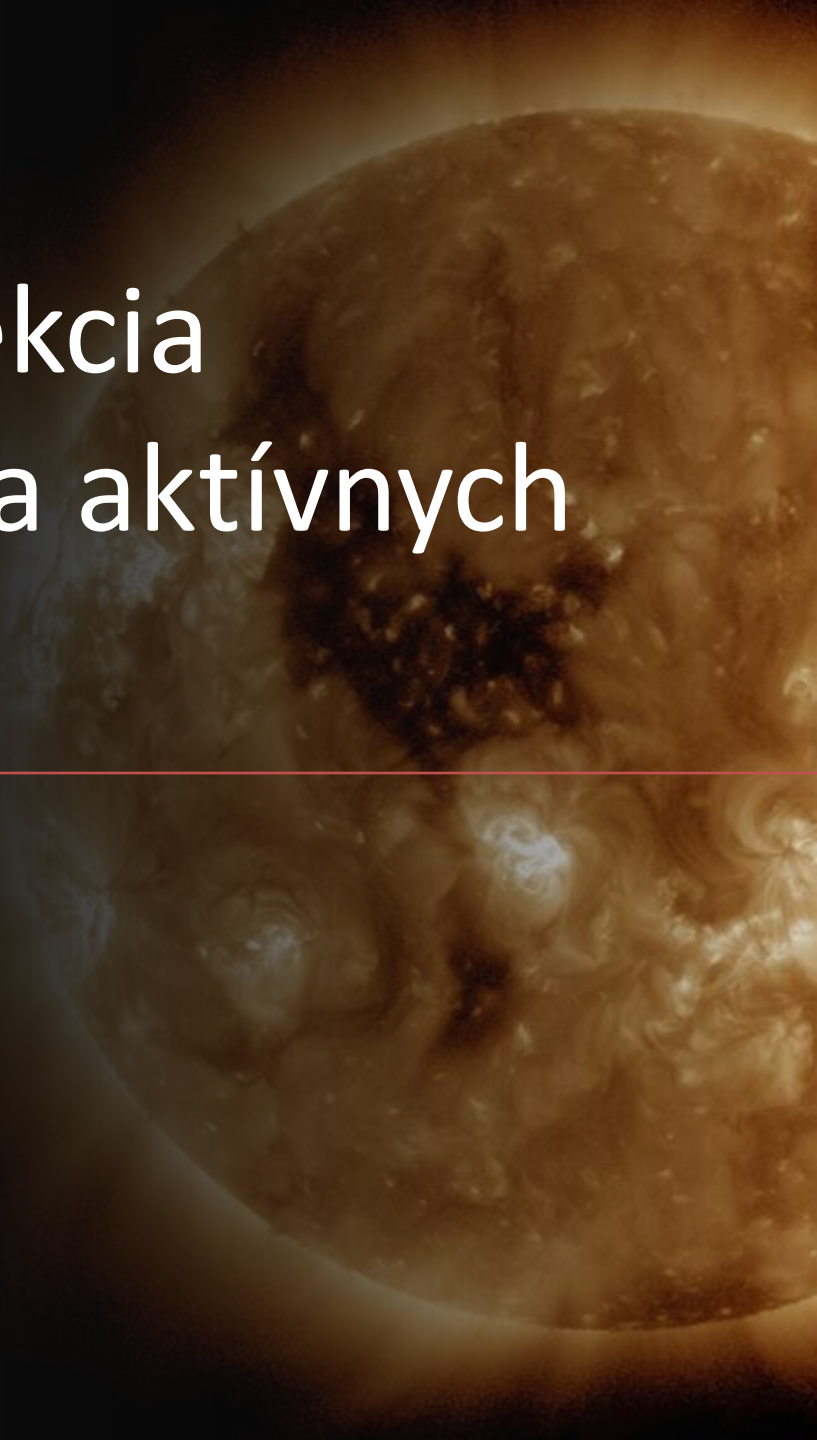
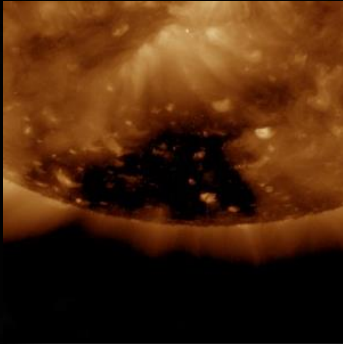


Automatická detekcia koronálnych dier a aktívnych oblastí na Slnku

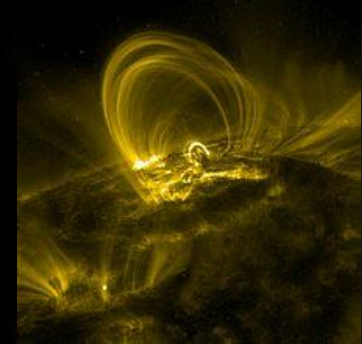
Martin Harman



Cieľ



Segmentácia koronálnych dier



Segmentácia aktívnych oblastí



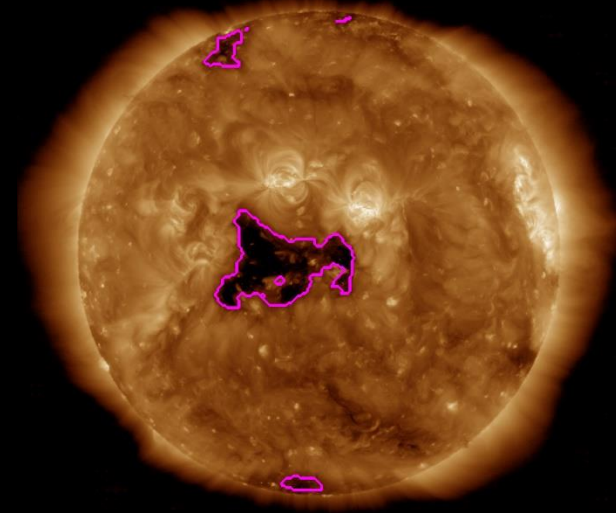
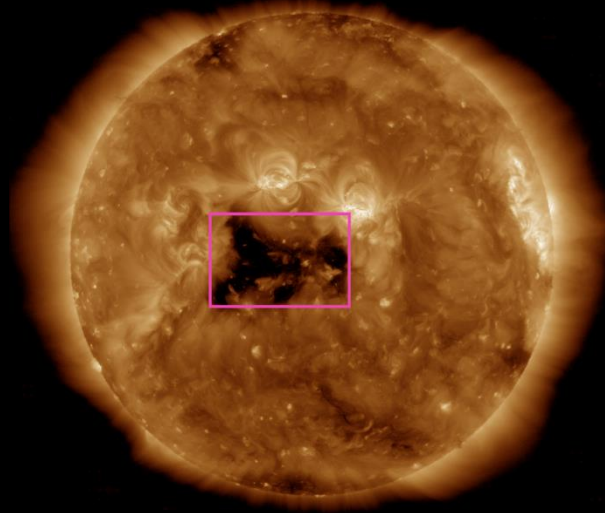
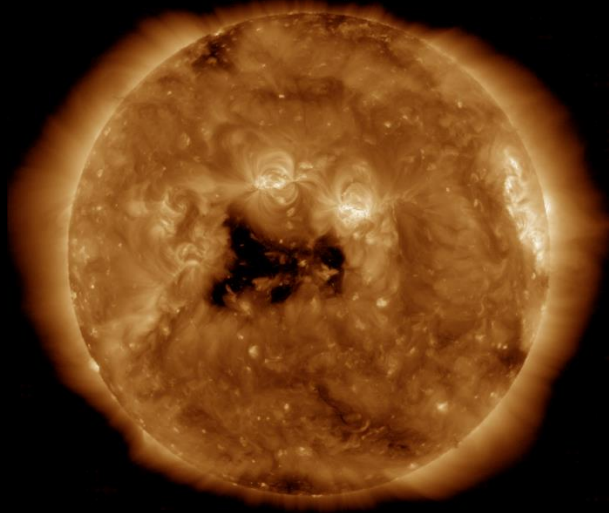
Využiť hlboké učenie

Prečo?

- Slnéčné počasie nás potenciálne ohrozuje
 - Výrony koronálnej hmoty
 - Slnéčné erupcie
- Spracovanie veľkého množstva dát
 - Prevažne pomocou klasických algoritmov
- Sledovanie v reálnom čase
 - Dáta pre systém včasného varovania
 - Dáta pre štatistiky a dátovú analýzu

Klasifikácia vs Detekcia vs Segmentácia

Output: Sun $p=0.98$



AI – ML - DL

Artificial Intelligence (AI)

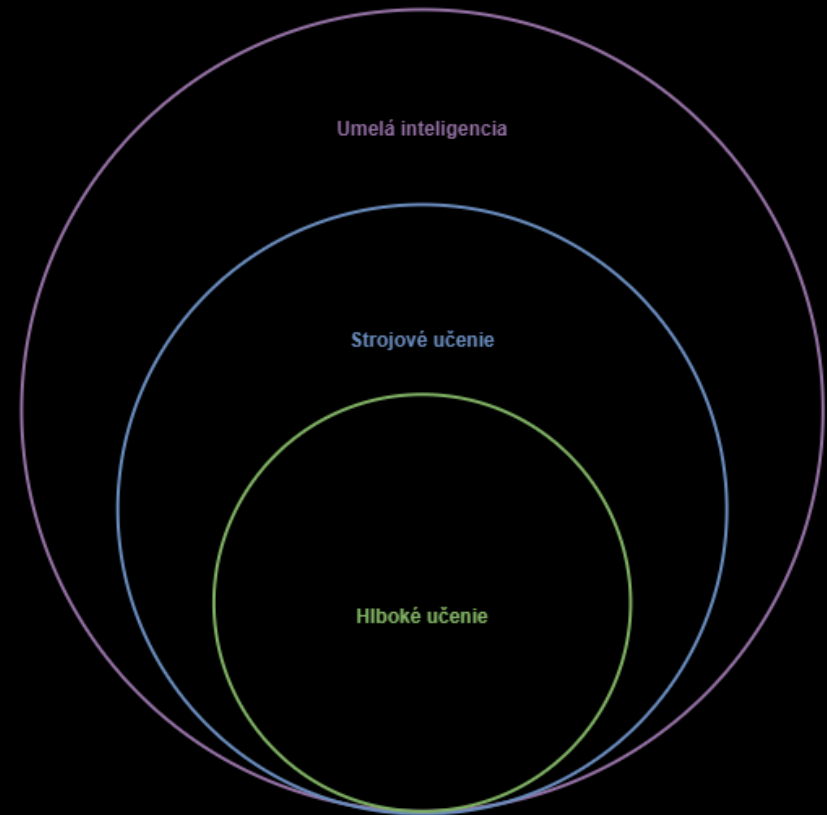
- Schopnosť imitovať ľudskú inteligenciu

Machine Learning (ML)

- Schopnosť učiť sa z dát
- Potrebuje extrahované príznaky (features)

Deep Learning (DL)

- Schopnosť učiť sa z veľkého počtu dát
- Nepotrebuje extrahované príznaky



Konvolučné neurónové siete

- Najčastejšie využívaná na rozoznávanie obrazu
- Prehĺbenie siete - použitím menej parametrov
- Zmenšenie veľkosti snímky

- Konvolučná vrstva

1	1	1	0	0
0	1	1	1	0
0	0	1	1	1
0	0	1	1	0
0	1	1	0	0

Vstup 5x5

*

1	0	1
0	1	0
1	0	1

Konvolučný filter
3x3
(posun 1h, 1v)

=

4		

Výstup 3x3

- Vzorkovacia vrstva

42	6	15	9
25	12	3	1
14	30	8	65
4	20	33	5

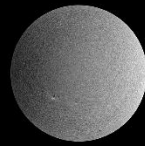


42	15
30	65

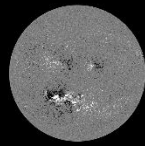
Max pooling 2x2

Solar Dynamics Observatory

- Atmospheric Imaging Assembly - vyhotovuje snímky slnka každých 10 sekúnd v 10 vlnových dĺžkach.
- EUV Variability Experiment - meria spektrum extrémne ultrafialového žiarenia.
- Helioseismic and Magnetic Imager - meria slnečné magnetické pole.



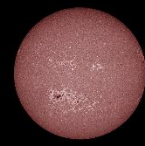
HMI Dopplergram
Surface movement
Photosphere



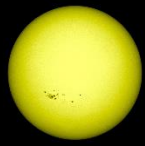
HMI Magnetogram
Magnetic field polarity
Photosphere



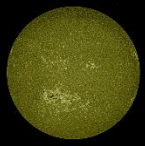
HMI Continuum
Matches visible light
Photosphere



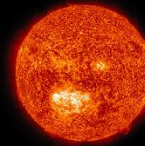
AIA 1700 Å
4500 Kelvin
Photosphere



AIA 4500 Å
6000 Kelvin
Photosphere



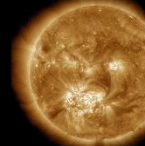
AIA 1600 Å
10,000 Kelvin
Upper photosphere/
Transition region



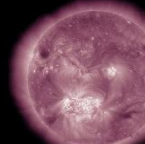
AIA 304 Å
50,000 Kelvin
Transition region/
Chromosphere



AIA 171 Å
600,000 Kelvin
Upper transition
Region/quiet corona



AIA 193 Å
1 million Kelvin
Corona/flare plasma



AIA 211 Å
2 million Kelvin
Active regions



AIA 335 Å
2.5 million Kelvin
Active regions

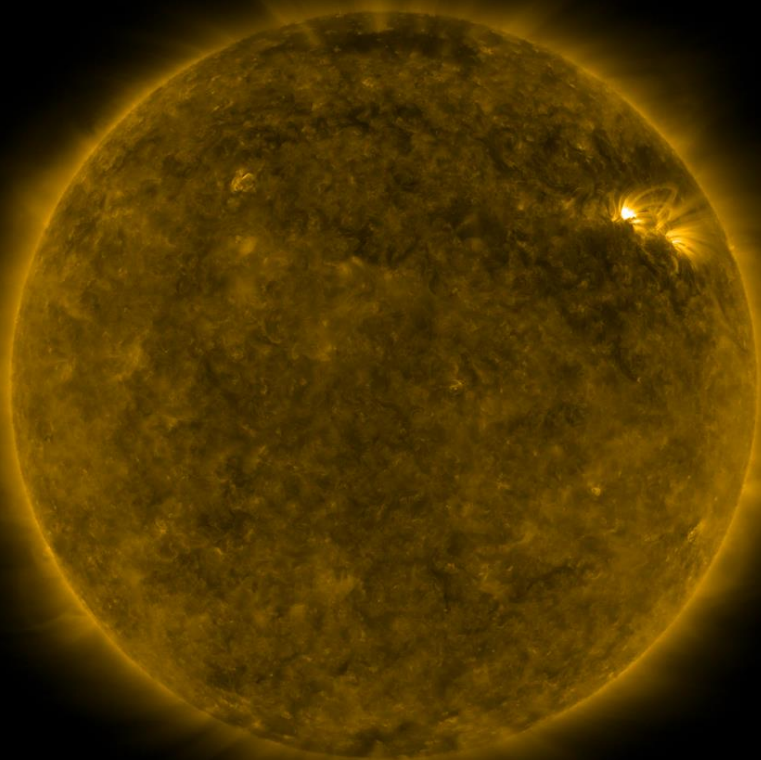


AIA 094 Å
6 million Kelvin
Flaring regions

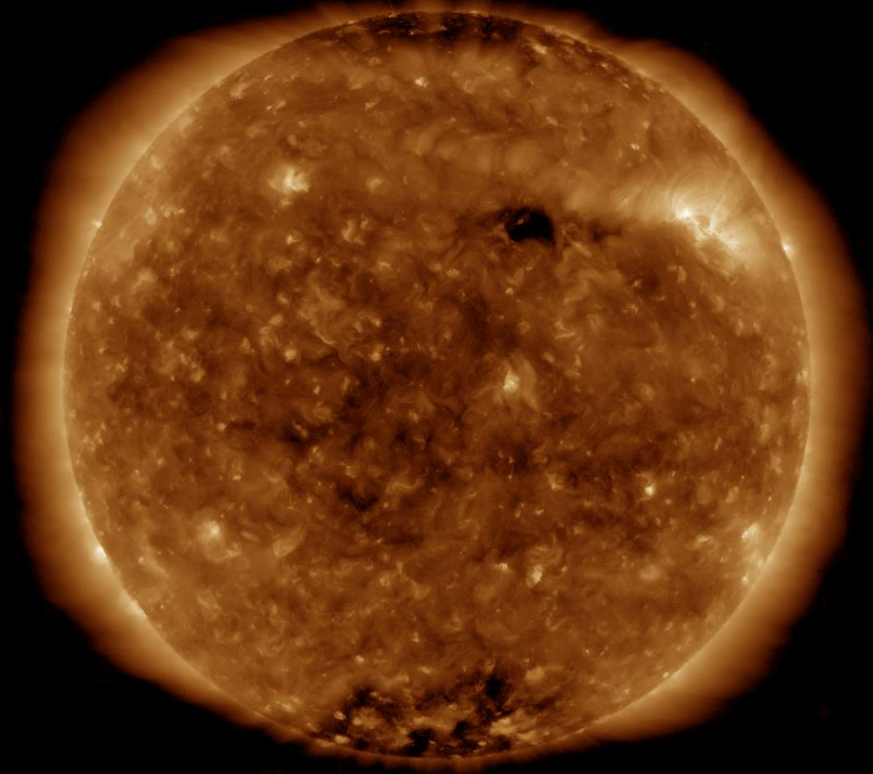


AIA 131 Å
10 million Kelvin
Flaring regions

171 Å

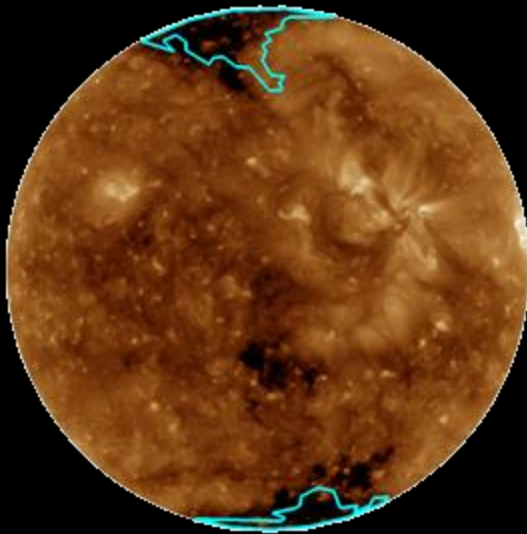


193 Å

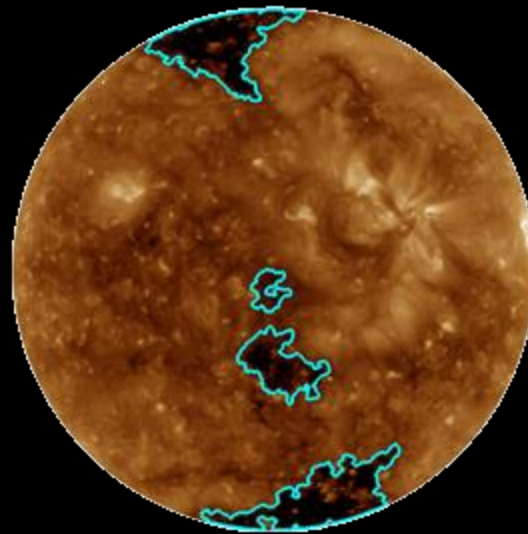


Anotácie

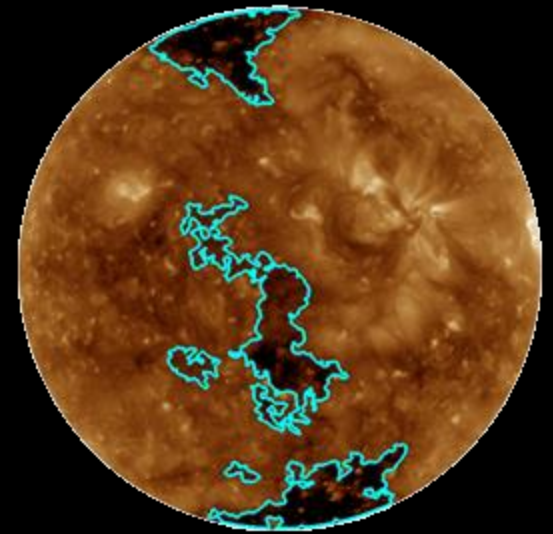
SPoCA



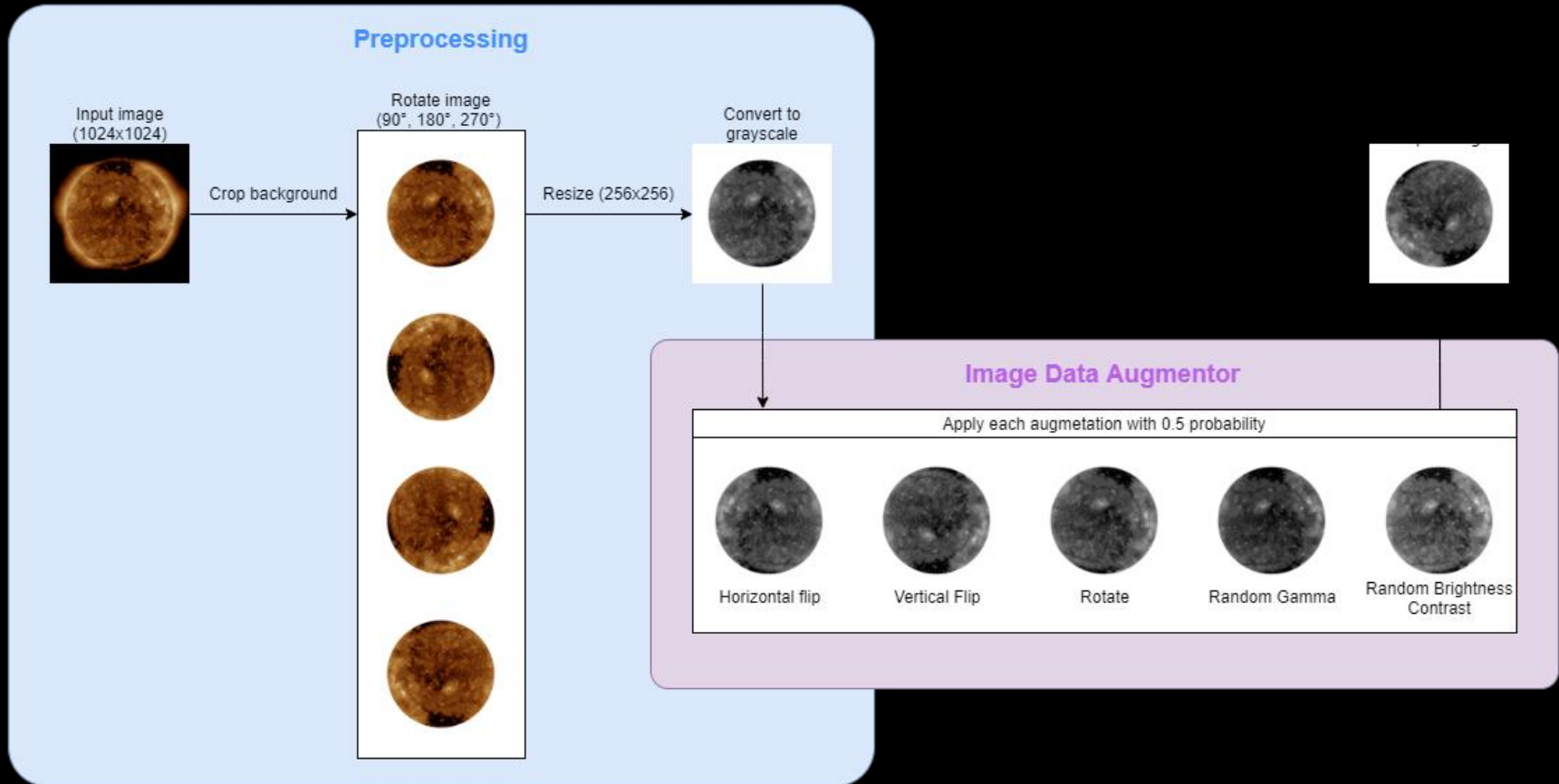
Region Growth



CHIMERA

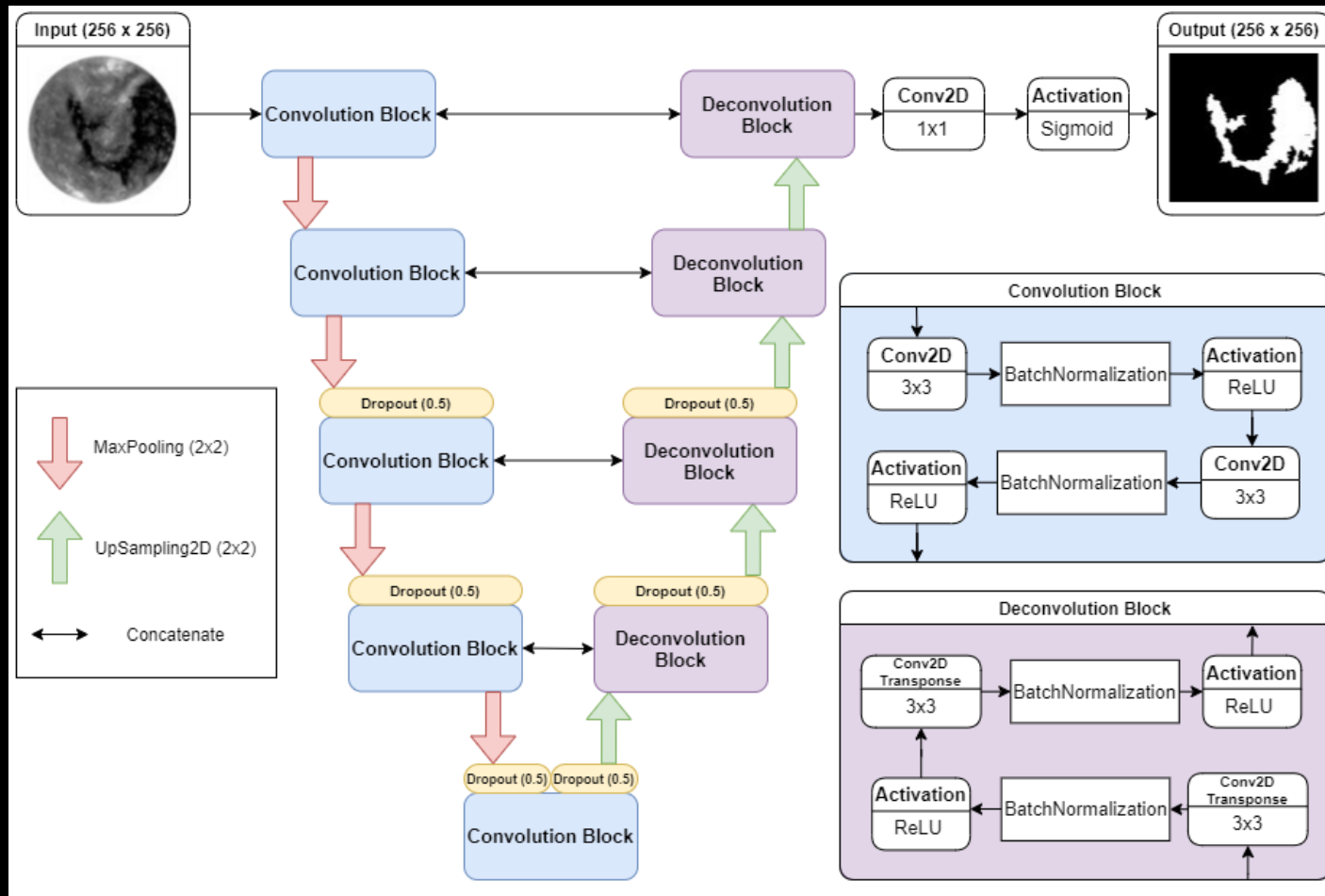


Preprocessing



SCSS-Net

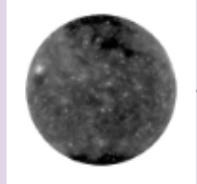
Solar corona structures segmentation – založený na U-Net architektúre



Postprocessing

Postprocessing

Model Input



Prediction

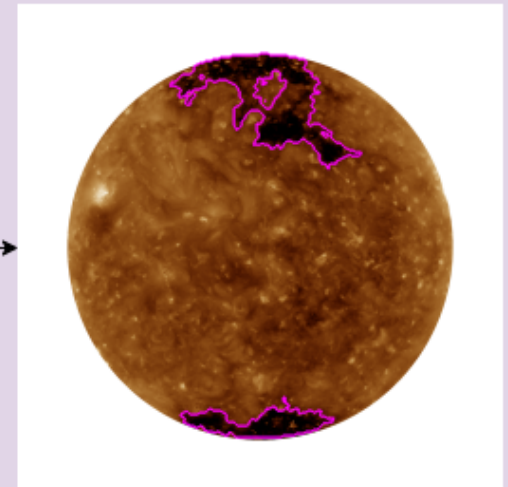
Model Output

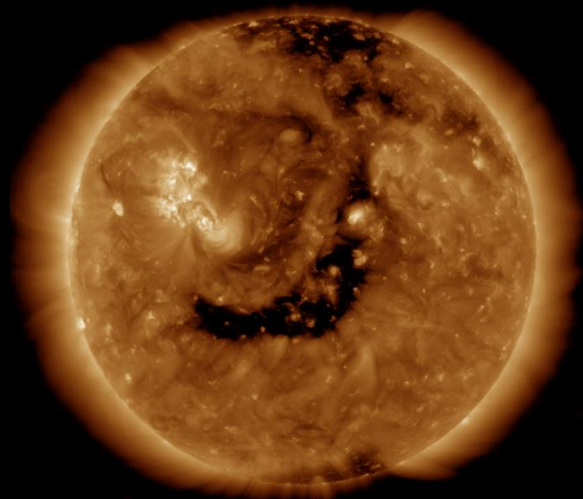


Thresholding



Conversion to original image





Bez prahu

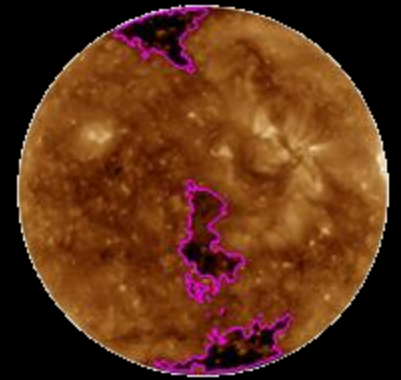
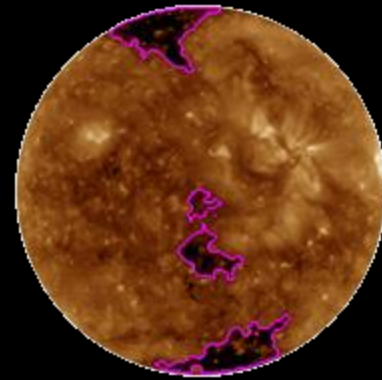
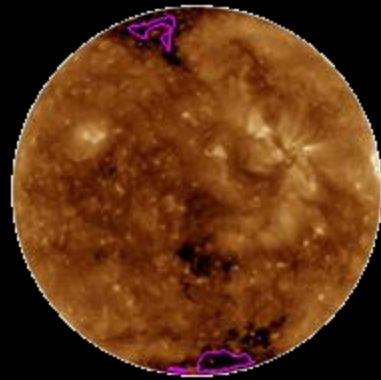
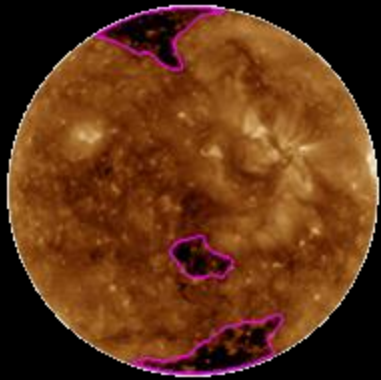
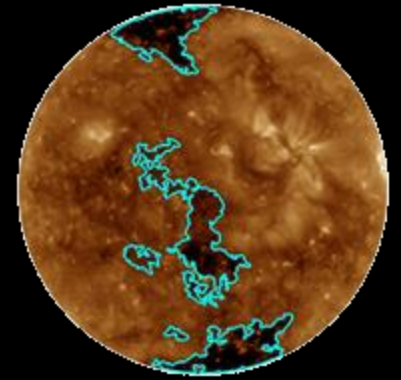
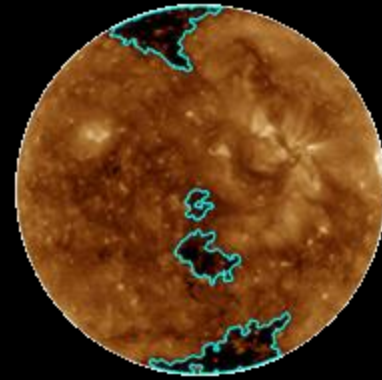
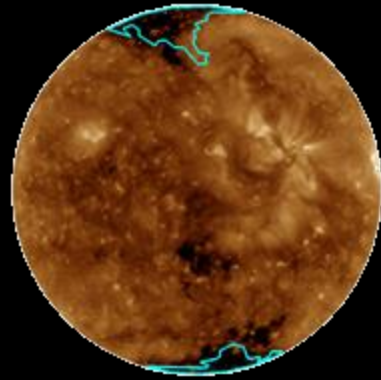


Prah = 0,5



Prah = 0,7

Vyhodnotenie

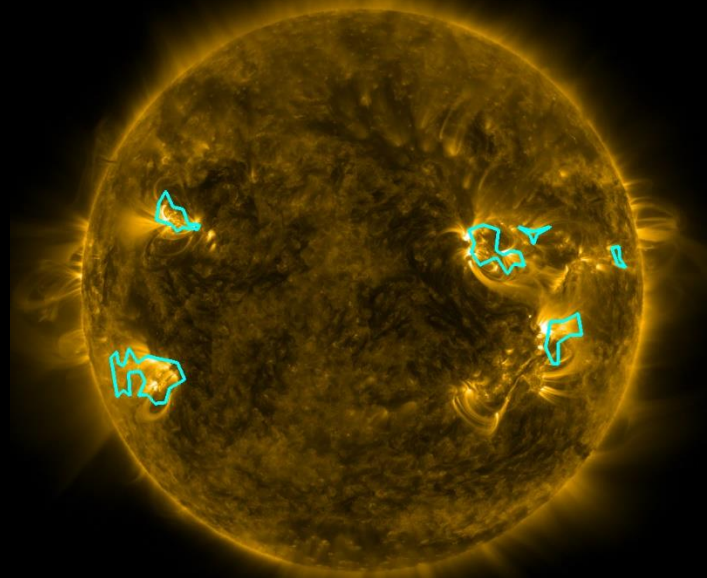


Vlastné

SPoCA

Region
Growth

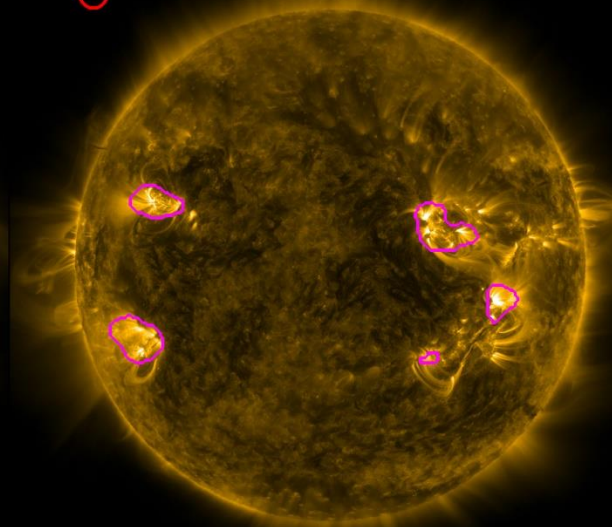
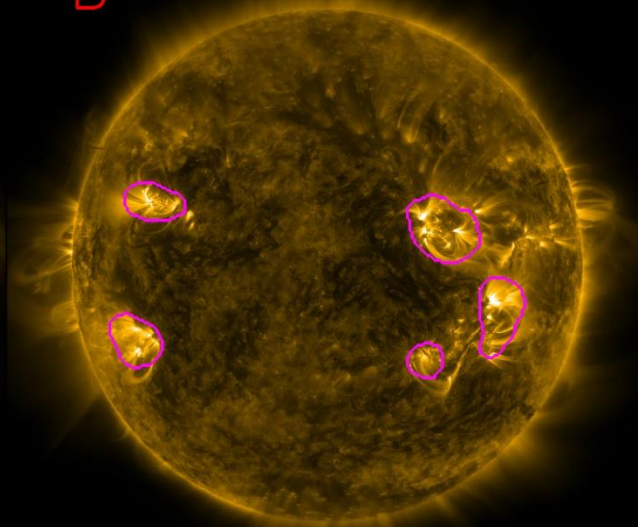
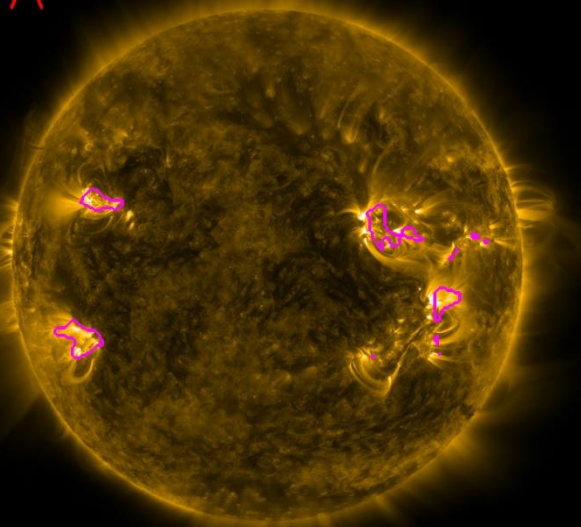
CHIMERA



A

B

C



SPOCA

Vlastné

SPOCA + Vlastné



SCSS-Net: solar corona structures segmentation by deep learning

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ABSTRACT

Structures in the solar corona are the main drivers of space weather processes that might directly or indirectly affect the Earth. Thanks to the most recent space-based solar observatories, with capabilities to acquire high-resolution images continuously, the structures in the solar corona can be monitored over the years with a time resolution of minutes. For this purpose, we have developed a method for automatic segmentation of solar corona structures observed in the EUV spectrum that is based on a deep-learning approach utilizing convolutional neural networks. The available input data sets have been examined together with our own data set based on the manual annotation of the target structures. Indeed, the input data set is the main limitation of the developed model's performance. Our *SCSS-Net* model provides results for coronal holes and active regions that could be compared with other generally used methods for automatic segmentation. Even more, it provides a universal procedure to identify structures in the solar corona with the help of the transfer learning technique. The outputs of the model can be then used for further statistical studies of connections between solar activity and the influence of space weather on Earth.

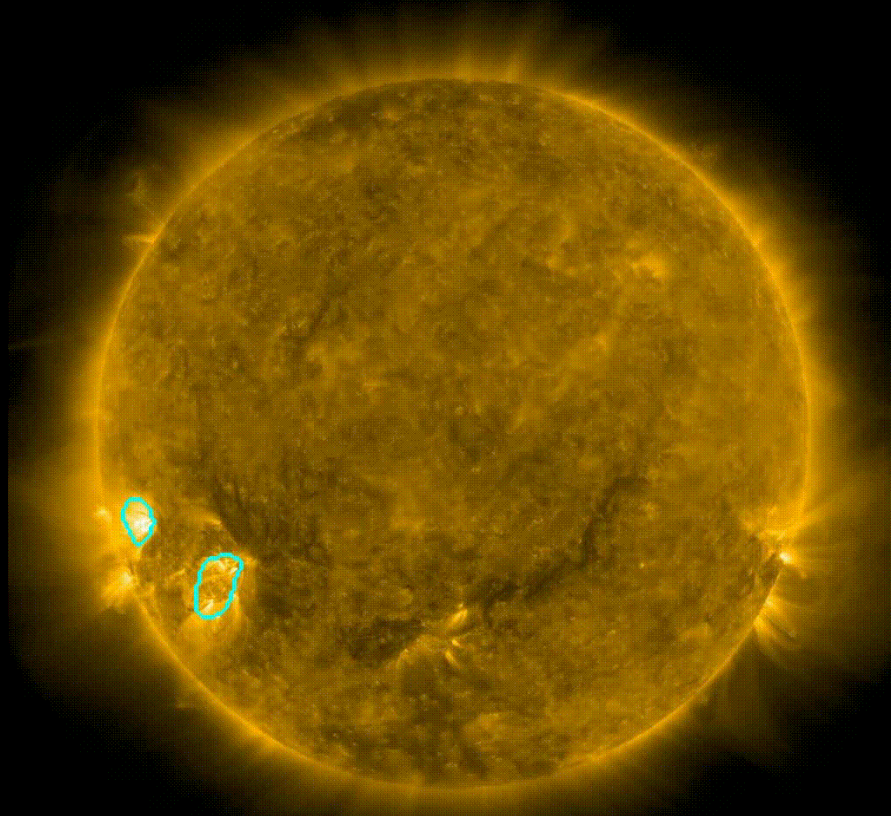
Key words: methods: data analysis – techniques: image processing – Sun: corona – software: development.



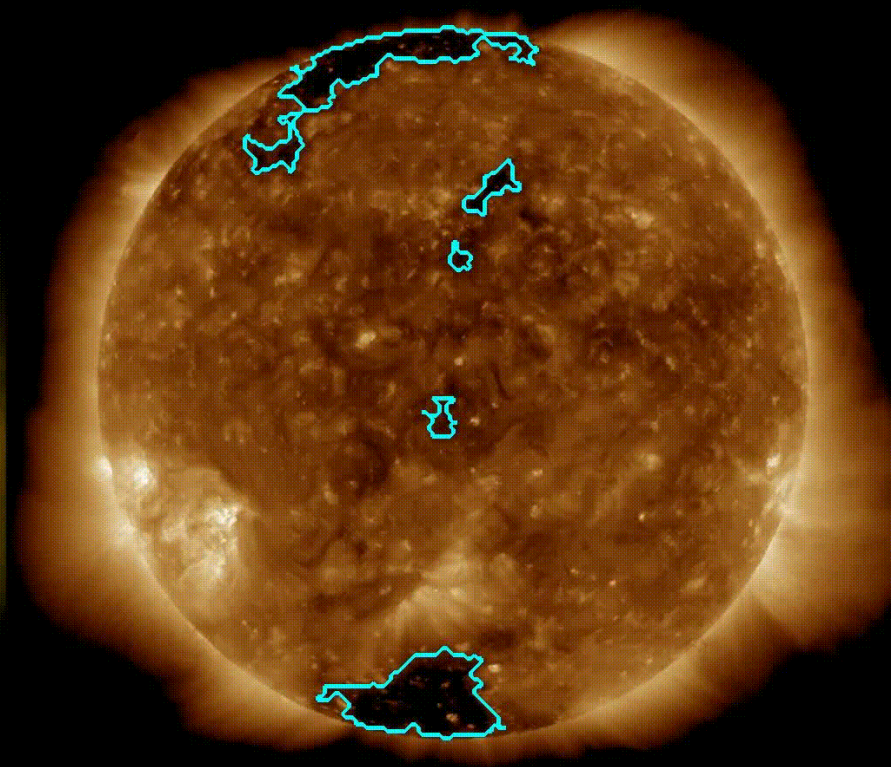
github.com/matinus99/sun-segmentation

github.com/space-lab-sk/scss-net

Ďakujem za pozornosť

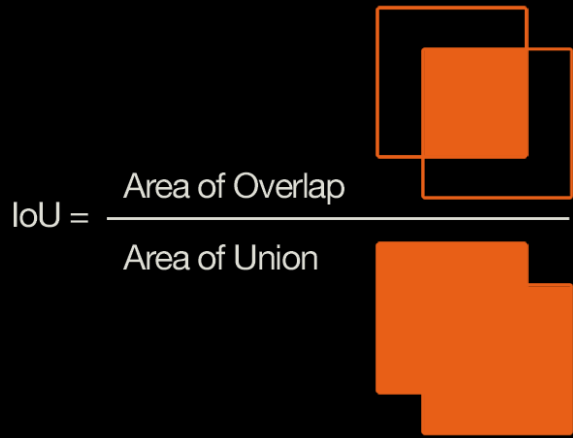


SDO/AIA 171 2020-12-15 00:36:34 UT

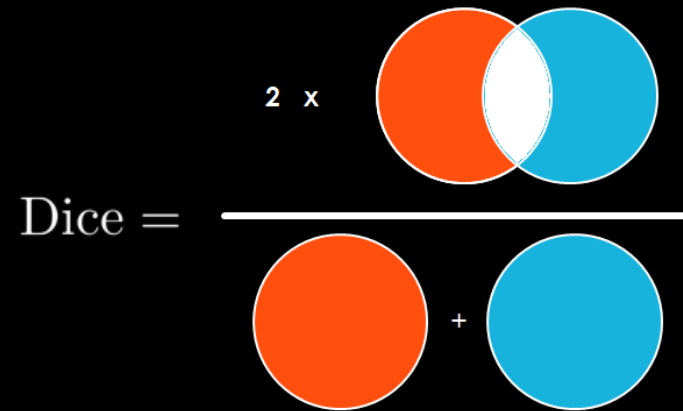


SDO/AIA 193 2020-12-15 00:27:17 UT

Metriky



$$IoU = \frac{TP}{TP + FP + FN}$$



$$Dice = \frac{2TP}{2TP + FP + FN}$$

Výsledky v číslach

Aktívne oblasti			
Trénovacia množina	Testovacia množina	Dice	IoU
Vlastné	360	0,44	0,28
SPoCA	360	0,68	0,51
SPoCA + vlastné	360	0,56	0,39

Koronálne diery			
Trénovacia množina	Testovacia množina	Dice	IoU
Vlastné	353	0,83	0,71
SPoCA	353	0,35	0,21
Chimera	353	0,85	0,73
Region growth	353	0,88	0,78