1 逻辑回归实战01

根据学生两门课的成绩，判断学生是否能通过测试

In [2]:

```
import pandas as pd
```

In [3]:

```
from __future__ import print_function, division
import numpy as np
import matplotlib as mpl
import matplotlib.pyplot as plt
%matplotlib inline
```

In [166]:

```
df = pd.read_csv('data/ex2data1.txt',header=None)
df.columns=['class1','class2','pass']
```

In [167]:

```
df.head()
```

Out[167]:

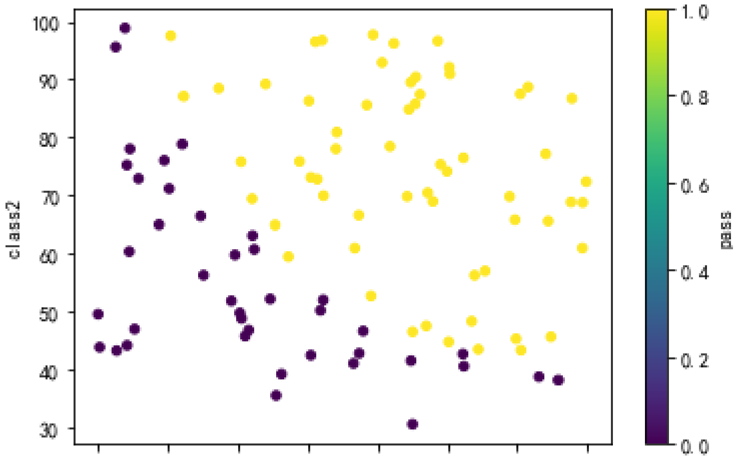
	class1	class2	pass
0	34.623660	78.024693	0
1	30.286711	43.894998	0
2	35.847409	72.902198	0
3	60.182599	86.308552	1
4	79.032736	75.344376	1

In [168]:

```
df.plot(kind='scatter',x='class1',y='class2',c='pass',cmap='viridis')
```

Out[168]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x200a180cf60>
```



In [169]:

```python
import tensorflow as tf
from tensorflow.contrib import slim

x_data = df[['class1','class2']].values
y_data = df[['pass']].values

tf.reset_default_graph()
x_placeholder = tf.placeholder(tf.float32,shape=[None,2])
y_placeholder = tf.placeholder(tf.float32,shape=[None,1])

with tf.variable_scope('network'):
#     下面这几行代码是如果自己手动写，要怎么写，和下面用slim写的是等价的
#     W = tf.Variable(tf.random_normal([2,1]))
#     b = tf.Variable(tf.random_normal([1,1]))
#     y_predict = tf.matmul(x_placeholder,W)+b
    #####################################################
    y_predict = slim.fully_connected(inputs=x_placeholder,
                                     num_outputs=1,
                                     activation_fn=None,
                                     weights_initializer=tf.random_normal_initializer,
                                     biases_initializer=tf.random_normal_initializer)
    #####################################################
loss = slim.losses.sigmoid_cross_entropy(logits=y_predict,multi_class_labels=y_placeholder)
train = tf.train.AdamOptimizer().minimize(loss)
with tf.Session() as sess:
    sess.run(tf.global_variables_initializer())
    for i in range(100000):
        if i%10000==0:
            var_list =tf.get_collection('trainable_variables',scope='network')+[loss]
            _ = sess.run(var_list,feed_dict={x_placeholder:x_data,y_placeholder:y_data})
            print(_)
        sess.run(train,feed_dict={x_placeholder:x_data,y_placeholder:y_data})
    #后续作图准备
    _y_predict = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder:x_data,y_placeholde
    x = np.linspace(0,100,101)
    y = np.linspace(0,100,101)
    X,Y = np.meshgrid(x,y)
    Z = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder: np.hstack([X.flatten()[:,Nc
```

```
[array([[ 0.3757934 ],
       [-0.51759624]], dtype=float32), array([0.7306016], dtype=float32), 7.5186114]
[array([[0.06604161],
       [0.05953157]], dtype=float32), array([-7.519258], dtype=float32), 0.3150997]
[array([[0.13268252],
       [0.12695749]], dtype=float32), array([-15.95037], dtype=float32), 0.22181107]
[array([[0.19406368],
       [0.18915717]], dtype=float32), array([-23.639708], dtype=float32), 0.2038608
3]
[array([[0.20623168],
       [0.20147157]], dtype=float32), array([-25.16134], dtype=float32), 0.20349766]
[array([[0.2062324 ],
       [0.20147227]], dtype=float32), array([-25.161417], dtype=float32), 0.2034977
4]
[array([[0.20623997],
       [0.20147985]], dtype=float32), array([-25.16143], dtype=float32), 0.20349774]
[array([[0.20623237],
       [0.20147225]], dtype=float32), array([-25.16142], dtype=float32), 0.20349774]
[array([[0.20623244],
       [0.20147233]], dtype=float32), array([-25.16142], dtype=float32), 0.2034977]
```

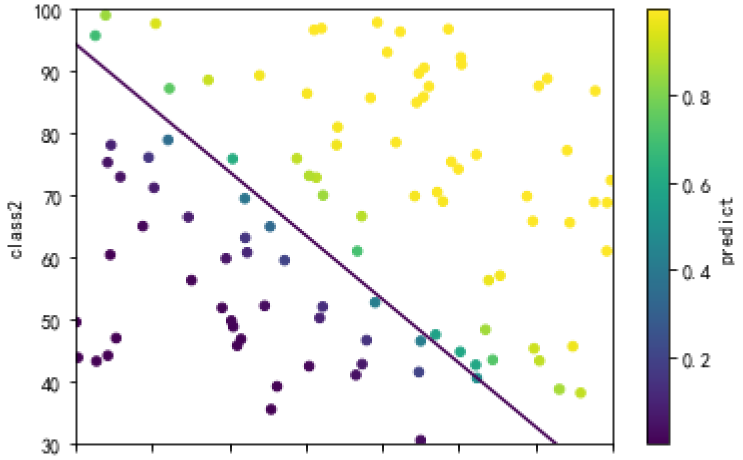
```
[array([[0.20623256],
       [0.20147243]], dtype=float32), array([-25.161425], dtype=float32), 0.2034977]
```

In [170]:

```
df['predict']=_y_predict
df.plot(kind='scatter',x='class1',y='class2',c='predict',cmap='viridis')
plt.contour(X,Y,Z.reshape([101,101]),0.5)
plt.xlim(30,100)
plt.ylim(30,100)
```

Out[170]:

```
(30, 100)
```



In [171]:

```
df.head()
```

Out[171]:

	class1	class2	pass	predict
0	34.623660	78.024693	0	0.090075
1	30.286711	43.894998	0	0.000042
2	35.847409	72.902198	0	0.043439
3	60.182599	86.308552	1	0.990281
4	79.032736	75.344376	1	0.998170

分割线是WX+b=0，也就是0.20623253*class1+0.20147243*class2-25.16144=0，这条直线就是分割线，分割了两类考生

2 逻辑回归实战02

此任务基于ex2data2.txt数据集的代码实现，ex2data2.txt数据集与ex2data1.txt数据集的格式基本一致，代码实现的流程上一致，不同处是特征提取和边界函数的图像绘制上。 在ex2data1.txt数据集中边界函数是一个一元一次函数，因此，基于ex2data1.txt数据集画边界函数非常简单。而在ex2data2.txt数据集中我们要预设的边界函数是一个高阶函数，因此再使用上面的代码不能绘制出高阶函数的曲线，此外，在此案例中，两个特征不能满足边界函数的要求，需要通过数据集中的数据计算出多个新的特征，以满足边界函数的要求。这是此案例中要解决的两个难点。

In [4]:

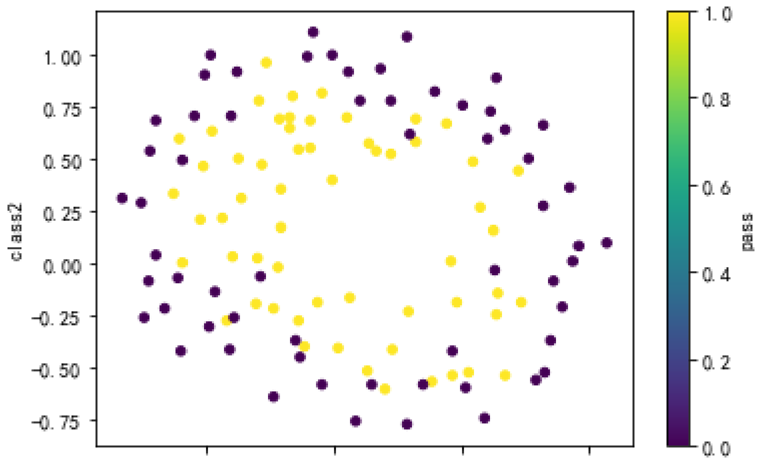
```
df = pd.read_csv('data/ex2data2.txt',header=None)
df.columns=['class1','class2','pass']
```

In [5]:

```
df.plot(kind='scatter',x='class1',y='class2',c='pass',cmap='viridis')
```

Out[5]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x26f1dc1eef0>
```



In [9]:

```
import tensorflow as tf
from tensorflow.contrib import slim

x_data = df[['class1','class2']].values
y_data = df[['pass']].values

tf.reset_default_graph()
x_placeholder = tf.placeholder(tf.float32,shape=[None,2])
y_placeholder = tf.placeholder(tf.float32,shape=[None,1])

with tf.variable_scope('network'):
#     W = tf.Variable(tf.random_normal([2,1]))
#     b = tf.Variable(tf.random_normal([1,1]))
#     y_predict = tf.matmul(x_placeholder,W)+b
    y_predict = slim.fully_connected(inputs=x_placeholder,
                                     num_outputs=1,
                                     activation_fn=None,
                                     weights_initializer=tf.random_normal_initializer,
                                     biases_initializer=tf.random_normal_initializer)
loss = slim.losses.sigmoid_cross_entropy(logits=y_predict,multi_class_labels=y_placeholder)
train = tf.train.AdamOptimizer().minimize(loss)
with tf.Session() as sess:
    sess.run(tf.global_variables_initializer())
    for i in range(100000):
        if i%10000==0:
            var_list =tf.get_collection('trainable_variables',scope='network')+[loss]
            _ = sess.run(var_list,feed_dict={x_placeholder:x_data,y_placeholder:y_data})
            print(_)
        sess.run(train,feed_dict={x_placeholder:x_data,y_placeholder:y_data})
    _y_predict = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder:x_data,y_placeholde
    x = np.linspace(-1,1,101)
    y = np.linspace(-1,1,101)
    X,Y = np.meshgrid(x,y)
    Z = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder: np.hstack([X.flatten()[:,No
```

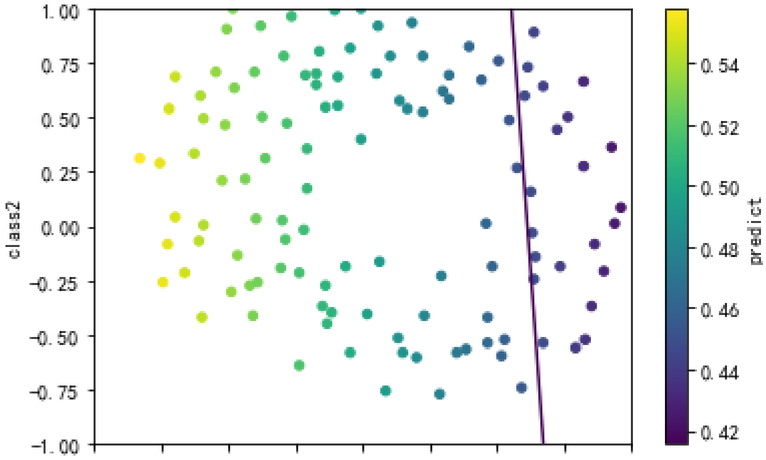
```
[array([[-0.74088323],
       [ 1.0360608 ]], dtype=float32), array([0.4907411], dtype=float32), 0.7868959]
[array([[-0.30352116],
       [-0.01813178]], dtype=float32), array([-0.0141842], dtype=float32), 0.6902411
6]
[array([[-0.30352262],
       [-0.0181339 ]], dtype=float32), array([-0.01418649], dtype=float32), 0.690241
04]
[array([[-0.30352113],
       [-0.01813099]], dtype=float32), array([-0.01418287], dtype=float32), 0.690241
16]
[array([[-0.30356297],
       [-0.01817384]], dtype=float32), array([-0.01422629], dtype=float32), 0.690241
1]
[array([[-0.30352178],
       [-0.01813124]], dtype=float32), array([-0.01418336], dtype=float32), 0.690241
16]
[array([[-0.3035215 ],
       [-0.01813188]], dtype=float32), array([-0.01418274], dtype=float32), 0.690241
1]
[array([[-0.30352113],
       [-0.01813167]], dtype=float32), array([-0.01418304], dtype=float32), 0.690241
1]
[array([[-0.30353963],
        [-0.01815367]], dtype=float32), array([-0.01420495], dtype=float32), 0.690241
1]
[array([[-0.3035297],
        [-0.0181419]], dtype=float32), array([-0.01419346], dtype=float32), 0.690241
2]
```

In [10]:

```
df['predict']=_y_predict
df.plot(kind='scatter',x='class1',y='class2',c='predict',cmap='viridis')
plt.contour(X,Y,Z.reshape([101,101]),0)
plt.xlim(-1,1)
plt.ylim(-1,1)
```

Out[10]:

```
(-1, 1)
```



可以看到如果只是简单的分类器，其分界线只能是一条简单的直线，不能够很好的分类数据，上面这种问题叫做欠拟合问题，我们尝试使用拥有一层隐藏层的神经网络来进行学习

In [47]:

```
import tensorflow as tf
from tensorflow.contrib import slim

x_data = df[['class1','class2']].values
y_data = df[['pass']].values

tf.reset_default_graph()
x_placeholder = tf.placeholder(tf.float32,shape=[None,2])
y_placeholder = tf.placeholder(tf.float32,shape=[None,1])

with tf.variable_scope('network'):
    #####################################################
    #增加了sigmoid为激活函数的隐藏层
    y_hidden = slim.fully_connected(inputs=x_placeholder,
                                     num_outputs=3, # 这个地方神经元的个数怎么来的？？？
                                     activation_fn=tf.nn.sigmoid,
                                     weights_initializer=tf.random_normal_initializer,
                                     biases_initializer=tf.random_normal_initializer,scope='hid
    #####################################################
    y_predict = slim.fully_connected(inputs=y_hidden,
                                     num_outputs=1,
                                     activation_fn=None,
                                     weights_initializer=tf.random_normal_initializer,
                                     biases_initializer=tf.random_normal_initializer)
loss = slim.losses.sigmoid_cross_entropy(logits=y_predict,multi_class_labels=y_placeholder)
train = tf.train.AdamOptimizer().minimize(loss)
with tf.Session() as sess:
    sess.run(tf.global_variables_initializer())
    for i in range(100000):
        if i%10000==0:
#             var_list =tf.get_collection('trainable_variables',scope='network')+[loss]
            _ = sess.run(loss,feed_dict={x_placeholder:x_data,y_placeholder:y_data})
            print(_)
        sess.run(train,feed_dict={x_placeholder:x_data,y_placeholder:y_data})
    _y_predict = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder:x_data,y_placeholde
    x = np.linspace(-1,1,101)
    y = np.linspace(-1,1,101)
    X,Y = np.meshgrid(x,y)
    Z = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder: np.hstack([X.flatten()[:,No
print('finish train')
```

```
0.695479
0.444692
0.38587135
0.34929916
0.33740705
0.33213437
0.32973254
0.3286818
0.3282636
0.32807797
finish train
```

In [48]:

```
tf.get_collection('trainable_variables',scope='network')
```

Out[48]:

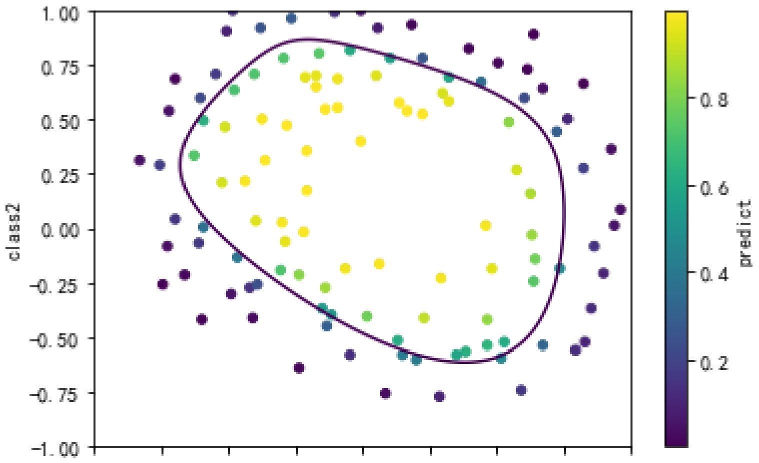
```
[<tf.Variable 'network/hidden_layer/weights:0' shape=(2, 3) dtype=float32_ref>,
 <tf.Variable 'network/hidden_layer/biases:0' shape=(3,) dtype=float32_ref>,
 <tf.Variable 'network/fully_connected/weights:0' shape=(3, 1) dtype=float32_ref>,
 <tf.Variable 'network/fully_connected/biases:0' shape=(1,) dtype=float32_ref>]
```

In [16]:

```
df['predict']=_y_predict
df.plot(kind='scatter',x='class1',y='class2',c='predict',cmap='viridis')
plt.contour(X,Y,Z.reshape([101,101]),0.5)
plt.xlim(-1,1)
plt.ylim(-1,1)
```

Out[16]:

```
(-1, 1)
```



In [17]:

```
df['p_label']=df['predict'].apply(lambda x:0 if x<0.5 else 1)
```

In [18]:

```
print('错误率：',(df['pass'] != df['p_label']).sum()/len(df))
```

```
错误率： 0.15254237288135594
```

```
可以看到，通过合理的设置隐藏层神经元的个数和激活函数，我们得到了一个效果更好的分类器，甚至可以说这个分类器完全符合了我们内心的期望。
不过，还有几个“小问题”让人困惑，为什么隐藏层是3个神经元，激活函数又为什么是sigmoid呢？
```

2.1 过拟合问题

多层的神经网络可以更好的学习到数据集中的信息，但过于复杂的神经网络却又将带来另一个问题：过于强大的学习能力将导致神经网络学习到仅仅属于训练数据的特征。

过拟合的检测：我们可以将训练数据人工的分成两部分，一部分用作训练，另一部分用于检测训练的效果，神经网络将不会学习到用于检测的数据的信息，这样，就可以相对有效的发现过拟合问题。

过拟合的预防：如果存在过拟合问题，就需要进行应对。 **一是简化神经网络的结构，去除多余的神经元或是神经网络层（如上面，最合适的网络层数是2层） 二是控制训练步数 三是加入正则化项**

In [6]:

```
from sklearn.model_selection import train_test_split
```

In [7]:

```
x_train,x_test,y_train,y_test = train_test_split(df[['class1','class2']].values,df[['pass']].va
```

2.1.1 选择合适的网络结构

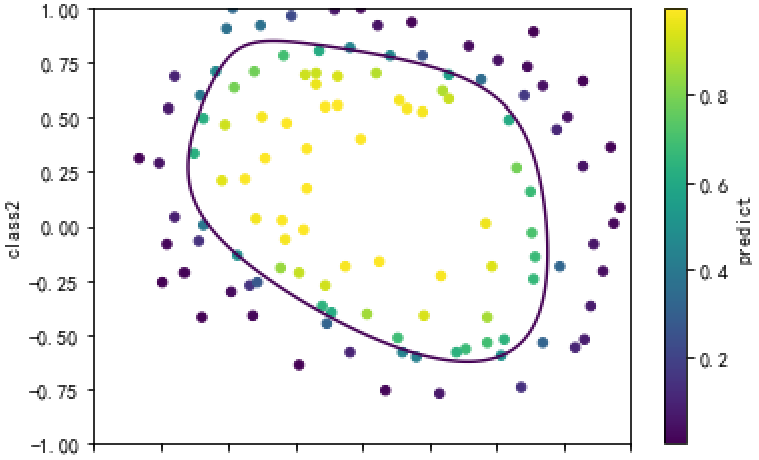
In [36]:

```
import tensorflow as tf
from tensorflow.contrib import slim

tf.reset_default_graph()
x_placeholder = tf.placeholder(tf.float32,shape=[None,2])
y_placeholder = tf.placeholder(tf.float32,shape=[None,1])

with tf.variable_scope('network'):
    #增加了sigmoid为激活函数的隐藏层
    y_hidden = slim.fully_connected(inputs=x_placeholder,
                                     num_outputs=3,
                                     activation_fn=tf.nn.sigmoid,
                                     weights_initializer=tf.random_normal_initializer,
                                     biases_initializer=tf.random_normal_initializer)
    y_predict = slim.fully_connected(inputs=y_hidden,
                                     num_outputs=1,
                                     activation_fn=None,
                                     weights_initializer=tf.random_normal_initializer,
                                     biases_initializer=tf.random_normal_initializer)
loss = slim.losses.sigmoid_cross_entropy(logits=y_predict,multi_class_labels=y_placeholder)
train = tf.train.AdamOptimizer().minimize(loss)
with tf.Session() as sess:
    sess.run(tf.global_variables_initializer())
    for i in range(100000):
        if i%10000==0:
#             var_list =tf.get_collection('trainable_variables',scope='network')+[loss]
            _ = sess.run(loss,feed_dict={x_placeholder:x_test,y_placeholder:y_test})
            print(_)
        sess.run(train,feed_dict={x_placeholder:x_train,y_placeholder:y_train})
    _y_predict = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder:x_data,y_placeholde
    x = np.linspace(-1,1,101)
    y = np.linspace(-1,1,101)
    X,Y = np.meshgrid(x,y)
    Z = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder: np.hstack([X.flatten()[:,No
print('finish train')

df['predict']=_y_predict
df.plot(kind='scatter',x='class1',y='class2',c='predict',cmap='viridis')
plt.contour(X,Y,Z.reshape([101,101]),0.5)
plt.xlim(-1,1)
plt.ylim(-1,1)
```

```
0.6967212
0.73453176
0.47987664
0.44582617
0.43720293
0.4354018
0.43547377
0.43574756
0.4359843
0.4361996
finish train
```

Out[36]:

```
(-1, 1)
```


1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
class2
0.8
0.6
0.4
0.2
predict

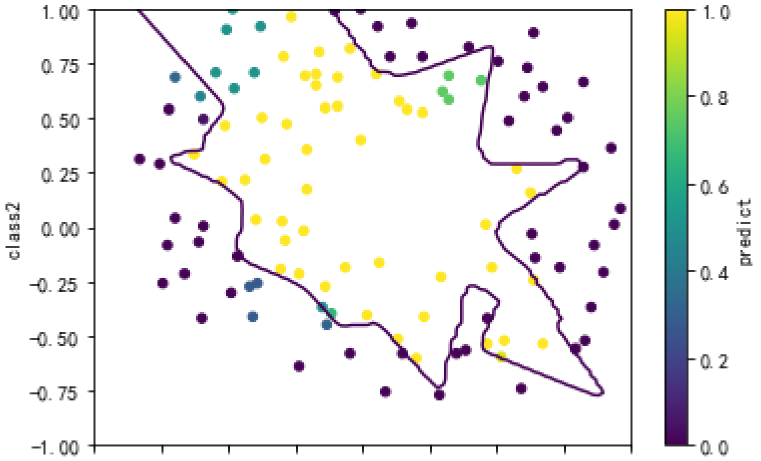
In [74]:

```
import tensorflow as tf
from tensorflow.contrib import slim

tf.reset_default_graph()
x_placeholder = tf.placeholder(tf.float32,shape=[None,2])
y_placeholder = tf.placeholder(tf.float32,shape=[None,1])

with tf.variable_scope('network'):
    #增加了sigmoid为激活函数的隐藏层
    #####################################################
    y_hidden = slim.fully_connected(inputs=x_placeholder,
                                    num_outputs=10,
                                    activation_fn=tf.nn.sigmoid,
                                    weights_initializer=tf.random_normal_initializer,
                                    biases_initializer=tf.random_normal_initializer)
    #####################################################
    y_predict = slim.fully_connected(inputs=y_hidden,
                                    num_outputs=1,
                                    activation_fn=None,
                                    weights_initializer=tf.random_normal_initializer,
                                    biases_initializer=tf.random_normal_initializer)
loss = slim.losses.sigmoid_cross_entropy(logits=y_predict,multi_class_labels=y_placeholder)
train = tf.train.AdamOptimizer().minimize(loss)
with tf.Session() as sess:
    sess.run(tf.global_variables_initializer())
    for i in range(100000):
        if i%10000==0:
            # var_list =tf.get_collection('trainable_variables',scope='network')+[loss]
            _ = sess.run(loss,feed_dict={x_placeholder:x_test,y_placeholder:y_test})
            print(_)
        sess.run(train,feed_dict={x_placeholder:x_train,y_placeholder:y_train})
    _y_predict = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder:x_data,y_placeholde
    x = np.linspace(-1,1,101)
    y = np.linspace(-1,1,101)
    X,Y = np.meshgrid(x,y)
    Z = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder: np.hstack([X.flatten()[:,Nc
print('finish train')

df['predict']=_y_predict
df.plot(kind='scatter',x='class1',y='class2',c='predict',cmap='viridis')
plt.contour(X,Y,Z.reshape([101,101]),0.5)
plt.xlim(-1,1)
plt.ylim(-1,1)
```

```
0.781873 0.85464996
0.28550002 0.5205145
0.16668887 1.3128357
0.11656834 2.1929893
0.09934766 2.934678
0.09252071 3.9337816
0.08873161 4.758818
0.08659734 5.2791214
0.08526293 6.034591
0.08437831 6.6956086
finish train
```

Out[74]:

```
(-1, 1)
```



2.1.2 控制训练步数 early stoping

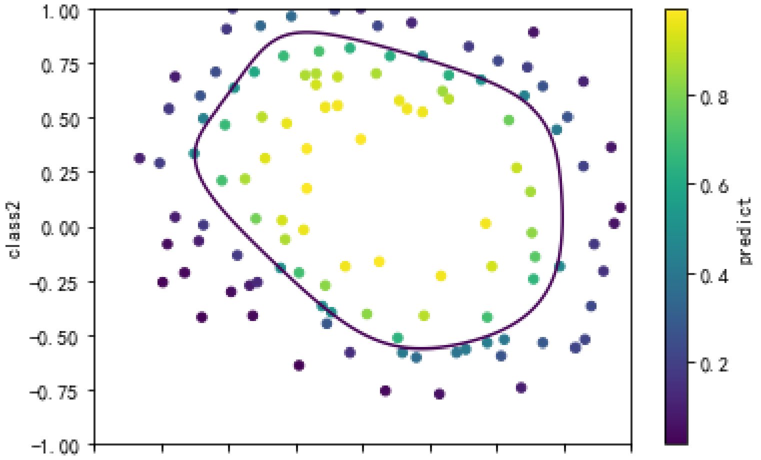
In [22]:

```
import tensorflow as tf
from tensorflow.contrib import slim

tf.reset_default_graph()
x_placeholder = tf.placeholder(tf.float32,shape=[None,2])
y_placeholder = tf.placeholder(tf.float32,shape=[None,1])

with tf.variable_scope('network'):
    #增加了sigmoid为激活函数的隐藏层
    y_hidden = slim.fully_connected(inputs=x_placeholder,
                                     num_outputs=10,
                                     activation_fn=tf.nn.sigmoid,
                                     weights_initializer=tf.random_normal_initializer,
                                     biases_initializer=tf.random_normal_initializer)
    y_predict = slim.fully_connected(inputs=y_hidden,
                                     num_outputs=1,
                                     activation_fn=None,
                                     weights_initializer=tf.random_normal_initializer,
                                     biases_initializer=tf.random_normal_initializer)
loss = slim.losses.sigmoid_cross_entropy(logits=y_predict,multi_class_labels=y_placeholder)
train = tf.train.AdamOptimizer().minimize(loss)
with tf.Session() as sess:
    sess.run(tf.global_variables_initializer())
    #####################################################
    # 通过定义一个临时变量，用来监控测试集上loss的变化，当
    # loss不再减小时，停止训练。
    tmp = float('inf')
    #####################################################
    for i in range(100000):
        if i%1000==0:
            _ = sess.run(loss,feed_dict={x_placeholder:x_test,y_placeholder:y_test})
            #####################################################
            if tmp<_:break
            tmp=_
            #####################################################
            print(_)
        sess.run(train,feed_dict={x_placeholder:x_train,y_placeholder:y_train})
    _y_predict = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder:x_data,y_placeholde
    x = np.linspace(-1,1,101)
    y = np.linspace(-1,1,101)
    X,Y = np.meshgrid(x,y)
    Z = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder: np.hstack([X.flatten()[:,No
print('finish train')

df['predict']=_y_predict
df.plot(kind='scatter',x='class1',y='class2',c='predict',cmap='viridis')
plt.contour(X,Y,Z.reshape([101,101]),0.5)
plt.xlim(-1,1)
plt.ylim(-1,1)
```

```
1.7334943
0.6701691
0.6421815
0.59852725
0.5446656
0.49174085
0.44674873
0.43317357
finish train
```

Out[22]:

```
(-1, 1)
```



一种更加优雅规范的做法：不要因为某一次训练loss不再下降就停止训练

In [18]:

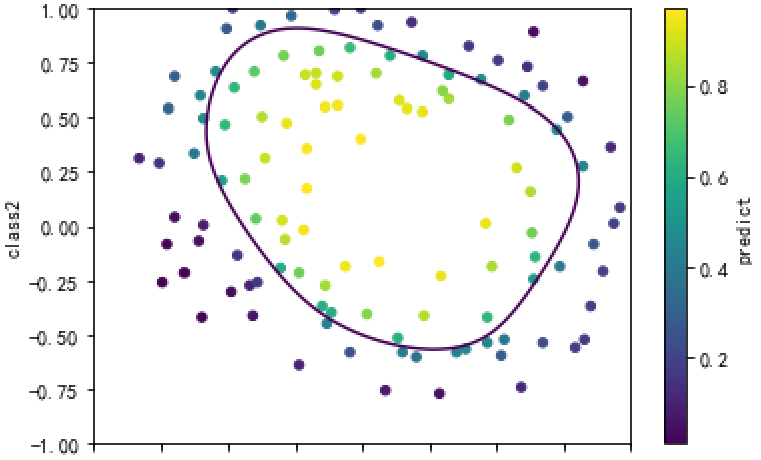
```
import tensorflow as tf
from tensorflow.contrib import slim

tf.reset_default_graph()
x_placeholder = tf.placeholder(tf.float32,shape=[None,2])
y_placeholder = tf.placeholder(tf.float32,shape=[None,1])

with tf.variable_scope('network'):
    #增加了sigmoid为激活函数的隐藏层
    y_hidden = slim.fully_connected(inputs=x_placeholder,
                                    num_outputs=10,
                                    activation_fn=tf.nn.sigmoid,
                                    weights_initializer=tf.random_normal_initializer,
                                    biases_initializer=tf.random_normal_initializer)
    y_predict = slim.fully_connected(inputs=y_hidden,
                                    num_outputs=1,
                                    activation_fn=None,
                                    weights_initializer=tf.random_normal_initializer,
                                    biases_initializer=tf.random_normal_initializer)
loss = slim.losses.sigmoid_cross_entropy(logits=y_predict,multi_class_labels=y_placeholder)
train = tf.train.AdamOptimizer().minimize(loss)
##############################################################
best_loss = float('inf')
saver = tf.train.Saver()
early_stopping_step=2000
##############################################################

with tf.Session() as sess:
    sess.run(tf.global_variables_initializer())
    for i in range(100000):
        ######################################################################
        sess.run(train,feed_dict={x_placeholder:x_train,y_placeholder:y_train})
        if i%200==0:
            loss_value = sess.run(loss,feed_dict={x_placeholder:x_test,y_placeholder:y_test})
            if (loss_value < best_loss):
                stopping_step = 0
                best_loss = loss_value
                saver.save(sess,'early_stoping/checkpoint.ckpt')
            else:
                stopping_step += 200
            if stopping_step >= early_stopping_step:
                print("Early stopping is trigger at step: {} loss:{}".format(i,loss_value))
                saver.restore(sess,'early_stoping/checkpoint.ckpt')
                break
        ########################################################################


    _y_predict = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder:x_data,y_placeholde
    x = np.linspace(-1,1,101)
    y = np.linspace(-1,1,101)
    X,Y = np.meshgrid(x,y)
    Z = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder: np.hstack([X.flatten()[:,No
print('finish train')

df['predict']=_y_predict
df.plot(kind='scatter',x='class1',y='class2',c='predict',cmap='viridis')
plt.contour(X,Y,Z.reshape([101,101]),0.5)
plt.xlim(-1,1)
plt.ylim(-1,1)
```

```
1.7666477
1.0974907
0.79573274
0.7229387
0.70771897
0.7033955
0.7012843
0.69954187
0.6978175
0.69599795
0.6939398
0.69143444
0.68826336
0.6842845
0.6794184
0.6735848
0.6667021
0.6587679
0.649987
0.6408434
0.63198555
0.62398577
0.61716783
0.61157715
0.60699415
0.6028858
0.59844893
0.5931085
0.58649945
0.5779239
0.5667274
0.55325437
0.538905
0.5252481
0.5132442
0.50310653
0.49464786
0.48745155
0.48084375
0.47504357
0.47094816
0.46851206
0.46709013
0.46604612
0.465186
0.4646383
0.46432632
0.46412107
0.46437523
0.46594653
0.46915329
0.47292104
0.4758243
0.47776258
0.47957495
0.48174477
0.48431143
0.48721075
Early stopping is trigger at step: 11400 loss:0.487210750579834
```

```
INFO:tensorflow:Restoring parameters from early_stoping/checkpoint.ckpt
finish train
```

Out[18]:

```
(-1, 1)
```



2.1.3 加入正则化项

In [80]:

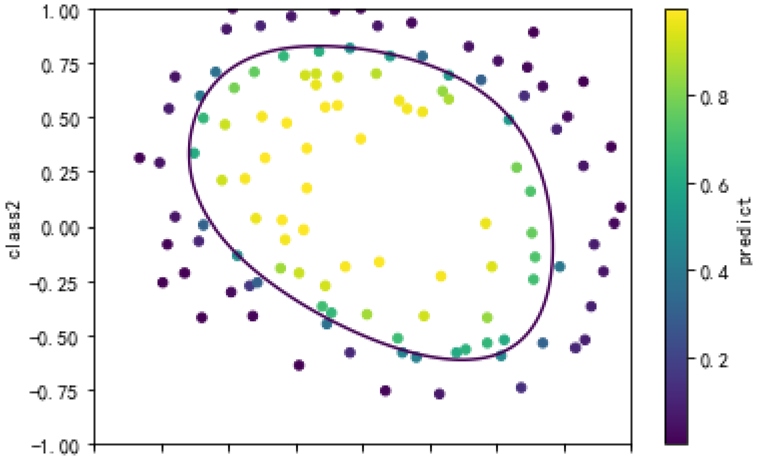
```
import tensorflow as tf
from tensorflow.contrib import slim

tf.reset_default_graph()
x_placeholder = tf.placeholder(tf.float32,shape=[None,2])
y_placeholder = tf.placeholder(tf.float32,shape=[None,1])

with tf.variable_scope('network'):
    #增加了sigmoid为激活函数的隐藏层
    y_hidden = slim.fully_connected(inputs=x_placeholder,
                                     num_outputs=10,
                                     activation_fn=tf.nn.sigmoid,
                                     weights_initializer=tf.random_normal_initializer,
                                     biases_initializer=tf.random_normal_initializer,
                                    #####################################################
                                    # 通过增加l1正则化项（l1正则化项是各项可训练参数的绝对
                                    # 值之和），使得一部分作用较小的神经元的权重为0，从而达
                                    # 到简化神经网络的作用，在添加了正则化项之后，还需要在
                                    # loss处（如下所示），将正则化项加入进去。
                                     weights_regularizer=slim.l1_regularizer(0.001),
#                                      biases_regularizer=slim.l1_regularizer(0.001),
                                     scope='hidden_layer')
                                    #####################################################
    y_predict = slim.fully_connected(inputs=y_hidden,
                                     num_outputs=1,
                                     activation_fn=None,
                                     weights_initializer=tf.random_normal_initializer,
                                     biases_initializer=tf.random_normal_initializer)
loss = slim.losses.sigmoid_cross_entropy(logits=y_predict,multi_class_labels=y_placeholder)
#####################################################
loss += sum(tf.get_collection('regularization_losses'))
#####################################################
train = tf.train.AdamOptimizer().minimize(loss)
with tf.Session() as sess:
    sess.run(tf.global_variables_initializer())

    for i in range(100000):
        if i%10000==0:
            _ = sess.run(loss,feed_dict={x_placeholder:x_test,y_placeholder:y_test})
            print(_)
        sess.run(train,feed_dict={x_placeholder:x_train,y_placeholder:y_train})
    _y_predict = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder:x_data,y_placeholde
    x = np.linspace(-1,1,101)
    y = np.linspace(-1,1,101)
    X,Y = np.meshgrid(x,y)
    Z = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder: np.hstack([X.flatten()[:,No
print('finish train')

df['predict']=_y_predict
df.plot(kind='scatter',x='class1',y='class2',c='predict',cmap='viridis')
plt.contour(X,Y,Z.reshape([101,101]),0.5)
plt.xlim(-1,1)
plt.ylim(-1,1)
```

```
1.9574324
0.49430093
0.4615253
0.45184383
0.44693694
```

```
0.44671717
0.4464599
0.44659802
0.44665545
0.44685894
finish train
```

Out[80]:

```
(-1, 1)
```



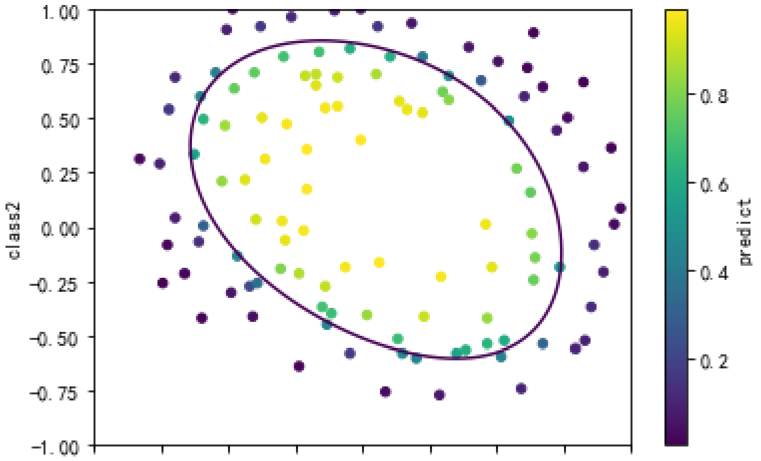
In [73]:

```
import tensorflow as tf
from tensorflow.contrib import slim

tf.reset_default_graph()
x_placeholder = tf.placeholder(tf.float32,shape=[None,2])
y_placeholder = tf.placeholder(tf.float32,shape=[None,1])

with tf.variable_scope('network'):
    #增加了sigmoid为激活函数的隐藏层
    y_hidden = slim.fully_connected(inputs=x_placeholder,
                                    num_outputs=10,
                                    activation_fn=tf.nn.sigmoid,
                                    weights_initializer=tf.random_normal_initializer,
                                    biases_initializer=tf.random_normal_initializer,
                                   ####################################################
                                    weights_regularizer=slim.l2_regularizer(0.01),scope='hidde
                                   ####################################################
    y_predict = slim.fully_connected(inputs=y_hidden,
                                    num_outputs=1,
                                    activation_fn=None,
                                    weights_initializer=tf.random_normal_initializer,
                                    biases_initializer=tf.random_normal_initializer)
loss = slim.losses.sigmoid_cross_entropy(logits=y_predict,multi_class_labels=y_placeholder)
####################################################
loss += sum(tf.get_collection('regularization_losses'))
####################################################
train = tf.train.AdamOptimizer().minimize(loss)
with tf.Session() as sess:
    sess.run(tf.global_variables_initializer())

    for i in range(100000):
        if i%10000==0:
            _ = sess.run(loss,feed_dict={x_placeholder:x_test,y_placeholder:y_test})
            print(_)
        sess.run(train,feed_dict={x_placeholder:x_train,y_placeholder:y_train})
    _y_predict = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder:x_data,y_placeholde
    x = np.linspace(-1,1,101)
    y = np.linspace(-1,1,101)
    X,Y = np.meshgrid(x,y)
    Z = sess.run(tf.nn.sigmoid(y_predict),feed_dict={x_placeholder: np.hstack([X.flatten()[:,No
print('finish train')

df['predict']=_y_predict
df.plot(kind='scatter',x='class1',y='class2',c='predict',cmap='viridis')
plt.contour(X,Y,Z.reshape([101,101]),0.5)
plt.xlim(-1,1)
plt.ylim(-1,1)
```

```
[0.8361516]
[0.6122475]
[0.51862377]
[0.479687]
[0.46127415]
[0.45173717]
[0.44646496]
[0.44350407]
[0.44154915]
[0.44036916]
finish train
```

Out[73]:

```
(-1, 1)
```



In [ ]:

```
 
```