HIGH VOLTAGE BATTERY PACK INDIVIDUAL MODULES DATA

Lahore driven vehicles

Data collected from HV battery packs from Toyota Prius and Toyota Aqua (Prius c) that were driven in Lahore from the years 2011 to 2018 The data contains the discharge times of individual modules of the HV battery pack

In [ ]:
```python
#importing libraries
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
```

In [ ]:
```python
#importing data csv file
s = pd.read_csv("batterydata.csv")
s.head()
```

Out[ ]:

	s.no	modules	2011 prius	2012 prius	2013 prius	2014 prius	2015 prius	2016 prius	2017 prius	2011 aqua	2012 aqua	2013 aqua	2014 aqua	2015 aqua	2016 aqua	2017 aqua	2018 aqua
0	1	1	27.0	29.0	30.0	30.0	32.0	36.0	40.0	27.0	27.0	28.0	29.0	29.0	32.0	36.0	39.0
1	2	2	27.0	28.0	29.0	29.0	30.0	34.0	38.0	26.0	27.0	27.0	28.0	28.0	30.0	33.0	36.0
2	3	3	24.0	28.0	28.0	28.0	29.0	30.0	35.0	NaN	26.0	27.0	27.0	27.0	29.0	31.0	33.0
3	4	4	25.0	20.0	20.0	21.0	26.0	28.0	30.0	22.0	22.0	24.0	24.0	26.0	28.0	30.0	32.0
4	5	5	17.0	20.0	20.0	20.0	24.0	NaN	29.0	17.0	20.0	23.0	24.0	NaN	25.0	28.0	30.0

In [ ]:
```python
s.shape #determining size and shape of the data
```

Out[ ]:
```
(28, 17)
```

In [ ]:
```python
s.describe()
```

Out[ ]:

	s.no	modules	2011 prius	2012 prius	2013 prius	2014 prius	2015 prius	2016 prius	2017 prius	2011 aqua	2012 aqua	2013 aqua	2014 aqua	2015 aqua	2016 aqua	2017 aqua	2018 aqua
count	28.000000	28.000000	23.000000	27.000000	26.000000	25.00000	26.000000	24.000000	23.000000	16.000000	18.000000	19.000000	19.000000	15.000000	18.000000	19.000000	19.000000
mean	14.500000	14.500000	20.217391	21.074074	21.076923	22.60000	22.653846	25.333333	28.521739	20.875000	21.777778	22.315789	22.894737	24.200000	25.166667	27.052632	30.368421
std	8.225975	8.225975	6.639801	6.498082	7.013832	6.69577	7.205233	6.951175	7.902069	5.998611	5.374838	5.344287	5.829949	6.537802	6.099662	6.948011	7.440210
min	1.000000	1.000000	10.000000	11.000000	10.000000	11.00000	10.000000	13.000000	15.000000	10.000000	10.000000	12.000000	12.000000	12.000000	10.000000	15.000000	18.000000
25%	7.750000	7.750000	14.500000	15.500000	15.000000	17.00000	17.250000	18.750000	25.000000	17.750000	18.500000	19.000000	19.500000	21.500000	21.250000	22.500000	25.000000
50%	14.500000	14.500000	18.000000	20.000000	20.000000	22.00000	23.500000	26.500000	29.000000	21.500000	22.000000	23.000000	24.000000	27.000000	27.500000	29.000000	30.000000
75%	21.250000	21.250000	26.000000	27.500000	28.000000	28.00000	28.750000	30.250000	35.000000	26.000000	26.750000	27.000000	28.000000	29.000000	29.750000	32.000000	35.500000
max	28.000000	28.000000	29.000000	31.000000	32.000000	34.00000	35.000000	36.000000	41.000000	27.000000	28.000000	29.000000	30.000000	31.000000	32.000000	36.000000	43.000000

The data contained some missing values hence checking each column

In [ ]:
```python
s.isnull().sum()
```

Out[ ]:
```
s.no          0
modules       0
2011 prius    5
2012 prius    1
2013 prius    2
2014 prius    3
2015 prius    2
2016 prius    4
2017 prius    5
2011 aqua    12
2012 aqua    10
2013 aqua     9
2014 aqua     9
2015 aqua    13
2016 aqua    10
2017 aqua     9
2018 aqua     9
dtype: int64
```

Analyzing Prius Data

Removing all the columns of Aqua since it only has 20 modules as opposed to prius in which the hv battery contains 28 modules hence the Aqua column contained 8 nan values so analyzing the Prius data separately

In [ ]:
```python
columns_to_drop = [col for col in s.columns if 'aqua' in col]
prius_data  = s.drop(columns=columns_to_drop)
prius_data.head()
```

Out[ ]:

	s.no	modules	2011 prius	2012 prius	2013 prius	2014 prius	2015 prius	2016 prius	2017 prius
0	1	1	27.0	29.0	30.0	30.0	32.0	36.0	40.0
1	2	2	27.0	28.0	29.0	29.0	30.0	34.0	38.0
2	3	3	24.0	28.0	28.0	28.0	29.0	30.0	35.0
3	4	4	25.0	20.0	20.0	21.0	26.0	28.0	30.0
4	5	5	17.0	20.0	20.0	20.0	24.0	NaN	29.0

In [ ]:
```python
prius_data.isnull().sum()
```

Out[ ]:
```
s.no          0
modules       0
2011 prius    5
2012 prius    1
2013 prius    2
2014 prius    3
2015 prius    2
2016 prius    4
2017 prius    5
dtype: int64
```

Data Manipulation

The data set contains some missing values, as the quantity of nan values is rather less hence using interpolation to fill up the data with identical to the values surrounding thevmissing data to minimize the chance of error and get normalized data to somewhat accurate results

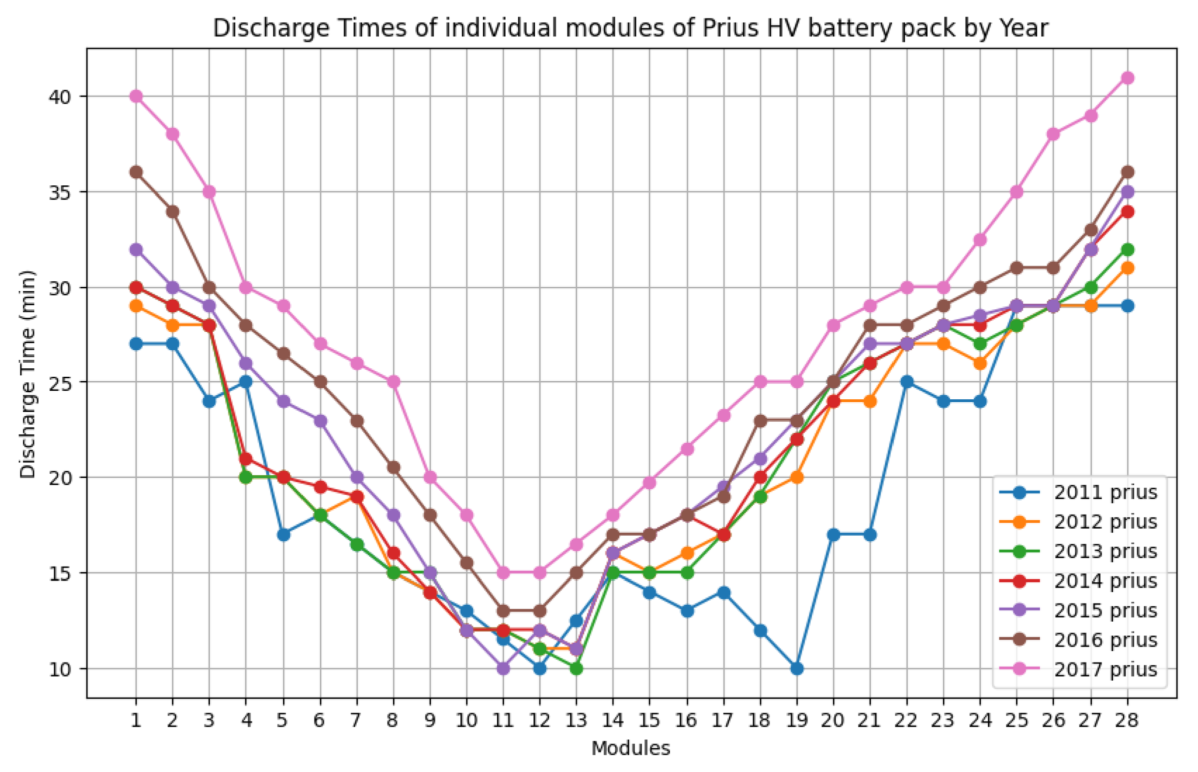
In [ ]:
```python
prius_data = prius_data.interpolate()
prius_data.head()
```

Out[ ]:

	s.no	modules	2011 prius	2012 prius	2013 prius	2014 prius	2015 prius	2016 prius	2017 prius
0	1	1	27.0	29.0	30.0	30.0	32.0	36.0	40.0
1	2	2	27.0	28.0	29.0	29.0	30.0	34.0	38.0
2	3	3	24.0	28.0	28.0	28.0	29.0	30.0	35.0
3	4	4	25.0	20.0	20.0	21.0	26.0	28.0	30.0
4	5	5	17.0	20.0	20.0	20.0	24.0	26.5	29.0

Plotting the trend for Visualization of the data to gain insights

In [ ]:
```python
modules = prius_data['modules']
# Extract the columns to plot (excluding the modules column)
columns_to_plot = prius_data.columns[2:]
# Plot the line plots
plt.figure(figsize=(10, 6))
plt.plot(modules, prius_data[columns_to_plot], marker='o')
plt.xticks(prius_data['modules'])
plt.grid(True)
# Set labels and title
plt.xlabel('Modules')
plt.ylabel('Discharge Time (min)')
plt.title('Discharge Times of individual modules of Prius HV battery pack by Year')
# Add a legend
plt.legend(columns_to_plot)
# Show the plot
plt.show()
```



Insights

The above plot depicts that the individual modules of the HV Battery Pack of the Toyota Prius show a very similar behaviour over the years

- The modules placed in the middle of the HV Battery Pack have the lowest discharge times showing that they get the weakest irrespective of the year of manufacturing of the HV Battery Pack
- The modules placed at the edges of the battery pack have a rather higher discharge time showing that the battery pack basically gets weaker from the middle but stays considerably strong from the edges
- As the years increase it can be observed that the modules obtained from the edges of the battery are much more healthier as comapred to those of obtained from much older battery pack models

Analyzing Aqua (Prius C) Data

Removing all the columns of Prius since it has 28 modules as opposed to Aqua in which the hv battery contains 20 modules hence the Prius column contained 8 extra values so analyzing the Aqua data separately

In [ ]:
```python
columns_to_drop = [col for col in s.columns if 'prius' in col]
Aqua_data  = s.drop(columns=columns_to_drop)
Aqua_data.head()
```

Out[ ]:

	s.no	modules	2011 aqua	2012 aqua	2013 aqua	2014 aqua	2015 aqua	2016 aqua	2017 aqua	2018 aqua
0	1	1	27.0	27.0	28.0	29.0	29.0	32.0	36.0	39.0
1	2	2	26.0	27.0	27.0	28.0	28.0	30.0	33.0	36.0
2	3	3	NaN	26.0	27.0	27.0	27.0	29.0	31.0	33.0
3	4	4	22.0	22.0	24.0	24.0	26.0	28.0	30.0	32.0
4	5	5	17.0	20.0	23.0	24.0	NaN	25.0	28.0	30.0

Data Manipulation

Removing the last 8 rows containing nan values since there are only 20 modules in the battery pack of Aqua as compared to 28 modules of the Toyota Prius

In [ ]:
```python
Aqua_data = Aqua_data.drop(Aqua_data.index[-8:])
Aqua_data.tail()
```

Out[ ]:

	s.no	modules	2011 aqua	2012 aqua	2013 aqua	2014 aqua	2015 aqua	2016 aqua	2017 aqua	2018 aqua
15	16	16	24.0	24.0	25.0	25.0	NaN	29.0	29.0	35.0
16	17	17	26.0	26.0	26.0	28.0	29.0	29.0	31.0	33.0
17	18	18	26.0	27.0	27.0	28.0	30.0	30.0	34.0	39.0
18	19	19	27.0	27.0	28.0	30.0	30.0	31.0	35.0	41.0
19	20	20	27.0	28.0	29.0	30.0	31.0	31.0	35.0	43.0

Checking for missing values within the rows of Aqua Modules

In [ ]:
```python
Aqua_data.isnull().sum()
```

Out[ ]:
```
s.no         0
modules      0
2011 aqua    4
2012 aqua    2
2013 aqua    1
2014 aqua    1
2015 aqua    5
2016 aqua    2
2017 aqua    1
2018 aqua    1
dtype: int64
```

Further cleaning the Data

The data set contains some missing values, as the quantity of nan values is rather less hence using interpolation to fill up the data with identical to the values surrounding thevmissing data to minimize the chance of error and get normalized data to somewhat accurate results

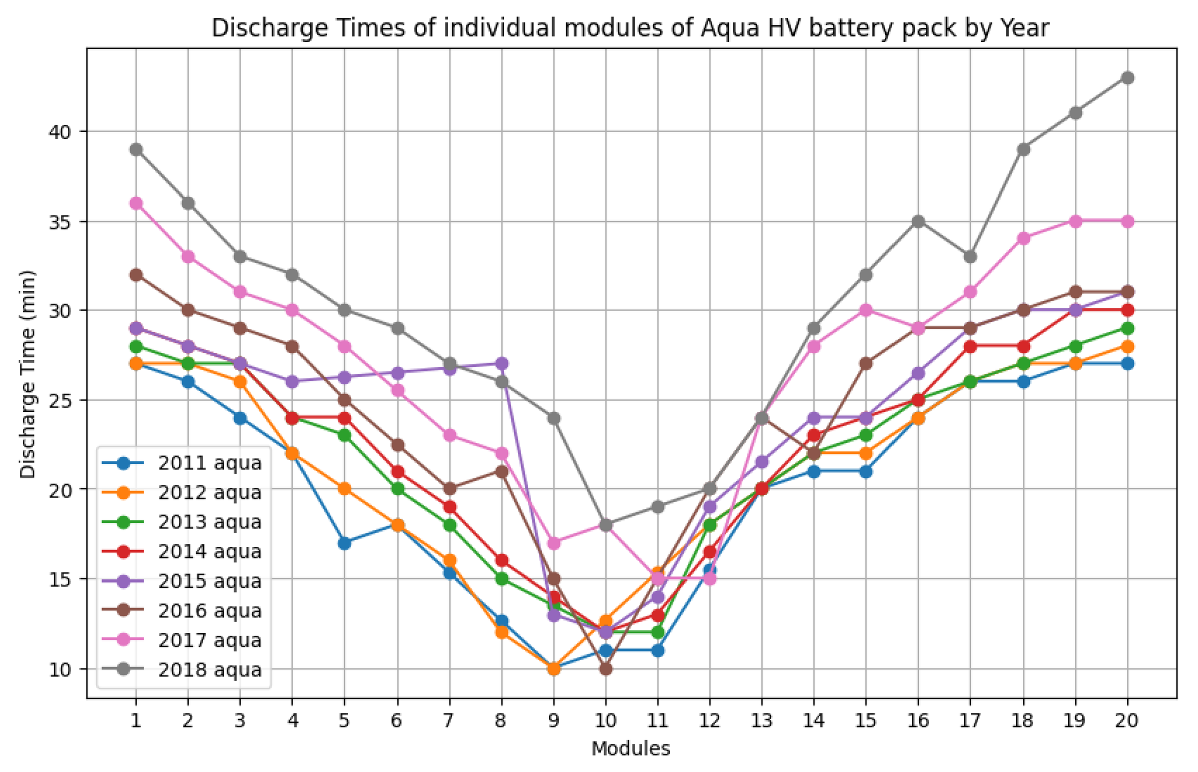
In [ ]:
```python
Aqua_data = Aqua_data.interpolate()
Aqua_data.head()
```

Out[ ]:

	s.no	modules	2011 aqua	2012 aqua	2013 aqua	2014 aqua	2015 aqua	2016 aqua	2017 aqua	2018 aqua
0	1	1	27.0	27.0	28.0	29.0	29.00	32.0	36.0	39.0
1	2	2	26.0	27.0	27.0	28.0	28.00	30.0	33.0	36.0
2	3	3	24.0	26.0	27.0	27.0	27.00	29.0	31.0	33.0
3	4	4	22.0	22.0	24.0	24.0	26.00	28.0	30.0	32.0
4	5	5	17.0	20.0	23.0	24.0	26.25	25.0	28.0	30.0

Plotting the trend for Visualization of the data to gain insights

In [ ]:
```python
modules = Aqua_data['modules']
# Extract the columns to plot (excluding the modules column)
columns_to_plot = Aqua_data.columns[2:]
# Plot the line plots
plt.figure(figsize=(10, 6))
plt.plot(modules, Aqua_data[columns_to_plot], marker='o')
plt.xticks(Aqua_data['modules'])
plt.grid(True)
# Set labels and title
plt.xlabel('Modules')
plt.ylabel('Discharge Time (min)')
plt.title('Discharge Times of individual modules of Aqua HV battery pack by Year')
# Add a legend
plt.legend(columns_to_plot)
# Show the plot
plt.show()
```



Insights

The above plot depicts that the individual modules of the HV Battery Pack of the Toyota Aqua (Prius C) show a very similar behaviour over the years and closely resembles the trend of Prius battery modules.

- The modules placed in the middle of the HV Battery Pack have the lowest discharge times showing that they get the weakest irrespective of the year of manufacturing of the HV Battery Pack
- The modules placed at the edges of the battery pack have a rather higher discharge time showing that the battery pack basically gets weaker from the middle but stays considerably strong from the edges
- As the years increase it can be observed that the modules obtained from the edges of the battery are much more healthier as comapred to those of obtained from much older battery pack models

In [ ]: