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PHYSICS



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Detecting and characterizing interstellar structures with Machine Learning methods

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July 26th, 2019, Garching



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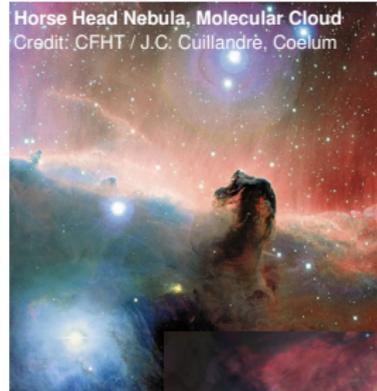
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Introduction



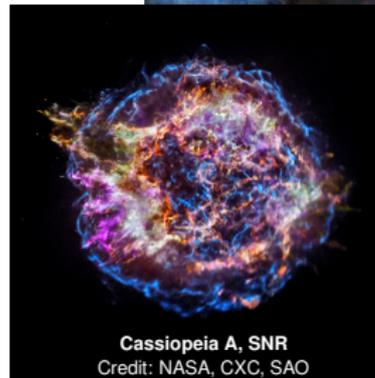
Interstellar Medium (ISM)

- mainly hydrogen
- different phases
- influenced by stars
- formation of interstellar structures



Structures

- Molecular Clouds
- Bubbles
- HII-regions
- HI-gas
- Supernova Remnants
- Filaments





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Data we use



Optical

- Magellanic Cloud Emission-Line Survey 2 (MCELS2),
Cerro Tololo Inter-American Observatory (CTIO)
- Southern H-Alpha Sky Survey Atlas (SHASSA, South),
Swarthmore College/Las Cumbres Observatory

Radio

- Australia Telescope Compact Array (ATCA)

X-ray

- XMM-Newton and/or
- eROSITA data



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Deep Learning



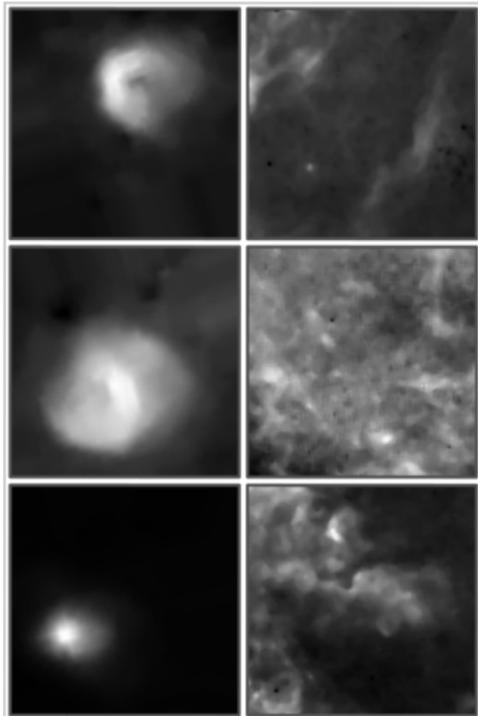
Deep Learning - Training Samples

Samples

- using SHASSA data as training samples
- only a few training samples
- training far from simple

Augmentation

- data augmentation
- combination of transformations



A few Training samples from SHASSA data.

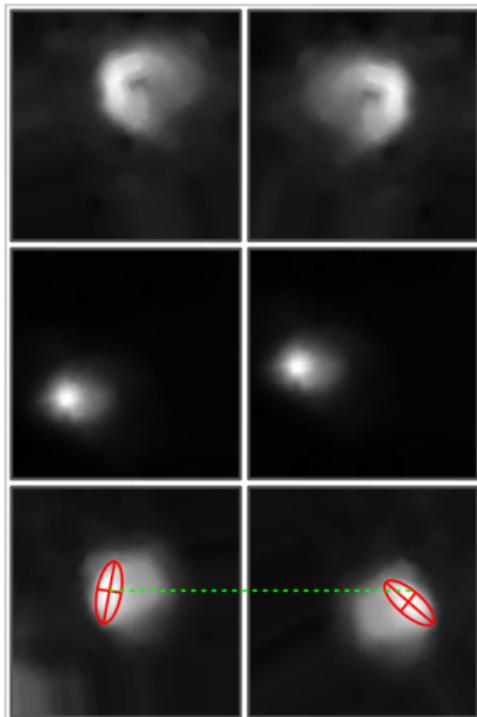
Deep Learning - Training Samples

Samples

- using SHASSA data as training samples
- only a few training samples
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Augmentation

- data augmentation
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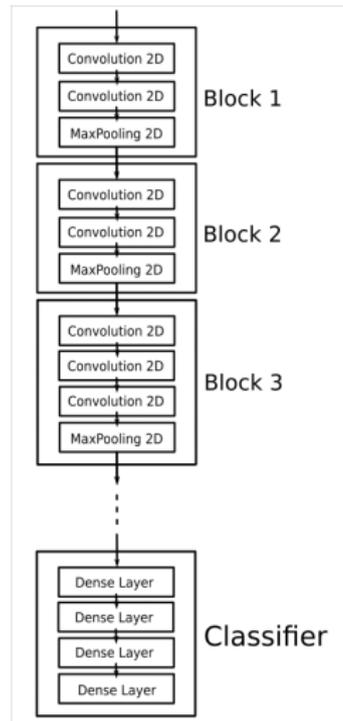


Augmentation examples (right) and training samples (left).

Deep Learning - Detecting bubble-like structures

Model

- using Keras (open source Deep Learning library)
- pre-trained VGG16 model (CNN for object recognition)
- exchange top layers
- fine tuning

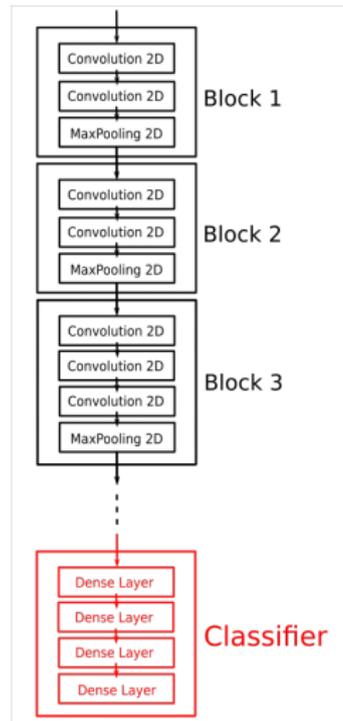


The structure of the VGG16 model.

Deep Learning - Detecting bubble-like structures

Model

- using Keras (open source Deep Learning library)
- pre-trained VGG16 model (CNN for object recognition)
- exchange top layers
- fine tuning

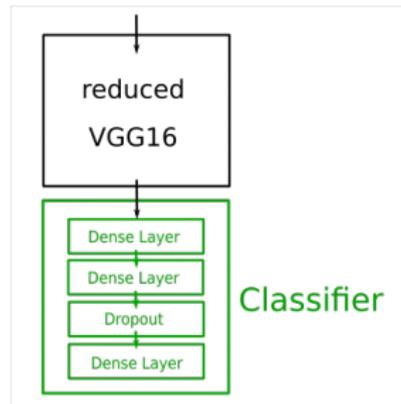


Remove top layers (red) of the VGG16 model.

Deep Learning - Detecting bubble-like structures

Model

- using Keras (open source Deep Learning library)
- pre-trained VGG16 model (CNN for object recognition)
- exchange top layers
- fine tuning



Add own top layers (green) to the reduced VGG16 model.

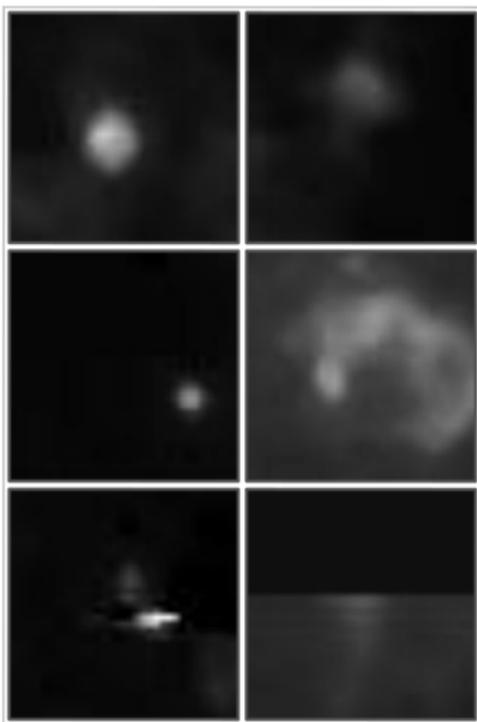
Deep Learning - Detected bubbles

First Results

- true/false-positives
- artefact

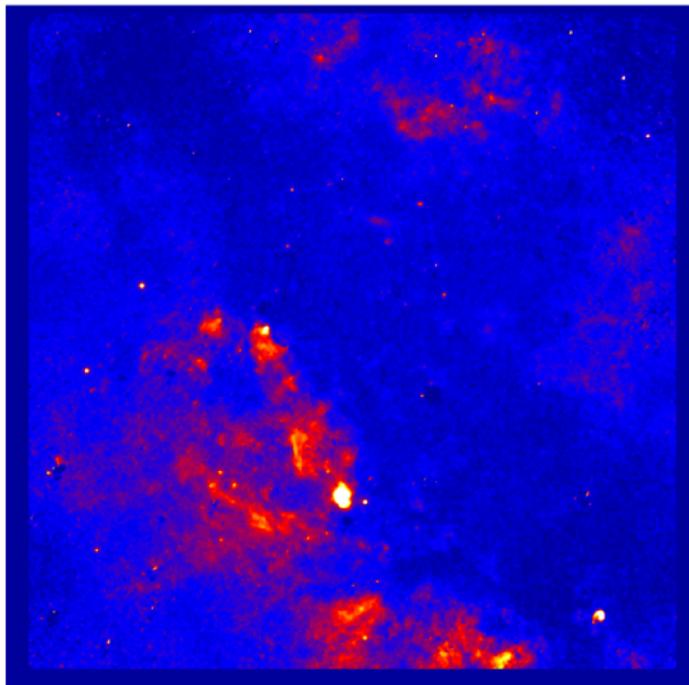
More Training Samples

- apply network to additional surveys
- IPHAS/VPHAS (North)
(INT/VST Photometric H-Alpha Survey)
- use true-positives as additional training samples



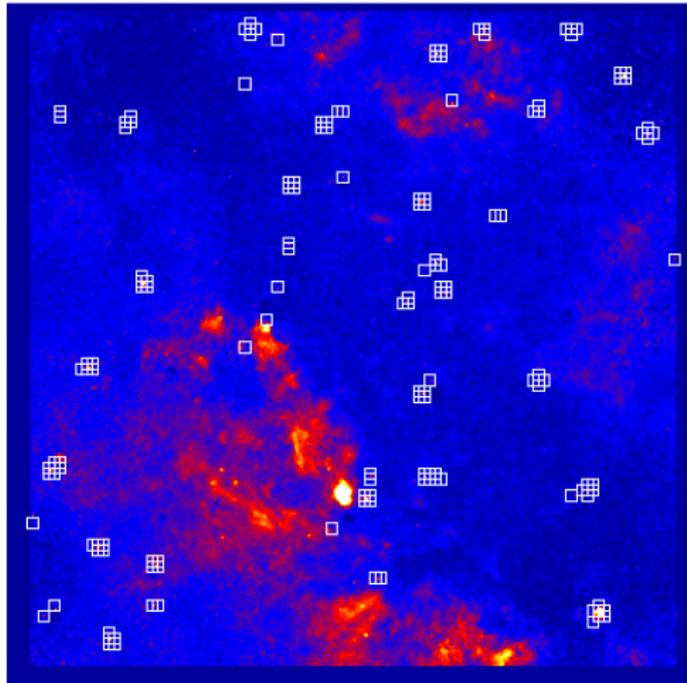
Detected bubble-like structure by the network

Deep Learning - Test



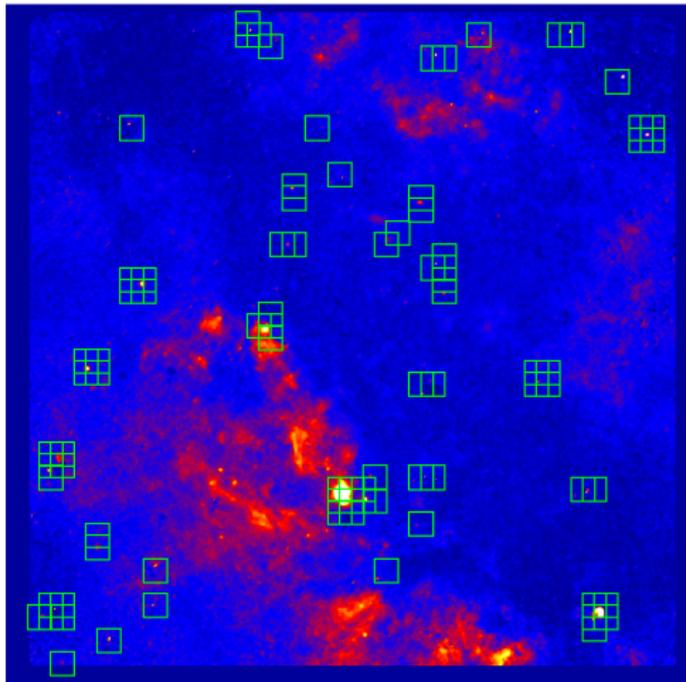
Test image taken from single SHASSA observation.

Deep Learning - Test



Detected bubble-like structures with defined box-size.

Deep Learning - Test



Detected bubble-like structures with larger box-size.

Outlook

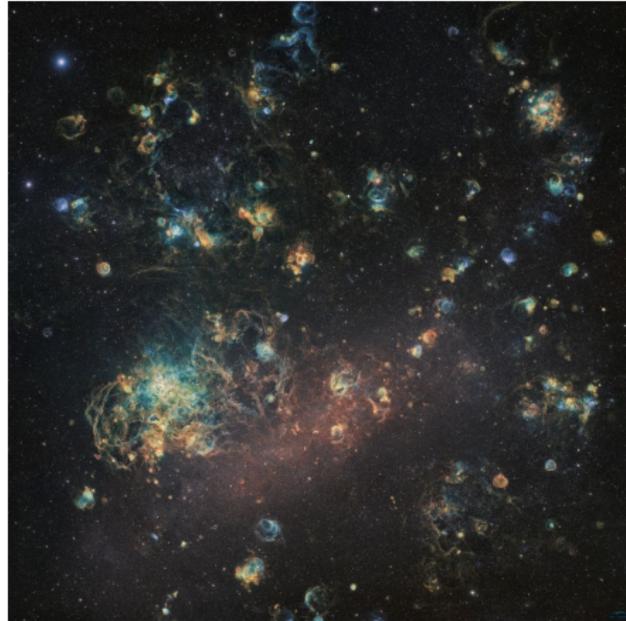
Further Steps

- filament detection
- characterization of detected structures
- origin of the structures

Future Goals

- characterize the new found structures (e.g. SNRs)
- improve understanding of structure formation

Thank you for listening



Credit: J. C. Canonne, N. Outters, P. Bernhard, D. Chaplain, L. Bourgon



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Backup



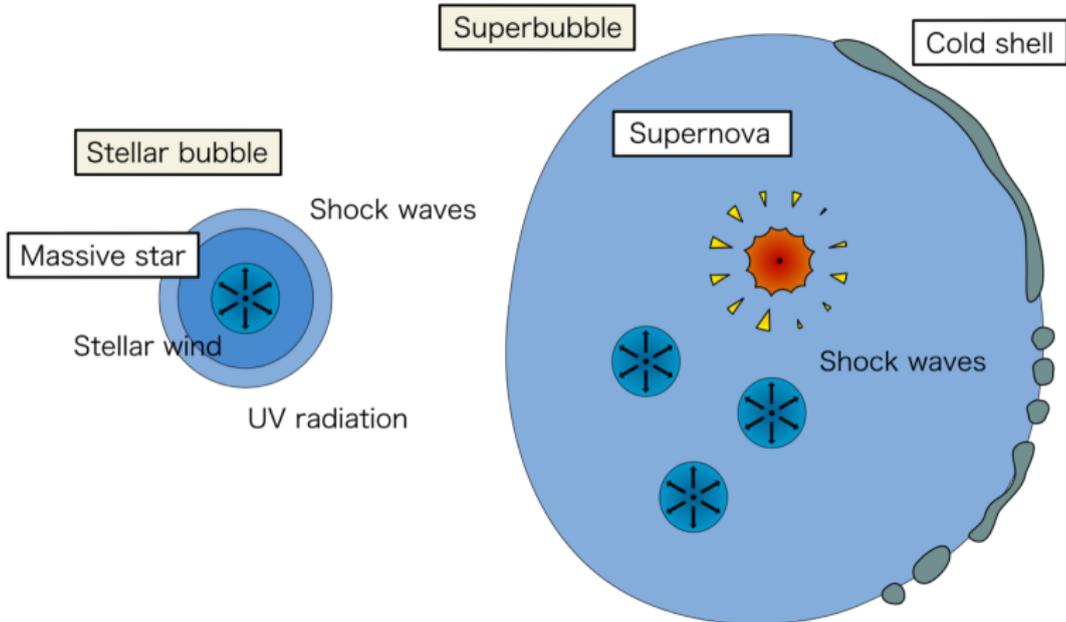
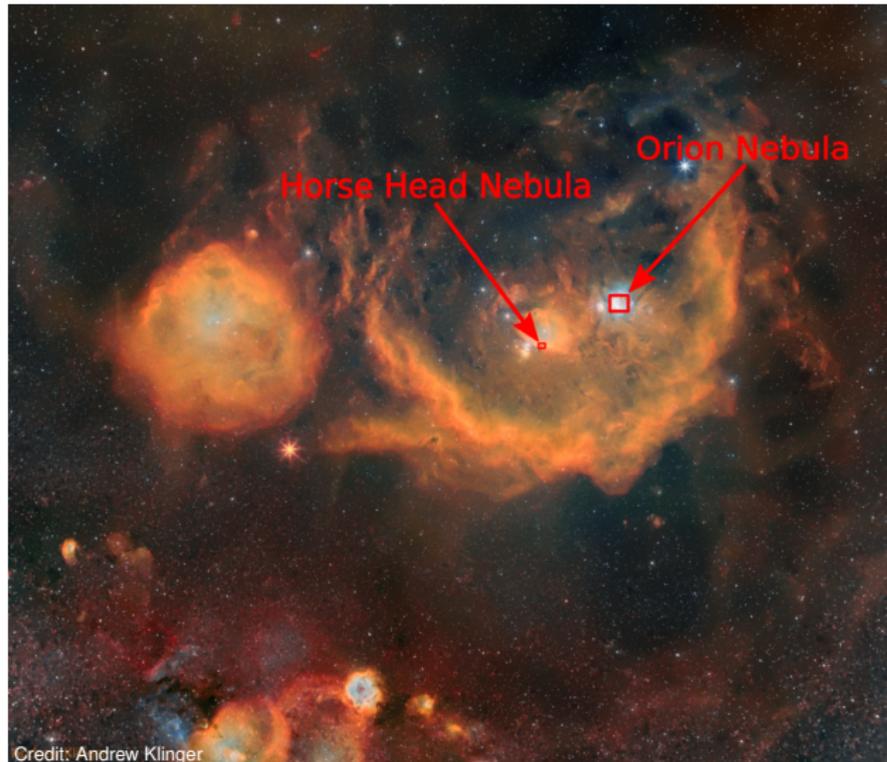


Illustration of bubble structure and evolution described by Weaver et al. (1977). Credit: M. Sasaki



Long exposure image of the Orion Complex. The scales of the Horse Head Nebula and the Orion Nebula are indicated with red boxes.

Deep Learning - Loss, Accuracy

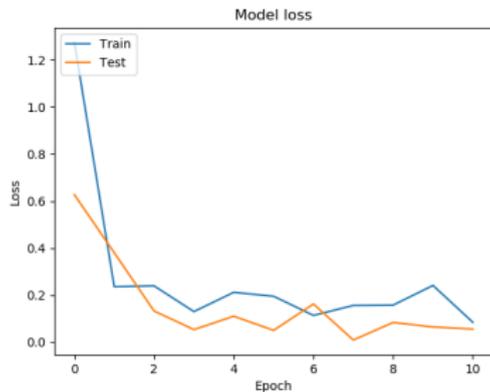


Figure: Loss of the combined models. Credit: Jonas Geyer-Ramsteck

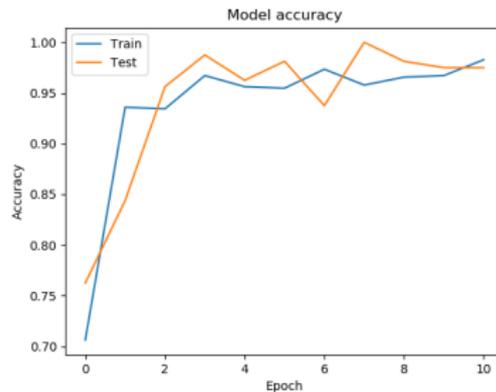


Figure: Accuracy of the combined models. Credit: Jonas Geyer-Ramsteck