Exploratory Data Analysis (EDA) Summary for BumperSats

1. Dataset Overview

We analyzed the satellite orbital elements data from the CelesTrak Geosynchronous Protected Zone (GPZ) catalog. This dataset contains key orbital parameters such as inclination, eccentricity, mean motion, BSTAR, and epoch timestamps for tracked objects.

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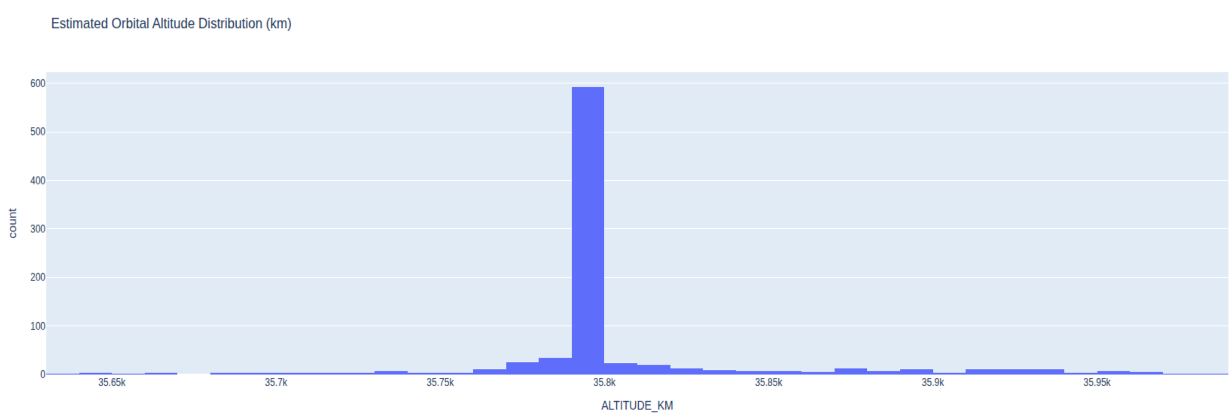
2. Orbital Altitude Estimation

Using mean motion values and Kepler's laws, we estimated the orbital altitudes of the objects:

- Most satellites are clustered around ~35,786 km altitude, consistent with geosynchronous orbits.
- This altitude distribution provides a foundational understanding of where debris and satellites are concentrated, informing risk zones for collision forecasting.



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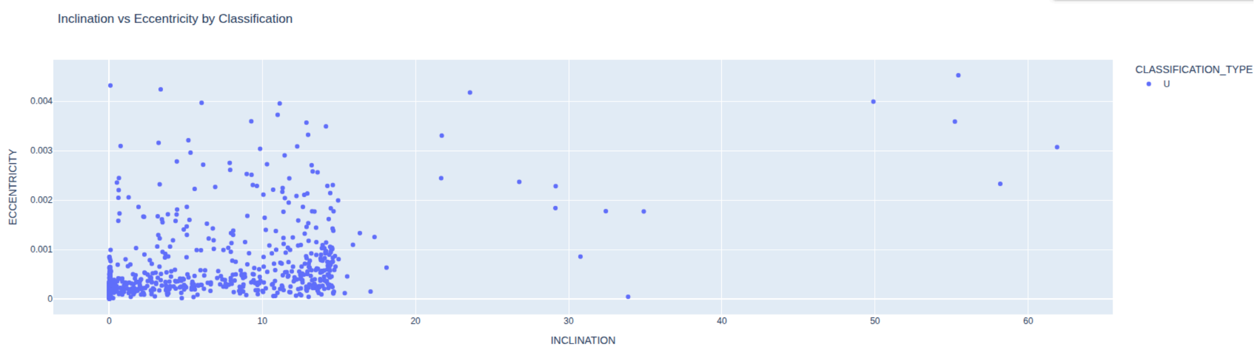
3. Inclination and Eccentricity Profiles

- Inclination values are tightly clustered around the equatorial plane (0°), as expected for geostationary satellites.

- Eccentricity is generally low, indicating nearly circular orbits.
- Scatter plots colored by classification type reveal subtle differences between operational satellites and potential debris.



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4. BSTAR (Atmospheric Drag Indicator) Analysis

- BSTAR values are uniformly zero across the dataset.
- This aligns with the high altitude of GPZ satellites, where atmospheric drag is negligible.
- Consequently, BSTAR is not a meaningful feature for debris or collision modeling in this orbital regime.

Implication: Future work focusing on Low Earth Orbit (LEO) debris should incorporate BSTAR, as atmospheric drag effects become significant.

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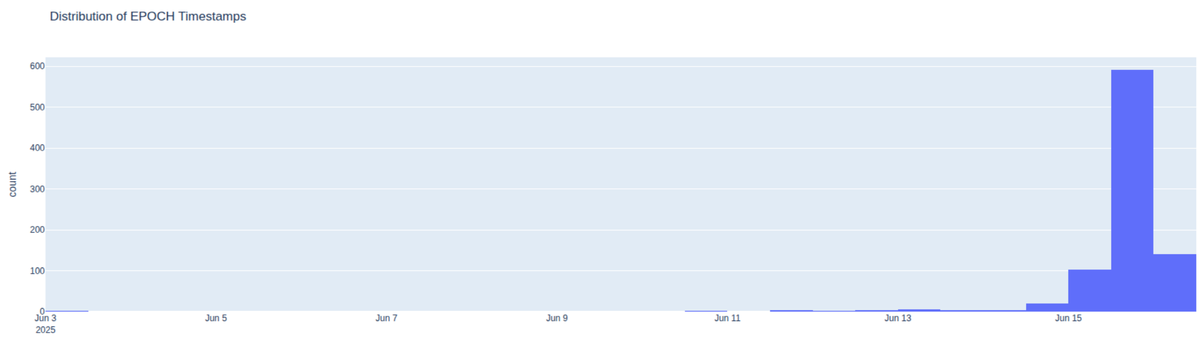
5. Temporal Trends (Epoch Analysis)

- Analysis of EPOCH timestamps confirms that data points are recent and consistent, enabling reliable temporal modeling.

- No significant drift or anomalies detected in satellite positional data over the sampled time frame.



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6. Summary and Next Steps

- The EDA confirms that the GPZ dataset predominantly represents stable geostationary satellites.

- Features such as inclination, eccentricity, and estimated altitude provide a solid foundation for initial debris detection and collision risk forecasting models.

- BSTAR can be safely ignored at this stage but remains critical for future LEO modeling.

- Next phases will focus on developing AI models to detect debris signatures and forecast collision risks using these orbital features.
