AI in Solar Observations: Classifying Active Sunspot Regions
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AIM OF PROJECT

This project explores the use of artificial intelligence (AI), specifically convolutional neural networks (CNNs), for the automated classification of sunspot groups using the McIntosh classification system. The model was trained on hand-drawn solar observations collected between 1944 and 2023 by the Astronomical Institute in Ondřejov, Czech Republic.

METHODS

Sunspots are dark regions on the Sun's surface caused by magnetic disturbances. Their changing appearance and distribution provides valuable information for studying solar activity, including phenomena like solar eruptions and auroras.

The McIntosh classification system categorizes sunspot groups using a three-letter code that describes their size, penumbra characteristics, and spatial distribution.

Solar drawings, a long-standing observational method, involve projecting and sketching the solar disk. Despite advances in digital imaging, these drawings remain scientifically valuable due to their historical continuity.

PROJECT WORK

Over 7,000 solar drawings were used. After preprocessing (resizing, centering, masking, and extracting sunspot regions), the sunspot groups were identified and matched with classification labels. These labeled images were used to train several CNN models:

- Binary classification models (e.g., Axx vs. Dai): Accuracy up to 98.21%
- Four-class models (e.g., Axx-Csi-Eac-Hsx): Accuracy around 92.86%
- Letter-by-letter models trained to classify individual components of the McIntosh code:
  - First letter (group size): 61.22%
  - Second letter (penumbra type): 50.00%
  - Third letter (spot distribution): 68.17%
  - Combined full-code prediction: 19.02% accuracy across all three letters

CONCLUSION

These results confirm that machine learning offers powerful tools for solar classification. The project suggests future developments, including expanding datasets, integrating heliographic data, and modeling sunspot evolution. A working prototype was developed that processes and labels sunspot drawings automatically, offering a useful aid for observatories.