SunDash: Monitoring and Analyzing Solar Activity

DS3500: Advanced Programming with Data

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Introduction / Background

Sunspot is a natural phenomenon when there are dark spots or regions appearing the on the surface of the Sun. The reason behind this fascinating phenomenon is that those dark regions on the surface of the Sun are cooler than their surroundings, where the center of the dark spot is around 6,300 degrees Fahrenheit, and the surrounding is at 10,000 degrees (Dobrijevic, 2022). Furthermore, the frequency of sunspot activities follows an eleven-year solar cycle, which is driven by the Sun's magnetic field (Dobrijevic, 2022). What is more fascinating, the formation of sunspots still remains unknown, and it has driven the astronomy sector for years to understand. Hence, this homework assignment allows us to study and examen the pattern of sunspot activity and combine the data visualization into a dashboard.

Data Sources, Methods, and Analysis

Starting by collecting data, we were instructed to explore the website of *Solar Influences Data Analysis Center*, where it offers extensive data on all aspects of the solar system. What I aimed was sunspot activity, and the website provides sunspot activity records starting from 1800 to 2020. This large amount of data is more than sufficient to be displayed on a visual and give us a

pattern to study. After receiving the data, I first processed the raw data and organized them in a way that is easy to manipulate and graph by using Pandas module, as inserted below.

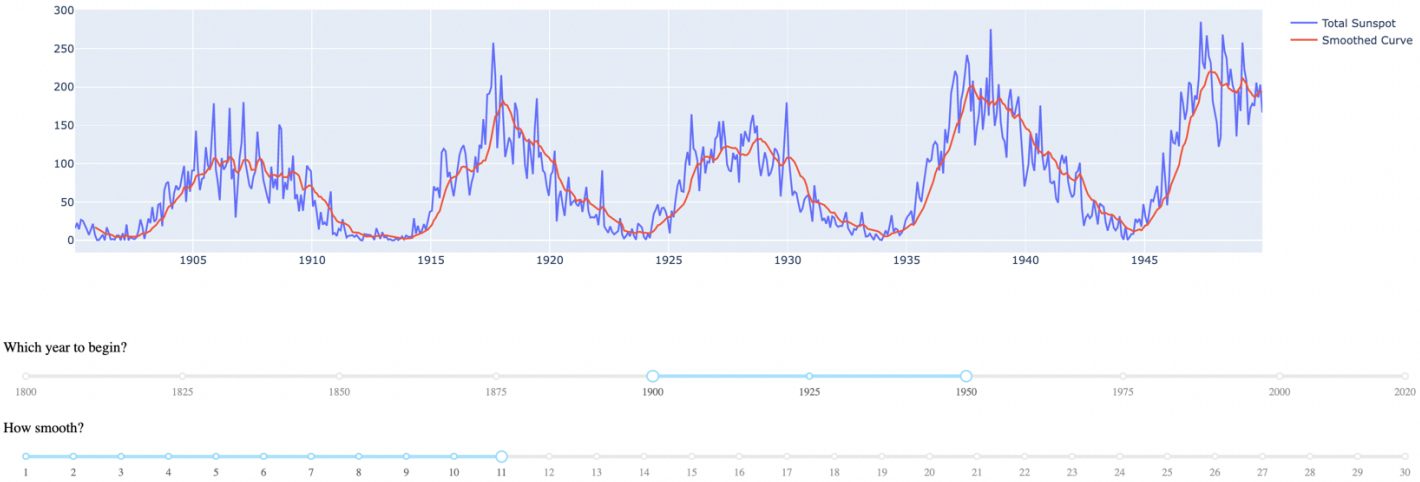
```python
def process_data():
    """ extract data from csv file, and process data into workable & graph-able data """

    # Extract data from CSV with semicolon separator
    monthly_data = pd.read_csv("SN_m_tot_V2.0.csv", sep=';')
    # Assign column names
    monthly_data.columns = ['Year', 'Month', 'Frac_Date', 'Monthly_Total_Sunspot', 'Standard_Dev',
                            'Num_Observations', 'Provisional_Indicator']
    # Return the processed data frame
    return monthly_data
```

Moreover, I began to build up my visualizations instead of starting to build the dashboard. I declared two functions dedicated for two visualizations: plot_data and plot_cycle.

```python
def plot_data(begin_date, end_date, window):
    """
    plot both the total sunspot activity and the smoothed sunspot activity
    based on the interval given.

    Arguments:
    begin_date (int): begin year for data interval
    end_date (int): end year for data interval
    window (int): how many months to smooth

    Return:
    graph figure
    """
    # Get data from process_data()
    df_data = process_data()

    # Cut the df into specific interval
    interval_data = df_data[(df_data['Year'] >= begin_date) & (df_data['Year'] < end_date)]

    # From the sliced interval, calculate the running average
    interval_data['Smoothed'] = interval_data['Monthly_Total_Sunspot'].rolling(window=window).mean()

    # Create two figures in one graph
    fig = go.Figure()
    fig.add_trace(go.Scatter(x=interval_data['Frac_Date'], y=interval_data['Monthly_Total_Sunspot'], mode='lines', name='Total Sunspot'))
    fig.add_trace(go.Scatter(x=interval_data['Frac_Date'], y=interval_data['Smoothed'], mode='lines', name='Smoothed Curve'))

    # Return figure
    return fig
```

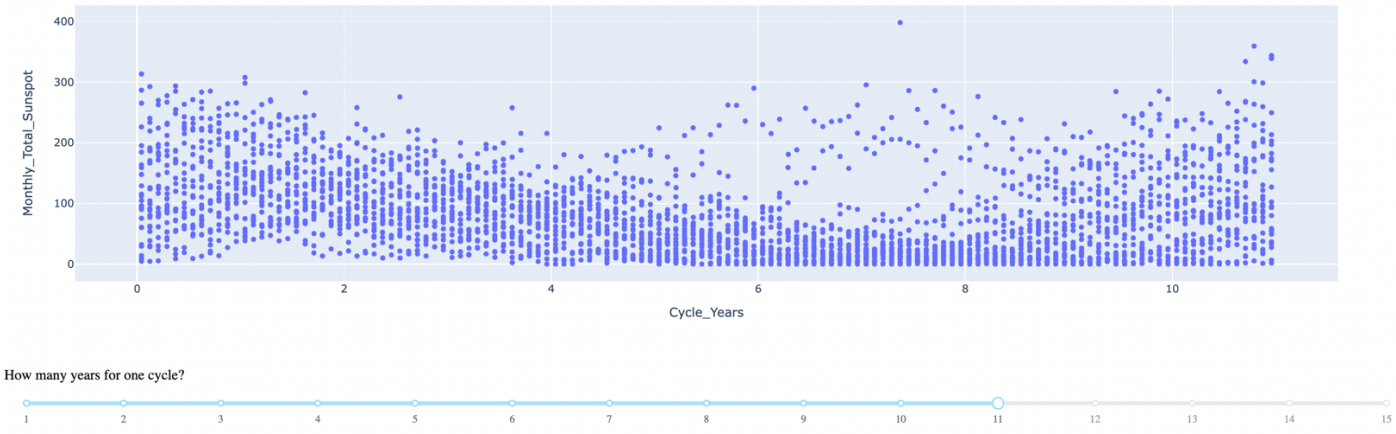
```python
def plot_cycle(cycle):
    """
    Plots the sunspot activity with given amount of cycle years

    Argument:
    cycle (int): years for one cycle

    Return:
    graph figure
    """
    # Get data from process_data()
    df_data = process_data()

    # Calculate cycle years
    df_data['Cycle_Years'] = df_data['Frac_Date'] % cycle

    # Create scatter plot
    fig = px.scatter(df_data, x='Cycle_Years', y='Monthly_Total_Sunspot')

    # Return figure
    return fig
```

After the visualizations are generated, they were transferred to the SunDash dashboard where the first visual is being displayed with two slide bar features that allow the user to interact with. The first slide bar allows the user to change the time interval, allowing the user to select their preferred range of years. The second feature allows the user to select the number of months being used to smooth in the given interval. The plot looks like this:



What is interesting about this plot is that with each peak to peak or trough to trough, there is a consistent pattern that follows a cycle of around 11 years. With every 11 years, sunspot activity will peak, although not at consistent heights. The largest peak of sunspot activity was recorded to be around 398, which dates to 1957. In contrast, the lowest sunspot peak was only about 104 dating back to 1804.

Moving on to the second visualization, where it visualizes all sunspot activities stacked in an interval of eleven-year cycle. This is inserted below.



Along with this second scatter plot, it comes with another slide bar user interaction, where it allows the user to select how many years will be counted as one full cycle of sunspot activity. The default is being set to 11, which is the correct number of years for one cycle. When it is being set to 11 years, a pattern is also form where the scatters form a downward parabola, illustrating that sunspot is at peak at the beginning of the cycle, gradually decrease until year 8, and gradually climb back up to peak by year 11. This visual also allows the user to examen the number of outliers there are.

Continuing with the dashboard design, two more real life images of the Sun are inserted at the bottom of the dashboard, where one is a static high-resolution image, and the other is a GIF of rotating sun. Both allows the user to grasp the fascinating phenomenon of sunspot activity.

Conclusions

After exploring the extensive dataset, visualizing the data, and designing the dashboard to organize the visuals, sunspot activity becomes even more intriguing and captivating. By implementing my findings into a dashboard makes everything much more professional and fun, although my dashboard may look nothing professional.

References

Dobrjevic, D. (2022). Sunspots: What are they, and why do they occur? *Space.* Retrieved from https://www.space.com/sunspots-formation-discovery-observations