Surface Albedo Prediction using Artificial Neural Networks

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Surface albedo describes the fraction of sunlight reflected by a surface using a value from zero to one.

This project utilized a supervised machine learning method called an artificial neural network.
Weather changes cause power fluctuations in PV arrays.
Prediction of these changes can make PV arrays more efficient.
Surface albedo is strongly correlated with irradiance and power.
- Obtain data from National Solar Radiation Database.
- Use data to train artificial neural network to predict surface albedo.
- Determine which features from dataset correlate most strongly to surface albedo.
CHALLENGES

- Limited time to explore research.
- COVID prevented traveling to Cyprus.
- Virtual communication only.
Artificial Neural Network Regressor

- Weather Station Data
- PV array
- Meteorological Features
- Ground Truth Surface Albedo
- Artificial Neural Network
- Predicted Surface Albedo
- Loss Function
WEATHER STATION DATA

**Global Horizontal Irradiance (GHI):** radiation received on a surface horizontal to the ground

**Direct Normal Irradiance (DNI):** radiation received on a surface perpendicular to the rays of the sun

**Global Horizontal Irradiance (GHI):**
- **Diffuse Horizontal Irradiance (DHI):** radiation scattered by the atmosphere received equally from all directions
- **Precipitable Water:** the amount of water in a column of atmosphere if all the water was precipitated as rain
- **Relative Humidity:** absolute humidity relative to a maximum humidity given the same temperature
- **Dew Point:** temperature below which water droplets begin to condense
- **Wind Speed**
- **Wind Direction**
- **Temperature**
- **Pressure**

**Cloud Type:** Clear, Probably Clear, Fog, Water, Super-Cooled Water, Mixed, Opaque Ice, Cirrus, Overlapping, Overshooting, Unknown, Dust, Smoke
- Pre-processed data.
- Standardization with StandardScaler.
- One-hot encoding of Cloud Type.
- 80/20 Train/Test split.
- Determined how many layers, nodes, and iterations to use for artificial neural network.
Use RMSE as a metric to calculate the distance between ground truth and predicted surface albedo.

Evaluate RMSE with varying learning rates, activation functions, solvers, and batch sizes.
Features were removed one at a time and prediction performance was measured.

GHI and DNI removal produced the largest RMSE.

This suggests strongest correlation to surface albedo.
The first three components contribute to 71% of the total variance. When running simulations with different numbers of principal components, the lowest RMSE was obtained using only one principal component.
CONCLUSION AND FUTURE WORK

- The four features most strongly correlated to surface albedo were GHI, DNI, Solar Zenith Angle, and Cloud Type.
- The lowest RMSE obtained over the course of my experiments was 0.0087 when removing Dew Point from the dataset.
- Explore how the features are related to each other.
- Compare using an auto-encoder to PCA.


