

Project Proposal: Classifying Sutherland Nights into Observing-Condition Regimes Using Unsupervised Learning

Background:

Astronomical observing conditions are influenced by a combination of meteorological factors, including temperature, humidity, dew point, wind speed, wind direction, and air pressure. While these variables are often studied individually, it is also scientifically useful to ask whether whole nights can be grouped into a small number of distinct weather regimes. Such groupings may reveal recurring patterns in site conditions and may provide insight into how different types of nights relate to observing quality.

Aim:

To investigate whether nights at the observing site can be grouped into distinct observing-condition regimes using unsupervised machine-learning techniques.

Research Question:

Can nightly weather data be separated into a small number of physically meaningful classes or regimes, and do these regimes correspond to recognisably different observing conditions?

Methodology:

The student will first derive a set of nightly summary features from the weather archive, such as median temperature, temperature range, median relative humidity, dew point separation, wind statistics, and pressure behaviour over the course of the night. After exploratory analysis and appropriate feature scaling, the student will apply one or more unsupervised learning techniques, such as k-means clustering, hierarchical clustering, or Gaussian mixture models, to identify possible groups of nights with similar meteorological characteristics. Dimensionality-reduction methods such as principal component analysis may also be used to visualise the structure of the data. The resulting clusters will then be interpreted physically by comparing the typical weather properties of each group. If atmospheric seeing data are available for part of the dataset, the student may additionally examine whether certain night classes tend to be associated with better or poorer seeing.

Skills Developed:

Exploratory data analysis, feature construction, unsupervised machine learning, dimensionality reduction, scientific interpretation of discovered patterns, and critical evaluation of whether statistically identified groups are physically meaningful.

Expected Outcomes:

The project should establish whether the site's weather archive contains evidence for distinct types of observing nights, whether these clusters are physically interpretable, and whether they may be useful for understanding or characterising observing conditions.

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