Earthquake Prediction Model Using Python:

- It is well known that if a disaster occurs in one region, it is likely to happen again. Some regions have frequent earthquakes, but this is only a comparative amount compared to other regions.

- So, predicting the earthquake with date and time, latitude and longitude from previous data is not a trend that follows like other things, it happens naturally.

- I will start this task to create a model for earthquake prediction by importing the necessary python libraries:

```
1. import numpy as np
2. import pandas as pd
3. import matplotlib.pyplot as plt
```

- Now let‘s load and read the dataset. The dataset that I am using here can be easily downloaded here:

```
1. data = pd.read_csv(“database.csv“)
2. data.columns
```

Index([‘Date‘, ‘Time‘, ‘Latitude‘, ‘Longitude‘, ‘Type‘, ‘Depth‘, ‘Depth Error‘,

‘Depth Seismic Stations‘, ‘Magnitude‘, ‘Magnitude Type‘,

‘Magnitude Error‘, ‘Magnitude Seismic Stations‘, ‘Azimuthal Gap‘,

‘Horizontal Distance‘, ‘Horizontal Error‘, ‘Root Mean Square‘, ‘ID‘,

‘Source‘, ‘Location Source‘, ‘Magnitude Source‘, ‘Status‘],

dtype=‘object‘)

- Now let‘s see the main characteristics of earthquake data and create an object of these characteristics, namely, date, time, latitude, longitude, depth, magnitude:

1. data = data[['Date', 'Time', 'Latitude', 'Longitude', 'Depth', 'Magnitude']]

2. data.head()

	date	Time	Latitude	Longitude	Depth	Magnitude
0	01/02/1965	13:44:18	19.246	145.616	131.6	6.0
1	01/04/1965	11:29:49	1.863	127.352	80.0	5.8
2	01/05/1965	18:05:58	-20.579	-173.972	20.0	6.2
3	01/08/1965	18:49:43	-59.076	-23.557	15.0	5.8
4	01/09/1965	13:32:50	11.938	126.427	15.0	5.8

- Since the data is random, so we need to scale it based on the model inputs. In this, we convert the given date and time to Unix time which is in seconds and a number. This can be easily used as an entry for the network we have built:

```
import datetime

import time
```

```
timestamp = []
for d, t in zip(data['Date'], data['Time']):
    try:
        ts = datetime.datetime.strptime(d+' '+t, '%m/%d/%Y %H:%M:%S')
        timestamp.append(time.mktime(ts.timetuple()))
    except ValueError:
        # print('ValueError')
        timestamp.append('ValueError')
timeStamp = pd.Series(timestamp)
data['Timestamp'] = timeStamp.values
final_data = data.drop(['Date', 'Time'], axis=1)
final_data = final_data[final_data.Timestamp != 'ValueError']
final_data.head()
```

	Latitude	Longitude	Depth	Magnitude	Timestamp
0	19.246	145.616	131.6	6.0	-1.57631e+08
1	1.863	127.352	80.0	5.8	-1.57466e+08
2	-20.579	-173.972	20.0	6.2	-1.57356e+08

3	-59.076	-23.557	15.0	5.8	-1.57094e+08
4	11.938	126.427	15.0	5.8	-1.57026e+08

Data Visualization:

- Now, before we create the earthquake prediction model, let's visualize the data on a world map that shows a clear representation of where the earthquake frequency will be more:

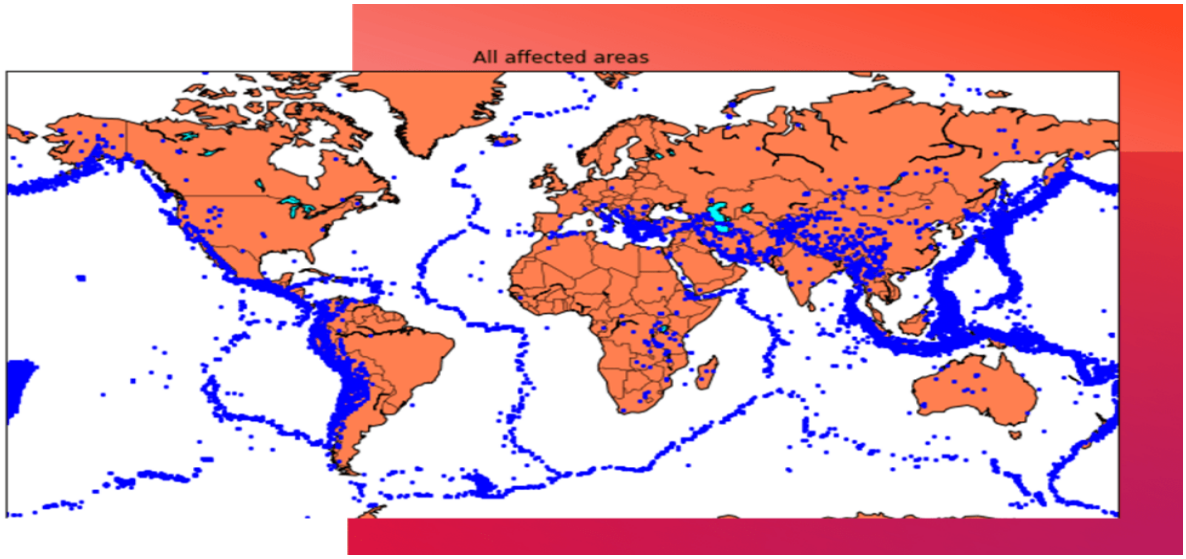
```
from mpl_toolkits.basemap import Basemap

m = Basemap(projection='mill',llcrnrlat=-80,urcrnrlat=80, llcrnrlon=
-180,urcrnrlon=180,lat_ts=20,resolution='c')

longitudes = data["Longitude"].tolist()
latitudes = data["Latitude"].tolist()
#m = Basemap(width=12000000,height=9000000,projection='lcc',
        #resolution=None,lat_1=80.,lat_2=55,lat_0=80,lon_0=-107.)
```

```
x,y = m(longitudes,latitudes)


fig = plt.figure(figsize=(12,10))
plt.title("All affected areas")
m.plot(x, y, "o", markersize = 2, color = 'blue')
m.drawcoastlines()
m.fillcontinents(color='coral',lake_color='aqua')
m.drawmapboundary()
m.drawcountries()
plt.show()
```



Splitting the Dataset:

- Now, to create the earthquake prediction model, we need to divide the data into Xs and ys which respectively will be entered into the model as inputs to receive the output from the model.

- Here the inputs are TImestamp, Latitude and Longitude and the outputs are Magnitude and Depth. I'm going to split the xs and ys into train and test with validation. The training set contains 80% and the test set contains 20%:

```
X = final_data[['Timestamp', 'Latitude', 'Longitude']]

y = final_data[['Magnitude', 'Depth']]

from sklearn.cross_validation import train_test_split


X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

print(X_train.shape, X_test.shape, y_train.shape, X_test.shape)
```

(18727, 3) (4682, 3) (18727, 2) (4682, 3)

Neural Network for Earthquake Prediction:

- Now I will create a neural network to fit the data from the training set. Our neural network will consist of three dense layers each with 16, 16, 2 nodes and reread. Relu and softmax will be used as activation functions:

```
from keras.models import Sequential

from keras.layers import Dense

def create_model(neurons, activation, optimizer, loss):

    model = Sequential()

    model.add(Dense(neurons,activation=activation,
input_shape=(3,)))

    model.add(Dense(neurons, activation=activation))

    model.add(Dense(2, activation='softmax'))

    model.compile(optimizer=optimizer,loss=loss,
metrics=['accuracy'])

    return model
```

Now I'm going to define the hyperparameters with two or more options to find the best fit:

```
from keras.wrappers.scikit_learn import KerasClassifier

model = KerasClassifier(build_fn=create_model, verbose=0)

# neurons = [16, 64, 128, 256]

neurons = [16]

# batch_size = [10, 20, 50, 100]

batch_size = [10]

epochs = [10]

# activation = ['relu', 'tanh', 'sigmoid', 'hard_sigmoid', 'linear', 'exponential']

activation = ['sigmoid', 'relu']

# optimizer = ['SGD', 'RMSprop', 'Adagrad', 'Adadelta', 'Adam', 'Adamax', 'Nadam']

optimizer = ['SGD', 'Adadelta']

loss = ['squared_hinge']

param_grid = dict(neurons=neurons, batch_size=batch_size, epochs=epochs, activation=activation, optimizer=optimizer, loss=loss)
```

Now we need to find the best fit of the above model and get the mean test score and standard deviation of the best fit model:

```
grid= GridSearchCV(estimator=model, param_grid=param_grid, n_jobs=-1)

grid_result = grid.fit(X_train, y_train)

print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))

means = grid_result.cv_results_['mean_test_score']

stds = grid_result.cv_results_['std_test_score']

params = grid_result.cv_results_['params']

for mean, stdev, param in zip(means, stds, params):

print("%f (%f) with: %r" % (mean, stdev, param))
```

Best: 0.957655 using {'activation': 'relu', 'batch_size': 10, 'epochs': 10, 'loss': 'squared_hinge', 'neurons': 16, 'optimizer': 'SGD'} 0.333316 (0.471398) with: {'activation': 'sigmoid', 'batch_size': 10, 'epochs': 10, 'loss': 'squared_hinge', 'neurons': 16, 'optimizer': 'SGD'} 0.000000 (0.000000) with: {'activation': 'sigmoid', 'batch_size': 10, 'epochs': 10, 'loss': 'squared_hinge', 'neurons': 16, 'optimizer': 'Adadelta'} 0.957655 (0.029957) with: {'activation': 'relu', 'batch_size': 10, 'epochs': 10, 'loss': 'squared_hinge', 'neurons': 16, 'optimizer': 'SGD'}

0.645111 (0.456960) with: {‘activation‘: ‘relu‘, ‘batch_size‘: 10, ‘epochs‘: 10, ‘loss‘: ‘squared_hinge‘, ‘neurons‘: 16, ‘optimizer‘: ‘Adadelta‘}

In the step below, the best-fit parameters are used for the same model to calculate the score with the training data and the test data:

```
model = Sequential()

model.add(Dense(16, activation=‘relu‘, input_shape=(3,)))

model.add(Dense(16, activation=‘relu‘))

model.add(Dense(2, activation=‘softmax‘))

model.compile(optimizer=‘SGD‘, loss=‘squared_hinge‘, metrics=[‘accuracy‘])

model.fit(X_train, y_train, batch_size=10, epochs=20, verbose=1, validation_data=(X_test, y_test))

[test_loss, test_acc] = model.evaluate(X_test, y_test)

print(“Evaluation result on Test Data : Loss = {}, accuracy = {}“.format(test_loss, test_acc))
```