**Outlined Proposal:**

This research project aims to study the spatial distribution and gravitational significance of black holes in relation to their distances from Earth and each other. Our study will utilize extensive datasets from some well-known astronomical archives such as NASA/IPAC Extragalactic Database (NED), Chandra X-ray Observatory, and the Event Horizon Telescope, we will conduct a comprehensive analysis to discover potential patterns and correlations. Our primary objective is to develop a machine learning model that can predict gravitational significance based on key features such as distance, mass, spin, and luminosity. By using simulation data and advanced modeling techniques, including clustering algorithms and deep learning, we aim to enhance our understanding of black hole interactions and their influence on surrounding cosmic structures.

**Tyler’s Many, Many Questions:**

* How do the detected gravitational waveforms vary with the properties of the merging black holes?
* What can we infer about the population distribution of black holes in the universe from the detected gravitational wave events?
* What are the typical environments where black hole mergers occur?
* What insights can gravitational waves provide about the early universe and the formation of the first black holes?
* How can black hole mergers be used as standard sirens to probe the large-scale structure of the universe?
* Can interactions with black holes explain the ejection of rogue planets from their original planetary systems?
* Can rogue planets in the vicinity of black holes have conditions suitable for life, given their isolation from stellar radiation?

**Considerations and Scope:**

* We obviously cannot get through all these questions in one semester’s worth of class time and research. I hope these questions serve as a guide to the directions of the research. The final scope will be defined throughout the first couple of weeks of the course.

**Week 1: Literature Review**

* Review recent research papers on black holes, their distances, gravitational significance, and spatial relationships.
* Use NASA's Astrophysics Data System (ADS) and other academic databases to find relevant publications.
* Summarize key findings and identify gaps in current research to ensure the novelty/uniqueness of the study.
* Document insights and potential research questions based on the literature review.

**Weeks 2-3: Identifying Good Datasets**

* Explore NASA/IPAC Extragalactic Database (NED) for black hole data.
* Review Chandra X-ray Observatory data archives.
* Search for relevant data in HEASARC and Event Horizon Telescope (EHT) archives.
* Access and evaluate Simbad Astronomical Database and ATNF Pulsar Catalogue for additional data.
* Explore Gravitational Wave Open Science Center (GWOSC) for black hole merger data.
* Use NASA's Astrophysics Data System (ADS) to find related research papers and datasets.
* Compile a list of useful datasets and APIs for data retrieval.
* Evaluate the quality and completeness of collected datasets.

**Weeks 4-5: Data Collection and Preprocessing**

* Download and organize datasets from identified sources.
* Clean the data, handle missing values, and normalize features.
* Merge datasets from different sources to create a comprehensive database.
* Document data preprocessing steps.
* Feature engineering: Extract and create relevant features (distance from Earth, mass, spin, luminosity, and others).
* Visualize data distributions and identify patterns or anomalies.
* Split data into training, validation, and test sets.

**Weeks 6-7: Exploratory Data Analysis (EDA)**

* Perform statistical analysis and correlation analysis on features.
* Use clustering algorithms (like k-means and DBSCAN) to identify groups of black holes.
* Visualize spatial distribution of black holes using 3D plots.
* Investigate relationships between distance, mass, and gravitational influence.
* Identify key features that impact gravitational significance.
* Summarize findings from EDA and refine research questions.

**Weeks 8-9: Model Development**

* Select appropriate machine learning algorithms (like regression, clustering, and/or neural networks).
* Develop initial ML models to predict gravitational significance based on features.
* Tune hyperparameters and evaluate model performance using validation data.
* Implement cross-validation to ensure model robustness.
* Compare performance of different algorithms and select the best model.
* Begin documenting the model development process.

**Weeks 10-11: Advanced Modeling and Analysis**

* Explore deep learning models (we will use CNNs for this project) for more complex pattern recognition.
* Implement advanced models and evaluate their performance.
* Use dimensionality reduction techniques (we will probably use PCA) to understand feature importance.
* Conduct simulations to model gravitational interactions between black holes.
* Integrate simulation results with ML models for enhanced predictions.
* Document findings from advanced modeling and analysis.

**Weeks 12-13: Validation and Evaluation**

* Validate final models using test data and compare with observed data.
* Perform error analysis and refine models if necessary.
* Conduct peer reviews or seek feedback from Dr. Jones and/or possibly Magers and other faculty.
* Prepare comprehensive evaluation reports and visualizations.
* Ensure all models and code are reproducible and well-documented.
* Finalize the model evaluation and validation phase.

**Week 14: Reporting and Presentation**

* Compile all findings, analyses, and results into a research paper or report.
* Create visualizations, graphs, and charts to support findings.
* Prepare a presentation summarizing the research, methodology, and results.
* Finalize all documents, reports, and presentations for honors college.
* Present the research to and find venues for such.

ssh-keygen -t rsa -b 4096 -C [your\_email@example.com](mailto:your_email@example.com)

eval "$(ssh-agent -s)"

ssh-add ~/.ssh/id\_rsa

cat ~/.ssh/id\_rsa.pub

cd path/to/your/project

git init

git remote add origin <https://github.com/your-username/your-repository-name.git>

git add .

git commit -m "Initial commit"

git push -u origin main