Homework 2

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Problem: Approximate the function z = 2x^2 - 3y^2 + 1 (no noise). Train the network using the following two loss functions: mean absolute value, mean squared error. What is the difference in performance on your test set? How numerically stable are these results?

In [1]:
```
import numpy as np
import pandas as pd
from keras.models import Sequential
from keras.layers import Dense, Dropout, Activation
from keras.optimizers import SGD, adam
from sklearn import preprocessing

import matplotlib.pyplot as plt
```

```
Using Theano backend.
```

In [2]:
```
from mpl_toolkits.mplot3d import Axes3D
```

In [3]:
```
%pylab inline
```

```
Populating the interactive namespace from numpy and matplotlib
```

Training Set Generation - No Noise

In [4]:
```
# create an XY grid from -10 to 10 at 0.1 increments, calculate Z using the

xy_range = np.arange(-10, 10.1, 0.1)

X = np.repeat(xy_range, len(xy_range))
Y = np.tile(xy_range, len(xy_range))
Z = 2 * (X **2) - 3 * (Y**2) + 1

XY_data = np.vstack((X,Y)).T
```

Function Approximation - Mean Absolute Error Loss Function

In [5]:
```
sgd = SGD(lr=0.5)
model = Sequential()
model.add(Dense(100, input_dim=2))
model.add(Activation('tanh'))
model.add(Dense(1))
model.compile(loss='mean_absolute_error', optimizer='sgd')

model.fit(XY_data, Z, nb_epoch=80, batch_size=10, verbose=False)
```

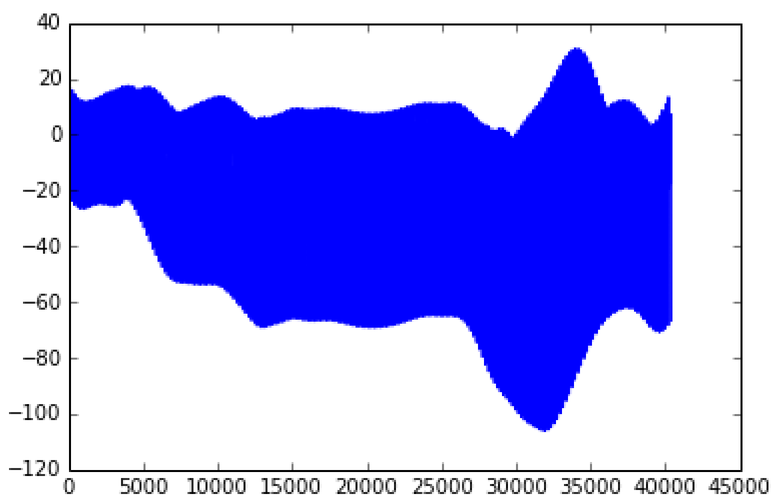
Out[5]: <keras.callbacks.History at 0x7f43890abed0>

In [6]:
```
score_mae = model.evaluate(XY_data, Z, batch_size=16, verbose=2)
score_mae
```

Out[6]: 7.8382119013323015

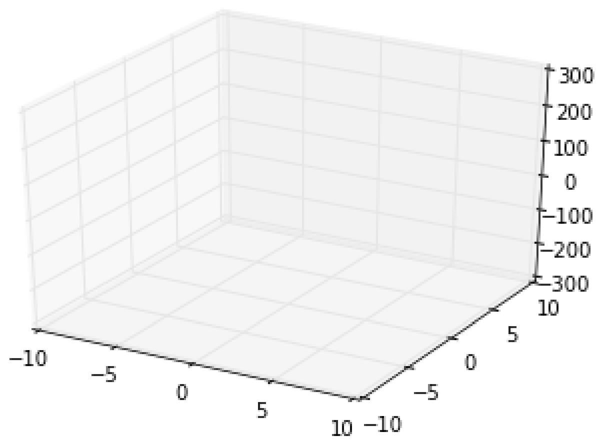
In [7]:
```
pred_z = model.predict(XY_data, batch_size=100)

pred_z = pred_z.reshape(len(Z),)
error_surface_mae = Z - pred_z
plt.plot(error_surface_mae)
```

Out[7]: [<matplotlib.lines.Line2D at 0x7f43839bc750>]



In [8]:
```
fig = plt.figure()
ax = fig.gca(projection='3d')
ax.plot_surface(X, Y, pred_z, rstride=1, cstride=1, cmap=cm.coolwarm, linewi
```

Out[8]: <mpl_toolkits.mplot3d.art3d.Poly3DCollection at 0x7f438386b690>



Function Approximation - Mean Square Error Loss Function

In [9]:
```
model_mse = Sequential()
model_mse.add(Dense(150, input_dim=2))
model_mse.add(Activation('tanh'))
model_mse.add(Dense(80))
model_mse.add(Activation('tanh'))
model_mse.add(Dense(1))
model_mse.compile(loss='mean_squared_error', optimizer='rmsprop')

model_mse.fit(XY_data, Z, nb_epoch=80, batch_size=10, verbose=False)
```

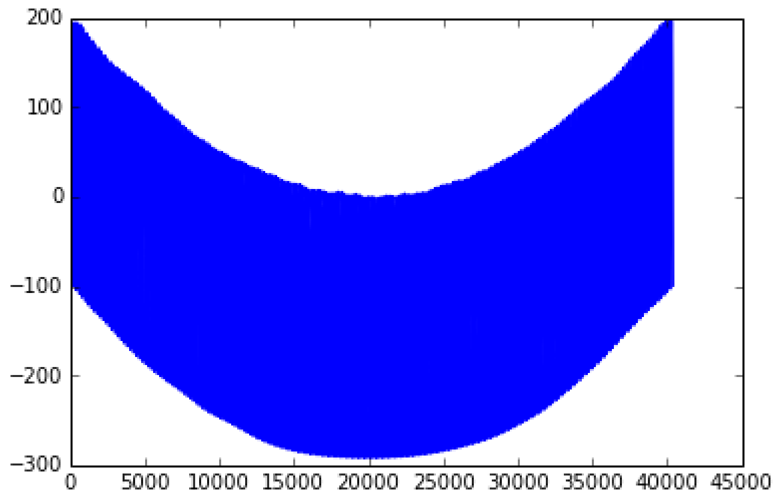
Out[9]: <keras.callbacks.History at 0x7f437f7d82d0>

In [10]:
```
score_mse = model.evaluate(XY_data, Z, batch_size=16, verbose=2)
score_mse
```

Out[10]: 7.8382119013323015

In [11]:
```
pred_z_mse = model_mse.predict(XY_data, batch_size=100)
plt.plot(pred_z_mse)
```

Out[11]: [<matplotlib.lines.Line2D at 0x7f437f0cad90>]



In [12]:
```
pred_z_mse = pred_z_mse.reshape(len(Z),)
```

In [13]:
```
error_mse = Z - pred_z_mse
```

Training Set Generation - With Noise

In [14]:
```
x_noise = np.random.laplace(loc=0, scale = 1, size=len(X))
y_noise = np.random.laplace(loc=0, scale = 1, size=len(Y))

X_n = X + x_noise
Y_n = Y + x_noise

Z_n = 2 * (X_n**2) - 3 * (Y_n**2) + 1

XY_data_n = np.vstack((X_n, Y_n)).T
```

In [15]:
```
indexes = np.arange(1, len(X) + 1, 1)
X_d = np.vstack((indexes, X)).T
Y_d = np.vstack((indexes, Y)).T
Z_d = np.vstack((indexes, Z)).T

X_d_n = np.vstack((indexes, X_n)).T
Y_d_n = np.vstack((indexes, Y_n)).T
Z_d_n = np.vstack((indexes, Z_n)).T
```

In [16]:

```
sgd = SGD(lr=0.5)
model_svd_n = Sequential()
model_svd_n.add(Dense(100, input_dim=2))
model_svd_n.add(Activation('tanh'))
model_svd_n.add(Dense(1))
model_svd_n.compile(loss='mean_absolute_error', optimizer='sgd')

model_svd_n.fit(XY_data_n, Z_n, nb_epoch=80, batch_size=10, verbose=2)
```

```
Epoch 11/80
1s - loss: 13.8754
Epoch 12/80
1s - loss: 13.2088
Epoch 13/80
1s - loss: 12.9001
Epoch 14/80
1s - loss: 12.7262
Epoch 15/80
1s - loss: 12.1947
Epoch 16/80
1s - loss: 12.0093
Epoch 17/80
1s - loss: 11.7677
Epoch 18/80
1s - loss: 11.5827
Epoch 19/80
1s - loss: 11.2505
Epoch 20/80
```

In [17]:

```
score_n = model.evaluate(XY_data_n, Z_n, batch_size=16, verbose=2)
score_n
```

Out[17]: 12.501418015416379

In [18]:

```
score_mae
```

Out[18]: 7.8382119013323015

The mean absolute error is about twice the value using the exact same model hyperparameters when noise generated with a Laplace distribution is added to the dataset.