CSE 564 Project Proposal
Beyond Earth: A Global View of Exoplanet Exploration

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I. Introduction

The cosmos continues to intrigue us with the possibility of life beyond Earth, and the study of exoplanets — planets orbiting stars outside our solar system — is at the heart of that pursuit. This project seeks to develop an interactive visualization dashboard that illustrates the global network of observatories contributing to the discovery of these distant worlds. By highlighting where discoveries have originated and offering tools to explore associated planetary data, this dashboard aims to provide a compelling, data-driven lens into our expanding astronomical catalog.

Rather than conducting deep statistical or habitability analysis, this initiative focuses on building a visual interface that facilitates intuitive exploration of discovery patterns across geography, time, and basic planetary characteristics. The platform will be designed with interactivity and clarity in mind, supporting both scientific communication and casual curiosity.

II. Background

The discovery of exoplanets — planets orbiting stars beyond our solar system — marks one of the most profound developments in modern astronomy. Since the first confirmed detection in the 1990s, the field has expanded rapidly, with thousands of exoplanets now cataloged across a wide spectrum of sizes, compositions, and orbital configurations. These discoveries have fueled public fascination and scientific inquiry into the nature of distant planetary systems and the potential for habitable worlds beyond Earth.

At the heart of this endeavor lies a vast and distributed network of observatories, both ground-based and space-borne. Each discovery represents not just a data point, but the culmination of decades of instrumentation, data analysis, and observational strategy. While databases such as the NASA Exoplanet Archive provide detailed records of these planets and their stellar hosts, they often lack an intuitive visual interface that connects this information to the geographic and institutional sources behind it.

Existing platforms largely focus on planetary metrics and classification, yet few contextualize the global nature of the discovery process itself. For researchers, educators, and enthusiasts alike, there is immense value in a tool that visually represents where exoplanet discoveries originate, how those observatories are distributed around the globe, and how their findings compare in terms of planetary characteristics.

This project emerges from that need — to build an interactive, visual dashboard that not only showcases planetary data, but also honors the collaborative and international nature of the search for other worlds. By fusing geospatial visualization with planetary metadata, this tool will bridge scientific insight and public engagement, making the data both more accessible and more meaningful.

III. Problem Statement

Over the past few decades, the discovery of exoplanets has surged, driven by advances in both space-based missions and ground-based observatories. Despite the growing volume of data available from repositories such as the NASA Exoplanet Archive, much of this information remains underutilized outside academic circles due to its tabular and static presentation formats.

There exists a need for an intuitive and visually engaging platform that can transform these rich datasets into meaningful, interactive narratives. Specifically, there is no consolidated, user-friendly tool that geographically contextualizes the global contributions to exoplanet discoveries, while simultaneously allowing users to explore planetary attributes and discovery metadata in a visually dynamic way.

Furthermore, current platforms often require domain expertise to interpret or manipulate, leaving out broader audiences such as students, educators, and enthusiasts who could otherwise benefit from engaging with this data. The lack of accessible interfaces that bridge geography, discovery history, and planetary characteristics limits the broader impact and educational potential of this research domain.

This project aims to address these gaps by developing a visualization dashboard that enables exploration of exoplanet data through interactive maps and charts. The tool will make it easier to identify which observatories are leading discovery efforts, how planetary characteristics vary across discovery sources, and how Earth-like these planets may be — all while remaining accessible to non-specialists and compelling to expert audiences alike.

IV. Data Source

The data leveraged in this project is derived from a cleaned and structured subset of the NASA Exoplanet Archive, specifically from the PSCompPars catalog. This dataset includes:

- Names of observatories and space missions responsible for exoplanet detection.
- Geographic coordinates (latitude and longitude) for Earth-based facilities.
- Supplementary planetary data such as planet name, discovery method, orbital period, and radius (in downstream versions of the dataset).

These entries are mapped to visual components in the dashboard, enabling contextual exploration of exoplanet discoveries across multiple dimensions. Space-based missions (e.g., K2, CoRoT) will also be featured distinctly to differentiate them from ground-based contributions.

V. Proposed Visualizations

This project envisions a modular visualization dashboard built using React and D3.js, supported by a Flask API backend. Each component will be developed to highlight unique aspects of the dataset while providing users with control over filtering and exploration.

A proposed plan of visualizations in the dashboard is listed as follows (subject to change):

1) **Interactive Geographic Map of Observatories:** A world map will serve as the entry point to the dashboard, visually marking the physical locations of all participating observatories. Clicking a marker will filter the dashboard to show only the planets discovered by that observatory or mission. This geographic representation will immediately convey the global distribution and collaboration in exoplanetary science.

2) **Bubble Chart of Planetary Characteristics:** A two-dimensional bubble chart will visualize exoplanets based on their relative distances and mass. Each bubble will represent an exoplanet, with its size corresponding to planetary radius. This chart provides a quick comparative view of discovered planets relative to Earth's parameters, and helps users identify outliers or clusters.

3) **Parallel Coordinates Plot:** To explore relationships between multiple features (e.g., radius, orbital period, number of stars in system), a parallel coordinates plot will be implemented. This allows users to observe trends and anomalies across a multi-attribute space, filtering by mission, year, or planet type.

4) **Clustering and PCA for Advanced Insight:** While the core focus is visualization, future extensions of the project may include dimensionality reduction techniques like PCA or basic clustering to group similar exoplanets. If implemented, this feature will serve as an exploratory aid rather than a conclusive analysis tool.

VI. Project Plan and Technical Stack (Proposed)

A proposed plan of implementation for the project is as follows (subject to change):

- **Frontend:** React.js + D3.js for dynamic rendering.
- **Backend:** Flask for serving data via RESTful endpoints.
- **Data Handling:** Pandas for CSV processing, GeoJSON for mapping.
- **Hosting:** Local development.

VII. Conclusions

This project will result in a polished, interactive visualization dashboard that spotlights the global effort behind exoplanetary discovery. By allowing users to explore planetary data through maps, charts, and multidimensional plots, the dashboard will serve both educational and exploratory purposes. While the scope will remain within the bounds of visualization and interface design, this project has strong potential to evolve into a deeper analytical platform in the future.

Ultimately, the goal is to create a compelling and informative interface that celebrates the scientific strides we've made in understanding our place in the universe — one exoplanet at a time.

VIII. Data Links

NASA Exoplanet Archive, a comprehensive and publicly accessible collection of data related to exoplanets and their star systems: NASA Exoplanet Archive – PSCompPars Table