ClimateWins- Real-World Applications of Machine Learning

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Project Overview

- Predict the consequences of climate change across European cities using Machine Learning.
  - Identify weather patterns outside the norm in Europe.
  - Determine if unusual weather patterns are increasing.
  - Generate possible weather conditions for the next 25-50 years.
  - Determine safest places for people to live in Europe for the next 25-50 years.

Thought Experiments- Summary

Can we use historical data to determine if extreme weather patterns are increasing?

Can generative machine learning help determine the likelihood of unpleasant weather for various seasons?

Can machine learning determine the safest areas to live in Europe?

Machine Learning Algorithms

Principal Component Analysis (PCA)	Simplifies data by examining greatest variance in a dataset. Assumes data is linear in nature and effective for large datasets.
K-Means Clustering	Unsupervised method that groups data points into "clusters" based on similarity.
Random Forests	Supervised method that provide generalizations across various conditions and can assist in identifying important hyperparameters for future modeling.
Convolution Neural Network (CNN)	Deep learning model that uses convolution/pooling layers to learn and build on complex datasets.
Generative Adversarial Networks (GANs)	Competing neural networks that both generate and discriminate on artificial data until the generator converges or deceives the discriminator.
Physics-Informed Neural Networks (PINNs)	Important method between AI and hard sciences. Loss function in neural network includes partial differential equations that prevent the model from predicting impossible weather conditions.
Quantum Machine Learning (QML)	Useful technique to handle immense amount of data when the sheer volume is intolerable in other methods.

Alternative Climate Data Sources

Deep Sea/Permafrost Sensors data	European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis v5 (ERA5)	Destination Earth (DestinE) Digital Twins
• There is limited data on arctic weather conditions and deep-sea changes that could tie in with current weather events.	• Tracks heatwaves, Mediterranean hurricanes, and storm surges.	• Designed to simulate extreme weather events.

Thought Experiment 1

Can we use historical data to determine if extreme weather patterns are increasing?

Method:

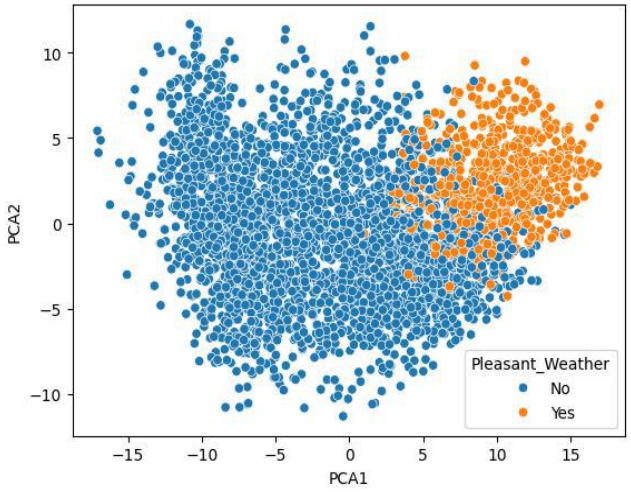
- Combination of PCA and clustering to determine historical patterns.

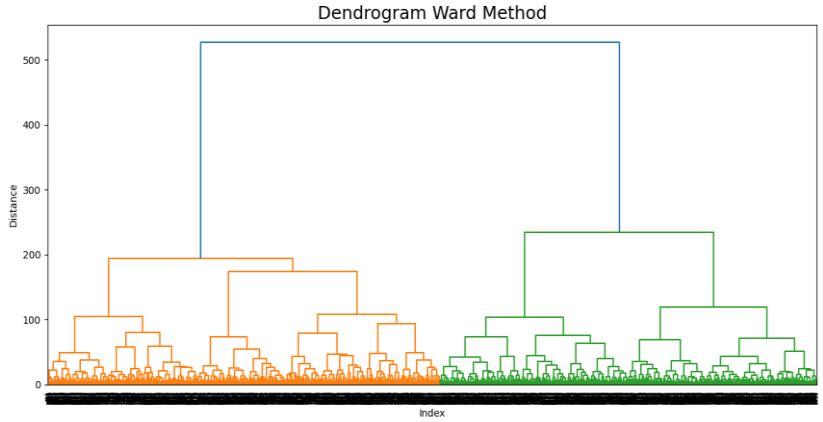
Approach:

- Inclusion of ERA5 data can assist in identifying extreme weather events and help identify frequency over time.

Data:

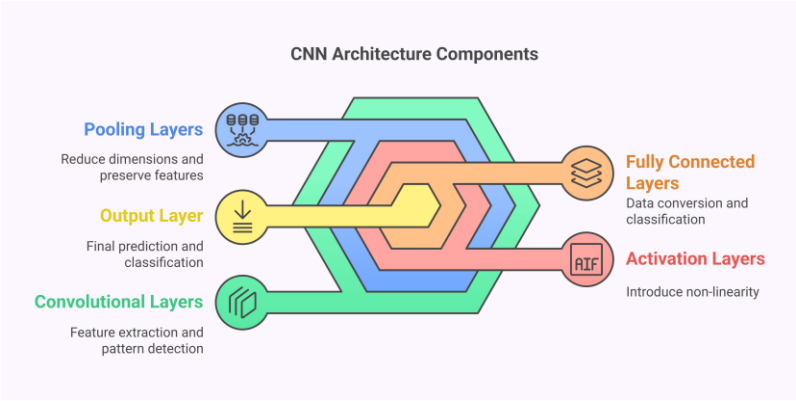
- Europe Climate Assessment Data and ERA5 Data





Thought Experiment 2

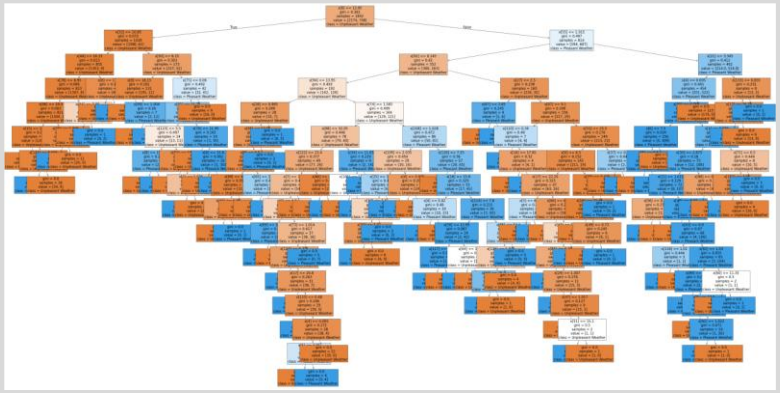
- ***Can generative machine learning help determine the likely of unpleasant weather for various seasons?***



- **Method:**
  - CNNs combined with GANs would provide the best results.
- **Approach:**
  - CNNs can establish baselines of average pleasant weather at a location. Including GANs can generate future weather states.
- **Data:**
  - Europe Climate Assessment Data and ERA5 Data

Thought Experiment 3

- ***Can machine learning determine the safest areas to live in Europe?***



- **Method:**
  - Random Forest Models or LSTM
- **Approach:**
  - These models allows for ranking and cities to be designated through the process. This can utilize various factors to establish safe areas.
- **Data:**
  - Europe Climate Assessment Data and Destination Earth (DestinE) Digital Twins

Recommendations/Summary

- **Recommendation**
  - Thought experiment 1 is a great first step for ClimateWins.
  - The data is already accessible, the PCA methods are easy to conduct, and further data can amplify the results.

- **Further Analysis**
  - Incorporating the ERA5 Data can expound on the findings for most of these thought experiences.
  - Limitations to historic data can be alleviated with several models, especially GANs.

Questions?

Thank You

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