Cloud Shape Classification System Based on Multi-Channel CNN and Improved FDM

MENGYANG ZHAO 1, CHORNG HWA CHANG 1, WENBIN XIE 2,3, ZHOU XIE 3, JINYONG HU

Ananyaa Kyra Srikanth (21pt01)

Shwetha S (21pt24)

Sherin. J A (21pt28)

Background

Accurate cloud classification is critical for weather prediction, traditionally requiring manual analysis by meteorologists. This paper proposes an automated system for classifying cloud shapes using a Convolutional Neural Network (CNN) with advanced image preprocessing to enhance classification accuracy.

Objective:

The goal is to classify static cloud observation photos into three main cloud types:

- Cumulus
- Cirrus
- Stratus

By automating this process, the system aims to reduce meteorologists' workload and improve the efficiency and accuracy of cloud classification for weather forecasting.

Methodology:

The system leverages a single-channel CNN with tailored preprocessing and training strategies:

- **Preprocessing:**
  - CLAHE (Contrast Limited Adaptive Histogram Equalization): Enhances image contrast to highlight cloud features.
  - SkyAware Transform: Emphasizes sky regions by darkening non-sky areas based on blue channel intensity, improving focus on clouds.
  - Data Augmentation: Applies random flips, rotations, color jitter, resized crops, Gaussian blur, and random erasing to increase model robustness.
- **CNN Classifier:**
  - Utilizes EfficientNet-B0, a pre-trained CNN, with frozen early layers to leverage learned features and a custom classifier for three-class output.
  - Employs dropout and weight decay for regularization.
- **Training Optimizations:**
  - Uses AdamW optimizer with gradient clipping to stabilize training.
  - Implements a ReduceLROnPlateau scheduler to adjust the learning rate based on validation performance.
  - Incorporates early stopping to halt training when validation accuracy plateaus, preventing overfitting.

Results:

- The system was trained and validated on a static dataset, achieving promising accuracy through robust preprocessing and transfer learning.
- The preprocessing steps effectively enhanced cloud features, contributing to reliable classification performance.

Dataset:

https://www.kaggle.com/datasets/mmichelli/cirrus-cumulus-stratus-nimbus-ccsn-database

Class: cirrus - 894 images

Class: stratus - 885 images

Class: cumulus - 764 images