Covid-19 visualization, prediction and forecasting

In [1]:

```python
# Importing all the important libraries.

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import matplotlib.colors as mcolors
import random
import math
import time
import datetime
import operator
from sklearn.model_selection import RandomizedSearchCV, train_test_split
from sklearn.svm import SVR
from sklearn.metrics import mean_squared_error,mean_absolute_error
from sklearn.linear_model import LinearRegression

plt.style.use('seaborn')
%matplotlib inline
```

In [2]:

```python
# loading all the three datasets

confirmed_cases = pd.read_csv("time_series_covid_19_confirmed.csv")
```

In [3]:

```python
deaths_reported = pd.read_csv("time_series_covid_19_deaths.csv")
```

In [4]:

```python
recovered_cases = pd.read_csv("time_series_covid_19_recovered.csv")
```

In [5]:

```python
# display the head of the Dataset

confirmed_cases.head()
```

Out[5]:

	Province/State	Country/Region	Lat	Long	1/22/20	1/23/20	1/24/20	1/25/20	1/26/20	1/27/20	...	6/13/20	6/14/20	6/15/20	6/16/20	6/17/20	6/18/20	6
0	NaN	Afghanistan	33.0000	65.0000	0	0	0	0	0	0	...	24102	24766	25527	26310	26874	27532	
1	NaN	Albania	41.1533	20.1683	0	0	0	0	0	0	...	1464	1521	1590	1672	1722	1788	
2	NaN	Algeria	28.0339	1.6596	0	0	0	0	0	0	...	10810	10919	11031	11147	11268	11385	
3	NaN	Andorra	42.5063	1.5218	0	0	0	0	0	0	...	853	853	853	854	854	855	
4	NaN	Angola	-11.2027	17.8739	0	0	0	0	0	0	...	138	140	142	148	155	166	

5 rows × 157 columns

In [6]:

```python
deaths_reported.head()
```

Out[6]:

	Province/State	Country/Region	Lat	Long	1/22/20	1/23/20	1/24/20	1/25/20	1/26/20	1/27/20	...	6/13/20	6/14/20	6/15/20	6/16/20	6/17/20	6/18/20	6
0	NaN	Afghanistan	33.0000	65.0000	0	0	0	0	0	0	...	451	471	478	491	504	546	
1	NaN	Albania	41.1533	20.1683	0	0	0	0	0	0	...	36	36	36	37	38	39	
2	NaN	Algeria	28.0339	1.6596	0	0	0	0	0	0	...	760	767	777	788	799	811	
3	NaN	Andorra	42.5063	1.5218	0	0	0	0	0	0	...	51	51	51	52	52	52	
4	NaN	Angola	-11.2027	17.8739	0	0	0	0	0	0	...	6	6	6	6	7	8	

5 rows × 157 columns

In [7]:

```python
recovered_cases.head()
```

Out[7]:

	Province/State	Country/Region	Lat	Long	1/22/20	1/23/20	1/24/20	1/25/20	1/26/20	1/27/20	...	6/13/20	6/14/20	6/15/20	6/16/20	6/17/20	6/18/20	6
0	NaN	Afghanistan	33.0000	65.0000	0	0	0	0	0	0	...	4201	4725	5164	5508	6158	7660	
1	NaN	Albania	41.1533	20.1683	0	0	0	0	0	0	...	1039	1044	1055	1064	1077	1086	
2	NaN	Algeria	28.0339	1.6596	0	0	0	0	0	0	...	7420	7606	7735	7842	7943	8078	
3	NaN	Andorra	42.5063	1.5218	0	0	0	0	0	0	...	781	781	789	789	791	792	
4	NaN	Angola	-11.2027	17.8739	0	0	0	0	0	0	...	61	61	64	64	64	64	

5 rows × 157 columns

In [8]:
```
# Extracting all the columns using the .keys() function.
cols = confirmed_cases.keys()
cols
```

Out[8]:
```
Index(['Province/State', 'Country/Region', 'Lat', 'Long', '1/22/20', '1/23/20',
       '1/24/20', '1/25/20', '1/26/20', '1/27/20',
       ...
       '6/13/20', '6/14/20', '6/15/20', '6/16/20', '6/17/20', '6/18/20',
       '6/19/20', '6/20/20', '6/21/20', '6/22/20'],
      dtype='object', length=157)
```

In [9]:
```
# Extracting only the dates columns that have information of confirmed,deaths and recovered cases.
confirmed =  confirmed_cases.loc[:, cols[4]:cols[-1]]
```

In [10]:
```
deaths = deaths_reported.loc[:, cols[4]:cols[-1]]
```

In [11]:
```
recoveries = recovered_cases.loc[:, cols[4]:cols[-1]]
```

In [12]:
```
# Check the head of the outbreak cases.
confirmed.head()
```

Out[12]:

	1/22/20	1/23/20	1/24/20	1/25/20	1/26/20	1/27/20	1/28/20	1/29/20	1/30/20	1/31/20	...	6/13/20	6/14/20	6/15/20	6/16/20	6/17/20	6/18/20	6/19/20	6/20/20
0	0	0	0	0	0	0	0	0	0	0	...	24102	24766	25527	26310	26874	27532	27878	28424
1	0	0	0	0	0	0	0	0	0	0	...	1464	1521	1590	1672	1722	1788	1838	1891
2	0	0	0	0	0	0	0	0	0	0	...	10810	10919	11031	11147	11268	11385	11504	11631
3	0	0	0	0	0	0	0	0	0	0	...	853	853	853	854	854	855	855	855
4	0	0	0	0	0	0	0	0	0	0	...	138	140	142	148	155	166	172	176

5 rows × 153 columns

In [13]:
```
# Finding the total confirmed cases,death cases and the recovered cases and append them to an 4 empty lists.
# Also, calculate the total mortality rate which is the death sum/confirmed cases.

dates = confirmed.keys()
world_cases = []
total_deaths = []
mortality_rate = []
total_recovered = []

for i in dates:
    confirmed_sum = confirmed[i].sum()
    death_sum = deaths[i].sum()
    recovered_sum = recoveries[i].sum()
    world_cases.append(confirmed_sum)
    total_deaths.append(death_sum)
    mortality_rate.append(death_sum/confirmed_sum)
    total_recovered.append(recovered_sum)
```

In [14]:
```
# Lets display each of the newly created variables
confirmed_sum
```

Out[14]:
```
9098643
```

In [15]:
```
death_sum
```

Out[15]:
```
472171
```

In [16]:
```
recovered_sum
```

Out[16]:
```
4526333
```

In [17]:
```
world_cases
```

Out[17]:
```
[555,
 654,
 941,
 1434,
 2118,
 2927,
 5578,
 6166,
 8234,
 9927,
 12038,
 16787,
 19881,
 23892,
 27635,
 30794,
 34391,
 37120,
 40150,
```

In [18]:

```
# Convert all the dates and the cases in the form of a numpy array

days_since_1_22 = np.array([i for i in range(len(dates))]).reshape(-1,1)
world_cases = np.array(world_cases).reshape(-1,1)
total_deaths = np.array(total_deaths).reshape(-1,1)
total_recovered = np.array(total_recovered).reshape(-1,1)
```

In [19]:

```
days_since_1_22
```

Out[19]:

```
array([[  0],
       [  1],
       [  2],
       [  3],
       [  4],
       [  5],
       [  6],
       [  7],
       [  8],
       [  9],
       [ 10],
       [ 11],
       [ 12],
       [ 13],
       [ 14],
       [ 15],
       [ 16],
       [ 17],
       [ 18],
```

In [20]:

```
world_cases
```

Out[20]:

```
array([[    555],
       [    654],
       [    941],
       [   1434],
       [   2118],
       [   2927],
       [   5578],
       [   6166],
       [   8234],
       [   9927],
       [  12038],
       [  16787],
       [  19881],
       [  23892],
       [  27635],
       [  30794],
       [  34391],
       [  37120],
       [  40150],
```

In [21]:

```
total_deaths
```

Out[21]:

```
array([[    17],
       [    18],
       [    26],
       [    42],
       [    56],
       [    82],
       [   131],
       [   133],
       [   171],
       [   213],
       [   259],
       [   362],
       [   426],
       [   492],
       [   564],
       [   634],
       [   719],
       [   806],
       [   906],
```

In [22]:

```
total_recovered
```

Out[22]:

```
array([[     28],
       [     30],
       [     36],
       [     39],
       [     52],
       [     61],
       [    107],
       [    126],
       [    143],
       [    222],
       [    284],
       [    472],
       [    623],
       [    852],
       [   1124],
       [   1487],
       [   2011],
       [   2616],
       [   3244],
```

In [23]:

```
# Future forecasting for the next 10 days

days_in_future = 10
future_forecast = np.array([i for i in range (len(dates)+days_in_future)]).reshape(-1,1)
adjusted_dates = future_forecast[:-10]
```

In [24]:

```
future_forecast
```

Out[24]:

```
array([[  0],
       [  1],
       [  2],
       [  3],
       [  4],
       [  5],
       [  6],
       [  7],
       [  8],
       [  9],
       [ 10],
       [ 11],
       [ 12],
       [ 13],
       [ 14],
       [ 15],
       [ 16],
       [ 17],
       [ 18],
```

In [25]:

```
# Convert all the integers into datetime for better visualization.
start = '1/22/2020'
start_date = datetime.datetime.strptime(start,'%m/%d/%Y')
future_forcast_dates = []
for i in range(len(future_forecast)):
    future_forcast_dates.append((start_date + datetime.timedelta(days=i)).strftime('%m/%d/%Y'))
```

In [26]:

```
# For visualization with the latest data of the 22nd of june

latest_confirmed = confirmed_cases[dates[-1]]
latest_deaths = deaths_reported[dates[-1]]
latest_recoveries = recovered_cases[dates[-1]]
```

In [27]:

```
# Find the list of unique countries
unique_countries = list(confirmed_cases['Country/Region'].unique())
unique_countries
```

Out[27]:

```
['Afghanistan',
 'Albania',
 'Algeria',
 'Andorra',
 'Angola',
 'Antigua and Barbuda',
 'Argentina',
 'Armenia',
 'Australia',
 'Austria',
 'Azerbaijan',
 'Bahamas',
 'Bahrain',
 'Bangladesh',
 'Barbados',
 'Belarus',
 'Belgium',
 'Benin',
 'Bhutan',
```

In [28]:

```python
# The next line of code will basically calculate the total number of confirmed cases by each country.

country_confirmed_cases = []
no_cases = []
for i in unique_countries:
    cases = latest_confirmed[confirmed_cases['Country/Region']==i].sum()
    if cases > 0:
        country_confirmed_cases.append(cases)
    else:
        no_cases.append(i)

for i in no_cases:
    unique_countries.remove(i)

unique_countries = [k for k, v in sorted(zip(unique_countries, country_confirmed_cases), key=operator.itemgetter(1), reverse=T
for i in range(len(unique_countries)):
    country_confirmed_cases[i] = latest_confirmed[confirmed_cases['Country/Region']==unique_countries[i]].sum()
```

In [29]:

```python
# Number of cases per Country/Region
print('Confirmed Cases by Countries/Regions:')
for i in range(len(unique_countries)):
    print(f'{unique_countries[i]}: {country_confirmed_cases[i]} cases')
```

```
Confirmed Cases by Countries/Regions:
US: 2312302 cases
Brazil: 1106470 cases
Russia: 591465 cases
India: 440215 cases
United Kingdom: 306761 cases
Peru: 257447 cases
Chile: 246963 cases
Spain: 246504 cases
Italy: 238720 cases
Iran: 207525 cases
France: 197381 cases
Germany: 191768 cases
Turkey: 188897 cases
Mexico: 185122 cases
Pakistan: 185034 cases
Saudi Arabia: 161005 cases
Bangladesh: 115786 cases
Canada: 103418 cases
```

In [30]:

```python
# Find the list of unique provinces
unique_provinces =  list(confirmed_cases['Province/State'].unique())
```

In [31]:

```python
# Finding the number of confirmed cases per provinces,state or city.
province_confirmed_cases = []
no_cases = []
for i in unique_provinces:
    cases = latest_confirmed[confirmed_cases['Province/State']==i].sum()
    if cases > 0:
        province_confirmed_cases.append(cases)
    else:
        no_cases.append(i)
# remove areas with no confirmed cases
for i in no_cases:
    unique_provinces.remove(i)
```

In [32]:

```python
# Number of cases per province/state/city
for i in range(len(unique_provinces)):
    print(f'{unique_provinces[i]}: {province_confirmed_cases[i]} cases')
```

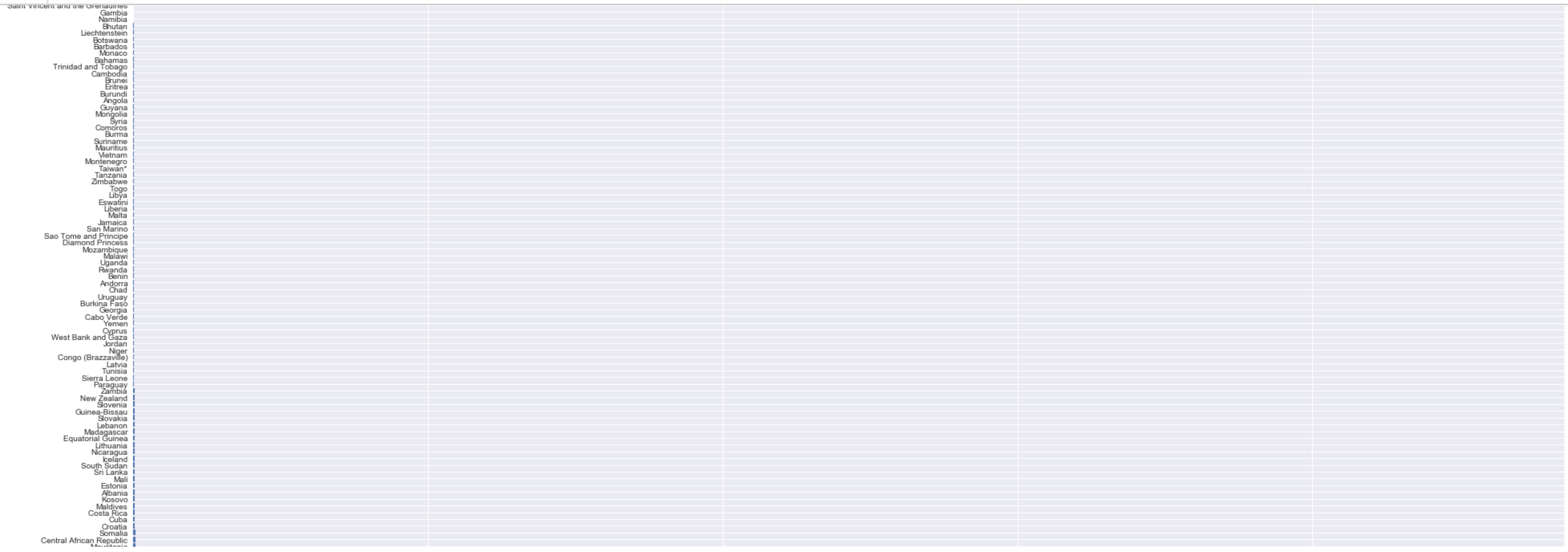
```
Australian Capital Territory: 108 cases
New South Wales: 3150 cases
Northern Territory: 29 cases
Queensland: 1066 cases
South Australia: 440 cases
Tasmania: 228 cases
Victoria: 1864 cases
Western Australia: 607 cases
Alberta: 7736 cases
British Columbia: 2822 cases
Grand Princess: 13 cases
Manitoba: 314 cases
New Brunswick: 164 cases
Newfoundland and Labrador: 261 cases
Nova Scotia: 1061 cases
Ontario: 35418 cases
Prince Edward Island: 27 cases
Quebec: 54835 cases
Saskatchewan: 751 cases
```

In [33]:

```
# Handling nan values if there is any,it is usually a float: float('nan')

nan_indices = []

for i in range(len(unique_provinces)):
    if type(unique_provinces[i]) == float:
        nan_indices.append(i)

unique_provinces = list(unique_provinces)
province_confirmed_cases = list(province_confirmed_cases)

for i in nan_indices:
    unique_provinces.pop(i)
    province_confirmed_cases.pop(i)
```

In [34]:

```
# Plot a bar graph to see the total confirmed cases across different countries.
plt.figure(figsize=(32,32))
plt.barh(unique_countries,country_confirmed_cases)
plt.title('Number of Covid-19 confirmed cases in Countries')
plt.xlabel('Number of Covid19 Confirmed cases')
plt.show()
```



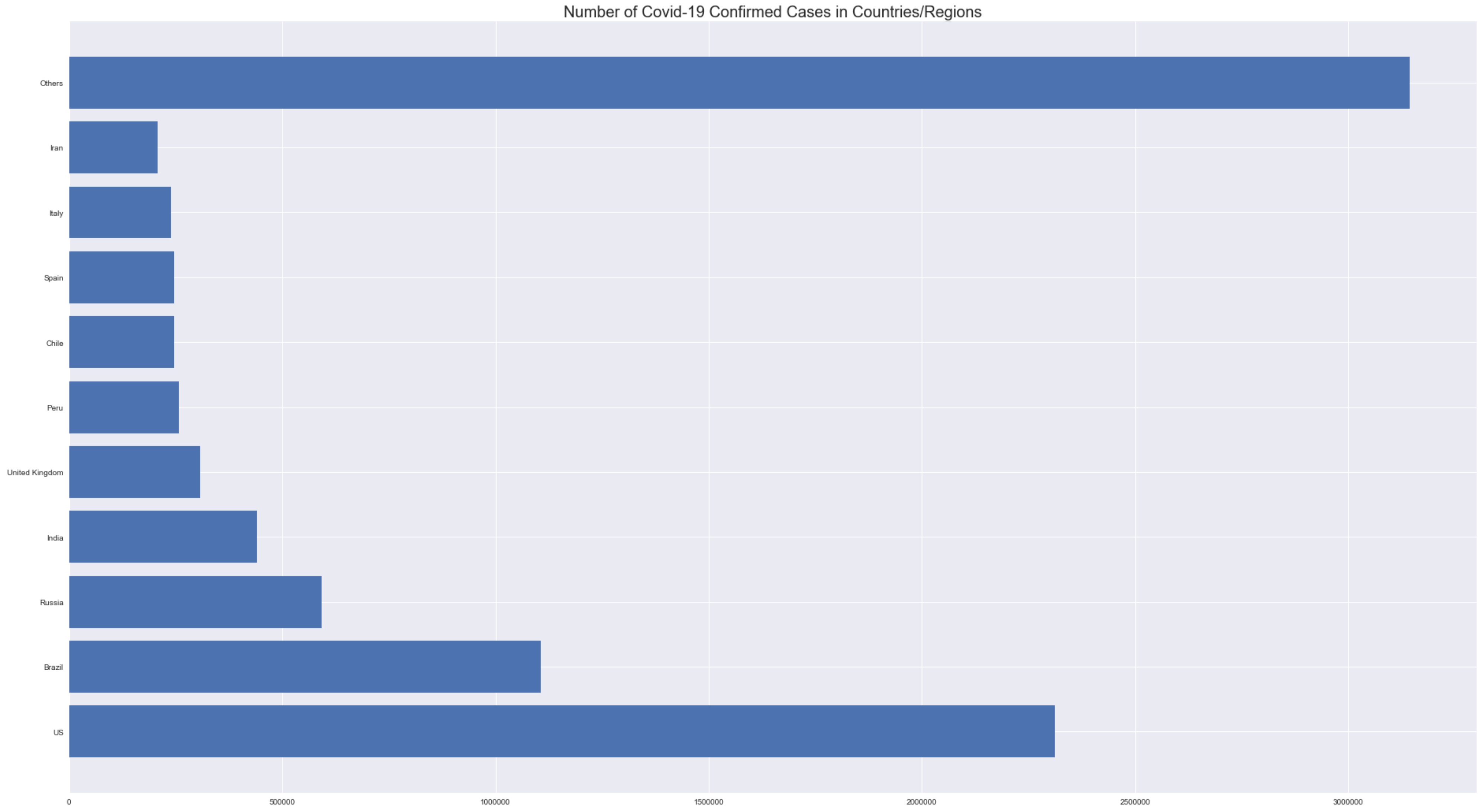
In [35]:

```
# Only show 10 countries with the most confirmed cases, the rest are grouped into the  category named others
visual_unique_countries = []
visual_confirmed_cases = []
others = np.sum(country_confirmed_cases[10:])
for i in range(len(country_confirmed_cases[:10])):
    visual_unique_countries.append(unique_countries[i])
    visual_confirmed_cases.append(country_confirmed_cases[i])

visual_unique_countries.append('Others')
visual_confirmed_cases.append(others)
```

Visual Representations (bar charts and pie charts)

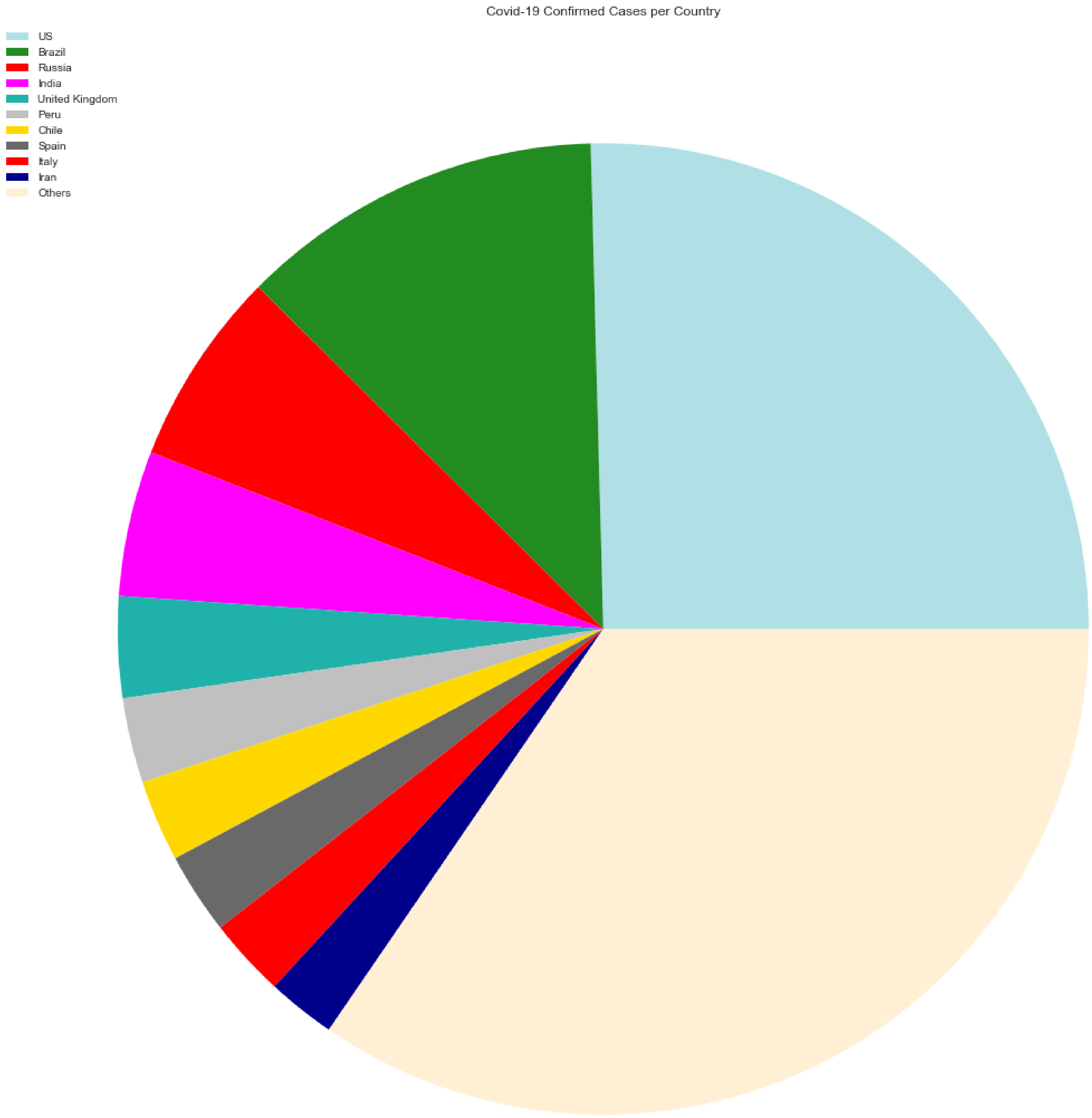
In [36]:

```
# Visualize the 10 Countries
plt.figure(figsize=(32, 18))
plt.barh(visual_unique_countries, visual_confirmed_cases)
plt.title('Number of Covid-19 Confirmed Cases in Countries/Regions', size=20)
plt.show()
```



In [37]:

```
# Create a Pie chart to see the total confirmed cases in 10 different countries.

c = random.choices(list(mcolors.CSS4_COLORS.values()),k = len(unique_countries))
plt.figure(figsize=(20,20))
plt.title('Covid-19 Confirmed Cases per Country')
plt.pie(visual_confirmed_cases, colors=c)
plt.legend(visual_unique_countries, loc='best')
plt.show()
```



In [38]:

```
X_train_confirmed, X_test_confirmed, y_train_confirmed, y_test_confirmed = train_test_split(days_since_1_22, world_cases, test
```

In [39]:

```
# Building the SVM Model
kernel = ['poly','sigmoid','rbf']
c = [0.01, 0.1, 1, 10]
gamma = [0.01, 0.1, 1]
epsilon = [0.01, 0.1, 1]
shrinking= [True, False]
svm_grid = {'kernel': kernel,'C': c,'gamma': gamma,'epsilon':epsilon,'shrinking':shrinking}
svm = SVR(kernel='poly')
svm_search = RandomizedSearchCV(svm, svm_grid, scoring='neg_mean_squared_error', cv=3, return_train_score=True, n_jobs=-1, n_i
svm_search.fit(X_train_confirmed, y_train_confirmed)
```

```
Fitting 3 folds for each of 40 candidates, totalling 120 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 8 concurrent workers.
[Parallel(n_jobs=-1)]: Done  34 tasks      | elapsed:    7.7s
[Parallel(n_jobs=-1)]: Done 105 out of 120 | elapsed:   25.0s remaining:    3.5s
[Parallel(n_jobs=-1)]: Done 120 out of 120 | elapsed:  9.6min finished
K:\conda\lib\site-packages\sklearn\model_selection\_search.py:813: DeprecationWarning: The default of the `iid` parameter will ch
ange from True to False in version 0.22 and will be removed in 0.24. This will change numeric results when test-set sizes are une
qual.
  DeprecationWarning)
K:\conda\lib\site-packages\sklearn\utils\validation.py:724: DataConversionWarning: A column-vector y was passed when a 1d array w
as expected. Please change the shape of y to (n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)
```

Out[39]:

```
RandomizedSearchCV(cv=3, error_score='raise-deprecating',
                   estimator=SVR(C=1.0, cache_size=200, coef0=0.0, degree=3,
                                 epsilon=0.1, gamma='auto_deprecated',
                                 kernel='poly', max_iter=-1, shrinking=True,
                                 tol=0.001, verbose=False),
                   iid='warn', n_iter=40, n_jobs=-1,
                   param_distributions={'C': [0.01, 0.1, 1, 10],
                                        'epsilon': [0.01, 0.1, 1],
                                        'gamma': [0.01, 0.1, 1],
                                        'kernel': ['poly', 'sigmoid', 'rbf'],
                                        'shrinking': [True, False]},
                   pre_dispatch='2*n_jobs', random_state=None, refit=True,
                   return_train_score=True, scoring='neg_mean_squared_error',
                   verbose=1)
```

In [40]:

```
# Finding the best parameters for the model
svm_search.best_params_
```

Out[40]:

```
{'shrinking': True, 'kernel': 'poly', 'gamma': 1, 'epsilon': 0.01, 'C': 0.1}
```

In [41]:

```
# Finding the best estimator and predict the future forecast
svm_confirmed = svm_search.best_estimator_
svm_pred = svm_confirmed.predict(future_forecast)
```

In [42]:

```
# The values of best estimator
svm_confirmed
```

Out[42]:

```
SVR(C=0.1, cache_size=200, coef0=0.0, degree=3, epsilon=0.01, gamma=1,
    kernel='poly', max_iter=-1, shrinking=True, tol=0.001, verbose=False)
```

In [43]:

```
# Predicted values for all the dates
svm_pred
```

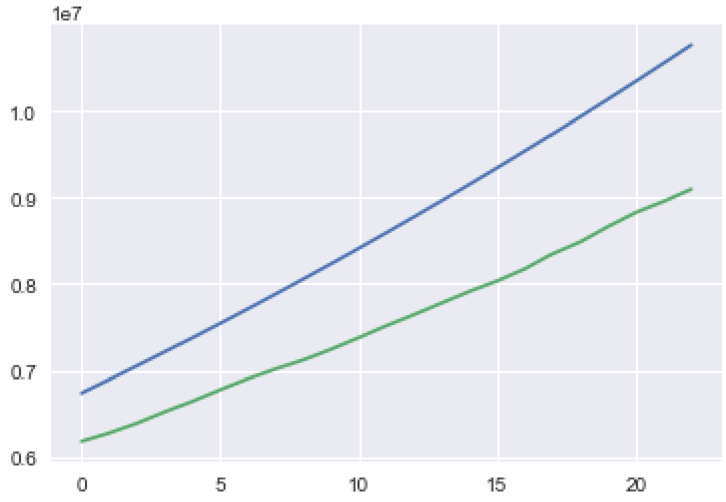
Out[43]:

```
array([1.92184167e+03, 1.92490680e+03, 1.94636273e+03, 2.00460026e+03,
       2.11801018e+03, 2.30498329e+03, 2.58391039e+03, 2.97318228e+03,
       3.49118976e+03, 4.15632361e+03, 4.98697465e+03, 6.00153367e+03,
       7.21839146e+03, 8.65593883e+03, 1.03325666e+04, 1.22666655e+04,
       1.44766264e+04, 1.69808400e+04, 1.97976972e+04, 2.29455888e+04,
       2.64429055e+04, 3.03080382e+04, 3.45593777e+04, 3.92153146e+04,
       4.42942400e+04, 4.98145445e+04, 5.57946189e+04, 6.22528541e+04,
       6.92076409e+04, 7.66773699e+04, 8.46804322e+04, 9.32352183e+04,
       1.02360119e+05, 1.12073526e+05, 1.22393828e+05, 1.33339418e+05,
       1.44928686e+05, 1.57180023e+05, 1.70111819e+05, 1.83742465e+05,
       1.98090352e+05, 2.13173872e+05, 2.29011414e+05, 2.45621370e+05,
       2.63022130e+05, 2.81232085e+05, 3.00269626e+05, 3.20153143e+05,
       3.40901028e+05, 3.62531672e+05, 3.85063464e+05, 4.08514797e+05,
       4.32904060e+05, 4.58249644e+05, 4.84569941e+05, 5.11883341e+05,
       5.40208235e+05, 5.69563014e+05, 5.99966068e+05, 6.31435788e+05,
       6.63990566e+05, 6.97648791e+05, 7.32428855e+05, 7.68349148e+05,
       8.05428062e+05, 8.43683987e+05, 8.83135313e+05, 9.23800432e+05,
       9.65697735e+05, 1.00884561e+06, 1.05326245e+06, 1.09896665e+06,
       1.14597660e+06, 1.19431068e+06, 1.24398729e+06, 1.29502482e+06,
       1.34744166e+06, 1.40135629e+06, 1.45643683e+06, 1.51315104e+06,
```

In [44]:

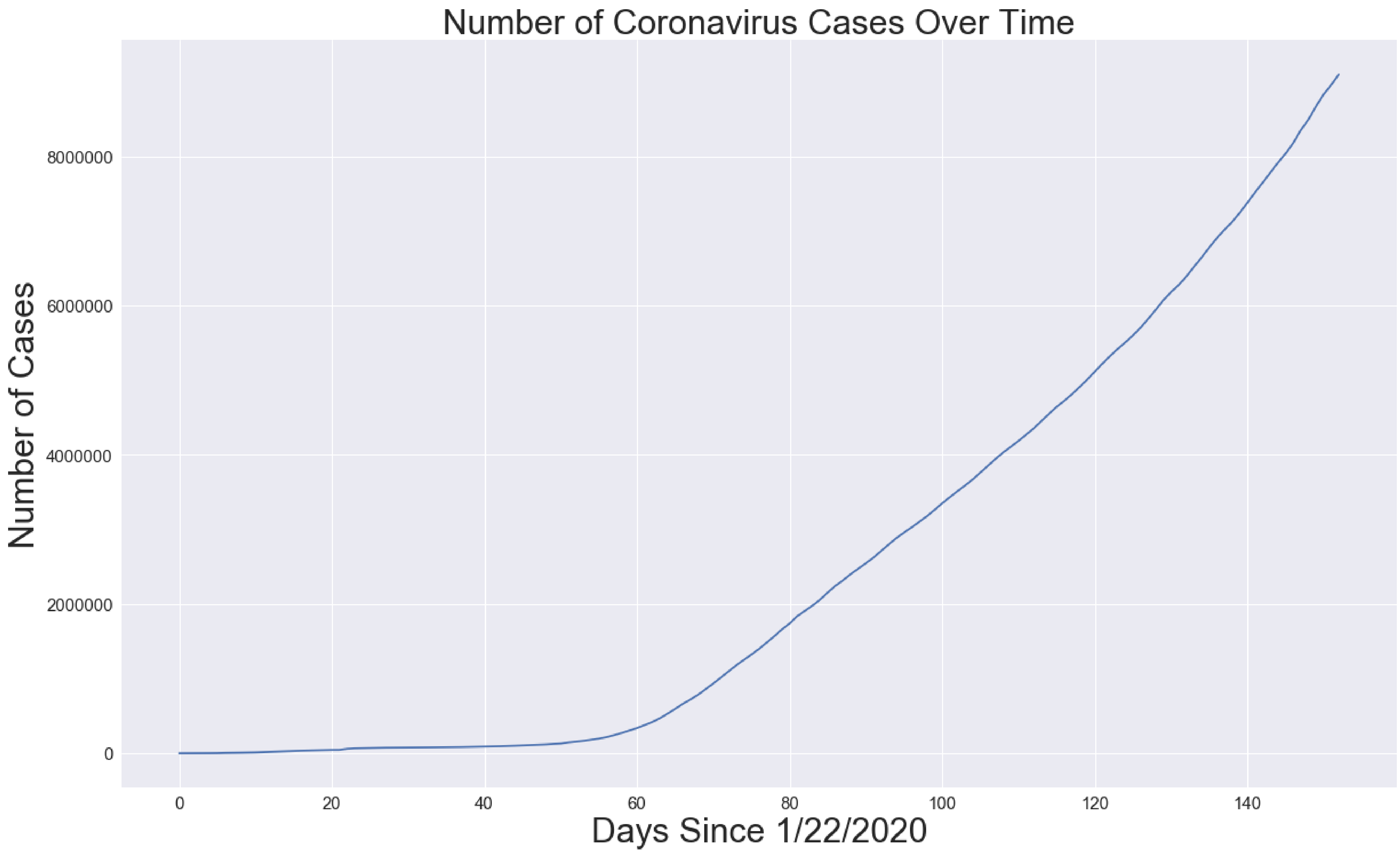
```
# check against testing data
svm_test_pred = svm_confirmed.predict(X_test_confirmed)
plt.plot(svm_test_pred)
plt.plot(y_test_confirmed)
print('MAE:', mean_absolute_error(svm_test_pred, y_test_confirmed))
print('MSE:',mean_squared_error(svm_test_pred, y_test_confirmed))
```

```
MAE: 1090973.2364436
MSE: 1300741123700.0754
```



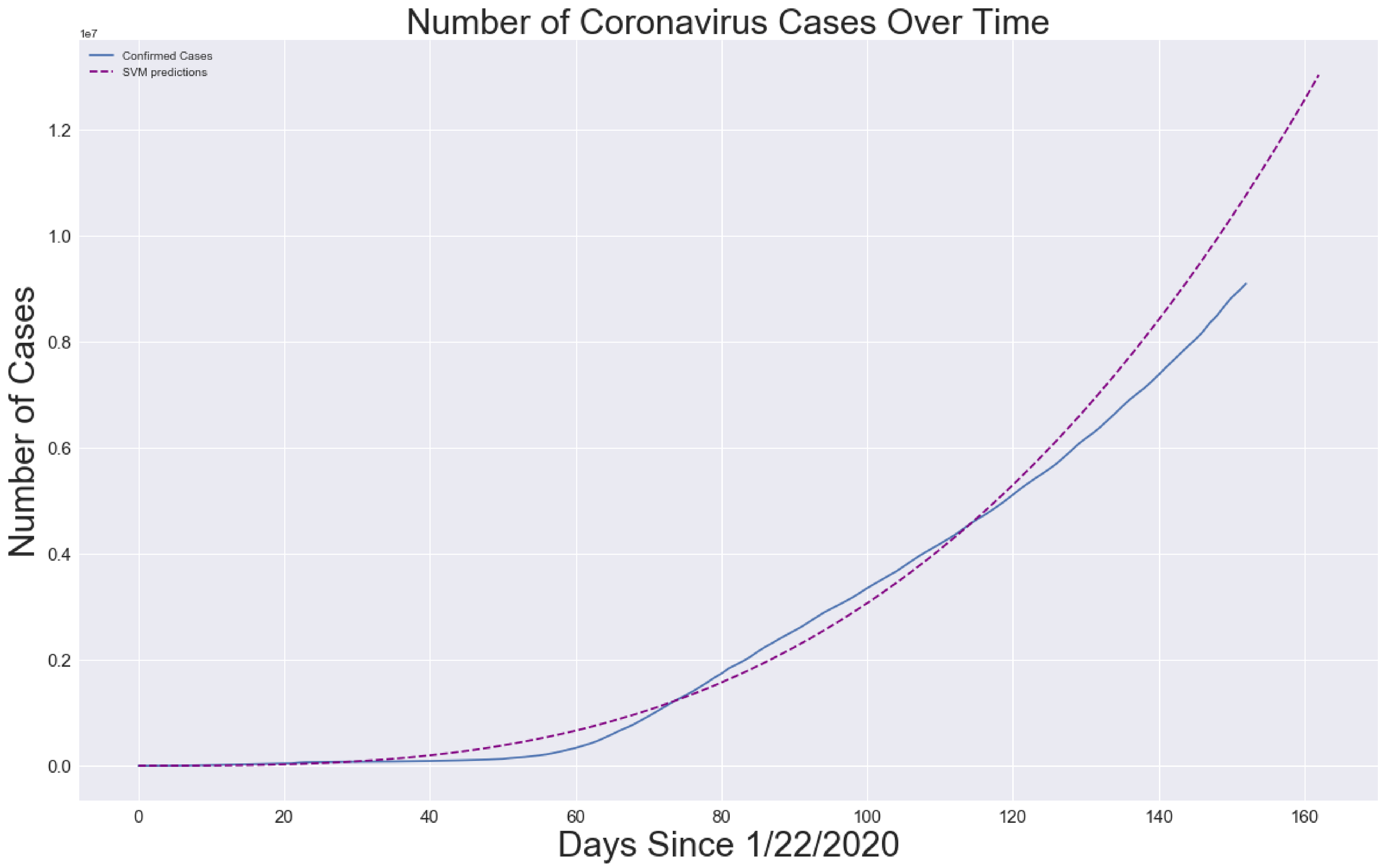
In [45]:

```python
# Total number of coronavirus cases over time
plt.figure(figsize=(20, 12))
plt.plot(adjusted_dates, world_cases)
plt.title('Number of Coronavirus Cases Over Time', size=30)
plt.xlabel('Days Since 1/22/2020', size=30)
plt.ylabel('Number of Cases', size=30)
plt.xticks(size=15)
plt.yticks(size=15)
plt.show()
```



In [46]:

```
# Confirmed vs Predicted Cases
plt.figure(figsize=(20, 12))
plt.plot(adjusted_dates, world_cases)
plt.plot(future_forecast, svm_pred, linestyle='dashed', color='purple')
plt.title('Number of Coronavirus Cases Over Time', size=30)
plt.xlabel('Days Since 1/22/2020', size=30)
plt.ylabel('Number of Cases', size=30)
plt.legend(['Confirmed Cases', 'SVM predictions'])
plt.xticks(size=15)
plt.yticks(size=15)
plt.show()
```



In [47]:

```
# Prediction for the next 10 days using SVM
print('SVM future predictions:')
set(zip(future_forcast_dates[-10:], svm_pred[-10:]))
```

```
SVM future predictions:
```

Out[47]:

```
{('06/23/2020', 10979931.628414027),
 ('06/24/2020', 11196596.682735316),
 ('06/25/2020', 11416093.921748988),
 ('06/26/2020', 11638441.734493129),
 ('06/27/2020', 11863658.510738246),
 ('06/28/2020', 12091762.639156215),
 ('06/29/2020', 12322772.516719691),
 ('06/30/2020', 12556706.531123988),
 ('07/01/2020', 12793583.072383754),
 ('07/02/2020', 13033420.534175746)}
```

In [48]:

```
# Using Linear Regression Model to make Predictions
linear_model = LinearRegression(normalize = True,fit_intercept = True)
linear_model.fit(X_train_confirmed, y_train_confirmed)
test_linear_pred = linear_model.predict(X_test_confirmed)
linear_pred = linear_model.predict(future_forecast)
print('MAE:', mean_absolute_error(test_linear_pred, y_test_confirmed))
print('MSE:',mean_squared_error(test_linear_pred, y_test_confirmed))
```

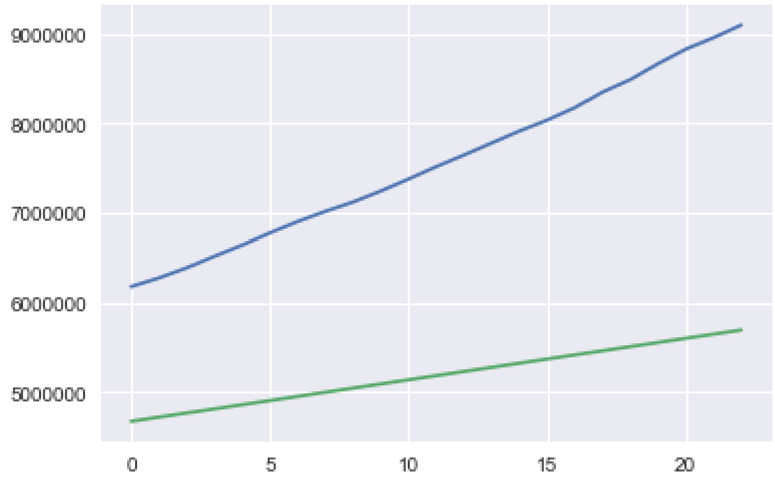
```
MAE: 2376440.8069835715
MSE: 5979711806506.45
```

In [49]:

```
plt.plot(y_test_confirmed)
plt.plot(test_linear_pred)
```

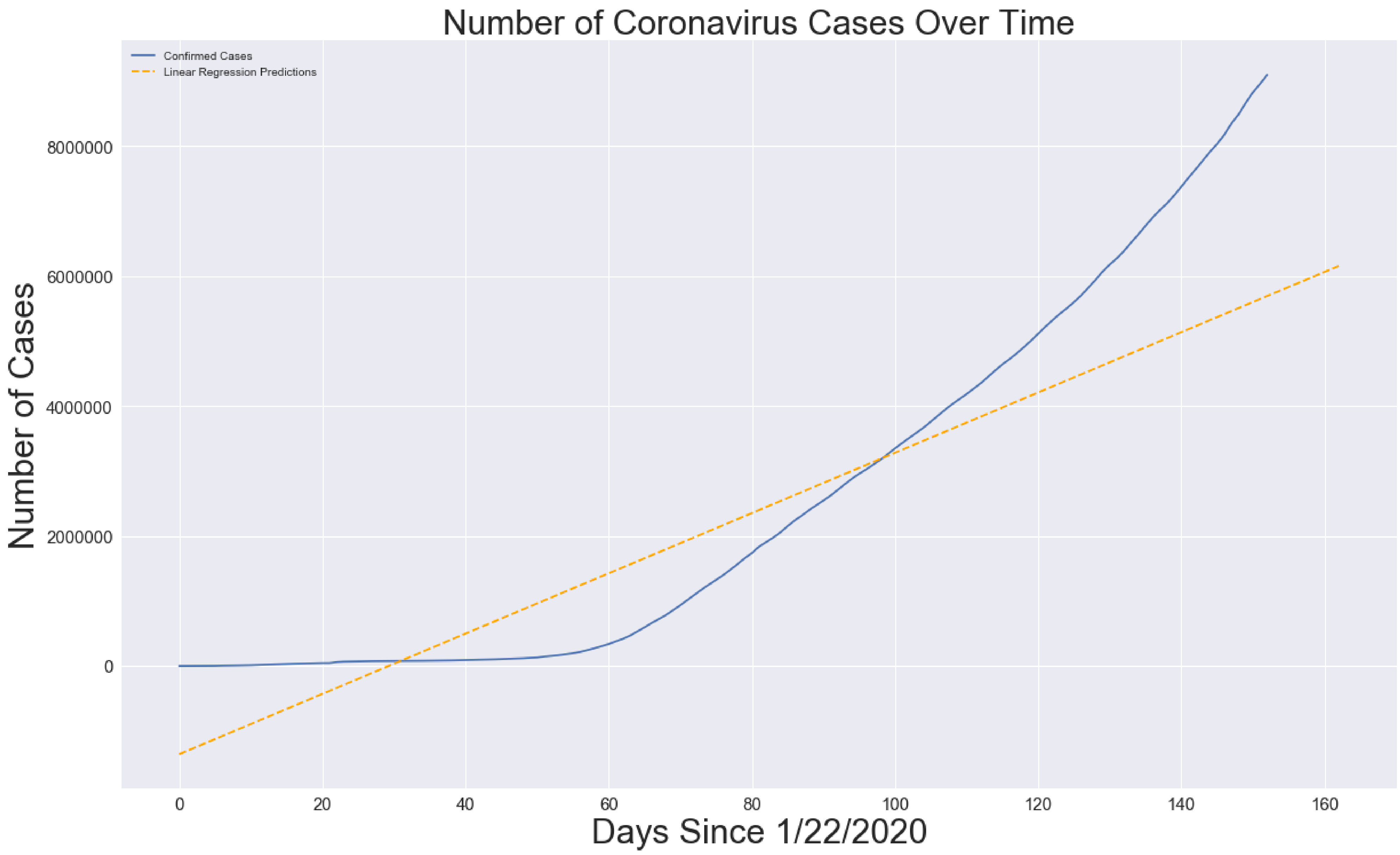
Out[49]:

```
[<matplotlib.lines.Line2D at 0x817eb0>]
```



In [50]:

```
# Graphing the number of confirmed cases, deaths, active cases, and the mortality rate over time, as well as the number of rec
plt.figure(figsize=(20, 12))
plt.plot(adjusted_dates, world_cases)
plt.plot(future_forecast, linear_pred, linestyle='dashed', color='orange')
plt.title('Number of Coronavirus Cases Over Time', size=30)
plt.xlabel('Days Since 1/22/2020', size=30)
plt.ylabel('Number of Cases', size=30)
plt.legend(['Confirmed Cases', 'Linear Regression Predictions'])
plt.xticks(size=15)
plt.yticks(size=15)
plt.show()
```



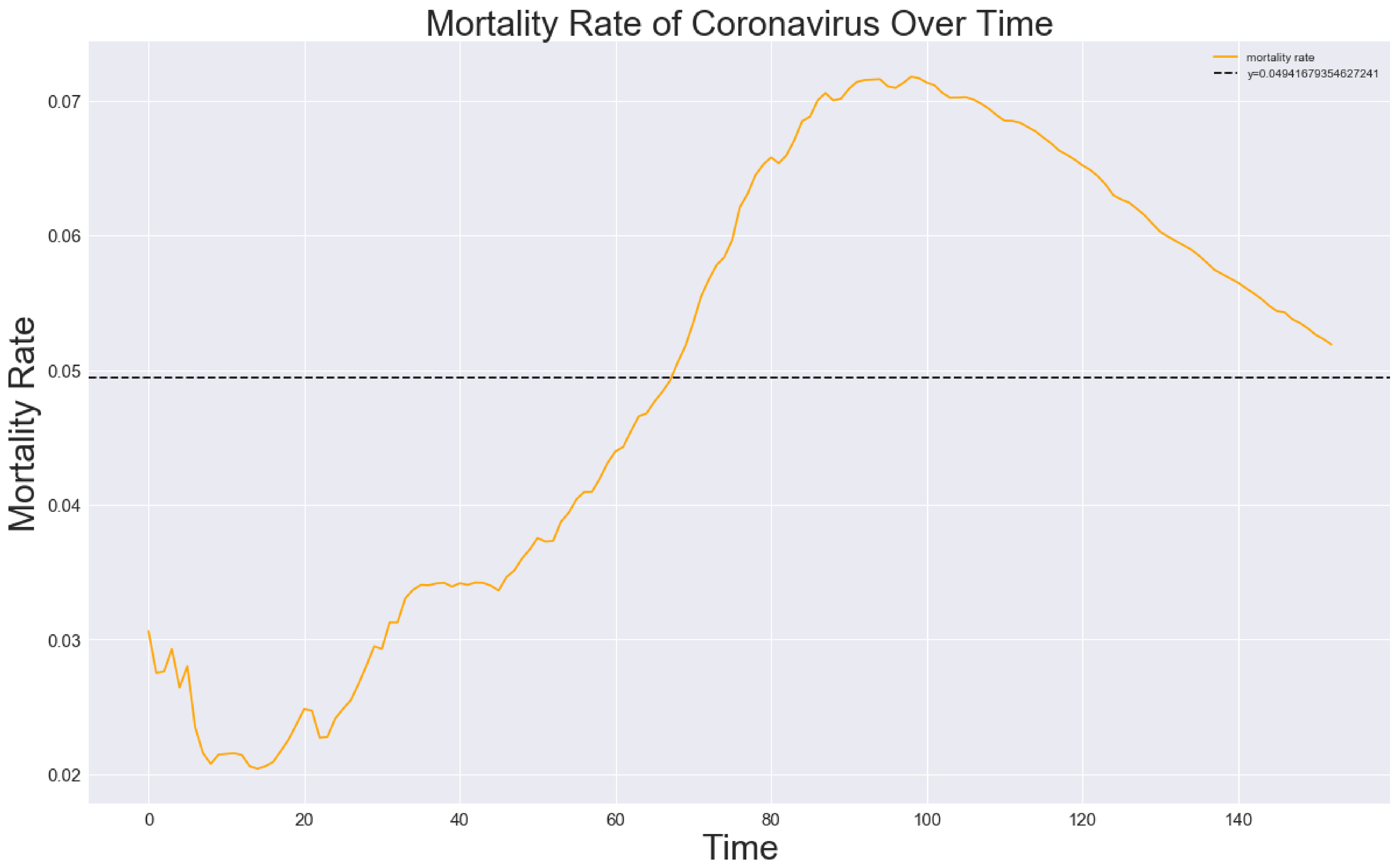
In [51]:

```python
# Prediction for the next 10 days using Linear Regression
print('Linear regression future predictions:')
print(future_forcast_dates[-10:],linear_pred[-10:])
```

```
Linear regression future predictions:
['06/23/2020', '06/24/2020', '06/25/2020', '06/26/2020', '06/27/2020', '06/28/2020', '06/29/2020', '06/30/2020', '07/01/2020', '0
7/02/2020'] [[5740468.66824073]
 [5786857.62450942]
 [5833246.58077811]
 [5879635.5370468 ]
 [5926024.49331549]
 [5972413.44958418]
 [6018802.40585287]
 [6065191.36212156]
 [6111580.31839026]
 [6157969.27465895]]
```

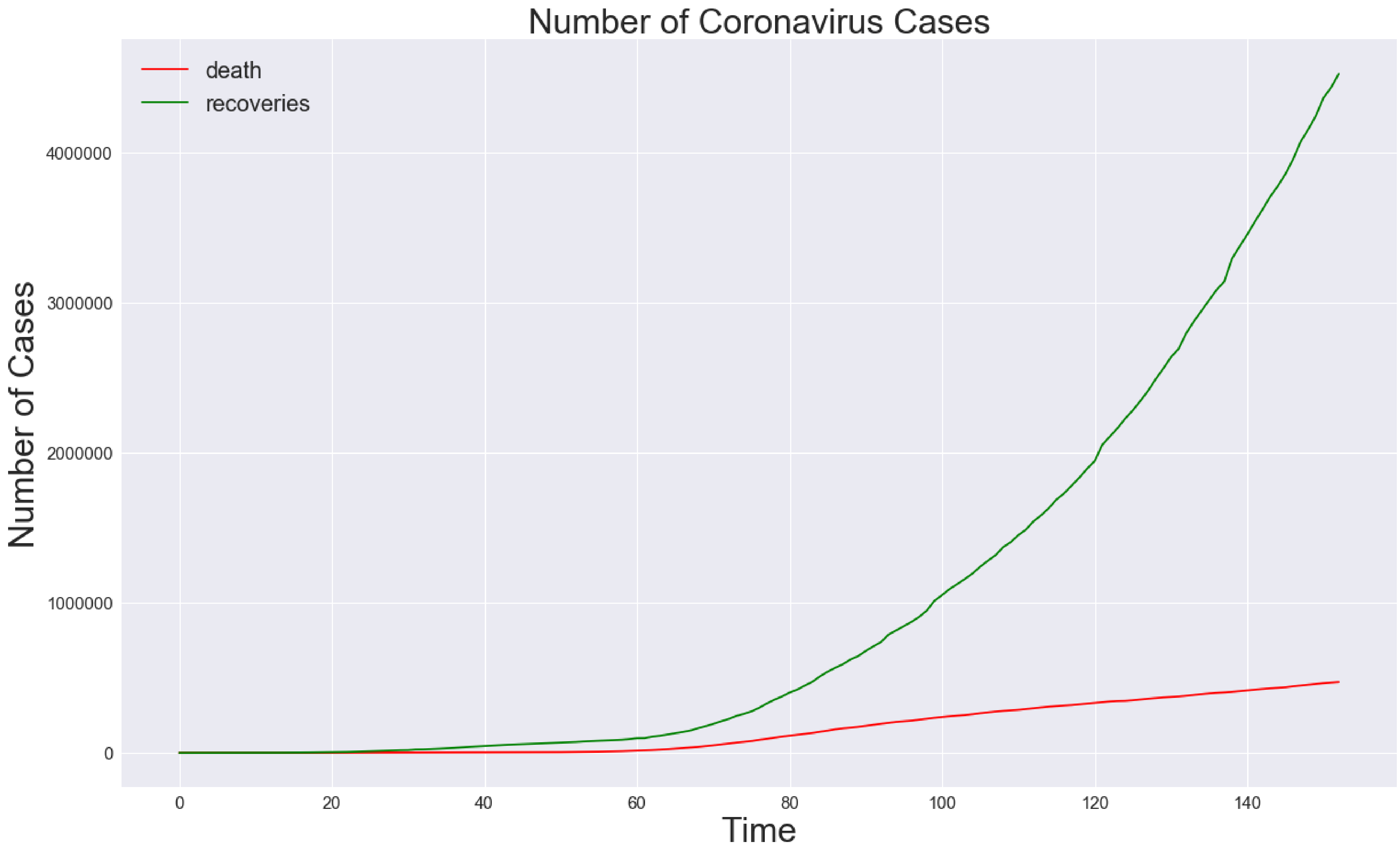
In [52]:

```python
mean_mortality_rate = np.mean(mortality_rate)
plt.figure(figsize=(20, 12))
plt.plot(adjusted_dates, mortality_rate, color='orange')
plt.axhline(y = mean_mortality_rate,linestyle='--', color='black')
plt.title('Mortality Rate of Coronavirus Over Time', size=30)
plt.legend(['mortality rate', 'y='+str(mean_mortality_rate)])
plt.xlabel('Time', size=30)
plt.ylabel('Mortality Rate', size=30)
plt.xticks(size=15)
plt.yticks(size=15)
plt.show()
```



In [53]:

```
# Number of Coronavirus cases recovered vs the number of deaths
plt.figure(figsize=(20, 12))
plt.plot(adjusted_dates, total_deaths, color='r')
plt.plot(adjusted_dates, total_recovered, color='green')
plt.legend(['death', 'recoveries'], loc='best', fontsize=20)
plt.title('Number of Coronavirus Cases', size=30)
plt.xlabel('Time', size=30)
plt.ylabel('Number of Cases', size=30)
plt.xticks(size=15)
plt.yticks(size=15)
plt.show()
```



In [ ]: