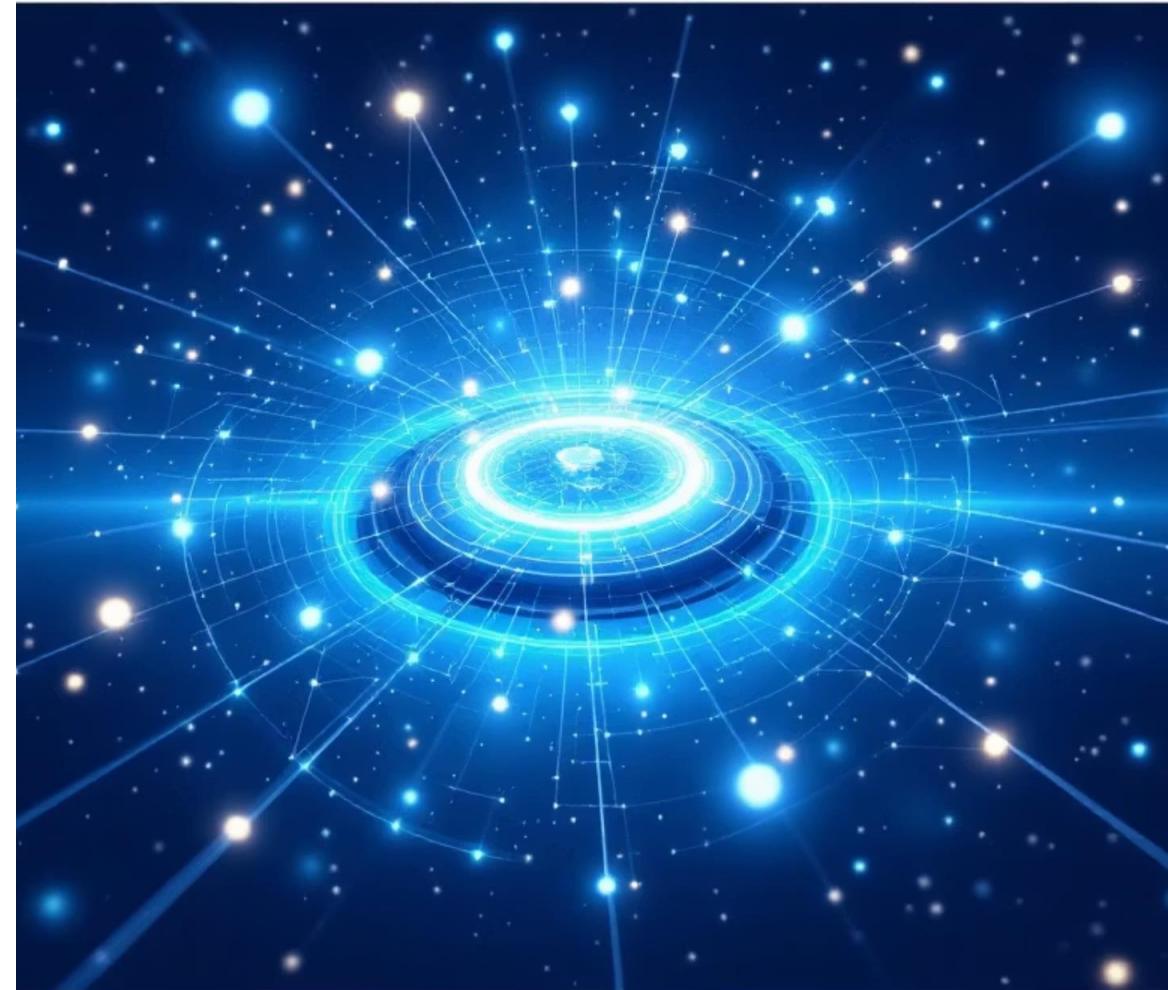


# AstroScope – Interactive Exoplanet Detection Platform

**NASA Space Apps Challenge 2025**

Celestial V





# AstroScope – Interactive Exoplanet Detection Platform

NASA Space Apps Challenge 2025

**AstroScope is a comprehensive platform for exploring, analyzing, and accurately predicting exoplanets using advanced machine learning and interactive visualization techniques.**



# The Challenge: Navigating Astronomical Data

## Data Deluge

Modern astronomical missions like Kepler and TESS generate millions of high-resolution observations annually, surpassing manual analysis capacity.

## Signal vs. Noise

Identifying genuine exoplanet transit signatures is extremely challenging due to high noise levels, instrumental errors, and common stellar false positives.

## The AstroScope Solution

We combine robust machine learning models, predictive accuracy, and user-friendly data visualization to deliver accurate, confirmed exoplanet detection.

# Core Technology Stack



## Python Ecosystem

- Pandas, NumPy for high-performance data manipulation.
- Scikit-learn for robust ML model construction.
- Matplotlib/Seaborn for exploratory data analysis.



## Machine Learning Engine

A high-performing Random Forest Classifier is employed, combined with Permutation Feature Importance for model interpretability.



## Interactive Dashboard

Streamlit provides the framework for a fast, responsive, and interactive web application for data exploration and prediction visualization.

# Leveraging the Kepler Exoplanet Candidate Data

Our predictive model is trained and validated using a subset of the official NASA Kepler Exoplanet Candidate Dataset, comprising approximately 8,000-10,000 distinct candidates.

- Target Variable: Confirmed Exoplanet (Binary: 0/1)
- Key Numeric Features: Orbital Period, Transit Time, Kepler Magnitude.
- Key Boolean Flags: Not Transit-Like Event, Stellar Eclipse, Centroid Offset, Ephemeris Contamination.



Feature engineering and interpretation of these specialized astronomical indicators are crucial for maximizing model accuracy and reducing false positives

# Methodology: From Data to Prediction



Data Processing

Model Training

Evaluation & Visualization

Deployment

## Data Preprocessing

Normalization of all numeric features and handling of missing values to ensure model stability and optimal performance.

## Model Evaluation

Rigorous evaluation using metrics like AUC, precision, and recall; feature importance visualization for model validation.

## Classifier Training

Training the Random Forest model using stratified splitting and class weighting to handle the inherent imbalance in confirmed exoplanet data.

# Interactive Detection Dashboard

The screenshot shows a Streamlit application titled "AstroScope: Intelligent Exoplanet Discovery Dashboard". On the left, there's a sidebar titled "Filter Candidates" with "Numeric Filters" for Orbital Period (days), Kepler Magnitude, and Transit Time (BKJD). Below that are "Flag Filters (Check for 1)" for Not Transit-Like, Stellar Eclipse, and Centroid Offset. The main area displays the title and a brief description: "Explore exoplanet candidates and predict probabilities of confirmed exoplanets using a Random Forest model. Use the filters and input section to interactively explore the dataset." A heading "Filtered Dataset (9563 rows)" is followed by a table with 7 rows of data.

|   | kepid    | kepoi_name | kepler_name   | koi_disposition | koi_pdisposition | koi_score | Not Transit-Like | Stellar Eclipse | Centro |
|---|----------|------------|---------------|-----------------|------------------|-----------|------------------|-----------------|--------|
| 0 | 11446443 | K00001.01  | Kepler-1 b    | CONFIRMED       | CANDIDATE        | None      | 0                | 0               |        |
| 1 | 10666592 | K00002.01  | Kepler-2 b    | CONFIRMED       | CANDIDATE        | None      | 0                | 1               |        |
| 2 | 10748390 | K00003.01  | Kepler-3 b    | CONFIRMED       | CANDIDATE        | None      | 0                | 0               |        |
| 3 | 3861595  | K00004.01  | Kepler-1658 b | CONFIRMED       | CANDIDATE        | None      | 0                | 0               |        |
| 4 | 8554498  | K00005.01  | None          | CANDIDATE       | CANDIDATE        | None      | 0                | 0               |        |
| 5 | 8554498  | K00005.02  | None          | FALSE POSITIVE  | FALSE POSITIVE   | None      | 1                | 0               |        |
| 6 | 3248033  | K00006.01  | None          | FALSE POSITIVE  | FALSE POSITIVE   | None      | 0                | 0               |        |

The Streamlit application allows users—from researchers to students—to dynamically analyze model predictions, explore feature distributions, and gain insight into the detection process.

# Interactive Detection Dashboard

The screenshot shows the AstroScope interface running on localhost:8501. On the left, there's a sidebar with 'Flag Filters (Check for 1)' and several dropdowns for 'Predict Your Exoplanet Candidate' including Orbital Period (days), Transit Time (BKJD), Kepler Mag, Not Transit-Like Flag, Stellar Eclipse Flag, Centroid Offset Flag, and Ephemeris Contamination Flag. A message at the bottom says 'Low Probability: 0.10'. In the center, there are two tables: 'Top 10 Predicted Exoplanets' and 'Top 10 Predicted Exoplanets' (repeated). The top table has columns for ID, Orbital Period (days), Transit Time (BKJD), Kepler Mag, Not Transit-Like, Stellar Eclipse, Centroid Offset, Ephemeris Contamination, and Predicted Probability. The bottom table is a bar chart titled 'Top 10 Predicted Exoplanets' with bars for IDs 1070 and 927.

| ID   | Orbital Period (days) | Transit Time (BKJD) | Kepler Mag | Not Transit-Like | Stellar Eclipse | Centroid Offset | Ephemeris Contamination | Predicted Probability |
|------|-----------------------|---------------------|------------|------------------|-----------------|-----------------|-------------------------|-----------------------|
| 1070 | 0.000045              | 0.037786            | 0.676383   | 0                | 0               | 0               | 0                       | 0.990000              |
| 927  | 0.000109              | 0.040291            | 0.532561   | 0                | 0               | 0               | 0                       | 0.990000              |
| 685  | 0.000104              | 0.040159            | 0.554422   | 0                | 0               | 0               | 0                       | 0.990000              |
| 800  | 0.000153              | 0.037612            | 0.605431   | 0                | 0               | 0               | 0                       | 0.990000              |
| 988  | 0.000042              | 0.037282            | 0.518447   | 0                | 0               | 0               | 0                       | 0.990000              |
| 1199 | 0.000022              | 0.036563            | 0.618394   | 0                | 0               | 0               | 0                       | 0.980000              |
| 1079 | 0.000037              | 0.037889            | 0.682289   | 0                | 0               | 0               | 0                       | 0.980000              |
| 1375 | 0.000065              | 0.037071            | 0.677687   | 0                | 0               | 0               | 0                       | 0.980000              |
| 834  | 0.000011              | 0.036936            | 0.602286   | 0                | 0               | 0               | 0                       | 0.980000              |
| 821  | 0.000106              | 0.037788            | 0.583570   | 0                | 0               | 0               | 0                       | 0.980000              |

| ID   | Orbital Period (days) | Transit Time (BKJD) | Kepler Mag | Not Transit-Like | Stellar Eclipse | Centroid Offset | Ephemeris Contamination | Predicted Probability |
|------|-----------------------|---------------------|------------|------------------|-----------------|-----------------|-------------------------|-----------------------|
| 1070 | 0.000045              | 0.037786            | 0.676383   | 0                | 0               | 0               | 0                       | 0.990000              |
| 927  | 0.000109              | 0.040291            | 0.532561   | 0                | 0               | 0               | 0                       | 0.990000              |
| 685  | 0.000104              | 0.040159            | 0.554422   | 0                | 0               | 0               | 0                       | 0.990000              |
| 800  | 0.000153              | 0.037612            | 0.605431   | 0                | 0               | 0               | 0                       | 0.990000              |
| 988  | 0.000042              | 0.037282            | 0.518447   | 0                | 0               | 0               | 0                       | 0.990000              |
| 1199 | 0.000022              | 0.036563            | 0.618394   | 0                | 0               | 0               | 0                       | 0.980000              |
| 1079 | 0.000037              | 0.037889            | 0.682289   | 0                | 0               | 0               | 0                       | 0.980000              |
| 1375 | 0.000065              | 0.037071            | 0.677687   | 0                | 0               | 0               | 0                       | 0.980000              |
| 834  | 0.000011              | 0.036936            | 0.602286   | 0                | 0               | 0               | 0                       | 0.980000              |
| 821  | 0.000106              | 0.037788            | 0.583570   | 0                | 0               | 0               | 0                       | 0.980000              |

Top 10 Predicted Exoplanets

| ID   | Predicted Probability |
|------|-----------------------|
| 1070 | 0.990000              |
| 927  | 0.990000              |
| 685  | 0.990000              |
| 800  | 0.990000              |
| 988  | 0.990000              |
| 1199 | 0.980000              |
| 1079 | 0.980000              |
| 1375 | 0.980000              |
| 834  | 0.980000              |
| 821  | 0.980000              |

Users can upload new transit data or select a candidate from the existing catalog to receive instant, interpretable exoplanet predictions.

# Impact & Future Trajectory



## Reliable Predictions

**AstroScope provides accurate and interpretable predictions, significantly streamlining the initial screening phase for exoplanet candidates.**



## Education & Outreach

**The interactive nature makes complex data science and astrophysics accessible for educational purposes and broader public engagement.**



## Scalable Research

**By automating the detection process, AstroScope enables researchers to focus their valuable time on novel discoveries rather than manual triage.**

## Future Enhancements



### Advanced ML Models

**Integration of Gradient Boosting or sophisticated Neural Network architectures to further enhance prediction accuracy.**



### Cloud Deployment

**Full cloud hosting to ensure global, 24/7 accessibility and real-time processing capabilities for new data streams.**



### Enhanced Visualizations

**Development of advanced visual elements, including 3D orbital simulations and feature heatmaps.**



# Thank You

The Celestial Voyagers Team appreciates your time  
and consideration.

AstroScope – Mapping the Cosmos, One Exoplanet at a Time.