Ex5_Florian_Schneider

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```
In [1]: import numpy as np
        import matplotlib.pyplot as plt
        %matplotlib inline
        import os
        import random

In [2]: def load_data():
            data = np.genfromtxt(os.getcwd() + '/dataCircle.csv', delimiter=',')
            pos = data[np.where(data[:, 2] == 1)]
            neg = data[np.where(data[:, 2] == -1)]
            return (pos, neg, data)

        pos, neg, data = load_data()

In [1]: def plot_data(pos, neg):
            fig, ax = plt.subplots(1)
            ax.plot(pos[:, 0], pos[:, 1], '.', c='green')
            ax.plot(neg[:, 0], neg[:, 1], '.', c='red')
            return fig, ax

In [4]: class Evaluation:

            def __init__(self, trueLabel = 'p', falseLabel = 'n'):
                self.tp = []
                self.tn = []
                self.fp = []
                self.fn = []
                self.trueLabel = trueLabel
                self.falseLabel = falseLabel
                self.total = 0

            def add(self, pred, label):
                if pred != self.trueLabel and pred != self.falseLabel or label != self.trueLabe
                    print("Error! Prediction and Label have to be either '"
                          + str(self.trueLabel) +"' or '"+str(self.falseLabel)+"' !")
                    return

                if pred == label:
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```
            if pred == self.trueLabel:
                self.tp.append((pred, label))
            if pred == self.falseLabel:
                self.tn.append((pred, label))
        if pred != label:
            if pred == self.trueLabel:
                self.fp.append((pred, label))
            if pred == self.falseLabel:
                self.fn.append((pred, label))
        self.total += 1

    def acc(self, v = True):
        trues = len(self.tp) + len(self.tn)
        acc = trues / self.total
        if v:
            print("Accuracy: %i / %i -> %f" % (trues, self.total, acc))
        return acc

    def prec(self, v = True):
        pred_pos = (len(self.tp) + len(self.fp))
        prec = len(self.tp) / pred_pos
        if v:
            print("Precision: %i / %i -> %f" % (len(self.tp), pred_pos, prec))
        return prec

    def rec(self, v = True):
        cond_pos = (len(self.tp) + len(self.fn))
        rec = len(self.tp) / cond_pos
        if v:
            print("Recall: %i / %i -> %f" % (len(self.tp), cond_pos, rec))
        return rec

    def f1(self, v = True):
        rec = self.rec(False)
        prec = self.prec(False)
        f1 = 2 * prec * rec / (prec + rec)
        if v:
            print("F1: %f" % (f1))
        return f1

    def print_summary(self):
        self.acc(True)
        self.prec(True)
        self.rec(True)
        self.f1(True)
```

```
In [5]: def init_distribution(data):
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        d1 = np.ones(data.shape[0], dtype=np.float128)
        d1 /= len(data)

        assert np.isclose(np.sum(d1), 1.0)
        return d1

    d1 = init_distribution(data)
```

In [6]:
```
class weak_classifier:
    def __init__(self, minn=-10., maxx=-10., axis='x', prec=0.1):
        self.minn = minn
        self.maxx = maxx
        f = 1 / prec
        self.theta = random.randrange(-10 *f , 10*f, 0.1*f)/f
        self.axis = axis

    def __str__(self):
        return "{%s %.2f}" % (self.axis, self.theta)

    def __repr__(self):
        return "{%s %.2f}" % (self.axis, self.theta)

    def pred(self, x, y):
        if self.axis =='x1':
            return 1 if x > self.theta else -1
        elif self.axis =='x2':
            return 1 if x < self.theta else -1
        elif self.axis =='y1':
            return 1 if y > self.theta else -1
        elif self.axis =='y2':
            return 1 if y < self.theta else -1

    def kronecker(self, x, y, label):
        return 1 if self.pred(x, y) != label else 0

    def plot(self, ax = None, a=1.):
        plt.xlim(self.minn, self.maxx)
        plt.ylim(self.minn, self.maxx)
        fig = None
        if ax == None:
            fig, ax = plt.subplots(1)
        if 'x' in self.axis:
            ax.axhline(self.theta, linewidth=5 * a, alpha=a)
        else:
            ax.axvline(self.theta, linewidth=5 * a, alpha=a)

class strong_classifier:
    def __init__(self, ats, hts):
```

```
        assert len(ats) == len(hts)
        self.ats = ats
        self.hts = hts

    def pred(self, x, y):
        F = 0
        for at, ht in zip(ats, hts):
            F += at * ht.pred(x, y)
        return np.sign(F)


    def plot_all(self, ax = None):
        fig = None
        if ax == None:
            fig, ax = plt.subplots(1)
        for at, ht in zip(ats, hts):
            ht.plot(ax, at)

    def __len__(self):
        return len(ats)
```

In [7]:
```
def generate_weak_classifiers(minn=-10, maxx=10., n=20):
    # generate lines parallel to the x or y axis as weak classifiers
    hts = []
    for i in range(n // 4):
        hts.append(weak_classifier(minn, maxx, 'x1')) # parallel to x axis

    for i in range(n // 4):
        hts.append(weak_classifier(minn, maxx, 'x2')) # parallel to x axis

    for i in range(n // 4):
        hts.append(weak_classifier(minn, maxx, 'y1')) # parallel to x axis

    for i in range(n // 4):
        hts.append(weak_classifier(minn, maxx, 'y2')) # parallel to x axis


    return hts
```

In [8]:
```
def compute_weighted_errors(hts, distr, data):
    # compute weighted errors for all weak classifiers
    ets = []
    for h in hts:
        e = 0
        for i, p in enumerate(data):
            x, y, label = p[0], p[1], p[2]
            e += distr[i] * h.kronecker(x, y, label)
        assert e >= 0 and e <= 1.0
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            ets.append(e)

        return ets

    def select_weak_classifier(hts, errors_t):
        # select weak classifier with minimum error
        return hts[np.argmin(errors_t)], np.min(errors_t)

    def compute_alpha_t(error_t):
        return 0.5 * np.log((1-error_t)/(error_t))

    def compute_zt(distr_t, alpha_t, ht, data):
        zt = 0
        for i, d in enumerate(data):
            zt += distr_t[i] * np.exp(-alpha_t * d[2] * ht.pred(d[0], d[1]))
        return zt

    def update_distribution(distr_t, alpha_t, zt, ht, data):
        assert np.isclose(np.sum(distr_t), 1.0)
        distr_t1 = np.zeros_like(distr_t)
        zt = 0
        for i, d in enumerate(data):
            x = distr_t[i] * np.exp(-alpha_t * d[2] * ht.pred(d[0], d[1]))
            zt += x
            distr_t1[i] = x
        distr_t1 /= zt

        assert np.isclose(np.sum(distr_t1), 1.0)
        return distr_t1
```

In [11]:
```
# load the data
pos, neg, data = load_data()

# initialize the distribution for the first timestep
distr = init_distribution(data)

# generate N weak classifiers
N = 250
#random.seed(42)
h = generate_weak_classifiers(n=N)

# train adaboos for T timesteps
T = 100
ats = []
ets = []
hts = []
distrs = []
distrs.append(distr)
```

```
    for t in range(T):
        # 1. Learn weak classifier ht using distribution Dt
        errors_t = compute_weighted_errors(h, distr, data)
        # for e in errors_t:
        #     print(e)
        ht, et = select_weak_classifier(h, errors_t)
        # print(et)
        # print(ht)
        # 2. Set weight t based on the error
        at = compute_alpha_t(et)
        # 3. Update the distribution based on the performance so far
        zt = compute_zt(distr, at, ht, data)
        distr = update_distribution(distr, at, zt, ht, data)
        # collect results
        distrs.append(distr)
        ats.append(at)
        hts.append(ht)
        ets.append(et)
```

```
In [16]: fig, ax = plt.subplots(1)
         ax.plot(np.arange(T), np.array(ets))
         ax.set(title='Errors over iteration')

         fig, ax = plt.subplots(1)
         ax.bar(np.arange(len(data)), distrs[0], linewidth=.25)
         ax.set(title='Initial uniform distribution over data')

         fig, ax = plt.subplots(1)
         ax.bar(np.arange(len(data)), distrs[-1], linewidth=.25)
         ax.set(title='Final distribution over data')

         fig, ax = plt.subplots(1)
         ax.bar(np.arange(len(ets)), ets)
         ax.set(title='Weights of the weak classifiers')

         H = strong_classifier(ats, hts)
         fig, ax = plot_data(pos, neg)
         H.plot_all(ax)
         ax.set(title='Data with weak classifiers. The bolder they are, the more important')

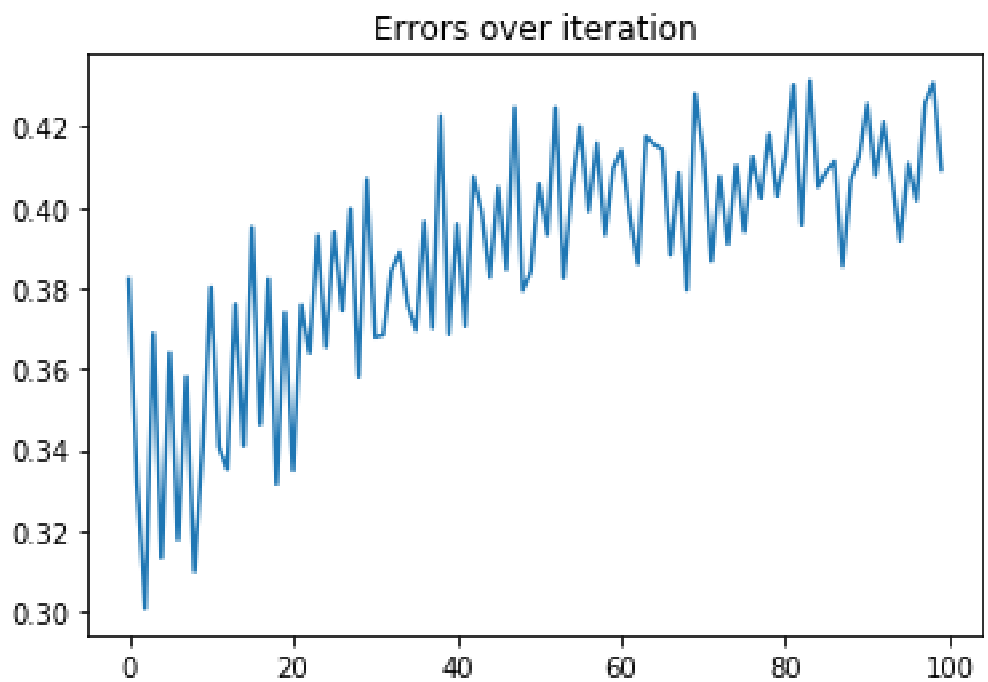


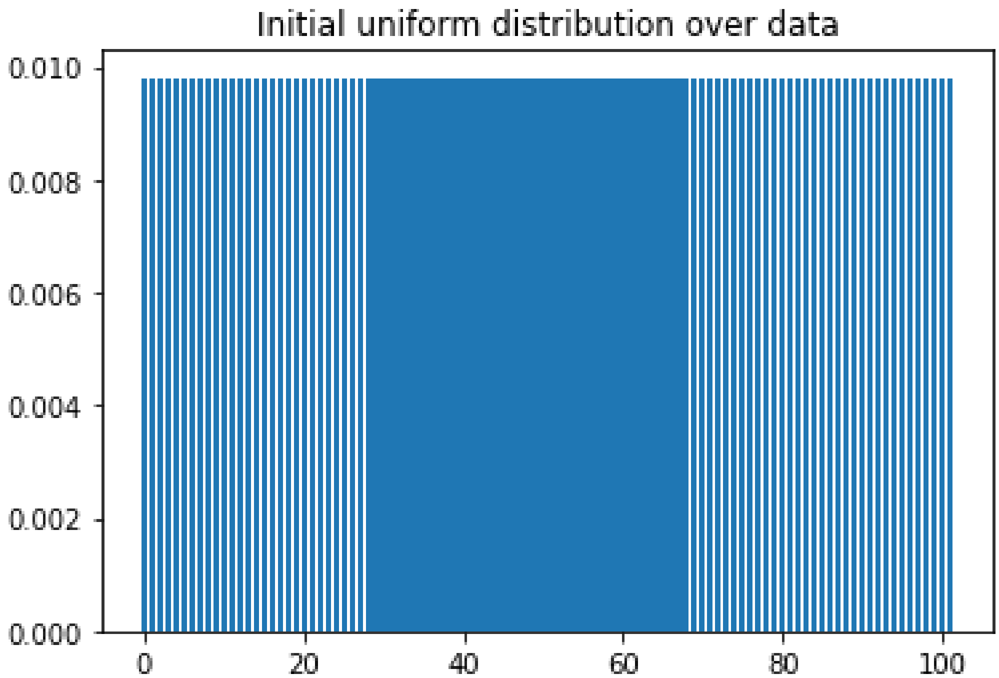

         evaluation = Evaluation(1, -1)
         for d in data:
             pred = H.pred(d[0], d[1])
             evaluation.add(pred, d[2])
```

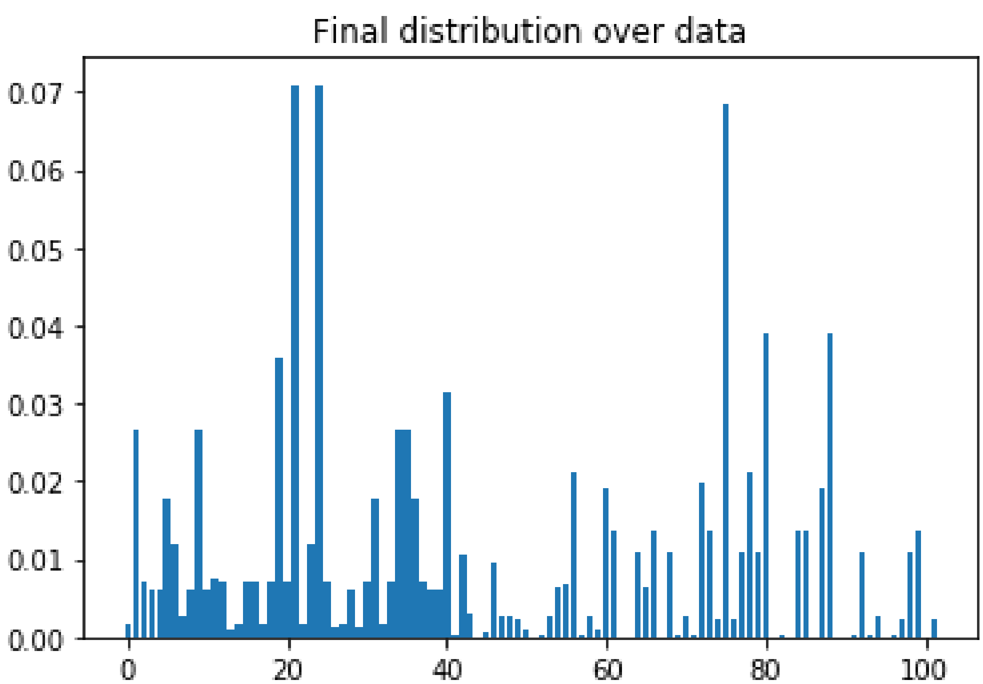
```
        if pred != d[2]:
            print("(%i, %i)\t-> Label: %i Prediction: %i \n" % (d[0], d[1], d[2], pred))
            ax.plot(d[0], d[1], 'o', c='black', linewidth=4)

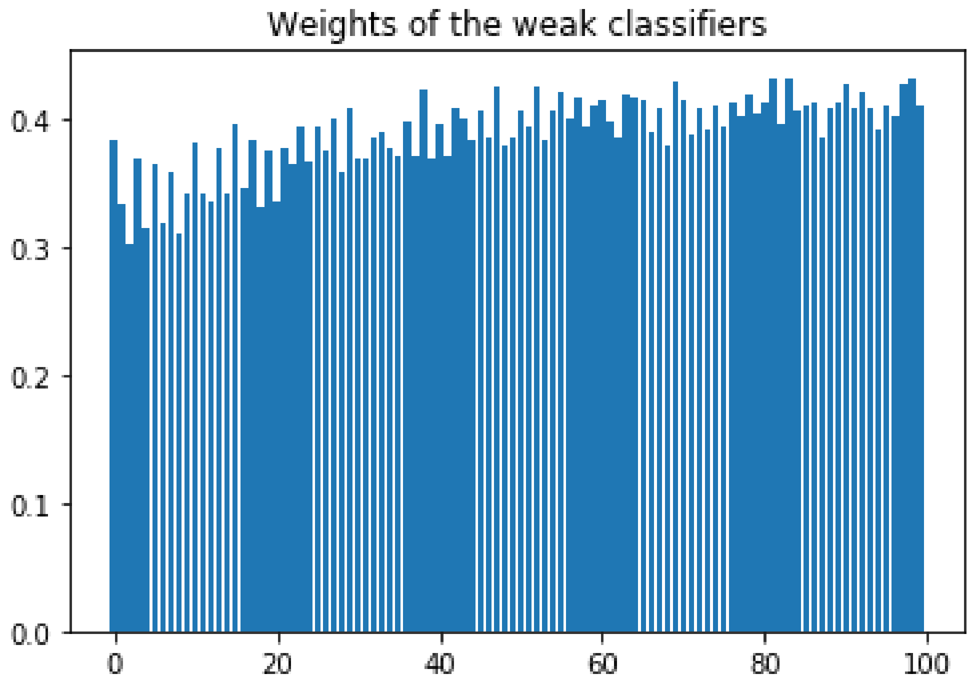
    evaluation.print_summary()
```

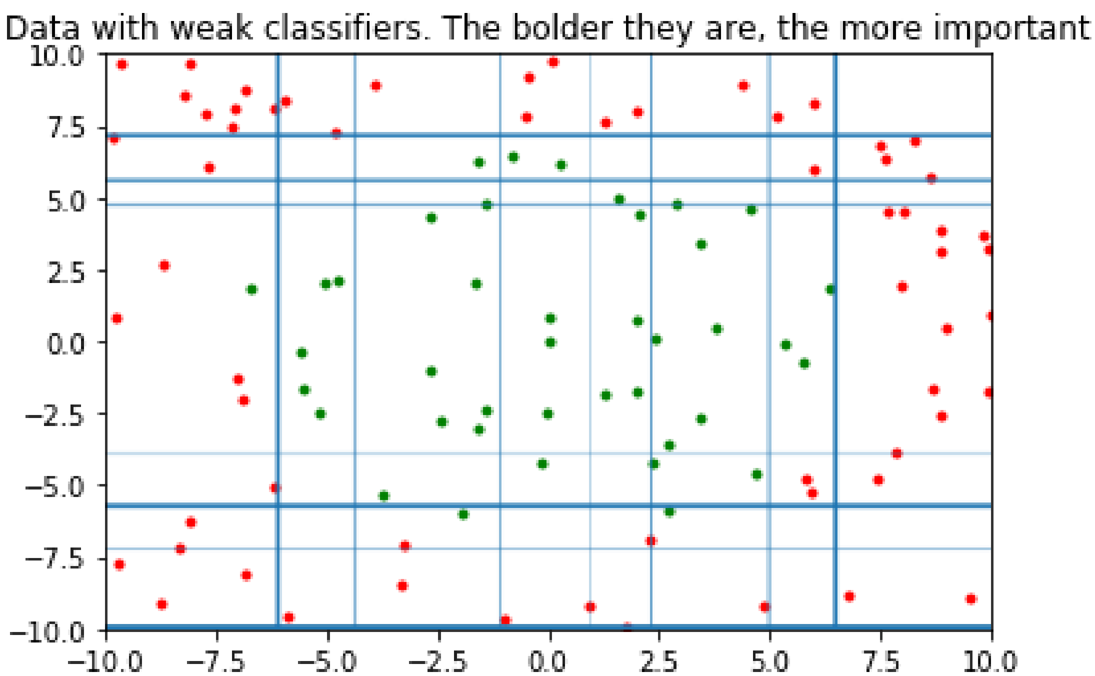
```
Accuracy: 102 / 102 -> 1.000000
Precision: 40 / 40 -> 1.000000
Recall: 40 / 40 -> 1.000000
F1: 1.000000
```




Initial uniform distribution over data
0.010
0.008
0.006
0.004
0.002
0.000
0
20
40
60
80
100


Final distribution over data
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
20
40
60
80
100


Weights of the weak classifiers
0.0
0.1
0.2
0.3
0.4
0
20
40
60
80
100


Data with weak classifiers. The bolder they are, the more important
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10.0
−10.0
−7.5
−5.0
−2.5
0.0
2.5
5.0
7.5
10.0