Weather Conditions and Climate Change with ClimateWins

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Introduction

- ClimateWins wants to assess what tools are available to categorize and predict the weather in mainland Europe. It's concerned with the increase in extreme weather events, especially in the past 10 to 20 years.
- Objectives
  - 1. Identify weather patterns outside the regional norm in Europe.
  - 2. Determine if unusual weather patterns are increasing.
  - 3. Generate possibilities for future weather conditions over the next 25 to 50 years based on current trends.
  - 4. Determine the safest places for people to live in Europe over the next 25 to 50 years.

Three Thought Experiments

Predict unusual weather patterns using random forest

Find trends based on historical weather patterns and weather station data

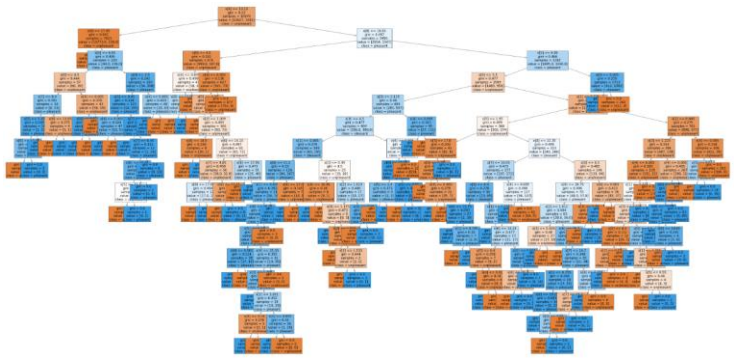
Identify and classify weather conditions

Detect patterns in satellite images and weather station data

Simulate weather scenarios to predict the impact of climate change

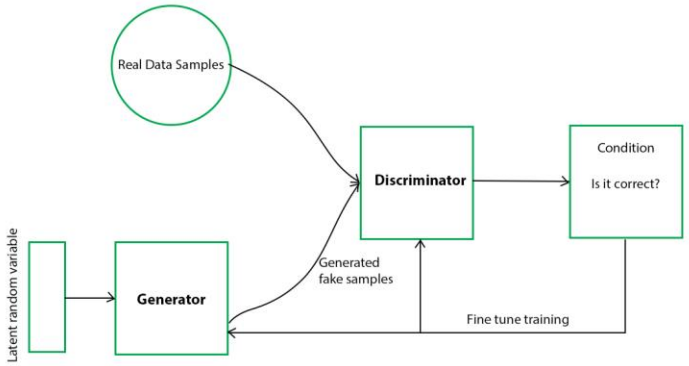
Generate synthetic weather data to create datasets for training models

Machine Learning Options



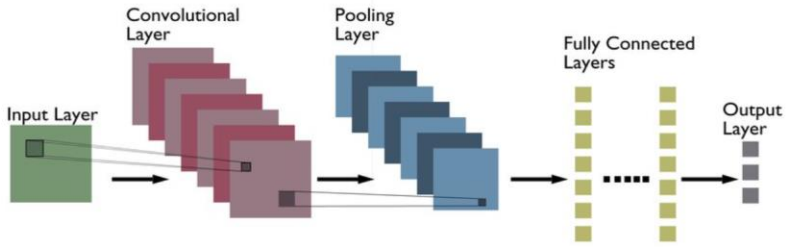
Random Forest

- Method that combines multiple decision trees to improve accuracy and reduce overfitting
- Creates trees using random subsets of data and features



Generative Adversarial Networks (GANs)

- Consist of two neural networks—a generator and a discriminator—that work against each other to create realistic data
- Generator creates fake data, while the discriminator evaluates it, refining both networks through a process of competition



Convolutional Neural Networks (CNNs)

- Uses layers to progressively capture complex patterns and structures in data

Experiment 1: Predict weather patterns in Europe

- **Method:** Use random forest to predict weather conditions based on historical data
- Handles complex, non-linear relationships like humidity and pressure
- Handles continuous variables such as temperature and wind speed
- Data includes precipitation, temperature, cloud cover, humidity, etc.
- Highlights important features that affect weather conditions
- Importance chart (Fig 1.) for Maastricht highlights precipitation and temperature
- **Accuracy:** 54%
- **Objective:** Predict future weather conditions and use precipitation and temperature to determine safest places to live

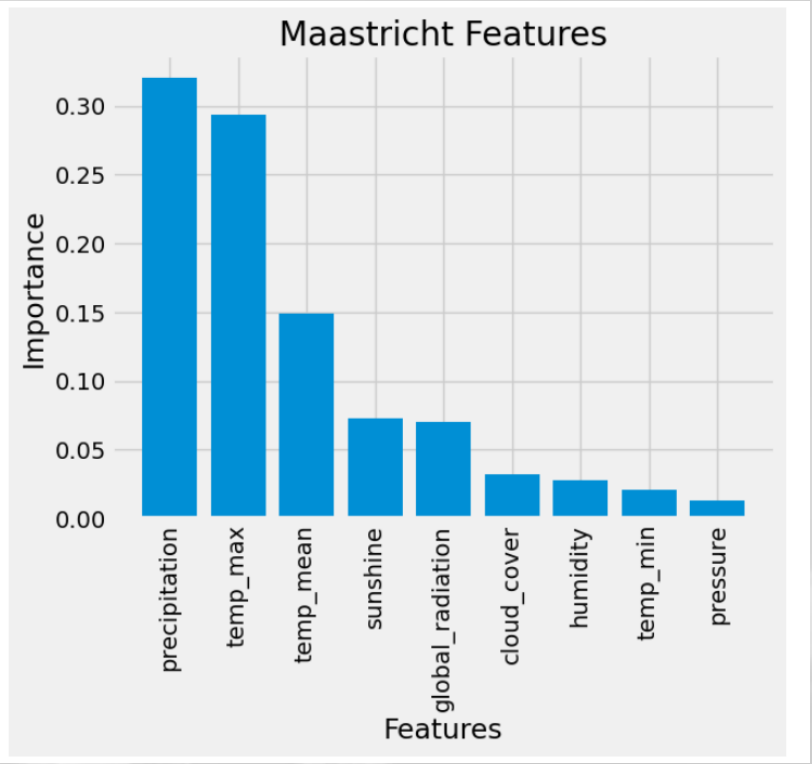


Figure 1: Feature Importance Analysis

Experiment 2: Identify and classify weather conditions

- **Method:** Use CNNs to classify and identify weather conditions
- CNNs excel at identifying patterns within data, especially in image data
- Good at detecting small differences, important for weather conditions with similar features
- Data includes weather station data and pleasant/unpleasant weather data
- Confusion matrix (Fig. 2) shows model was able to predict weather conditions for 7/15 stations
- **Accuracy:** 80%
- **Objective:** Classify future weather conditions based on input variables, recommend using image data

Pred	BASEL	BELGRADE	BUDAPEST	DEBILT	HEATHROW	LJUBLJANA	MADRID
True							
BASEL	3409	185	21	11	4	2	50
BELGRADE	228	807	14	6	2	3	32
BUDAPEST	48	60	71	5	5	3	22
DEBILT	27	13	15	21	3	1	2
DUSSELDORF	9	5	2	3	6	0	4
HEATHROW	21	5	2	2	29	1	22
KASSEL	4	2	3	0	0	1	1
LJUBLJANA	21	5	5	0	0	11	19
MAASTRICHT	6	0	0	0	0	0	3
MADRID	53	33	8	0	3	2	359
MUNCHENB	7	1	0	0	0	0	0
OSLO	2	0	0	0	0	0	3
STOCKHOLM	1	3	0	0	0	0	0
VALENTIA	1	0	0	0	0	0	0

Figure 2. Confusion matrix prediction results

Experiment 3: Simulate weather scenarios to improve weather predictions

- **Method**: Use GANs to generate data for CNNs to create weather forecasting training models
- GANs excel at generating synthetic weather images and enhancing low-res images
- Augment training datasets by creating new weather scenarios
- Data includes satellite and radar images of weather conditions
- Model was able to produce weather data with:
  - **Accuracy**: 94%
  - **Loss**: 2%
- Confusion Matrix (Fig. 3) shows weather prediction results based on 4 classifications: cloudy, rain, shine, and sunrise.
- **Objective**: Improve weather forecasting models to make more accurate predictions. These predictions can analyze weather conditions in the next 25 to 50 years

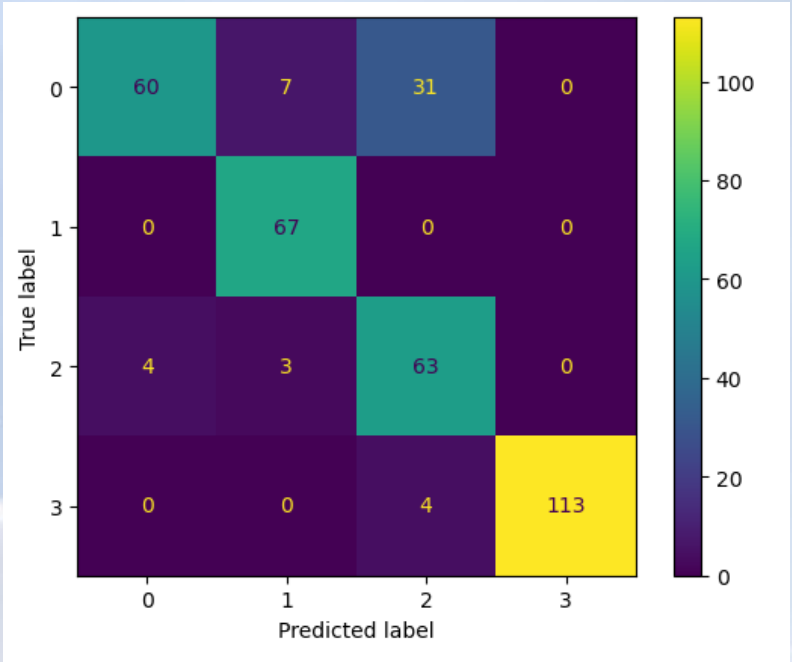
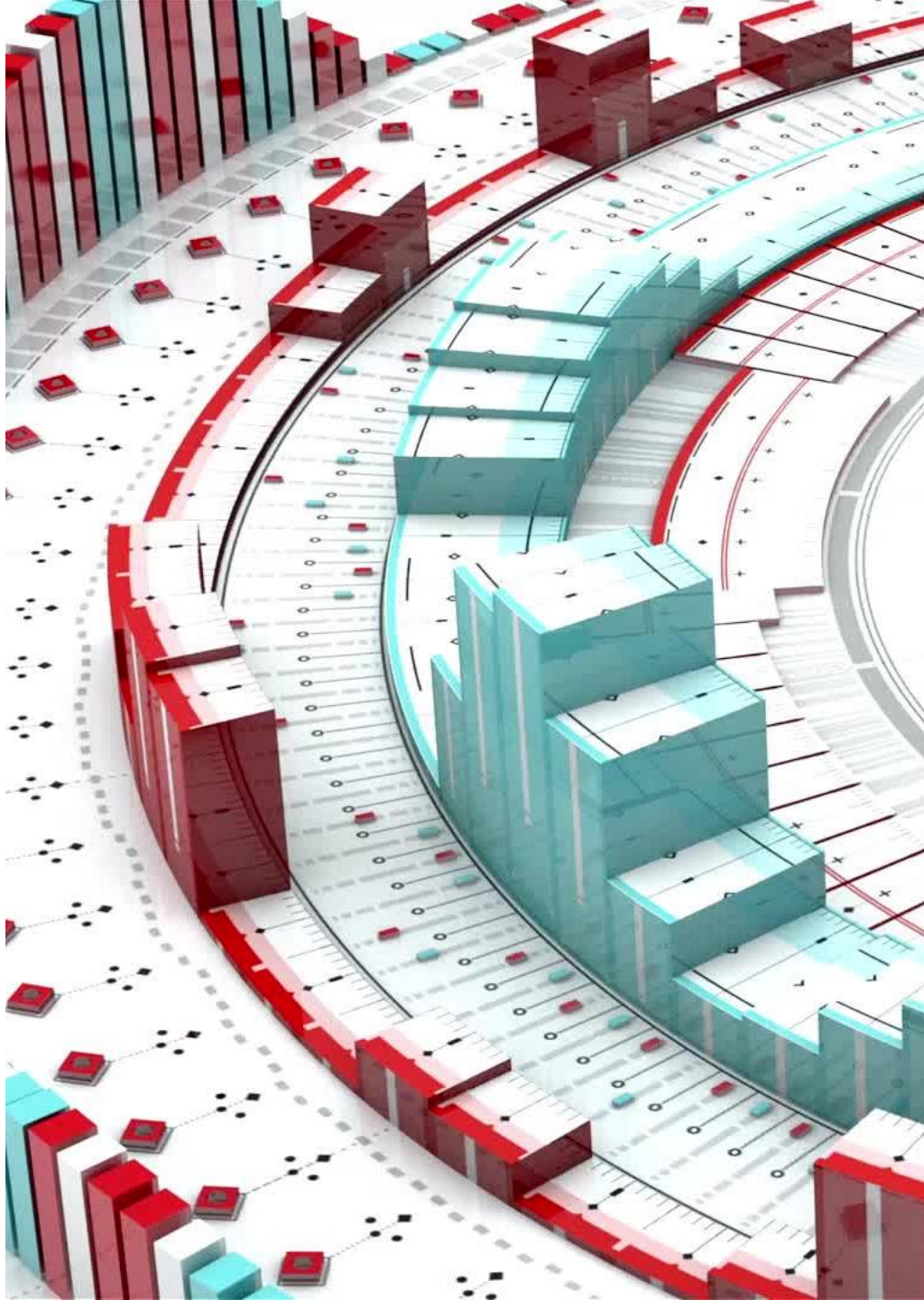


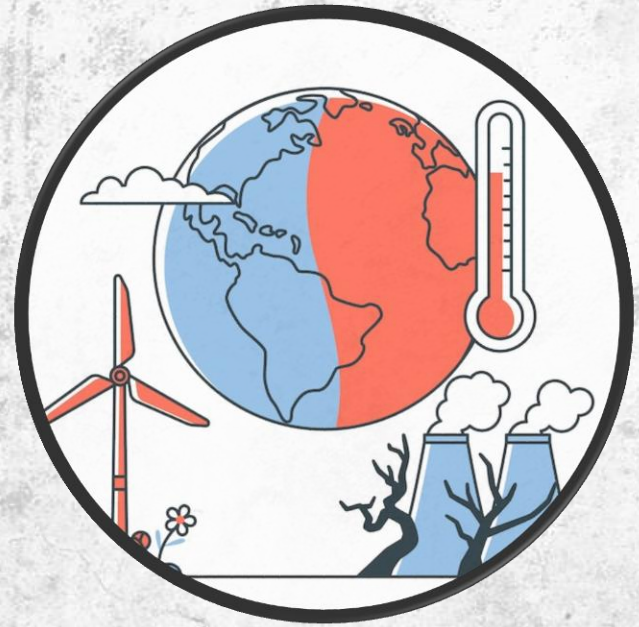
Figure 3. Confusion matrix

Additional Data

- **Geospatial data**: Used to train models based on space, time and location data – how weather in one area affects nearby areas
- **Satellite and radar images**: Used to train CNN models to detect new visual patterns and changes over time
- **Climate change data**: Can be used to train new models to predict future climate change impacts
- **Weather data for extreme events**: Train models to identify early signs of extreme events



Experiment Overview



Experiment 1 uses **random forest** to instantly classify weather conditions to make predictions. Random forest are **complicated** to understand but was able to highlight important variables that affect weather forecasts. **Accuracy: 54%**

Useful for exploring data and classifying data with multiple non-linear and continuous variables

Experiment 2 uses **CNNs** to identify and classify weather conditions to make predictions. CNN was able to predict weather conditions for **7/15 weather stations with 80% accuracy**.

Useful for making accurate predictions from weather data, especially image data

Experiment 3 uses **GANs and CNNs** to analyze and predict weather conditions based on images. GANs provide artificial data while CNNs processes the data to make predictions. **Accuracy: 94%**

Useful for uninterrupted machine learning based on continuous generated data to improve accuracy

Recommendation

- Use random forest for initial data exploration – highlights features that most affect prediction results
- Use GANs to enhance low-res data and generate artificial weather data
- Use CNNs to identify patterns within the data and classify/predict weather conditions

Next Steps

- Continue testing models to improve accuracy
- Refine models for use on complex datasets
- Experiment with different datasets to observe other variables that affect weather conditions

Thank you!

Any questions, please reach out to my email below

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Github link contains all datasets and visuals used in this project

https://github.com/nodnarbcode/ClimateWins-Unsupervised-Learning