Project Proposal: AI-Based Satellite Trajectory Prediction

1. Title

AI-Based Satellite Trajectory Prediction Using Historical TLE Data

2. Objective

To develop an AI model capable of predicting satellite trajectories using historical TLE (Two-Line Element) datasets, enhancing space situational awareness and supporting collision avoidance efforts.

3. Background

Space is becoming increasingly congested with operational satellites and debris. Traditional propagation methods (SGP4, etc.) are deterministic and can become imprecise over long durations. Leveraging AI allows for learning-based trajectory forecasting that adapts to real-world orbital behavior.

4. Dataset

- Source: Historical TLE data from Celestrak, Space-Track.org, and user-collected archives.
- Format: Paired TLE lines with timestamps.
- Preprocessing: Use Skyfield to convert TLEs to 3D position & velocity vectors.

5. Workflow

1. Data Parsing: Extract epochs, orbital elements from TLEs.
2. TLE Propagation: Use Skyfield to get (x, y, z), (vx, vy, vz) at each timestamp.
3. Dataset Creation: Build time-series data per satellite.
4. Model Training:
   - Inputs: Historical trajectory vectors
   - Output: Future satellite position
   - Models: LSTM, Transformer, or GNN
5. Evaluation: RMSE, trajectory deviation, angular drift.
6. Visualization: Use Plotly/Kepler.gl for orbit animation.
7. Deployment: REST API or web app for real-time prediction.

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6. Tech Stack

Python, NumPy, Pandas

Skyfield / SGP4

TensorFlow or PyTorch

Plotly / CesiumJS

Streamlit (optional)

7. Expected Outcome

- A predictive model for satellite or debris orbits.

- A tool to visualize and forecast orbital paths.

- Potential to be extended for collision prediction and avoidance systems.