Surface Albedo Prediction using Artificial Neural Networks

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Sensor Signal and Information Processing Center: http://sensip.asu.edu/nsf-ires-project

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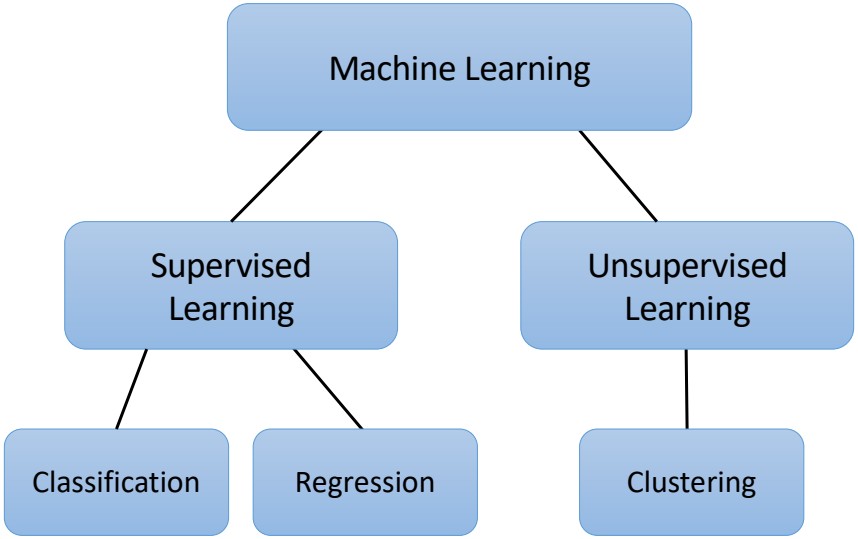
BACKGROUND

- 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.



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MOTIVATION

- 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.

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PROJECT AIM

- 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.

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CHALLENGES

- Limited time to explore research.
- COVID prevented traveling to Cyprus.
- Virtual communication only.

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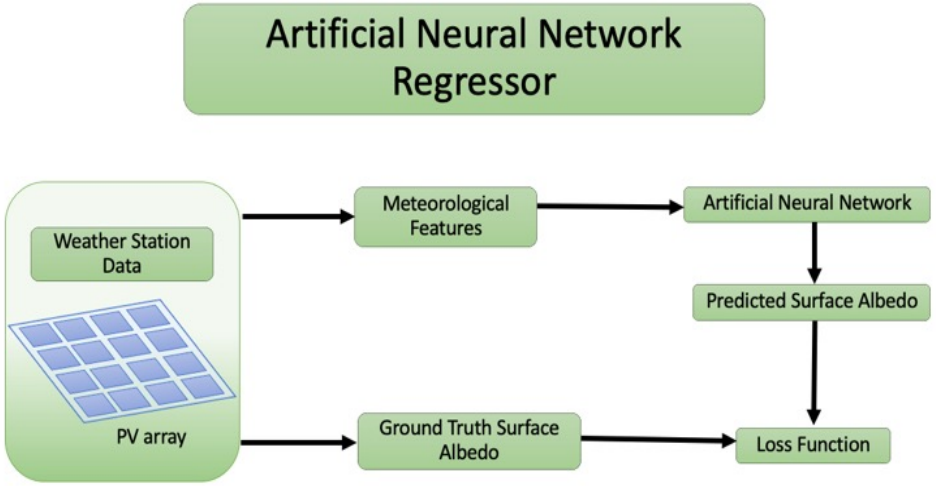
BLOCK DIAGRAM



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WEATHER STATION DATA

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

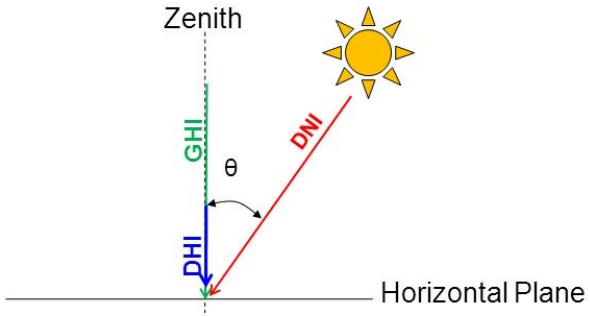
Dew Point: temperature below which water droplets begin to condense

Wind Speed

Wind Direction

Temperature

Pressure



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

Solar Zenith Angle: angle between sun's rays and the vertical

Cloud Type: Clear, Probably Clear, Fog, Water, Super-Cooled Water, Mixed, Opaque Ice, Cirrus, Overlapping, Overshooting, Unknown, Dust, Smoke

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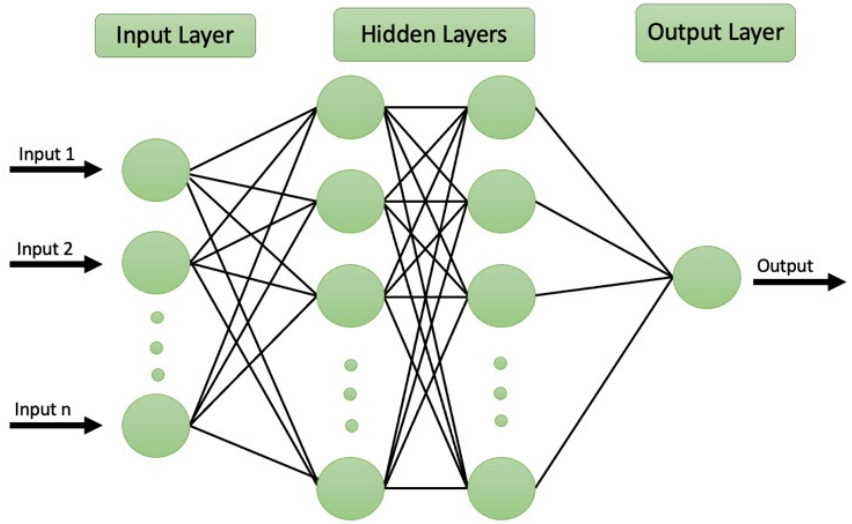
FIRST STEPS

- 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.



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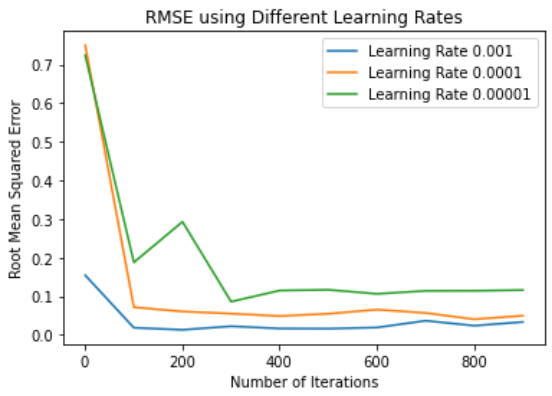
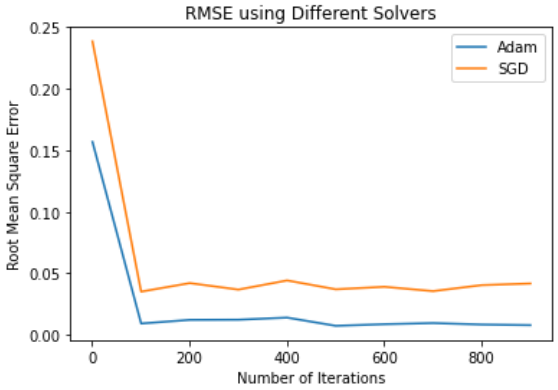
HYPERPARAMETER TUNING

- 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.





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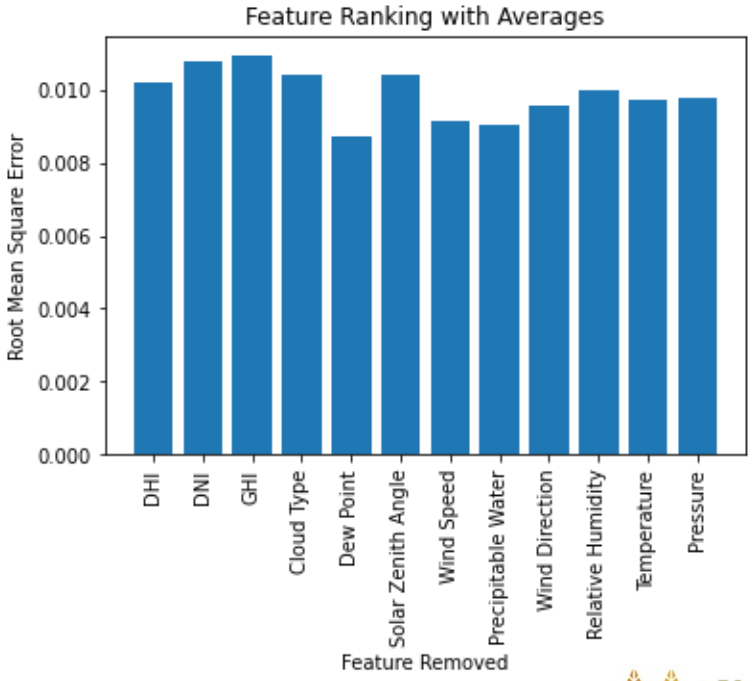
FEATURE RANKING

- 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.



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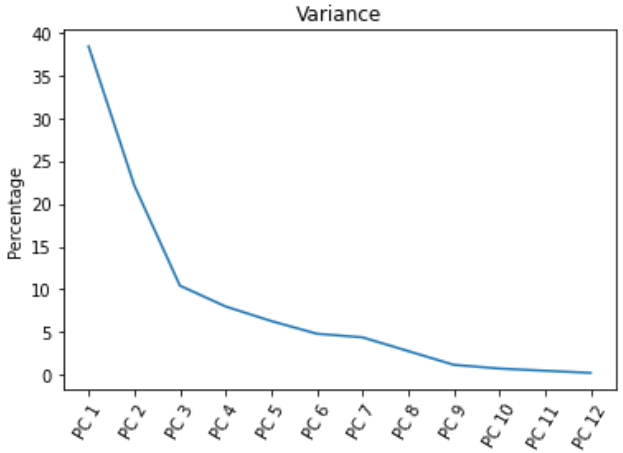
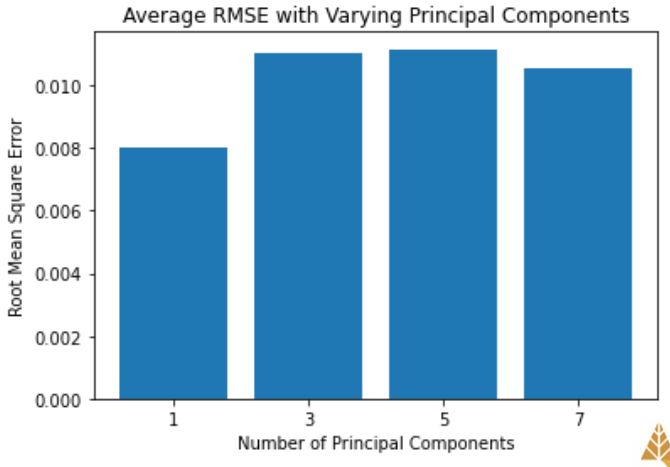
PRINCIPAL COMPONENT ANALYSIS

- 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.





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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.

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