Machine Learning Weather Model for SALT Dome Conditioning

Introduction

The Southern African Large Telescope (SALT), located at Sutherland, South Africa, requires precise dome temperature control to ensure optimal observing conditions. Currently, SALT staff manually predict sunset temperatures to condition the telescope dome interior. Incorrect predictions lead to temperature gradients, causing turbulence (dome seeing), which adversely affects observational efficiency. Automating this temperature prediction process using machine learning will enhance observational quality, operational efficiency, and energy utilization at SALT.

Research Objectives

This project aims to:

- Develop a computationally efficient machine learning model to accurately predict external sunset temperatures using historical weather data from SALT.
- Compare the effectiveness of several machine learning techniques, including multiple linear regression, decision trees, and random forest regression.
- Automate dome temperature adjustment, reducing manual intervention and increasing operational efficiency.

Methodology

- **Data Source:** Utilize historical temperature data from SALT's internal and external weather stations stored in an SQL database.
- **Data Preprocessing:** Clean and engineer daily summaries, extracting relevant predictive features such as daytime temperature trends, seasonal variations, and weather conditions.
- **Machine Learning Models:**
    - Implement multiple linear regression as a baseline model.
    - Explore decision trees and random forest regression to improve prediction accuracy while maintaining computational feasibility.
- **Model Validation:** Use metrics such as Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) on training and testing datasets. Compare model predictions to actual sunset temperatures.

Expected Outcomes

- Improved accuracy in predicting sunset temperatures, enhancing the quality of astronomical observations.
- Increased operational efficiency through automation, reducing the workload for technical staff.
- Potential reduction in energy consumption and equipment strain by precise, timely temperature conditioning.

Timeline

A structured six-month timeline includes:

- Data extraction and preprocessing
- Model development and evaluation
- Model refinement and tuning
- Final validation and implementation

Resources and Constraints

- The model will be designed to run on standard laptop hardware.
- Open-source software (Python with libraries like pandas and scikit-learn) will be used.
- Direct access to SALT’s SQL database will be provided.

Conclusion

This research project will deliver an automated machine learning weather model specifically designed to optimize SALT’s dome conditioning process, directly contributing to better observational performance and increased operational efficiency at one of the world's leading astronomical facilities.

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