Sunspot classification using artificial intelligence

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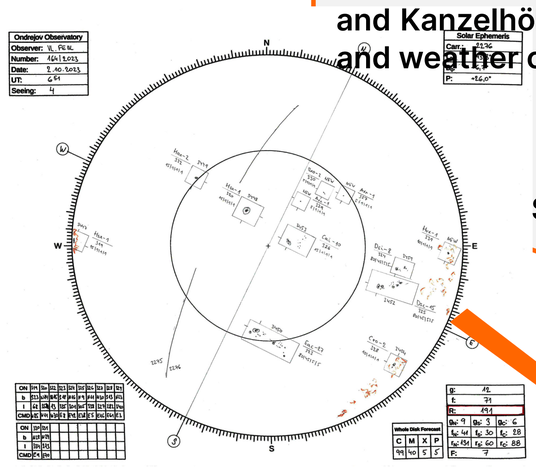
Abstract

Sunspots, visible through telescopes or with the naked eye at sunset, are caused by the Sun’s magnetic field. Studying these phenomena is crucial for predicting solar activity and understanding the Sun's cycle. My research focuses on automating the recognition, classification, and analysis of sunspots using hand-drawn observations. I trained a convolutional neural network to label sunspots based on the McIntosh classification system, aiming to bridge deep learning with solar astronomy.

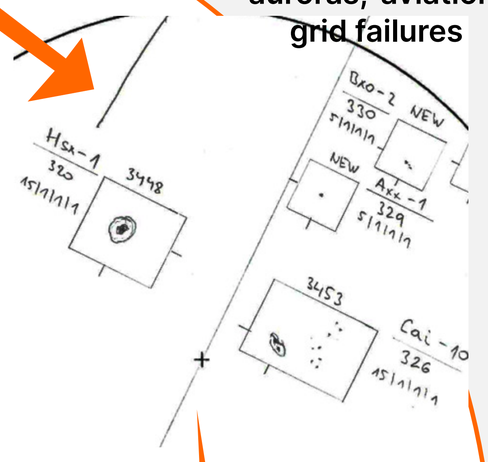
Sunspot drawing

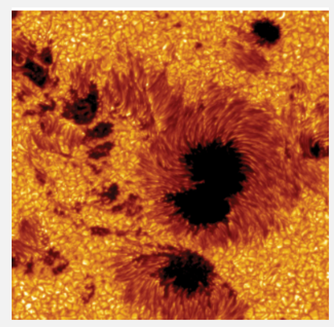
One of the earliest methods for capturing sunspots involved projecting the Sun's image onto paper and tracing it. This simple technique has been used for centuries and is still relevant for improving solar predictions when satellite data is lacking. However, the number of sunspot observers has declined, and public awareness of these historical records is low. I chose to work with sunspot drawings from the Ondřejov and Kanzelhöhe Observatories, which include details about the observer and weather conditions.



Sunspots

Sunspots are dark areas on the Sun caused by magnetic disturbances, consisting of a dark umbra and lighter penumbra. They are linked to solar flares and eruptions, which can impact Earth, causing auroras, aviation disruptions, and power grid failures

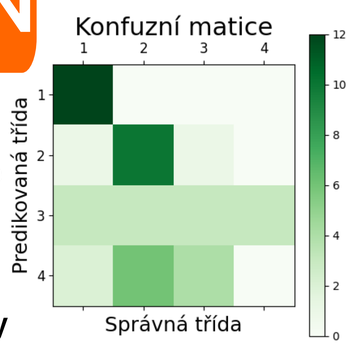


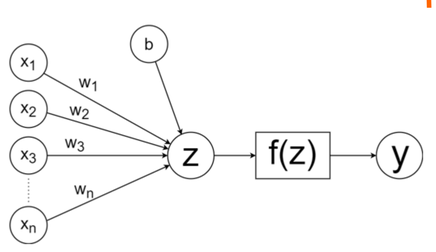


Adjust

AI and CNN

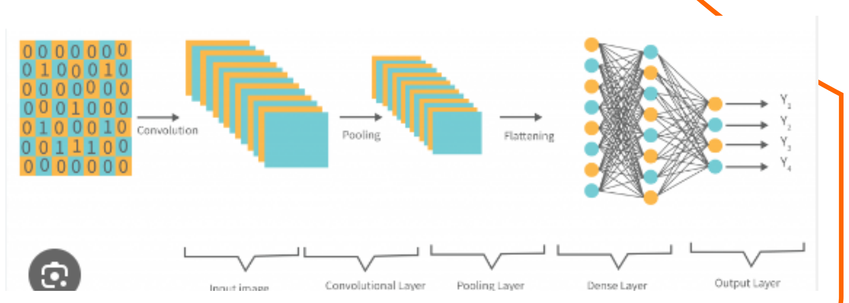
Neural networks, used in applications like large language models (LLMs) and image recognition, consist of neurons that compute values based on previous outputs. They typically have input, output, and hidden layers for complex calculations.





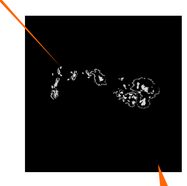
MODEL

A convolutional neural network (CNN) is a type of neural network designed for processing images. CNNs use filters, or kernels, to analyze and extract features from images.



Metods

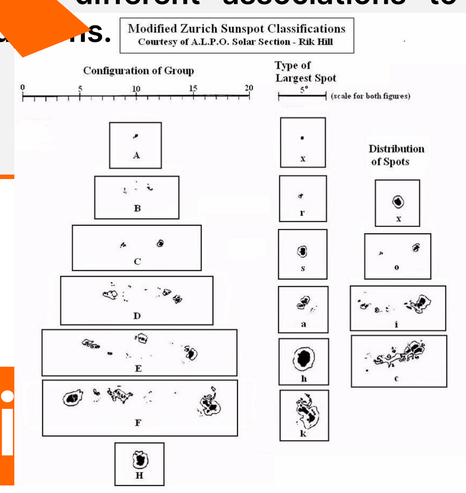
The processing was meda via python. Having the sunspotdrawing, I adjust its size and contrast to imporove the results of findingrectangels. After that, I extracted the individuals sunspot groops and converted them into friendly black and white picture. After that, i divided my datased 80:10:10 into train, valid and test images and trained the CNN models for every each letter in McIntosh classifications



Sampling

McIntosh classificatio

Classifying sunspots is crucial for understanding solar activity. I used the Zurich classification, which relies on visible data and is accessible for amateur astronomers. Each sunspot group is labeled with three letters indicating size, properties of the largest sunspot, and distribution within the group, with different associations to potential solar eruptions.



Ressults

I’ve trained several convolutional neural network (CNN) models capable of detecting sunspots at varying levels of complexity, showcasing the potential applications of AI in solar astronomy. Additionally, I have outlined several pathways for future research in this field.

Sources

Creati

Try to figure out, how is this research conected to:
- Luftwafe
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Try to catogories your own sunspot groop.