter(M[:, 0], M[:, 1], c=np.argmax(PI,axis = 1),
            s=100, cmap='Pastel2');
```



In [18]:

```
h = .02
x_min, x_max = X[:, 0].min() - .5, X[:, 0].max() + .5
y_min, y_max = X[:, 1].min() - .5, X[:, 1].max() + .5
xx, yy = np.meshgrid(np.arange(x_min, x_max, h),
                     np.arange(y_min, y_max, h))
```

In [19]:

```
def predict_proba(M,PI,X):
    tree = KDTree(M, leaf_size=2)
    dist, ind = tree.query(X, k=1)
    return dist,ind
```

In [20]:

```
dist,ind = predict_proba(M,PI,x_test)
```

In [21]:

```
Z = PI[ind][:,0,:]
```

In [22]:

```
s = (np.argmax(Z,axis = 1) == y_test)
score = s.sum()/len(s)
```

In [23]:

```
dist,ind = predict_proba(M,PI,np.c_[xx.ravel(), yy.ravel()])
```

In [24]:

```
Z = PI[ind][:,0,1]
```

In [25]:

```
Z = Z.reshape(xx.shape)
```

In [26]:

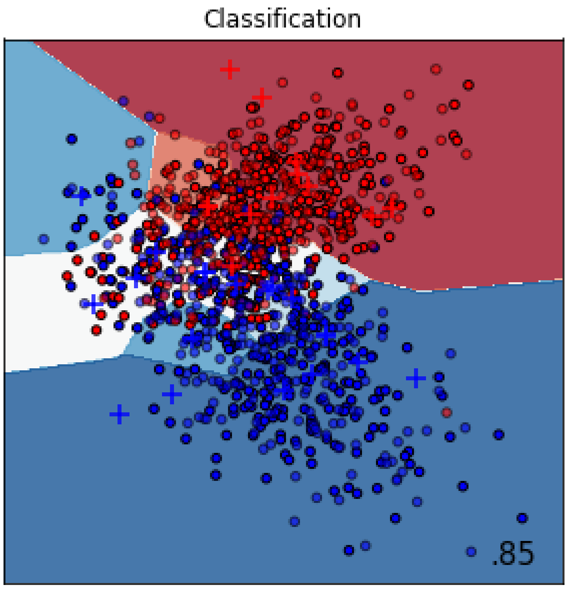
```
x_train.shape
```

Out[26]:

```
(600, 2)
```

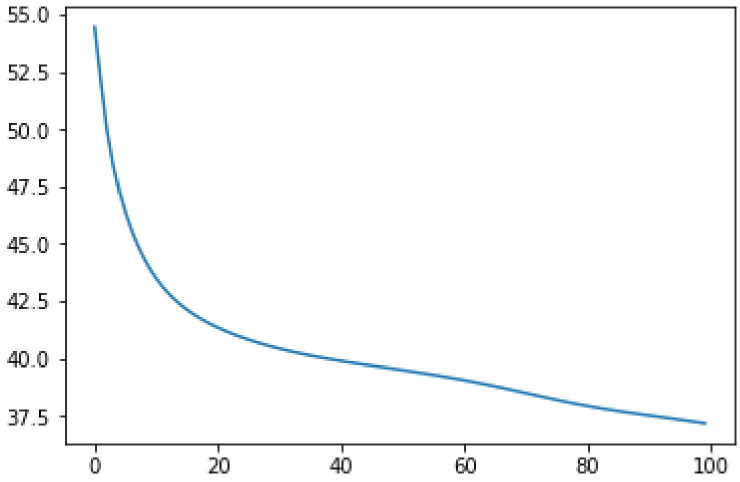
```
In [27]: figure = plt.figure(figsize=(5, 5))
         cm = plt.cm.RdBu
         ax = plt.subplot()
         ax.set_title("Classification")
         ax.contourf(xx, yy, Z, cmap=cm, alpha=.8)
         ax.scatter(x_train[:, 0], x_train[:, 1], c=y_train, cmap=cm_bright,s=20,
                        edgecolors='k')
         ax.scatter(x_test[:, 0], x_test[:, 1], c=y_test, cmap=cm_bright, alpha=
         0.6,s=20,
                        edgecolors='k')
         ax.scatter(M[:, 0], M[:, 1], c=np.argmax(PI,axis = 1),
                     s=100, cmap=cm_bright,marker='+',
                        edgecolors='k');
         ax.set_xlim(xx.min(), xx.max())
         ax.set_ylim(yy.min(), yy.max())
         ax.set_xticks(())
         ax.set_yticks(())
         ax.text(xx.max() - .3, yy.min() + .3, ('%.2f' % score).lstrip('0'),
                         size=15, horizontalalignment='right')
```

```
Out[27]: Text(5.330672605240474, -3.5971824908134398, '.85')
```



```
In [31]: plt.plot(loss)

Out[31]: [<matplotlib.lines.Line2D at 0x3ffd3c41e518>]
```


55.0
52.5
50.0
47.5
45.0
42.5
40.0
37.5
0
20
40
60
80
100