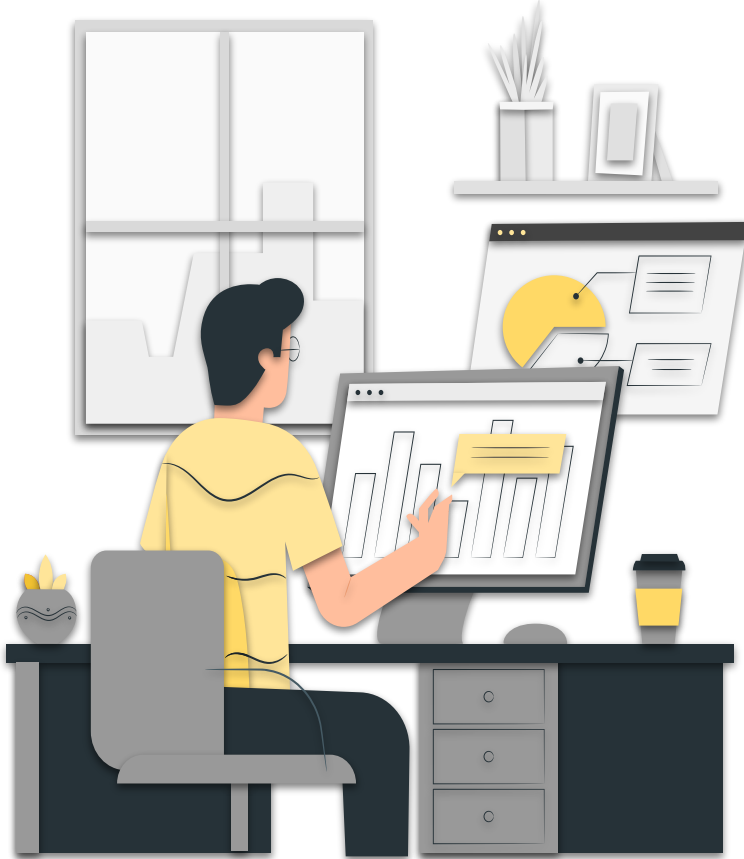


# Data Mining from Two Line Element(TLE) sets

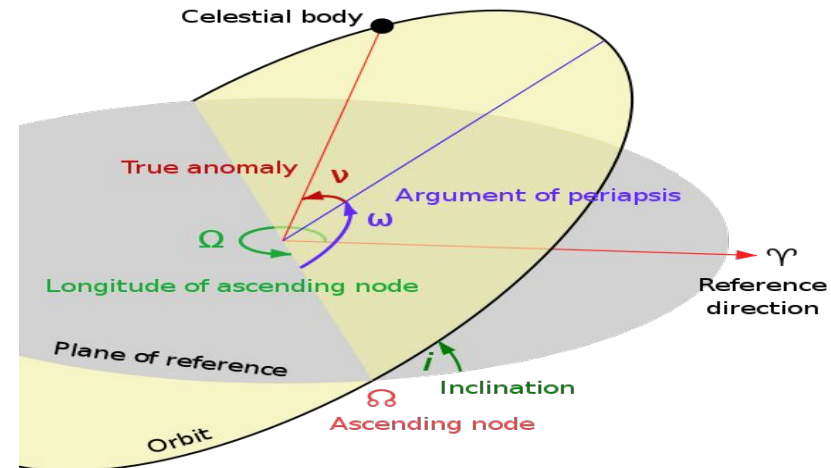
CS685A COURSE PROJECT

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Name of Satellite (11 characters)	International Designator	Epoch Year & Julian Day Fraction	1st derivative of Mean Motion or Ballistic Coefficient	2nd derivative of Mean Motion, usually blank	Drag term or radiation pressure coefficient	Ephemeris Type	Element Number & Check sum
TIGRISAT	14033AK	237.65733135	0.00000701	00000-0	11591-3	0	1958
1 40043 U 2 40043	097.9710	131.0170	0062706	350.459	009.5419	14.72239202	9677
Satellite Number	Inclination	Right Ascension of the Ascending Node	Eccentricity	Argument of Perigee	Mean Anomaly	Mean Motion	Revolution number at epoch & check sum

# TLE Data and its Interpretation



# Project Work

1

## Error Analysis

The Error in propagation of position and velocities through TLEs is analysed.

2

## Catalogue Formation

A Catalogue is created from recent TLE data, which contains several important fields in tabular format.

3

## Clustering and Patterns

Satellites within same orbital planes are grouped by clustering & patterns of orbital arrangements.

4

## Debris Prediction

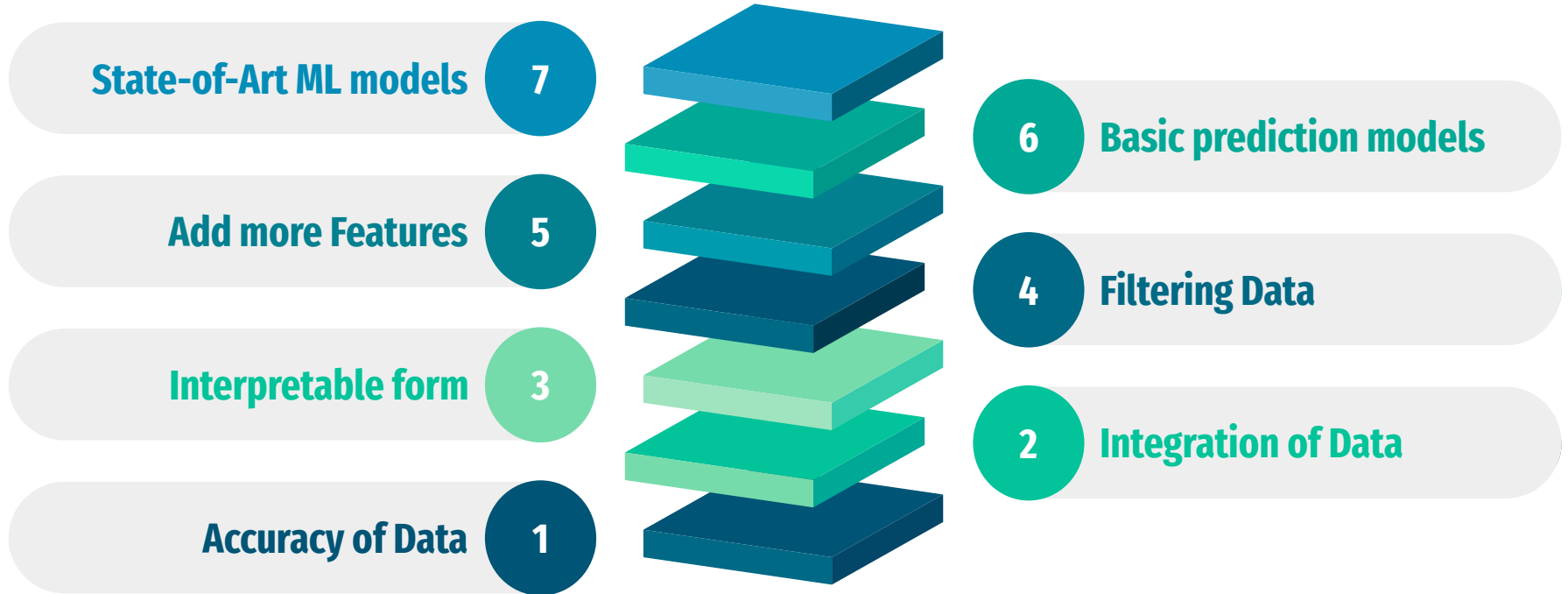
Classifier for predicting an celestial object as Space Debris or satellite.

5

## Maneuver Detection

Algorithms to detect possible maneuvers done for an active satellite.

# Data Mining Methodology



## **Data Mining Algorithms Used**

**K-Means  
Clustering**

**DBSCAN**

**Random Forest  
Trees**

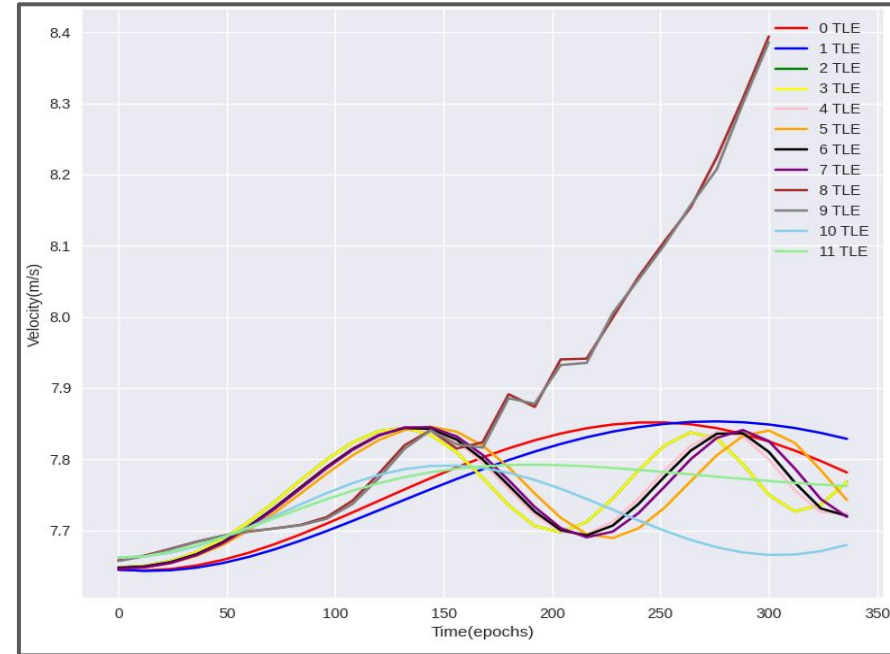
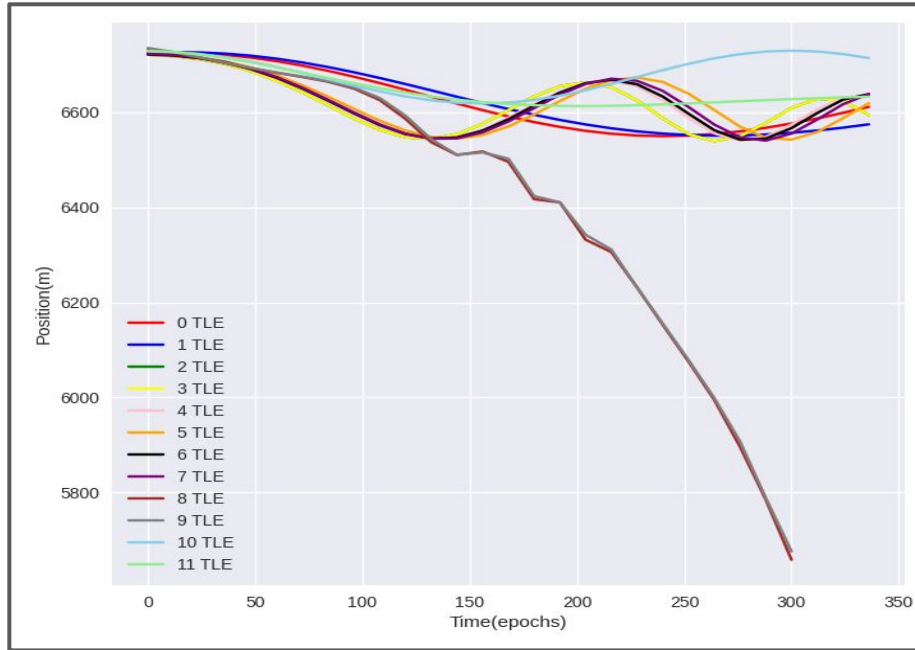
**Principal  
Component  
Analysis(PCA)**

**Fuzzy-C-Means  
Clustering**

**Statistical  
Prediction  
Model**

# Some Results

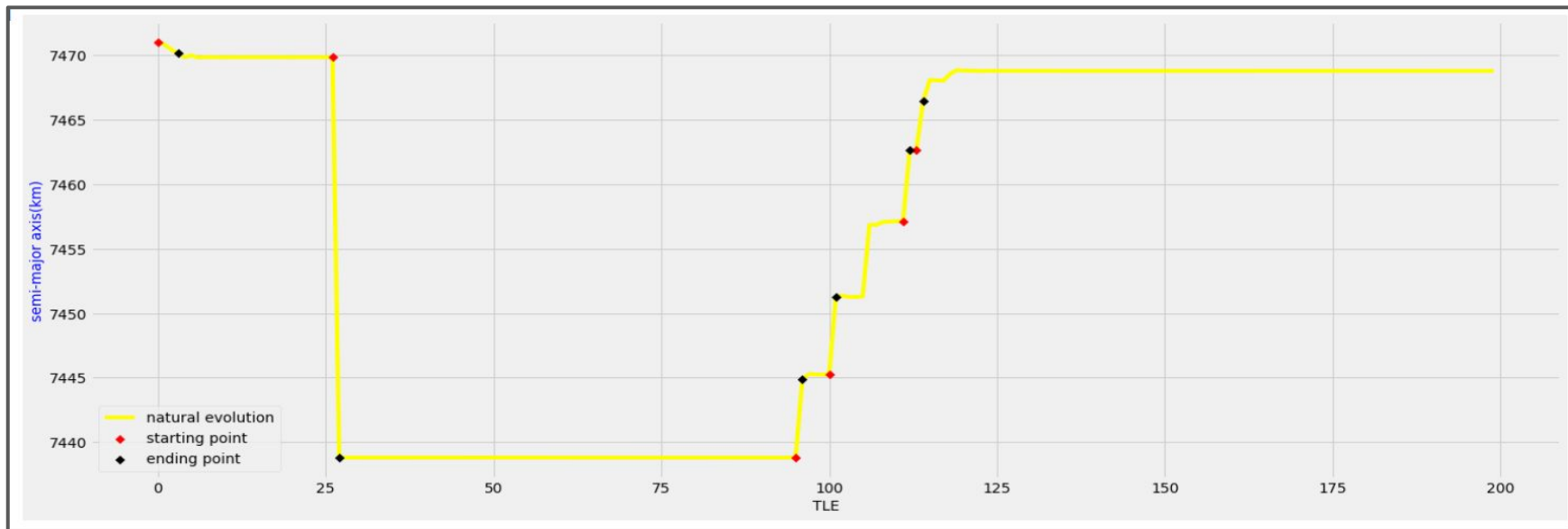
- ERROR ANALYSIS OF TLE DATA



The graphs are plots of future estimates of position and velocity respectively. The variation is observed across 11 TLEs of the same object(ISS-ZARYA) on a timespan of 350 epochs

# Some Results

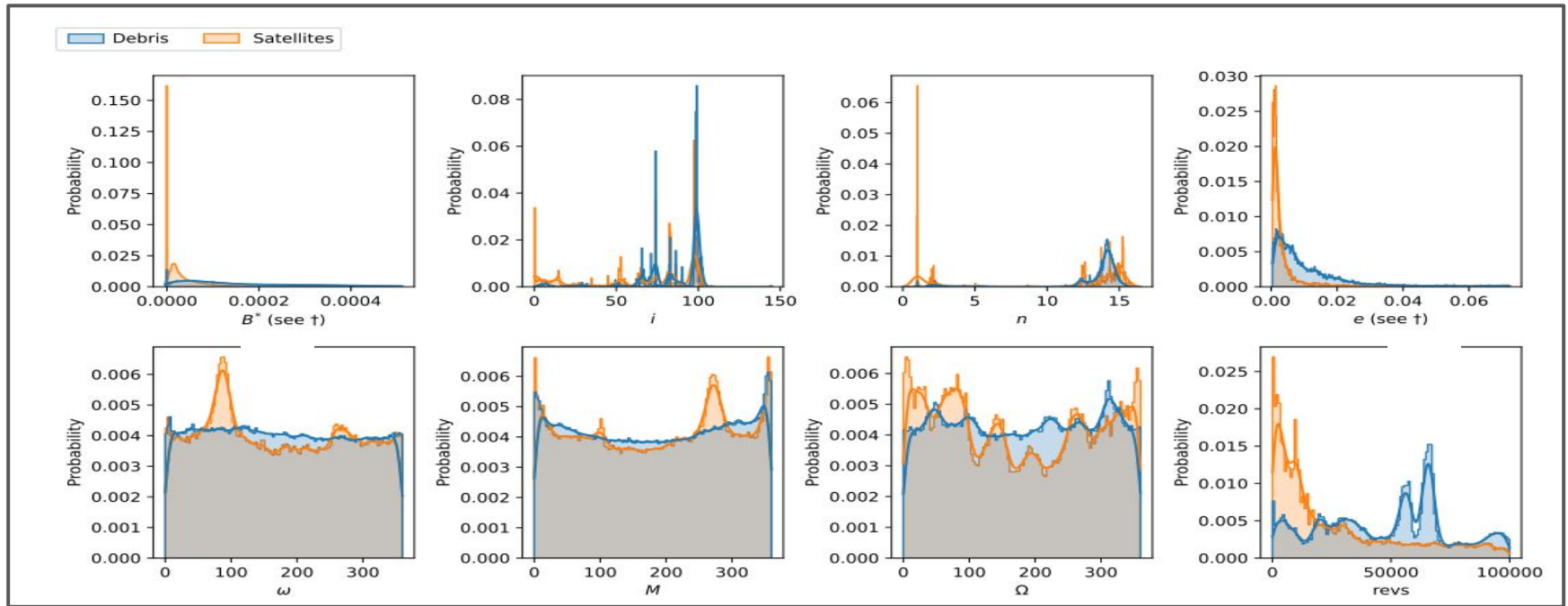
- MANEUVER DETECTION BY USING K-MEANS FOR YAOGAN 9A SATELLITE



Semi-major axis curve marked with orbit control points by the K-means clustering method: the yellow line indicates the natural evolution process; the red asterisk indicates the starting point of the orbital maneuver; and the black asterisk indicates the end point of the orbital maneuver.

# Some Results

- DEBRIS AND SATELLITE CLASSIFICATION



Distribution of orbital elements by object type

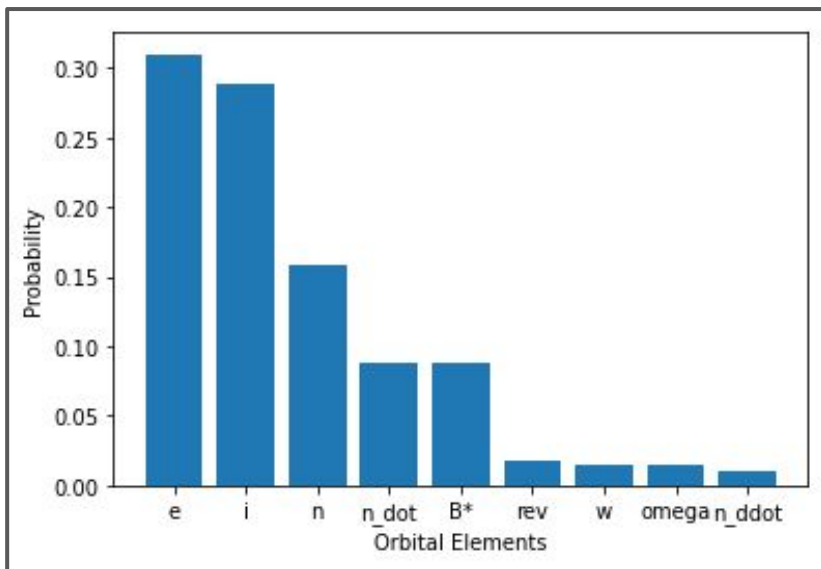


# Some Results

- DEBRIS AND SATELLITE CLASSIFICATION

	precision	recall	f1-score	support
Sat	0.96	0.88	0.92	45337
Deb	0.84	0.95	0.89	30116
accuracy			0.91	75453
macro avg	0.90	0.91	0.90	75453
weighted avg	0.91	0.91	0.91	75453
Accuracy = 0.9062197659470134				

Results of Random Forest Classifier



Random Forest Feature Importances

# Important Links for Project Work:

LINK TO PROJECT REPOSITORY: [https://github.com/Aaryansh7/CS685\\_project](https://github.com/Aaryansh7/CS685_project)

LINK TO DETAILED DOCUMENTATION:

<https://drive.google.com/file/d/1aS3vejtcCvXKGEEbKBBCp3sjcmPoqeuR/view?usp=sharing>

## References:

- [https://www.researchgate.net/publication/242742404\\_Satellite\\_Maneuver\\_Detection\\_Using\\_Two-line\\_Elements\\_Data](https://www.researchgate.net/publication/242742404_Satellite_Maneuver_Detection_Using_Two-line_Elements_Data)
- <https://ieeexplore.ieee.org/document/8830454>
- [https://www.researchgate.net/publication/222413947\\_Improved\\_orbit\\_predictions\\_using\\_two-line\\_elements](https://www.researchgate.net/publication/222413947_Improved_orbit_predictions_using_two-line_elements)

**THANK YOU**