Houston, We Have a Problem

Classifying Satellites and Space Junk

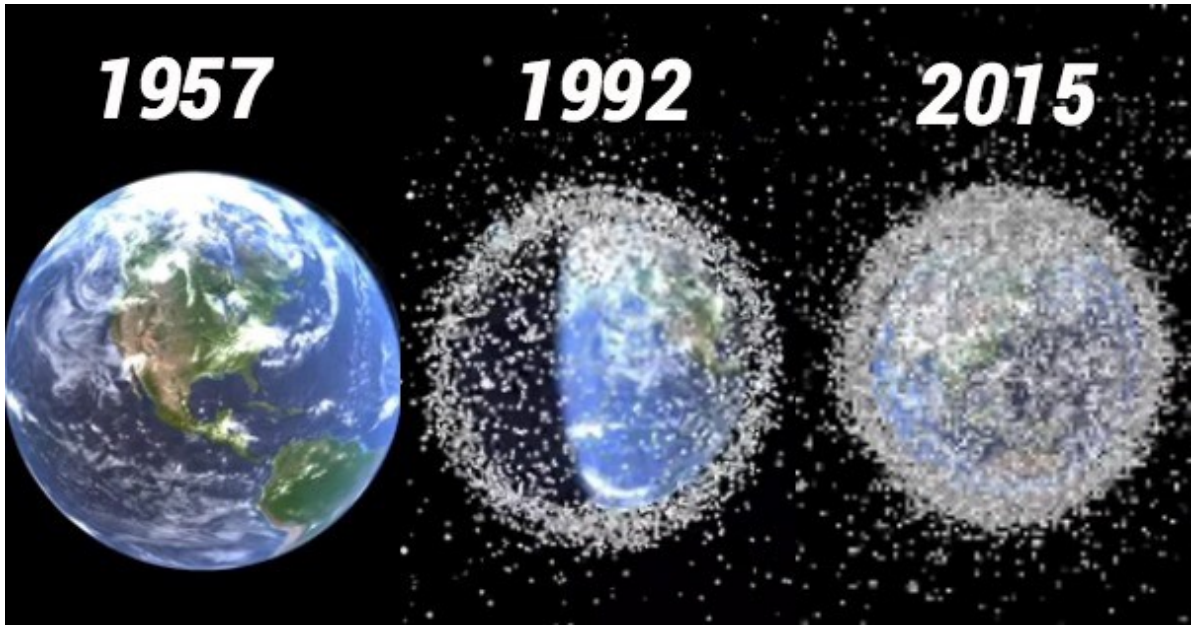
Allen Qu
Metis

Problem

- Kessler Syndrome:

high density of space objects →

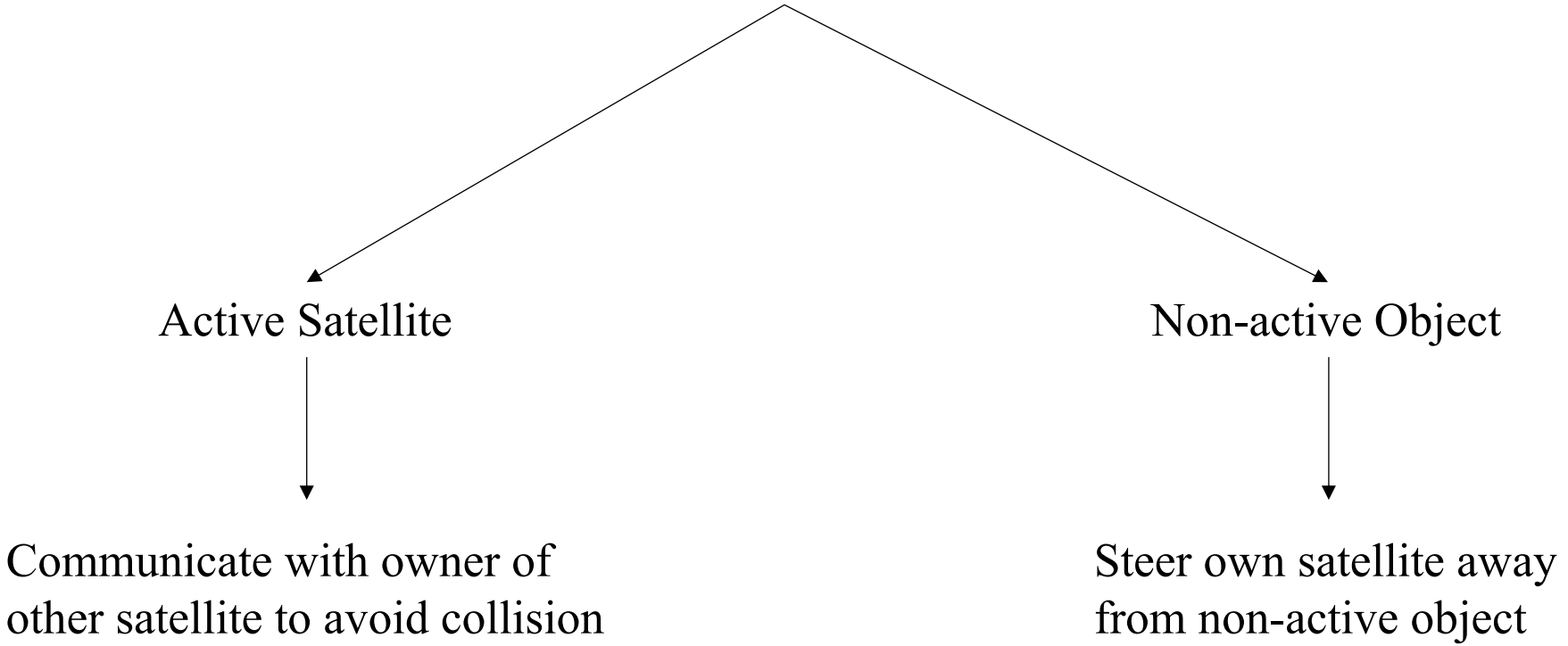
collisions → space debris



Risk for big loss in space assets for research, telecommunication, business

Solution

Train a machine learning model to classify unknown objects as either active satellites or non-active objects



Data Sources

- Dataset with ~2000 active satellites

Union of Concerned Scientists
Science for a healthy planet and safer world

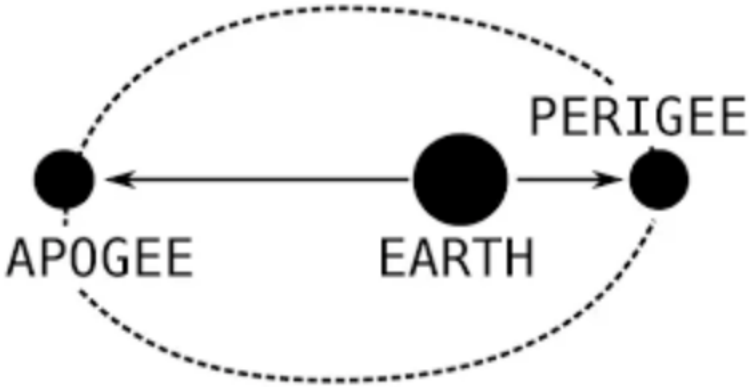
- Dataset with ~19000 objects in space

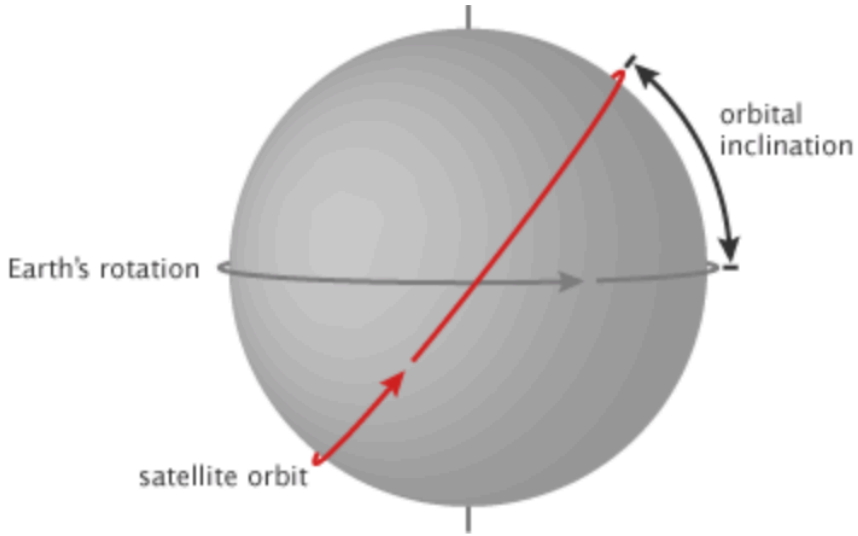
- Combined into one dataset

Data

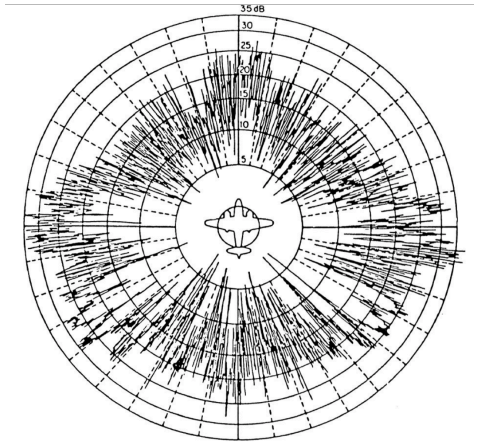
Original Features:

- ID Number
- Country
- Launch Date
- Period
- Inclination
- Apogee
- Perigee
- Radar Cross Section Size





RCS Size



Choosing the Right Model

Four Machine Learning Models Chosen for Satellite Classification

1. Logistic Regression – binary classification for 2 targets (active satellites and non-active satellites)

2. K-Nearest Neighbors – find similarities between active and non-active satellites

3. Random Forest – ensemble of comprehensible decision trees that consider all features and trace path to most likely class

4. XGBoost – also an ensemble of decision trees, except trees are shallow and pruned

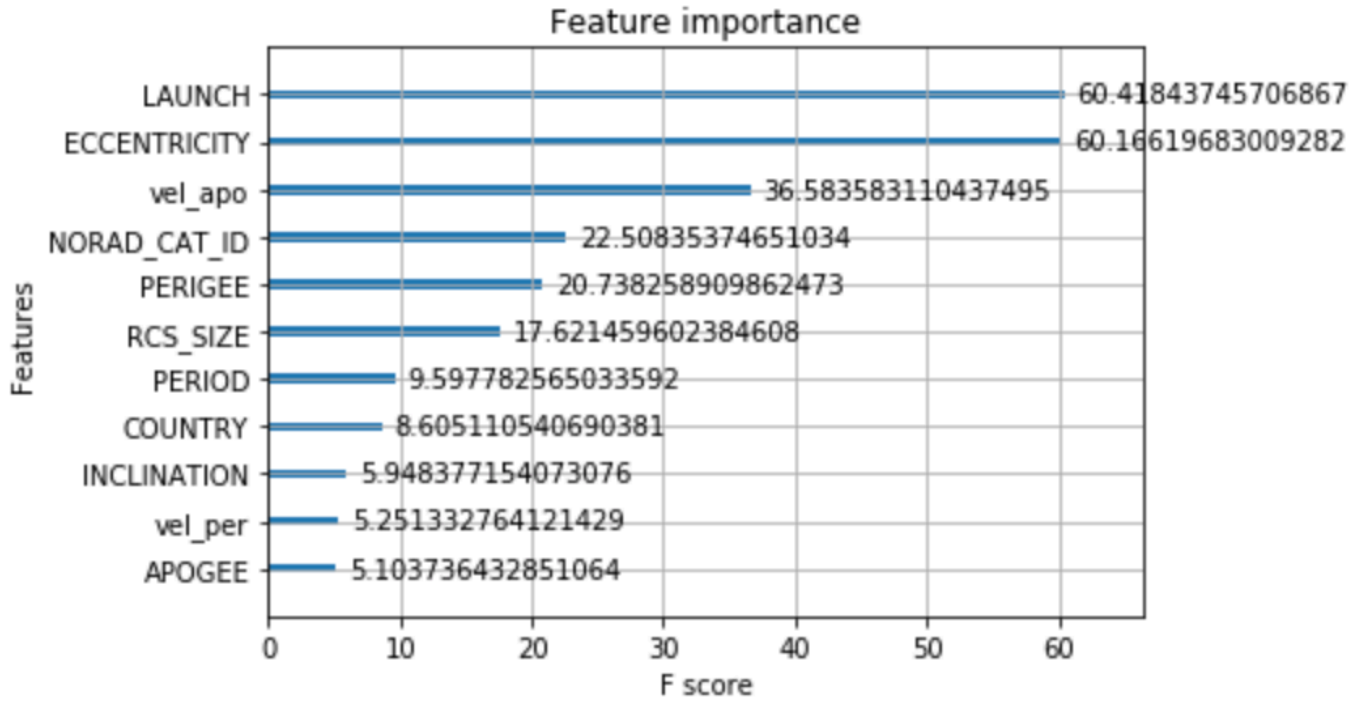
Modeling with XG-Boost

1. Balanced weights of classes (active and other)

2. Added features: Eccentricity, Velocity at Perigee, Velocity at Apogee

3. Stratified K-Fold CV

4. Adjusted Threshold to Optimize F1 Score



XGBoost Results

- Original F1 Score on Train Data: 0.820
- F1 Score on Train After Model Tuning: 0.872
- F1 Score on Test Data: 0.871
- AUC score on Test Data: 0.943

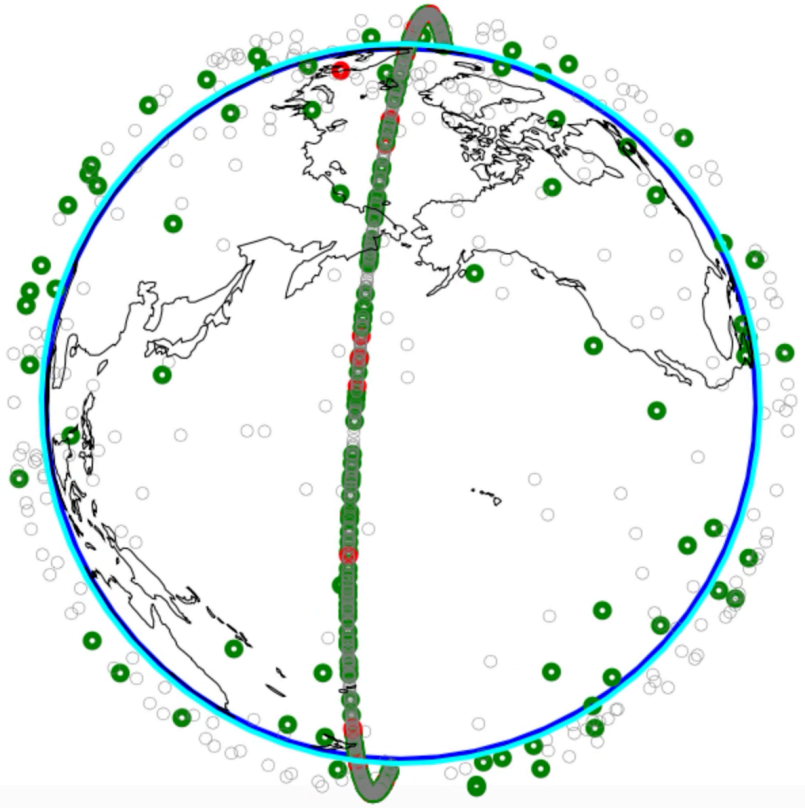
D3 Visualization of Model Predictions on Test Data (354 satellites)

Green → True Positive Active Satellites

Red → False Negative Active Satellite

Gray → Active Satellites from Training Data

Press Play! →



Appendix

D3.js Example Code for Spinning Globe and Point:

https://gist.github.com/franknoirot/896c8f60338d761753dd0ca98f2a629e

Thank you!