

图像分割

从传统方法到深度学习

2022/4/12

熊翊飞

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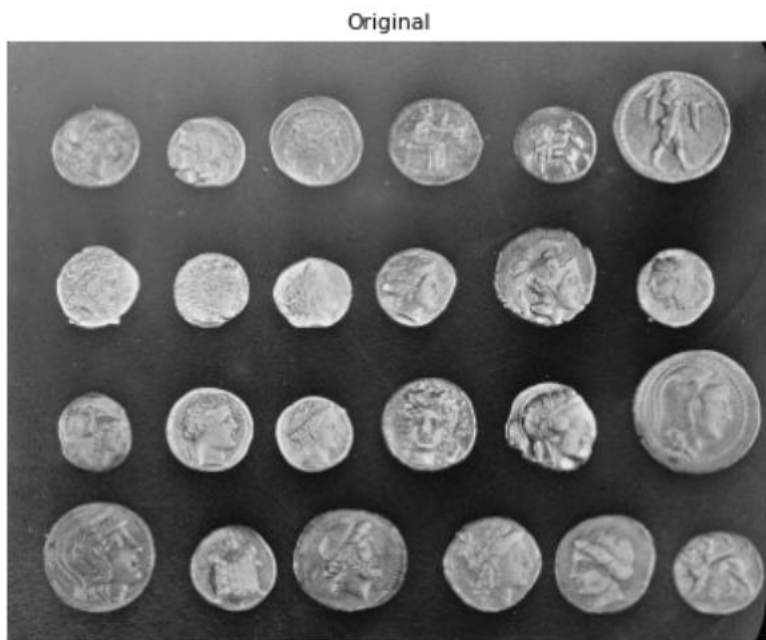
方法：深度学习(FCN、SegNet、U-Net、Mask R-CNN等)

天文应用：星系图像分割等

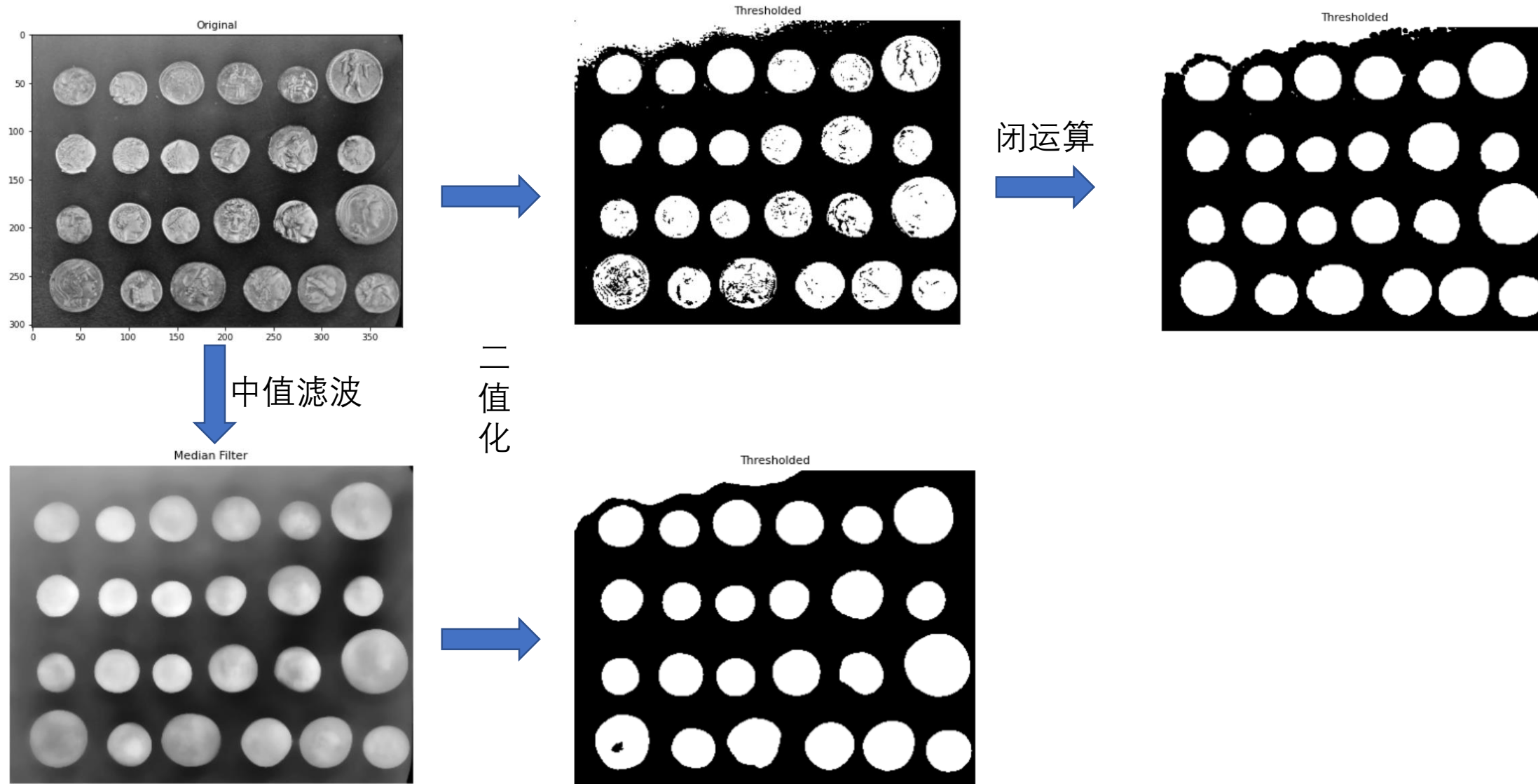
案例1:

将物体与背景分离

案例来源:https://scikit-image.org/docs/stable/auto_examples/index.html

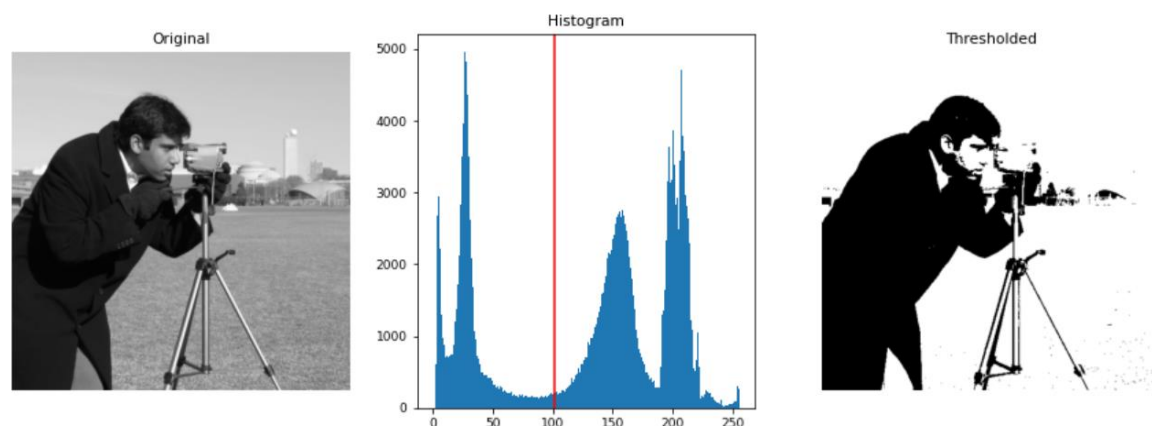


方案1:形态学滤波+二值化

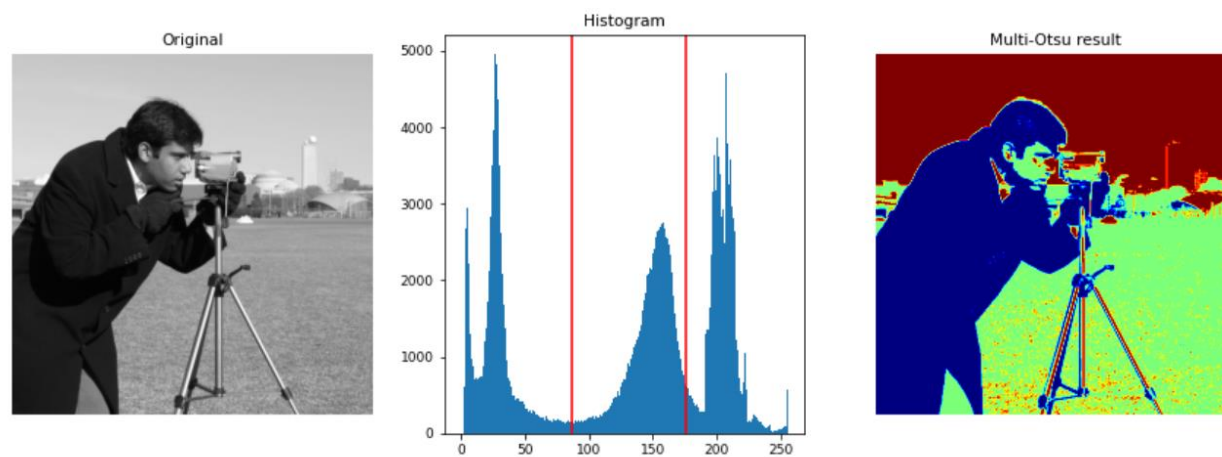


方案2:直方图阈值分割

单阈值

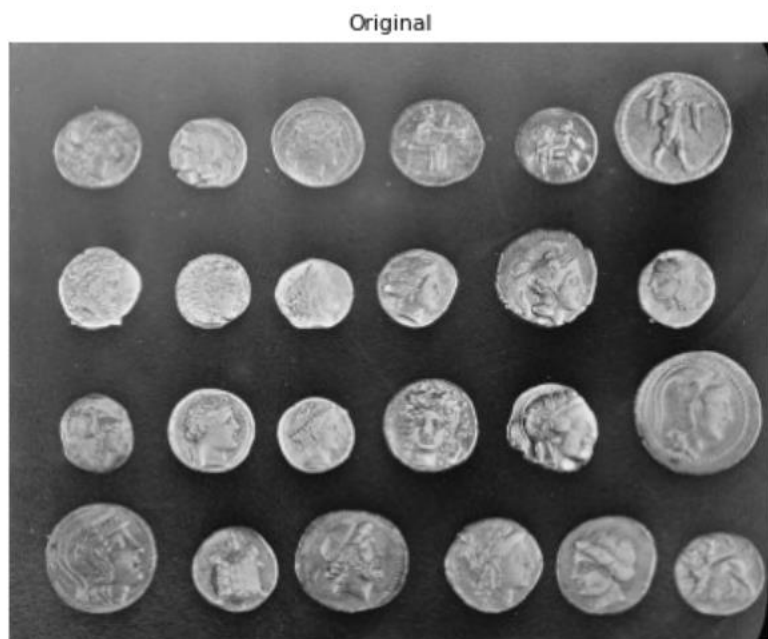


多阈值



案例2:

物体与物体之间分割



方法1:二值化+连通域

资料:

二值图像连通域标记: <https://zhuanlan.zhihu.com/p/394073982>

连通域的原理与Python实现:<https://zhuanlan.zhihu.com/p/97689424>

轮子:

https://scikit-image.org/docs/dev/auto_examples/segmentation/plot_label.html

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

(a)

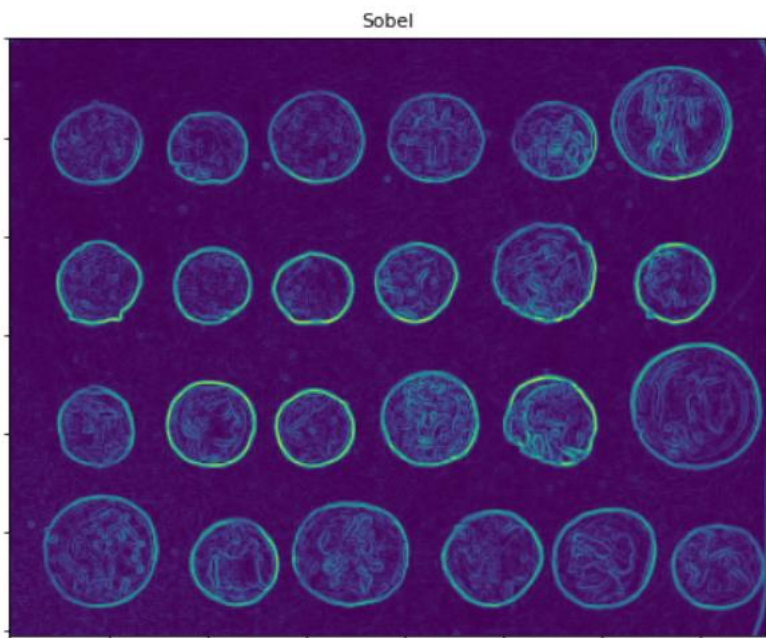
0	0	0	0	0	0	0
1	0	0	0	2	2	2
1	1	1	0	0	2	0
1	1	0	0	0	2	0
0	0	0	3	0	2	0
0	0	3	3	0	0	0
0	0	0	0	0	4	4

(b)

方法2:边缘检测+分水岭+连通域

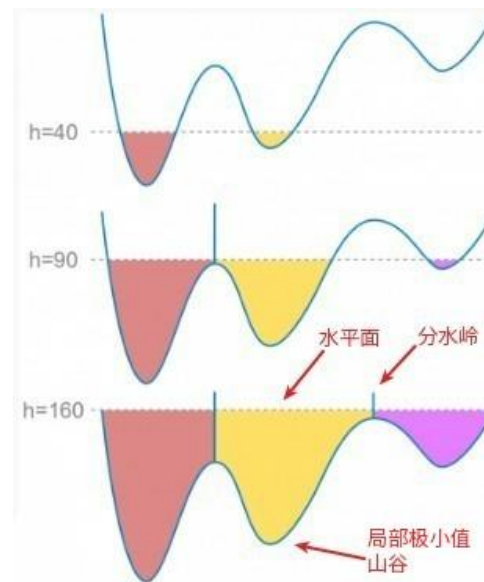
图像分割的经典算法：分水岭算法：<https://zhuatlan.zhihu.com/p/67741538>

轮子：<https://scikit-image.org/docs/stable/api/skimage.segmentation.html?highlight=watershed#skimage.segmentation.watershed>



边缘检测

其实就是对图像求导，边缘处导数会比较大



分水岭

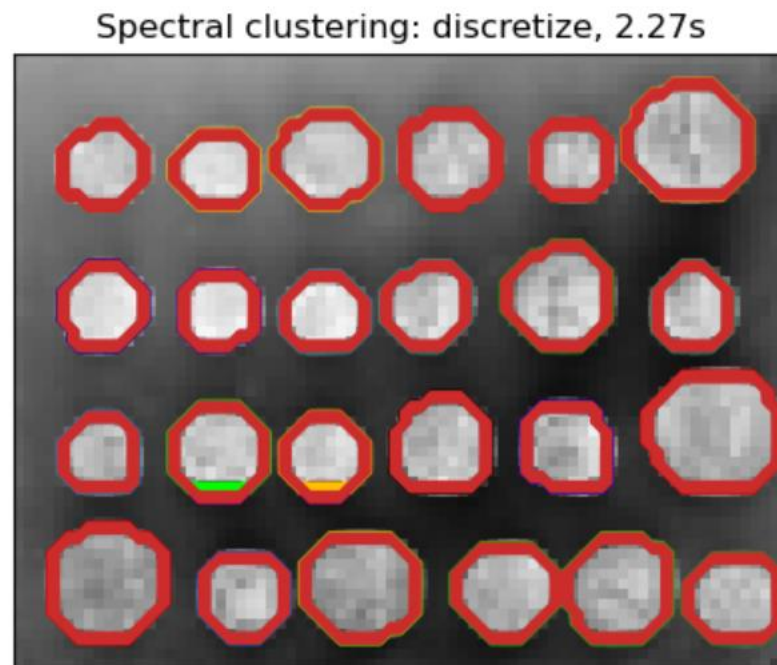
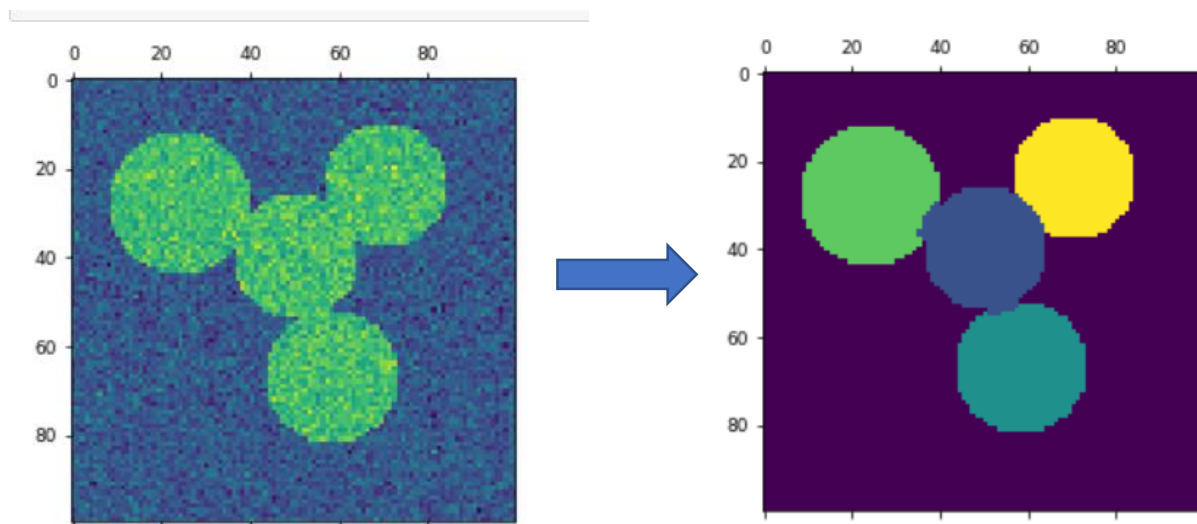
方法3:聚类

轮子:<https://scikit-learn.org/stable/modules/clustering.html>

例子:用谱聚类做图像分割:

https://scikit-learn.org/stable/auto_examples/cluster/plot_segmentation_toy.html#sphx-glr-auto-examples-cluster-plot-segmentation-toy-py

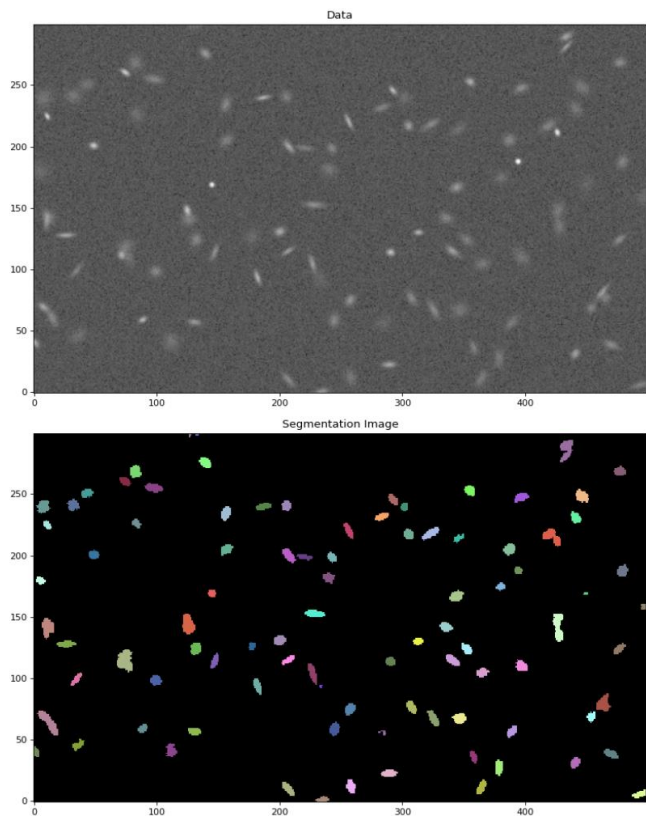
https://scikit-learn.org/stable/auto_examples/cluster/plot_coin_segmentation.html#sphx-glr-auto-examples-cluster-plot-coin-segmentation-py



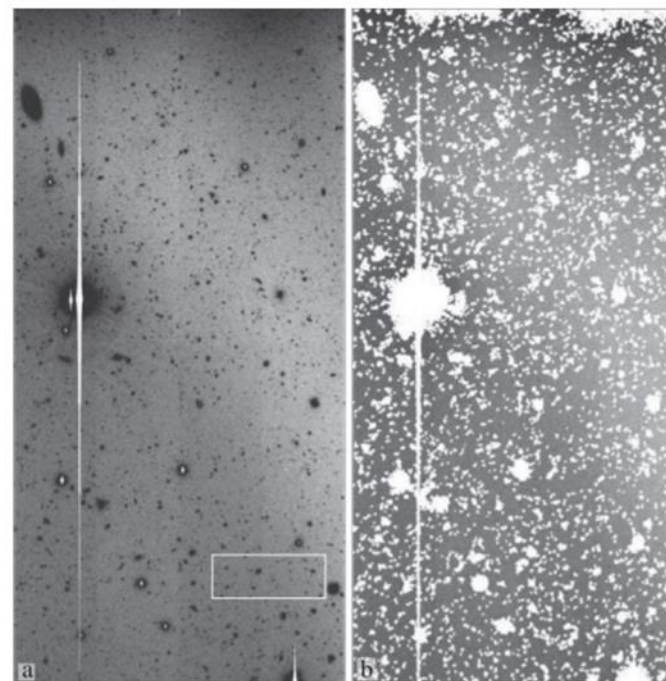
天文应用:巡天图像分割

1. **Photutils**的图像分割功能:<https://photutils.readthedocs.io/en/stable/segmentation.html>

2. **NoiseChisel**: https://www.gnu.org/software/gnuastro/manual/html_node/NoiseChisel.html



Photutils:巡天图像分割



NoiseChisel

天文应用:HII区分割

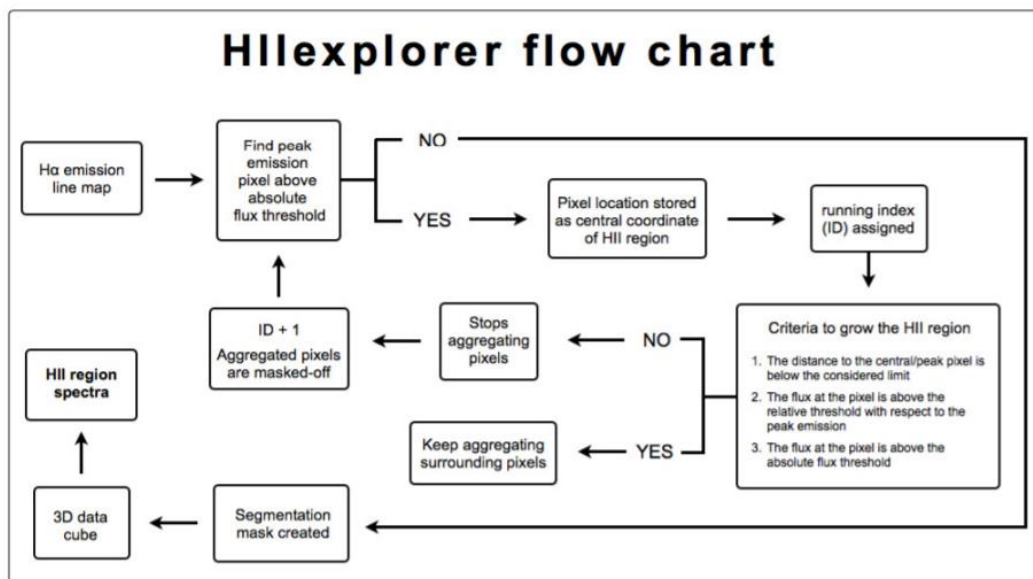
轮子:

1. **HIIexplorer**: http://www.caha.es/sanchez/HII_explorer/

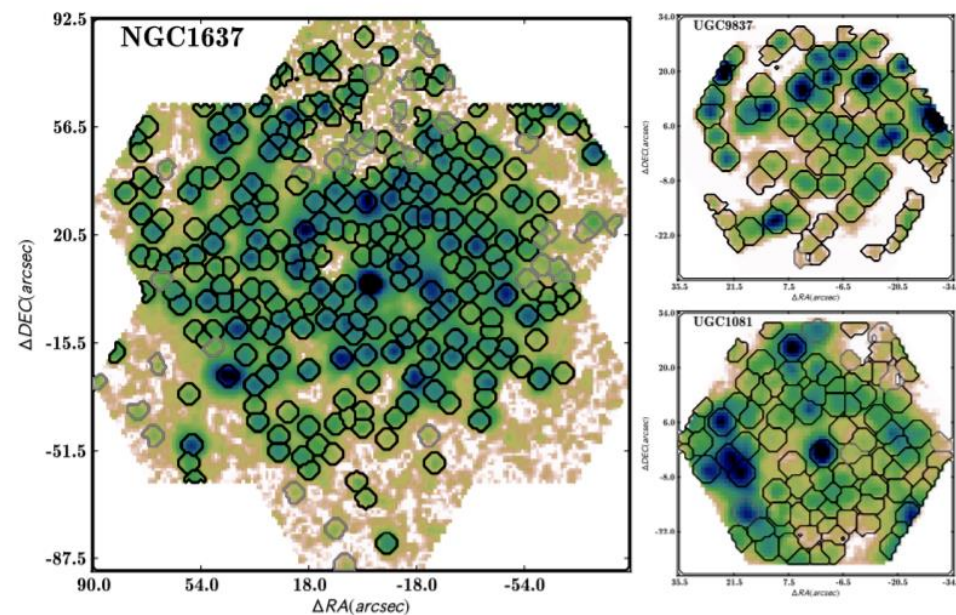
2. **pyHIIexplorer**: <https://github.com/cespinosa/pyHIIexplorerV2>

3. **HIIphot**: <https://arxiv.org/abs/astro-ph/0006026>

4. **pyHIIextractor**: <https://arxiv.org/pdf/2204.04252.pdf>



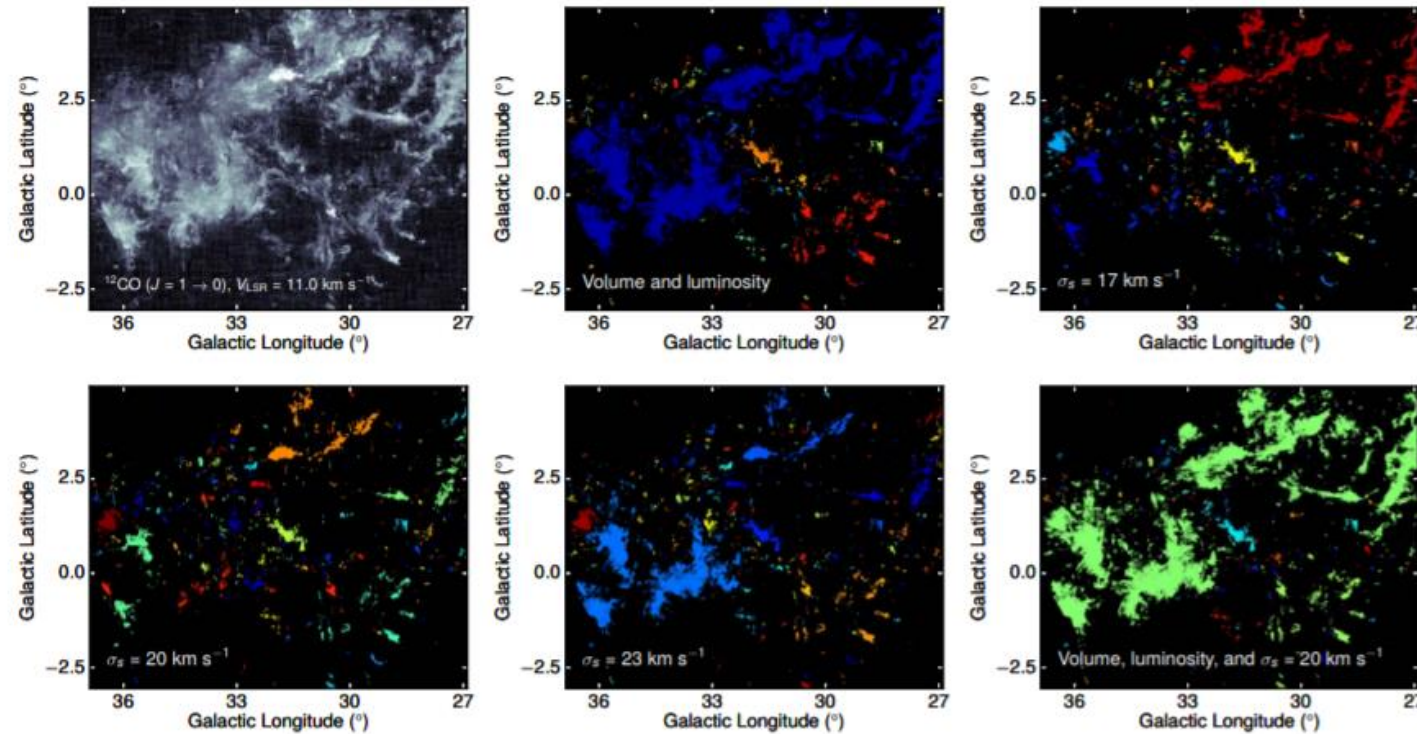
S. F. Sánchez et al.: Integral field spectroscopy of a sample of nearby galaxies. II.



天文应用:河内分子云分割

<https://arxiv.org/abs/2006.13654>: Distances and Statistics of Local Molecular Clouds in the First Galactic Quadrant

YAN ET AL.



紫台的银河画卷项目，基于聚类方法（谱聚类和DBSCAN）进行分子云图像分割

Spectral Clustering for Interstellar Molecular Emission Segmentation algorithm

案例3:复杂场景的图像分割

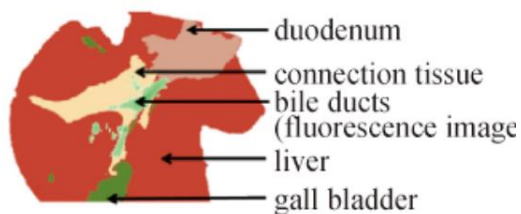
https://mp.weixin.qq.com/s/dvG_PqRiRjFdhzE1oVzWuQ 图像分割二十年，盘点影响力最大的10篇论文



自动驾驶

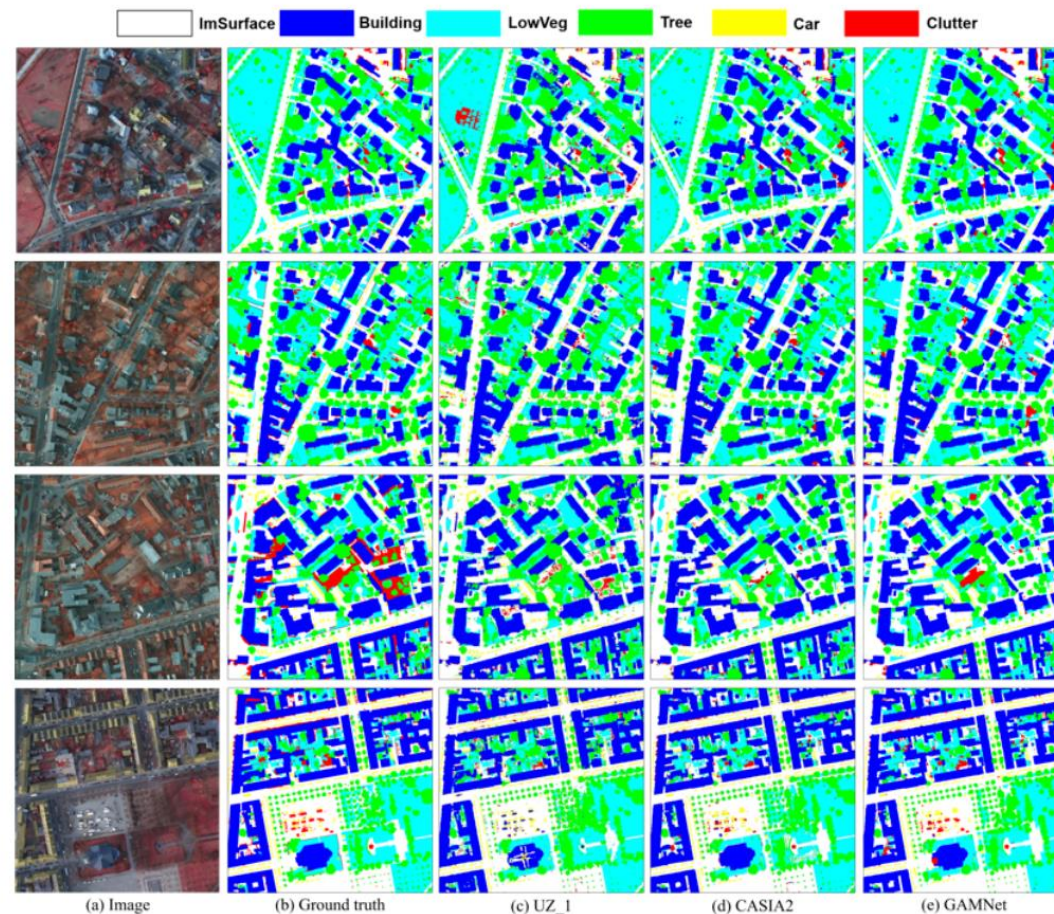


(a) 胆道组织结构
摄影图像



(b) 基于高光谱成像的胆道组织
类型分类, 叠加ICG装载的
微气球的荧光图像

医学图像分割



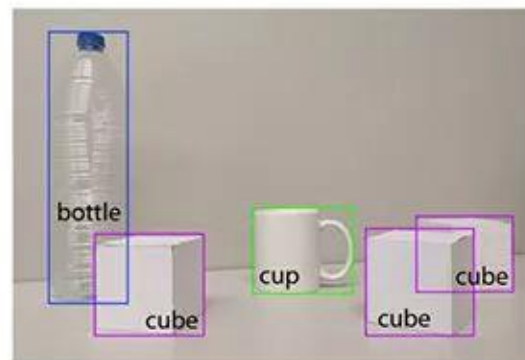
遥感图像分割

语义分割和实例分割

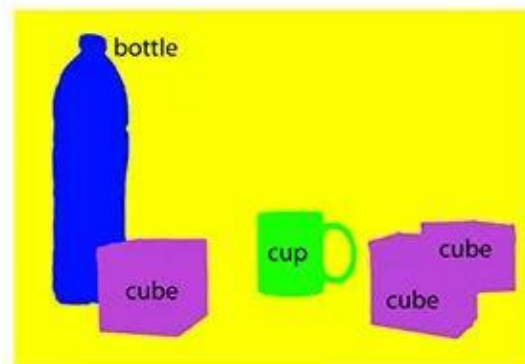
科普:<https://zhuanlan.zhihu.com/p/303355997>



(a) Image classification

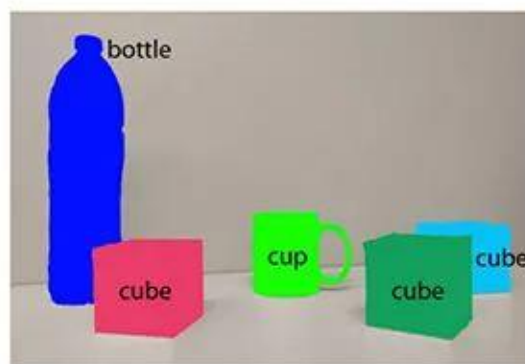


(b) Object localization



(c) Semantic segmentation

语义分割



(d) Instance segmentation

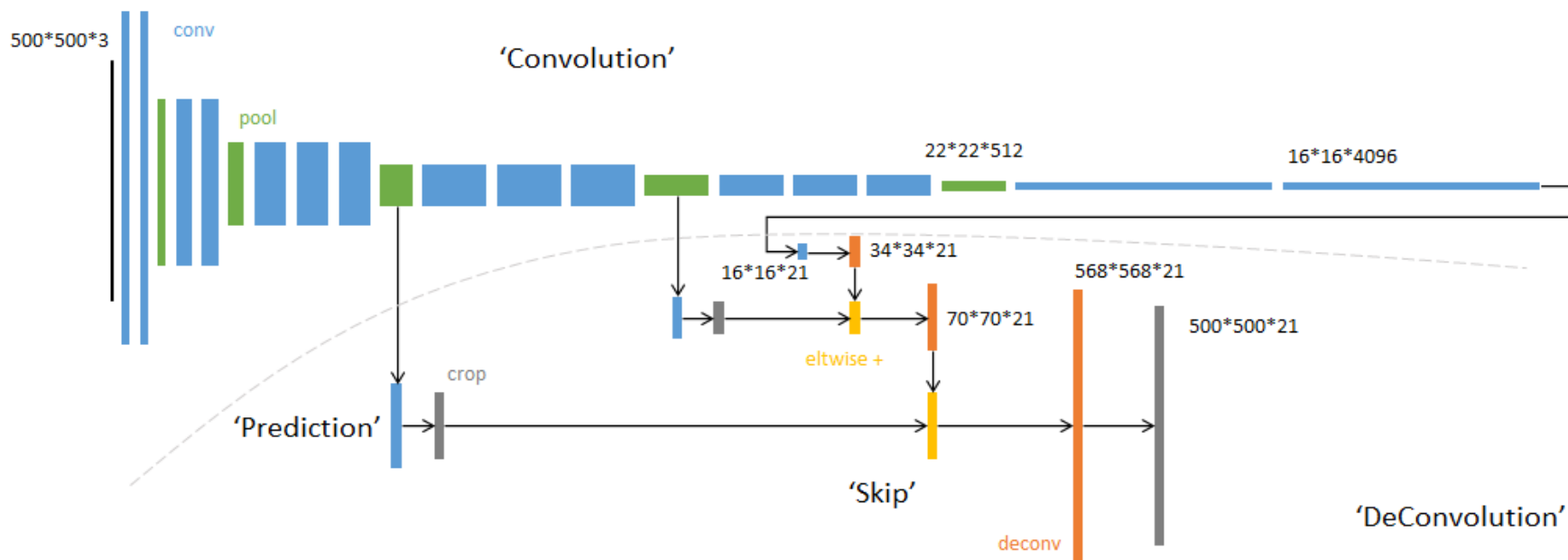
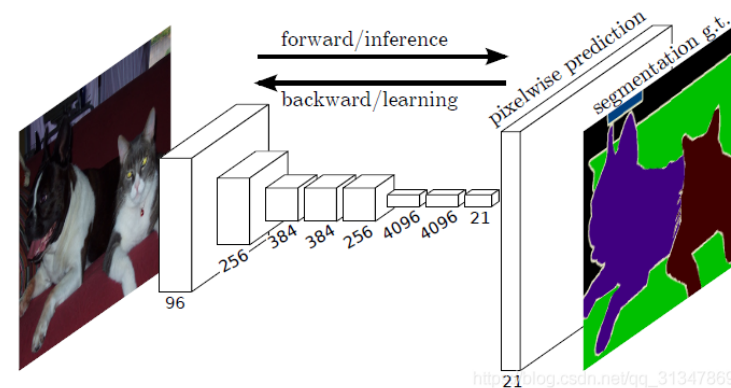
实例分割

FCN(Fully Convolutional Networks)

参考:

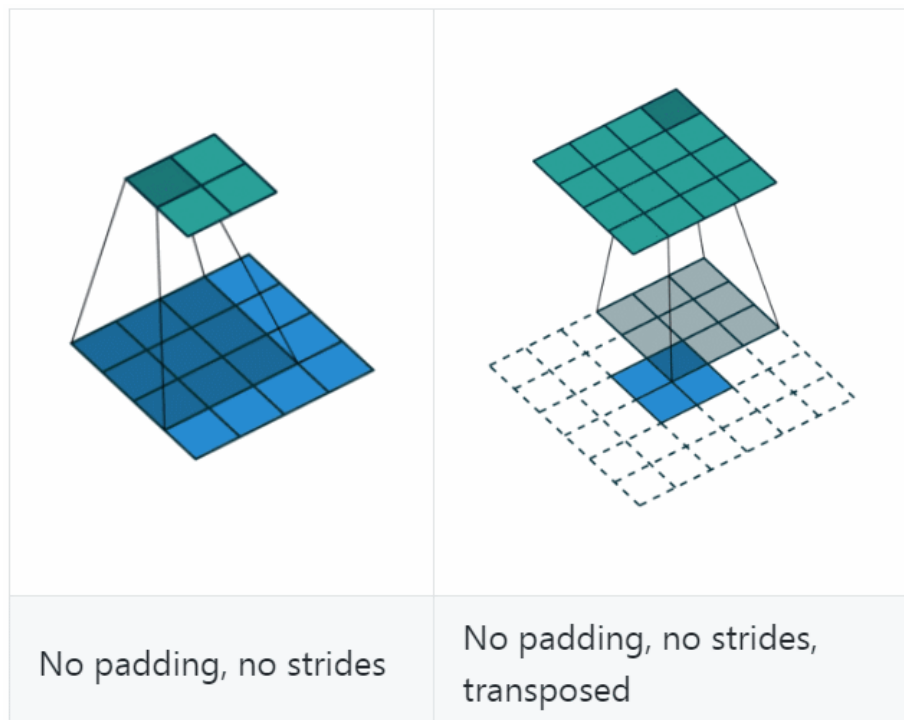
- <https://arxiv.org/abs/1411.4038>: Fully Convolutional Networks for Semantic Segmentation, 2015
- <https://blog.csdn.net/qinghuaci666/article/details/80863032>

FCN是深度学习语义分割的开山鼻祖
将传统CNN最后的全连接层换成了卷积层,输出是一个分割图
(20类目标+背景=21)



FCN的实现细节:

- 反卷积 (与天文上所说的反卷积不大一样)



卷积

反卷积 (上采样)

- 跳跃结构

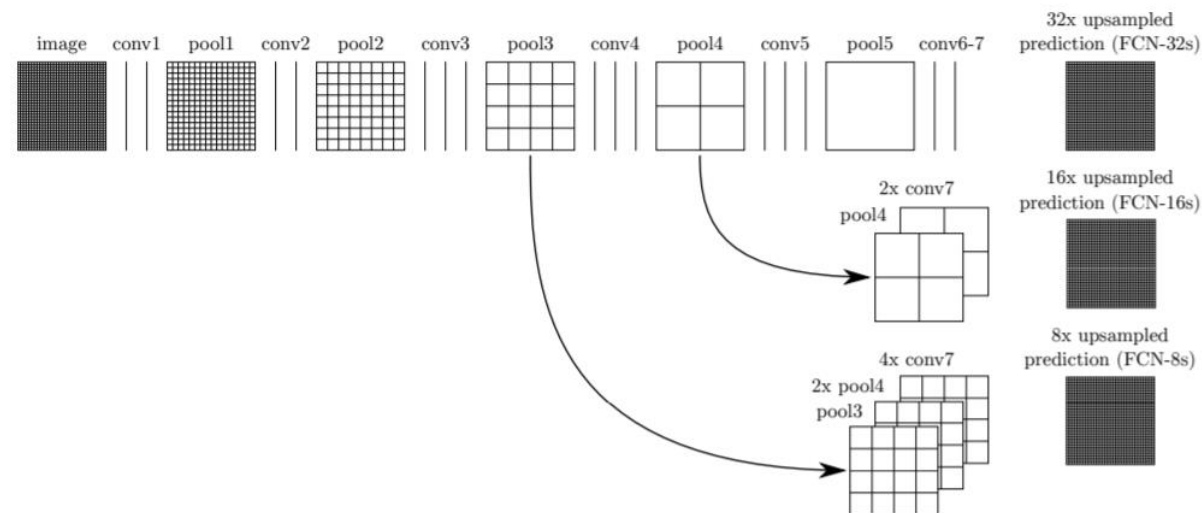
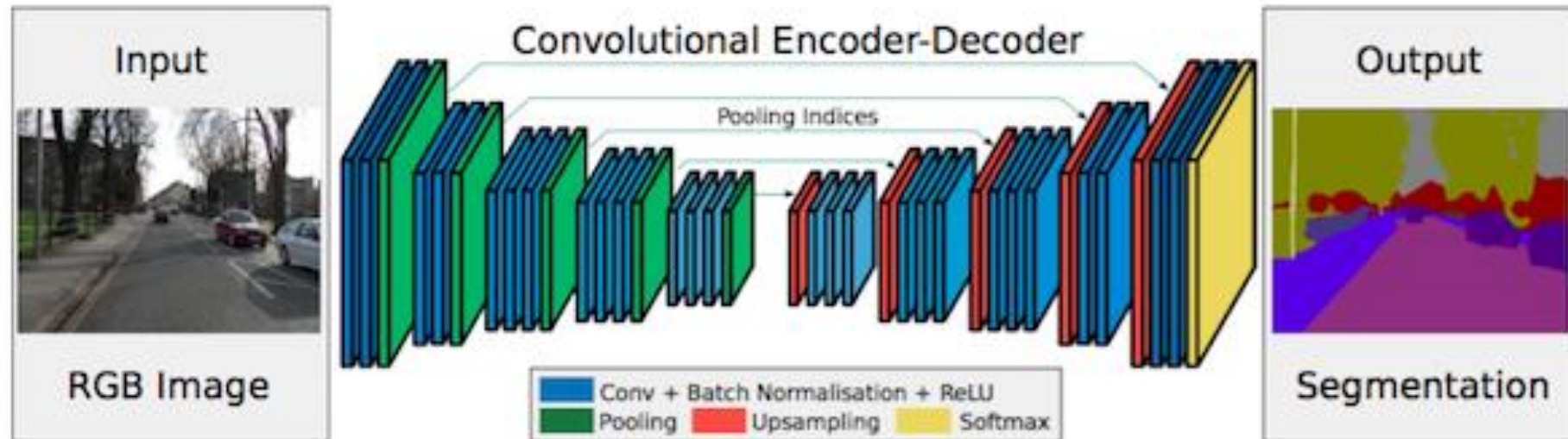


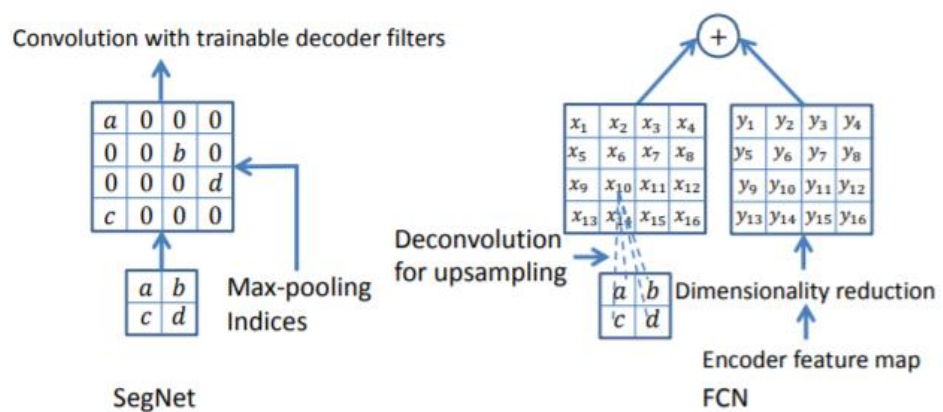
Figure 3. Our DAG nets learn to combine coarse, high layer information with fine, low layer information. Pooling and prediction layers are shown as grids that reveal relative spatial coarseness, while intermediate layers are shown as vertical lines. First row (FCN-32s): Our single-stream net, described in Section 4.1, upsamples stride 32 predictions back to pixels in a single step. Second row (FCN-16s): Combining predictions from both the final layer and the pool4 layer, at stride 16, lets our net predict finer details, while retaining high-level semantic information. Third row (FCN-8s): Additional predictions from pool3, at stride 8, provide further precision.

SegNet

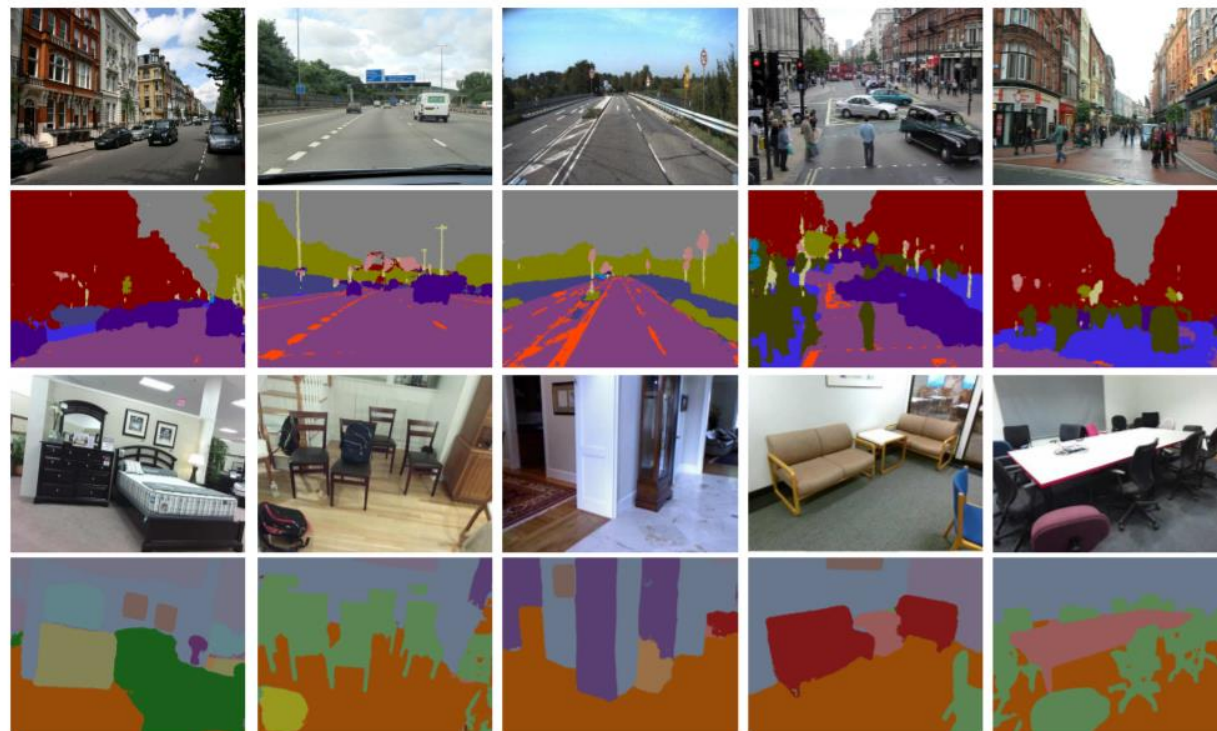
<https://arxiv.org/pdf/1511.00561.pdf>



SegNet的效果



SegNET的上采样方法：
最大池化层索引, 减少参数数量

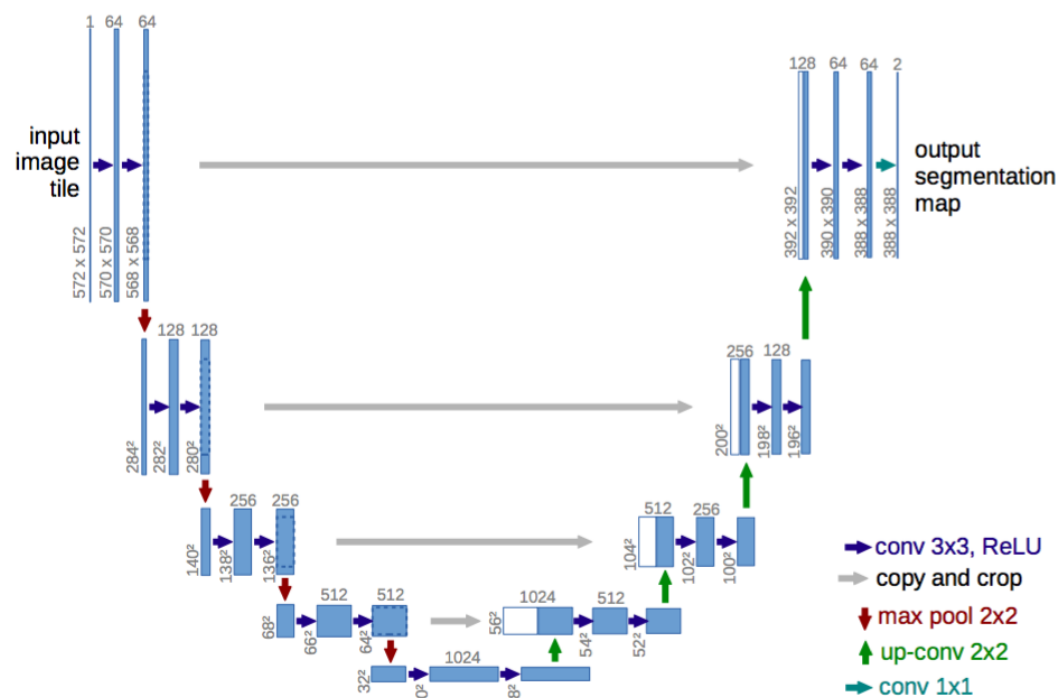


UNET

<https://arxiv.org/abs/1505.04597>: U-Net: Convolutional Networks for Biomedical Image Segmentation

https://zhuanlan.zhihu.com/p/150579454?utm_source=wechat_session&utm_medium=social&utm_oi=678639131815448576&utm_campaign=shareopen

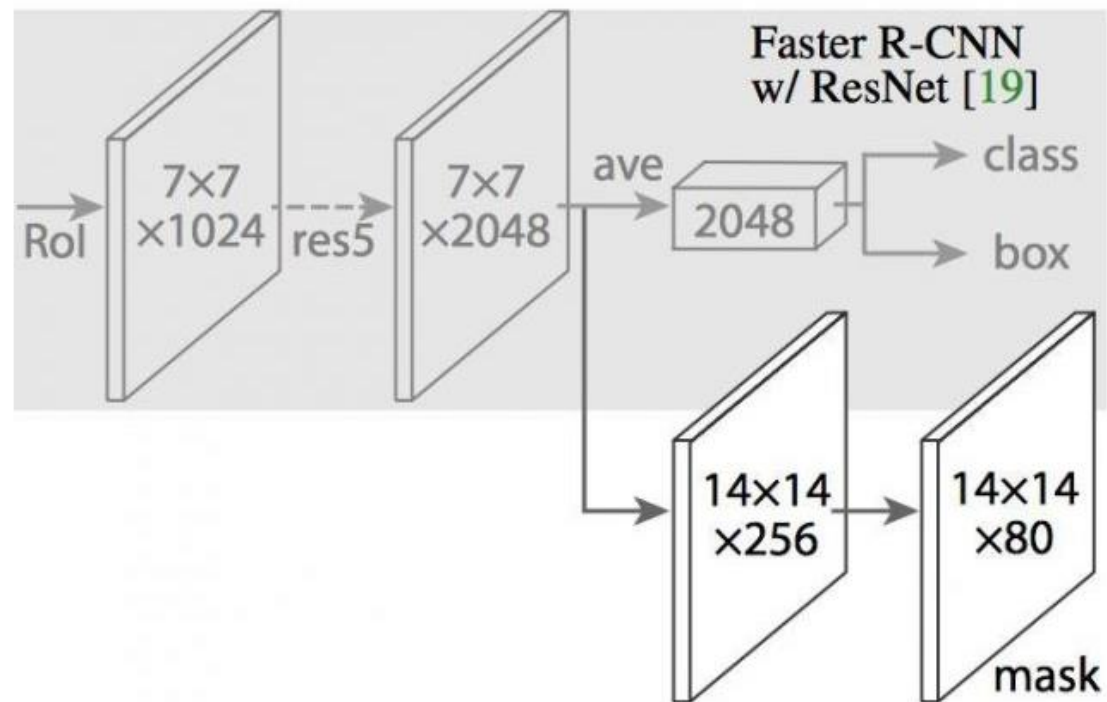
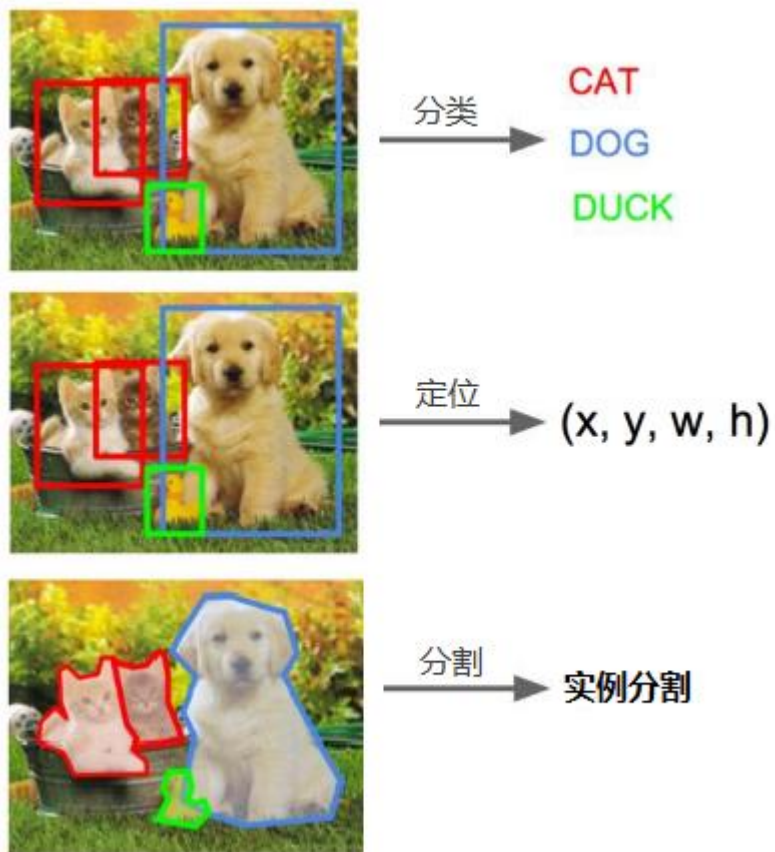
该网络大量应用于医学图像分割



Mask R-CNN

<https://arxiv.org/pdf/1703.06870v3.pdf>

科普: https://zhuanlan.zhihu.com/p/37998710?utm_source=wechat_session&utm_medium=social&utm_oi=678639131815448576&utm_campaign=shareopn



图像分割常用数据集

PASCAL VOC2012:

<http://host.robots.ox.ac.uk/pascal/VOC/>

CamVid:自动驾驶街景

<http://mi.eng.cam.ac.uk/research/projects/VideoRec/CamVid/>

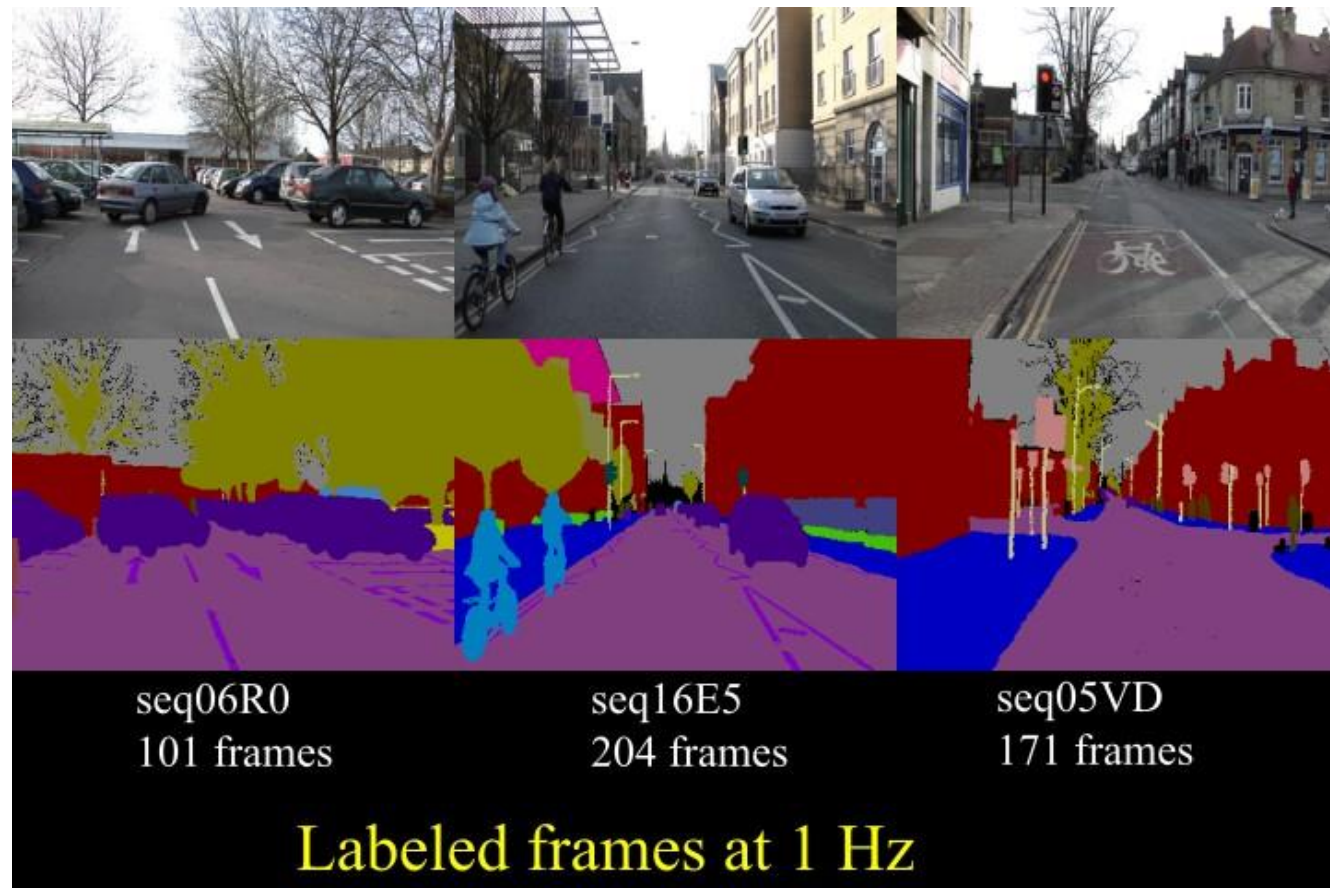
Lits Dataset: 医学:肝脏CT肿瘤

<https://competitions.codalab.org>

遥感数据集大全:

<https://mp.weixin.qq.com/s/3rZZID6Lfk5SxRxYoA3hSA>

<https://mp.weixin.qq.com/s/Qg4ci8bqCi15WF1ZFEJqFw>



最重要的是得有数据啊！

数据标记工具：

1. Labelme: <https://github.com/wkentaro/labelme>

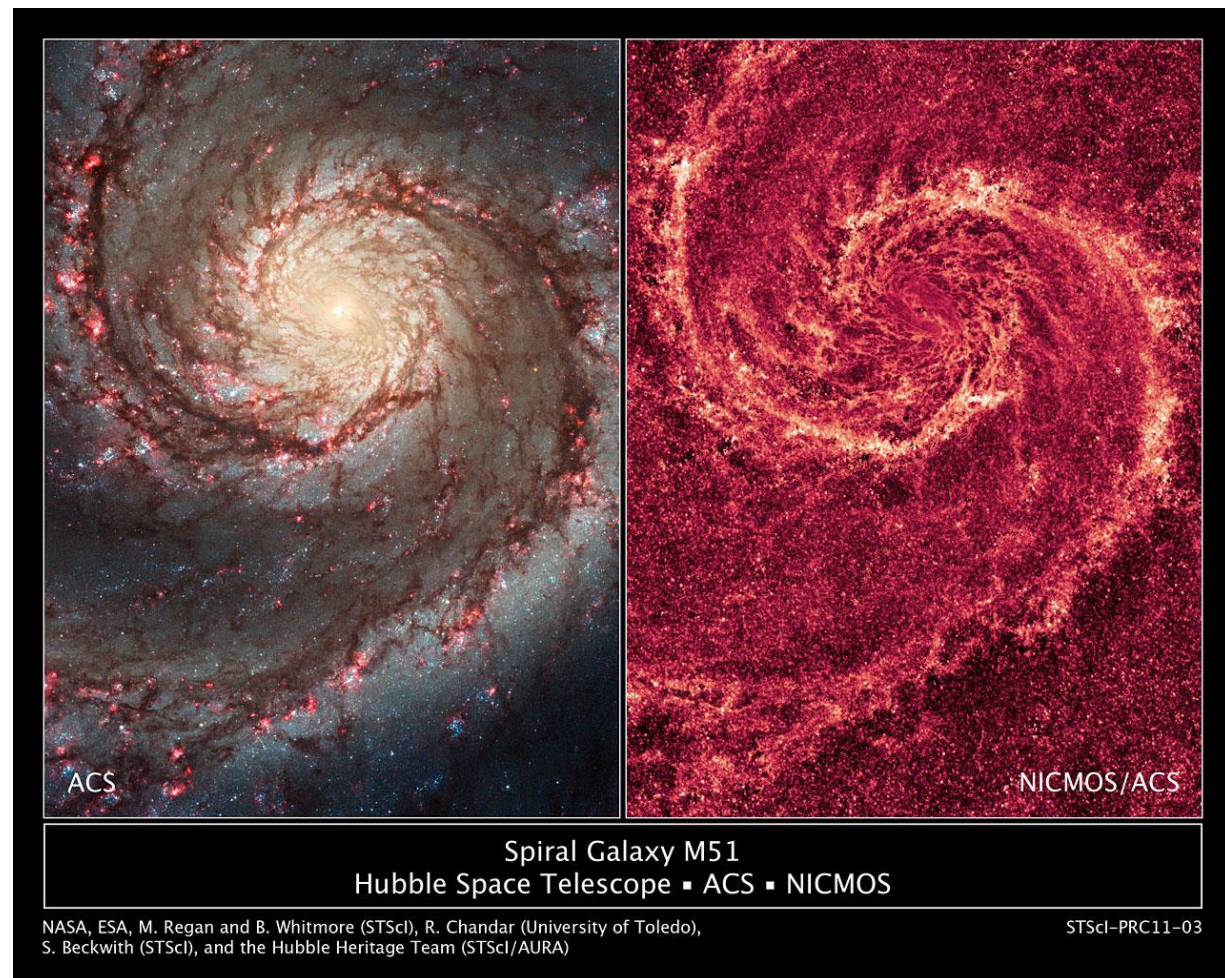
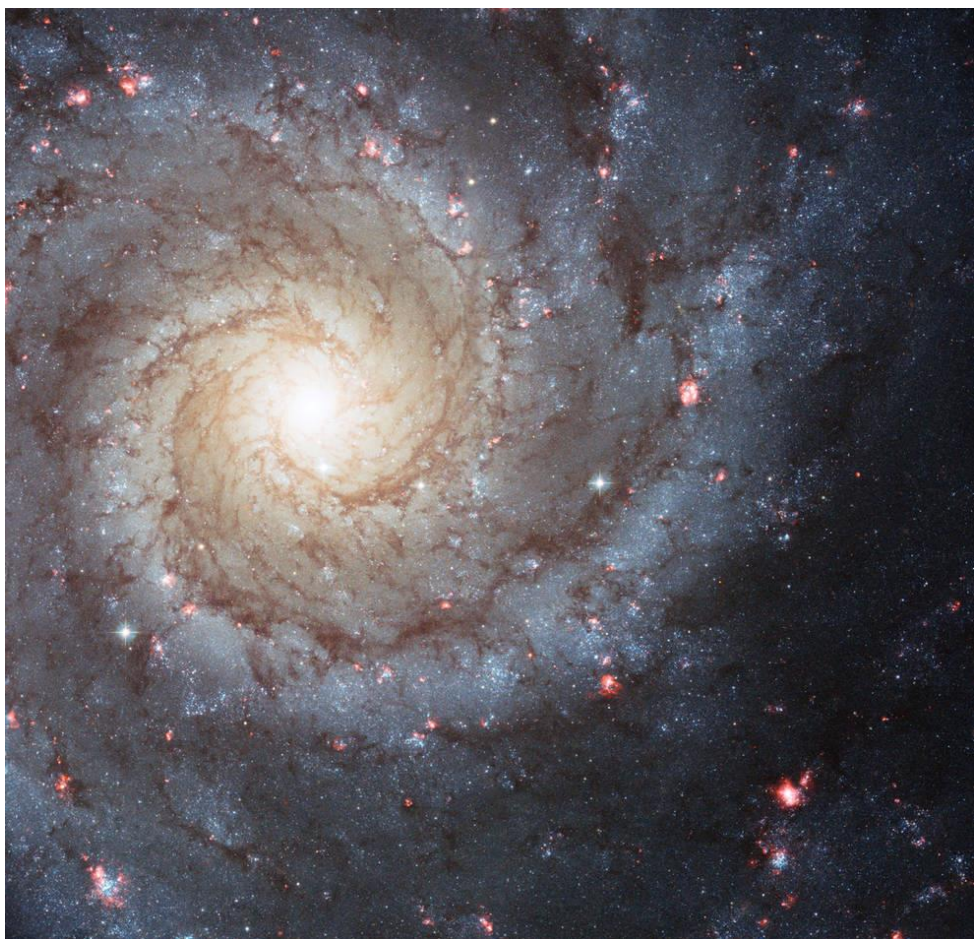
2. labelImg: <https://github.com/tzutalin/labelImg>



图像分割可能的天文应用

高分辨率星系光学图像分割：

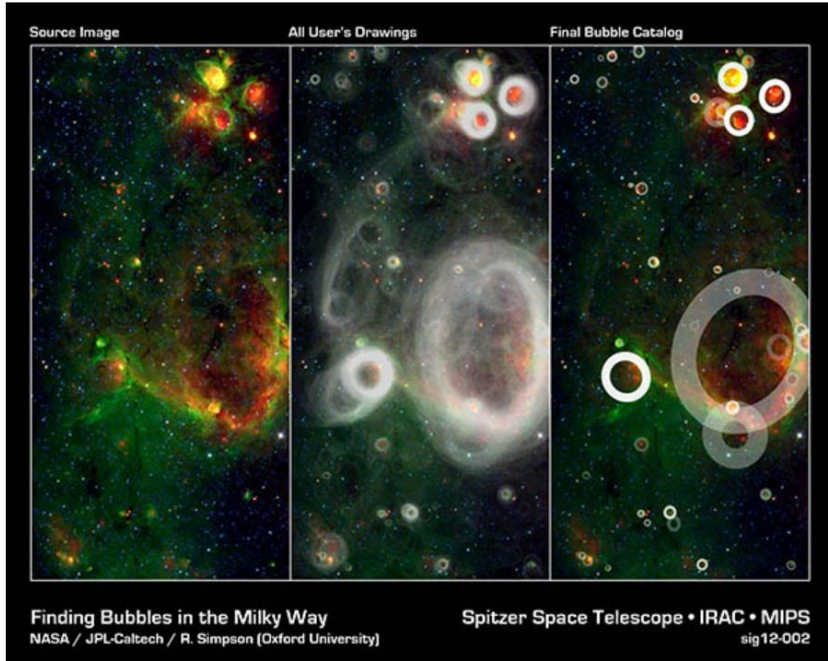
尘埃带、HII区、行星状星云、超新星遗迹、W-R星、星团…



图像分割可能的天文应用

Milky Way Project: 征集爱好者做的河内HII Bubble数据

<https://www.zooniverse.org/projects/povich/milky-way-project/about/results>



天文图像分割文章搜集

非深度学习方法:

1.Optimising and comparing source-extraction tools using objective segmentation quality criteria

<https://ui.adsabs.harvard.edu/abs/2021A%26A...645A.107H/abstract>

2.Graph-based interpretation of the molecular interstellar medium segmentation

<https://ui.adsabs.harvard.edu/abs/2015MNRAS.454.2067C/abstract>

3.Clustering by fast search and find of density peaks

<https://ui.adsabs.harvard.edu/abs/2014Sci...344.1492R/abstract>

4.Noise-based Detection and Segmentation of Nebulous Objects 【 NoiseChisel】

<https://ui.adsabs.harvard.edu/abs/2015ApJS..220....1A/abstract>

5.SpArcFiRe: Scalable Automated Detection of Spiral Galaxy Arm Segments

<https://ui.adsabs.harvard.edu/abs/2014ApJ...790...87D/abstract>

6.The VOISE algorithm: a versatile tool for automatic segmentation of astronomical images

<https://ui.adsabs.harvard.edu/abs/2009MNRAS.398.1254G/abstract>

天文图像分割文章搜集

FCN:

1. Searching for young stellar objects through SEDs by machine learning

<https://ui.adsabs.harvard.edu/abs/2021A%26C...3600470C/abstract>

Mask R-CNN

1. Deblending and classifying astronomical sources with Mask R-CNN deep learning

<https://ui.adsabs.harvard.edu/abs/2019MNRAS.490.3952B/abstract>

2. DeepGhostBusters: Using Mask R-CNN to Detect and Mask Ghosting and Scattered-Light Artifacts from Optical Survey Images

<https://ui.adsabs.harvard.edu/abs/2021arXiv210908246T/abstract>

3. Mask galaxy: Machine learning pipeline for morphological segmentation of galaxies

<https://ui.adsabs.harvard.edu/abs/2021ascl.soft01007F/abstract>

<https://ui.adsabs.harvard.edu/abs/2020A%26C...3300420F/abstract>

天文图像分割文章搜集

- **U-NET:**

1.Deep learning approach for identification of H II regions during reionization in 21-cm observations

<https://ui.adsabs.harvard.edu/abs/2021MNRAS.505.3982B/abstract>

2.Quantifying the fine structures of disk galaxies with deep learning: Segmentation of spiral arms in different Hubble types

<https://ui.adsabs.harvard.edu/abs/2021A%26A...647A.120B/abstract>

3.CASI: A Convolutional Neural Network Approach for Shell Identification

<https://ui.adsabs.harvard.edu/abs/2019ApJ...880...83V/abstract>

4.Extracting the Subhalo Mass Function from Strong Lens Images with Image Segmentation

<https://ui.adsabs.harvard.edu/abs/2022ApJ...927...83O/abstract>

5.Image segmentation for analyzing galaxy-galaxy strong lensing systems

<https://ui.adsabs.harvard.edu/abs/2022A%26A...657L..14O/abstract>

6.Learning to denoise astronomical images with U-nets

<https://ui.adsabs.harvard.edu/abs/2021MNRAS.503.3204V/abstract>

天文图像分割文章搜集

- 太阳冕洞/环形山:
 - 1. Image Processing Methods for Coronal Hole Segmentation, Matching, and Map Classification
 - <https://ui.adsabs.harvard.edu/abs/2020ITIP...29.1641J/abstract>
 - 2. Solar Filament Recognition Based on Deep Learning
 - <https://ui.adsabs.harvard.edu/abs/2019SoPh..294..117Z/abstract>
 - 3. Tracing H α Fibrils through Bayesian Deep Learning
 - <https://ui.adsabs.harvard.edu/abs/2021ApJS..256...20J/abstract>
 - 4. Automated crater detection on Mars using deep learning
 - <https://ui.adsabs.harvard.edu/abs/2019P%26SS..170...16L/abstract>