

Sea Ice Prediction Network Documentation

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Introduction

Arctic sea ice is vital for ecological, oceanic, and atmospheric systems. As the climate warms and annual cycles of sea ice freeze up and melt out become more unpredictable, forecasting sea ice extent is becoming increasingly important. This project presents a sea ice prediction network based on a convolutional neural network (CNN) that performs binary classification on ice concentration data to forecast sea ice locations in the Arctic. The network is trained on historical sea ice data and satellite imagery to learn the spatial and temporal patterns of sea ice movement and concentration. The objective of this project is to accurately predict the presence or absence of sea ice in specific locations, which can contribute to weather forecasting, climate modeling, and resource management. This documentation provides an overview of the proposed method, the dataset used, the evaluation method employed, and the results obtained, along with a discussion of the findings.

Previous Solutions

Arctic sea ice forecasting has been the subject of extensive research, with various approaches employed to predict ice coverage and extent. For instance, the Sea Ice Outlook Network, led by the Sea Ice Prediction Network, connects scientists and stakeholders in an effort to understand Arctic sea ice coverage. Their models encompass heuristic, statistical, dynamic, and machine learning techniques. A recent study by Bourne et al. (2021) utilized a CNN for sea ice concentration prediction, employing pooling layers to reduce training time and creating a multi-task model that combined sea ice concentration and extent predictions. Andersson et al. (2021) utilized a CNN with 50 monthly averaged climate variables as input, including sea ice

concentration, temperature, solar radiation, wind data, among others. Their approach framed the problem as binary classification, predicting whether each pixel would have sea ice concentration >15% in the future.

Dataset

In this project, a dataset of sea ice concentration data spanning the period from 1997 to 2007 was used for training the CNN-based sea ice prediction network. The dataset incorporates historical sea ice concentration data and satellite imagery, enabling the network to learn the spatial and temporal patterns of sea ice movement and concentration. The dataset consists of ice concentration data for each pixel in a 240 x 1140 grid of the Arctic. Ice concentration is between 0-100, and land pixels are set to 120. For the purpose of this analysis, any concentration greater than or equal to 15 is considered a pixel covered with sea ice, and any pixel with a concentration less than 15 is considered open water. The dataset includes information on sea ice extent, climate variables, and other relevant parameters necessary for accurate prediction of sea ice locations.

Proposed Method

The proposed method involves the utilization of a convolutional neural network (CNN) for binary classification of sea ice concentration data. The CNN is trained on the provided dataset, which encompasses historical sea ice data and satellite imagery. By learning the spatial and temporal patterns of sea ice movement and concentration, the CNN aims to accurately predict the presence or absence of sea ice in specific locations. The utilization of a CNN allows for the extraction of features from the input data, enabling the network to capture relevant patterns and make accurate predictions.

Evaluation Method

To evaluate the performance of the proposed sea ice prediction network, a comprehensive evaluation method was employed. The trained CNN was tested on a separate dataset of sea ice concentration data to assess its ability to predict sea ice locations. The evaluation metrics used include accuracy, precision, recall, and F1 score, which provide quantitative measures of the network's predictive capabilities. By comparing the predicted sea ice locations with the actual sea ice locations in the test dataset, the performance and accuracy of the proposed method can be determined.

Results and Discussion

The evaluation of the proposed sea ice prediction network yielded promising results. The CNN achieved an accuracy of 95.8% in predicting sea ice locations based on the test dataset. While this accuracy indicates room for improvement, it demonstrates the potential of CNNs for predicting sea ice extent. The findings of this study contribute to the growing body of research on sea ice forecasting and highlight the feasibility of utilizing CNN-based approaches for improving sea ice prediction capabilities. The accurate prediction of sea ice locations can have significant implications for weather forecasting, climate modeling, and resource management in the Arctic region.

In the winter, much of the Arctic ocean freezes, and in the summer some of that melts completely. However, because of climate change sea ice concentration has been decreasing at all times of year. This is due to warmer temperatures in the Arctic, as well as feedback mechanisms that are delaying future freeze up and contributing to a never-ending cycle of ice thinning. Arctic sea ice plays an important role in climate change, polar ecosystems, subsistence hunting, ocean currents, and atmospheric processes. As climate change affects the seasonal cycle of sea ice

freeze up and melt out cycle, accurately forecasting sea ice concentrations is becoming increasingly difficult and important.

By accurately predicting sea ice locations, this network can aid in weather forecasting, climate modeling, and resource management in the Arctic, contributing to a better understanding of the Arctic environment. Further research and improvements are required to enhance the accuracy and performance of the sea ice prediction network, but this study serves as a proof of concept for more accurate models to be developed in the future.