ENPM 701 - Homework 1

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Question 1

Consider a small ground robot using an ADXL327 3-axis accelerometer (ADXL327 Datasheet) **A sample of the data packets streamed from the robot has been provided in ELMS > HW #1 as "imudata.txt".**

Tasks:

- Load the data into Python/NumPy.
- Plot the raw data for the 5th column, which corresponds to the pitch angle.
- Label axes, add a title, and include a legend.
- Implement a moving average function without built-in functions.
- Plot the moving average on top of the raw data.
- Compute and display mean and standard deviation.

Python Code Implementation

The following Python script was used to process the IMU data:

Listing 1: Python script for IMU data processing

```
import numpy as np
import matplotlib.pyplot as plt

plt.style.use("default")

with open("imudata.txt", "r") as file:
    lines = file.readlines()

data = np.array([list(map(float, line.strip().split()[2:])) for line in
    lines])
pitch_raw = data[:, 3]

def moving_average(data, window_size):
    averaged_data = np.zeros(len(data))
    for i in range(len(data)):
        if i < window_size:
```

```
            averaged_data[i] = np.mean(data[:i+1])
        else:
            averaged_data[i] = np.mean(data[i-window_size+1:i+1])
    return averaged_data

window_sizes = [2, 4, 8, 16, 64, 128]
x_values = np.arange(len(pitch_raw))
colors = plt.get_cmap("cool")(np.linspace(0, 1, len(window_sizes)))

for i, window in enumerate(window_sizes):
    pitch_avg = moving_average(pitch_raw, window)
    mean_val = np.mean(pitch_avg)
    std_val = np.std(pitch_avg)

    plt.figure(figsize=(12, 6), facecolor="white")
    plt.plot(x_values, pitch_raw, linestyle="-", linewidth=0.6, alpha=0.3, color="gray")
    plt.scatter(x_values, pitch_raw, color="gray", alpha=0.6, s=12, marker="o", label="Raw Data")

    plt.plot(x_values, pitch_avg, linewidth=2.2, color=colors[i], linestyle="solid", alpha=0.85, label=f"{window}-pt Moving Average")
    plt.fill_between(x_values, pitch_avg - std_val, pitch_avg + std_val, color=colors[i], alpha=0.2)

    plt.annotate(f"Mean: {mean_val:.2f}\nStd Dev: {std_val:.2f}",
                 xy=(0.05 * len(pitch_raw), max(pitch_raw) * 0.85),
                 fontsize=14, color="black", bbox=dict(facecolor='white', edgecolor='gray', alpha=0.9))

    plt.xlabel("Sample Index", fontsize=14, fontweight="bold", family="serif")
    plt.ylabel("Pitch Angle (degrees)", fontsize=14, fontweight="bold", family="serif")
    plt.title(f"{window}-pt Moving Average", fontsize=16, fontweight="bold", color=colors[i], family="serif")
    plt.legend(fontsize=12, frameon=True, fancybox=True, shadow=True, loc="upper right")
    plt.grid(alpha=0.5)

    plt.savefig(f"pitch_analysis_{window}pt.png", dpi=300, bbox_inches="tight", facecolor="white")
    plt.savefig(f"pitch_analysis_{window}pt.pdf", dpi=300, bbox_inches="tight", facecolor="white")
    plt.show()
```

Results and Analysis

Each plot includes:

- Raw pitch angle data (small gray dots + light gray line).
- The moving average for different window sizes.
- A shaded region indicating one standard deviation.

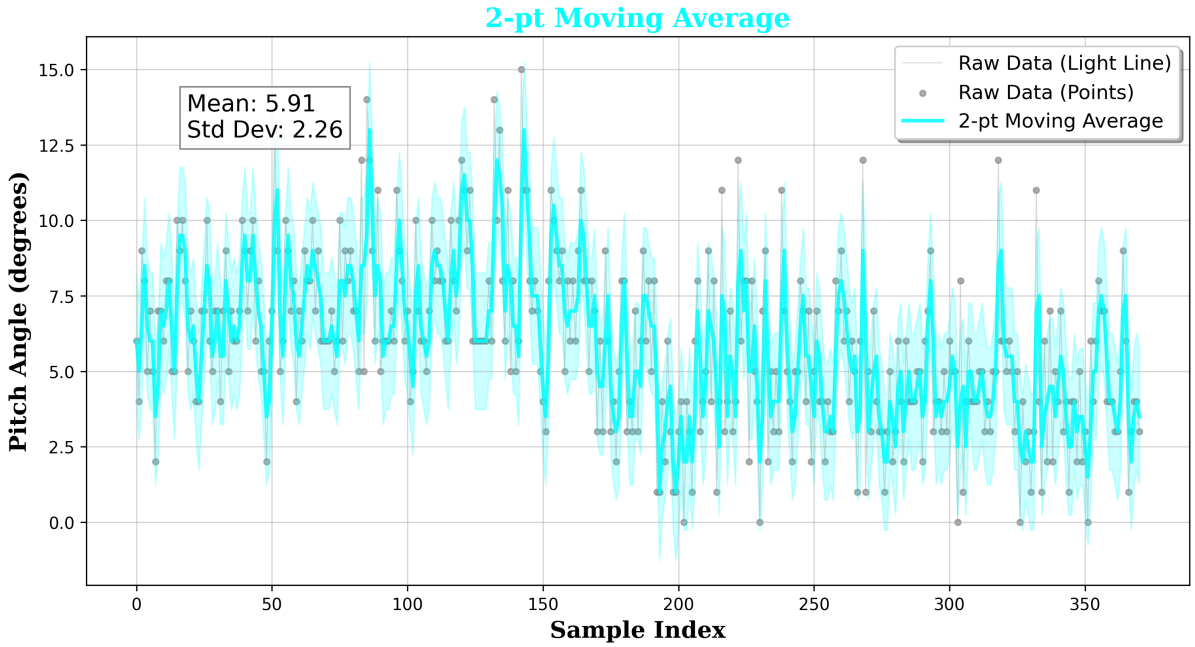

Figure 1: 2-Point Moving Average

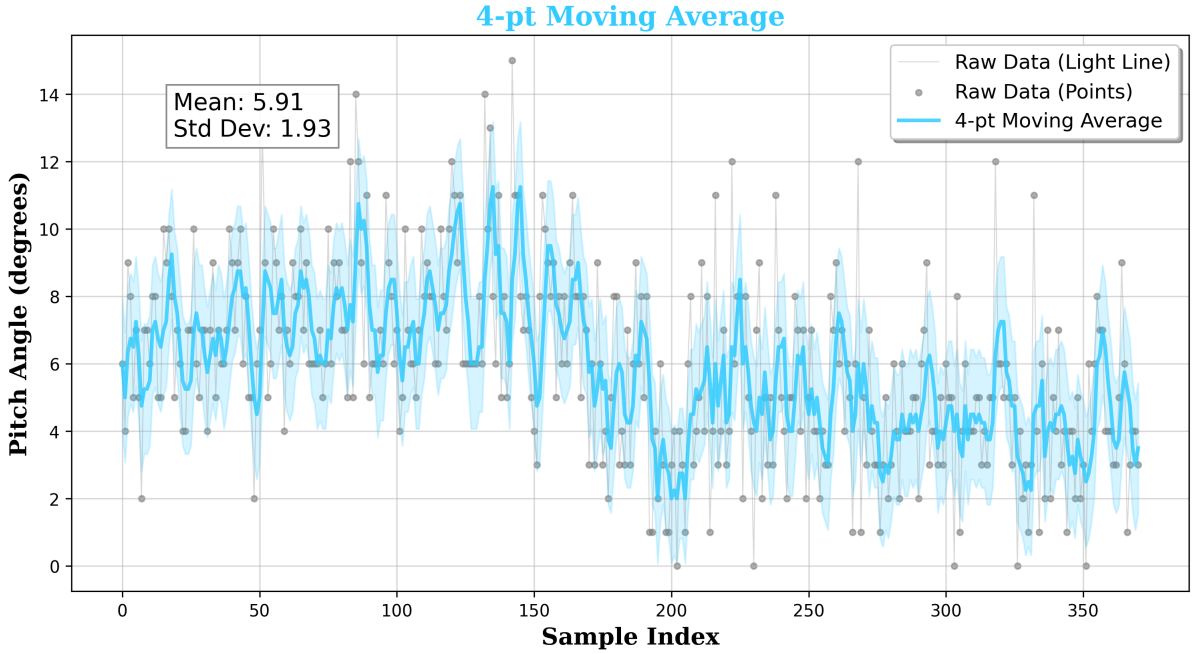

Figure 2: 4-Point Moving Average

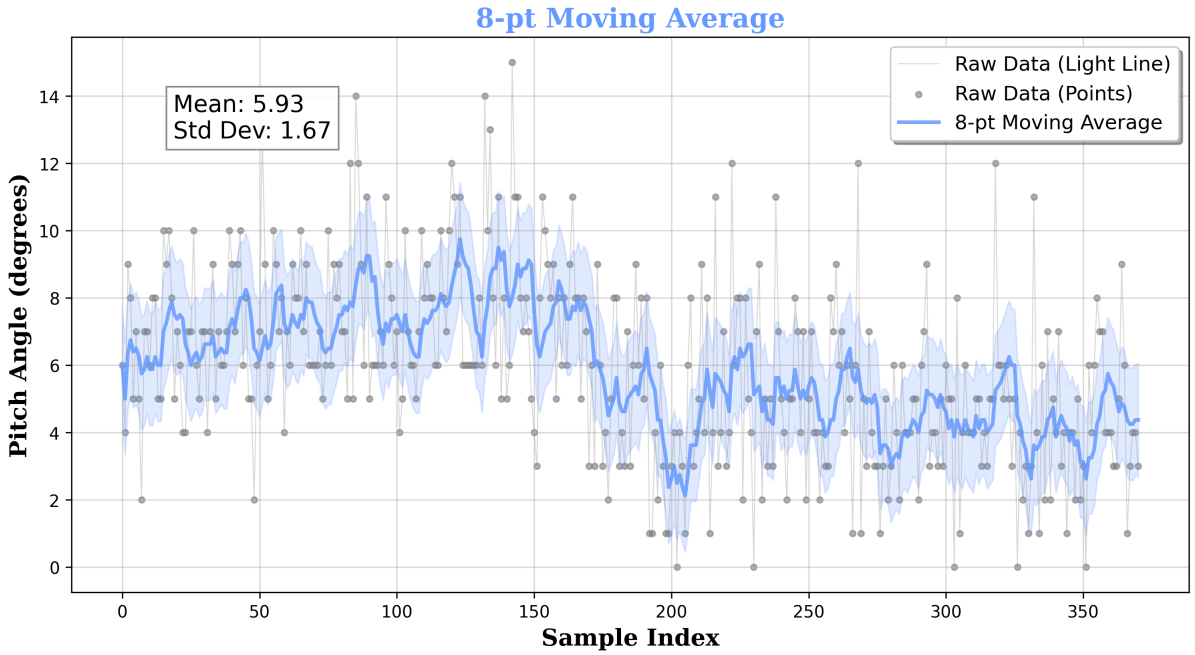

Figure 3: 8-Point Moving Average

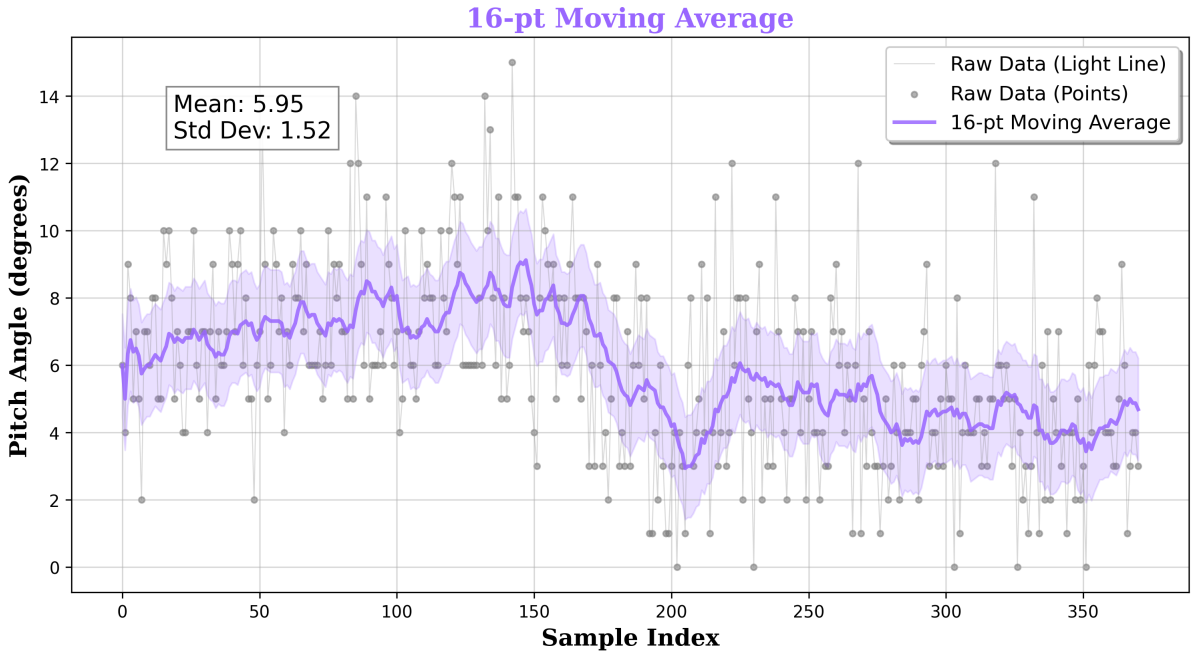

Figure 4: 16-Point Moving Average

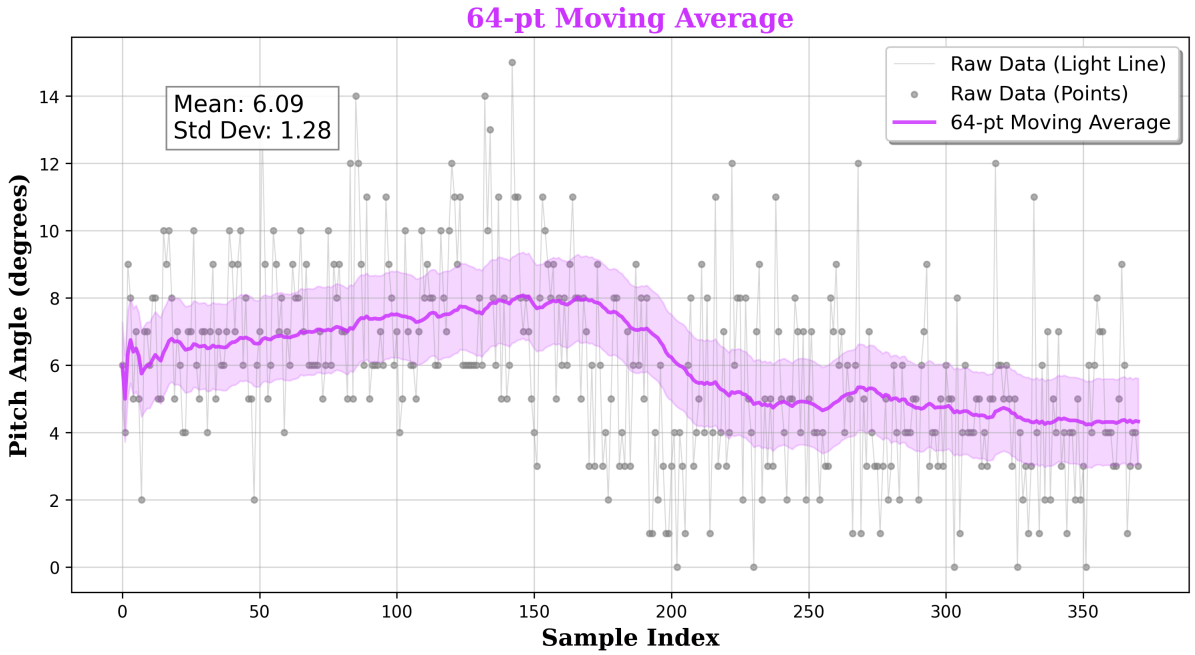

Figure 5: 64-Point Moving Average

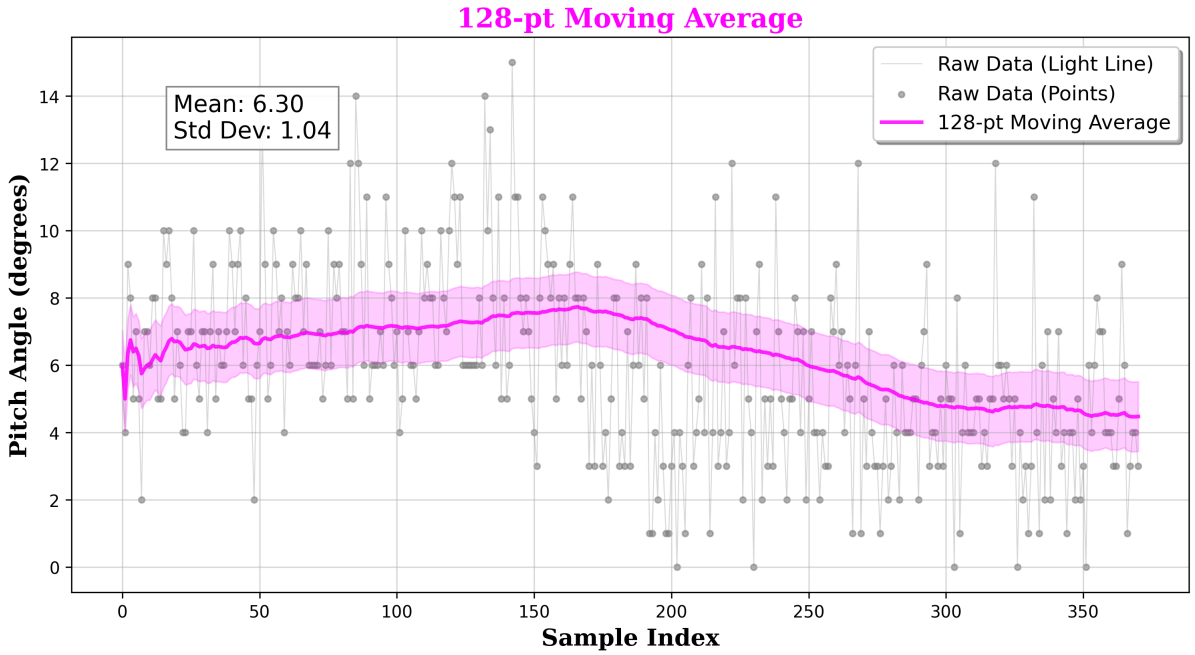

Figure 6: 128-Point Moving Average

Conclusion

The moving average smooths the raw pitch angle data, reducing noise. Larger window sizes result in greater smoothing but introduce lag.

The complete code is available at: `https://github.com/nslaul/ENPM_701_Homework_1`