MONAI Label: A Framework For Interactive Image Annotation Through AI

Andres Diaz-Pinto - November 2022

MONAI Label

https://github.com/Project-MONAI/MONAILabel

AGENDA

- What is MONAI Label?
- Why use MONAI Label?
- How to create a MONAI Label App?
- Scribbles in MONAI Label
- Active Learning Strategies

What is MONAI Label?

- An intelligent open source image labeling and learning tool that enables users to create annotated datasets and build AI annotation models for clinical evaluation
- Framework for developing and deploying MONAI Label Apps to train and do inference using Deep Learning models
- MONAI Label includes Active learning strategies to improve model performance.
- It is all Python and can be installed with simple “pip install monailabel”
- Supported viewers:

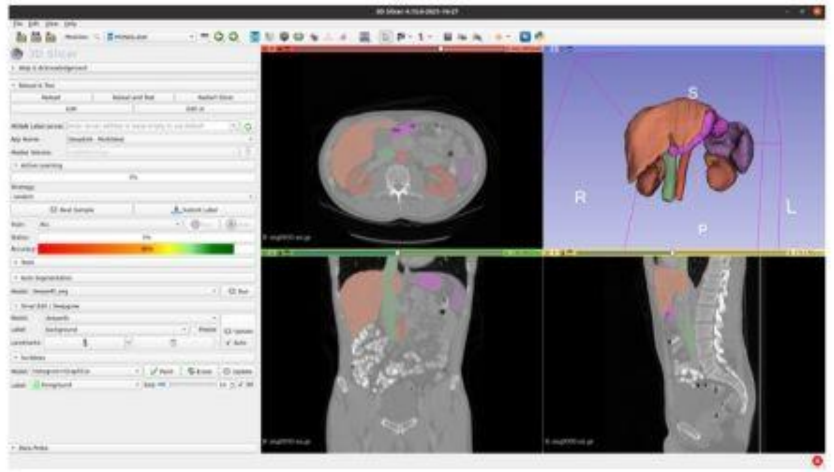
  For radiology app: 3D Slicer and Open Health Imaging Foundation (OHIF)
  For pathology app: Digital Slide Archive (DSA) and QuPath
  For endoscopy app: CVAT
- Continuous development since we started in Feb 2021

What is MONAI Label?

Sample Apps

Radiology

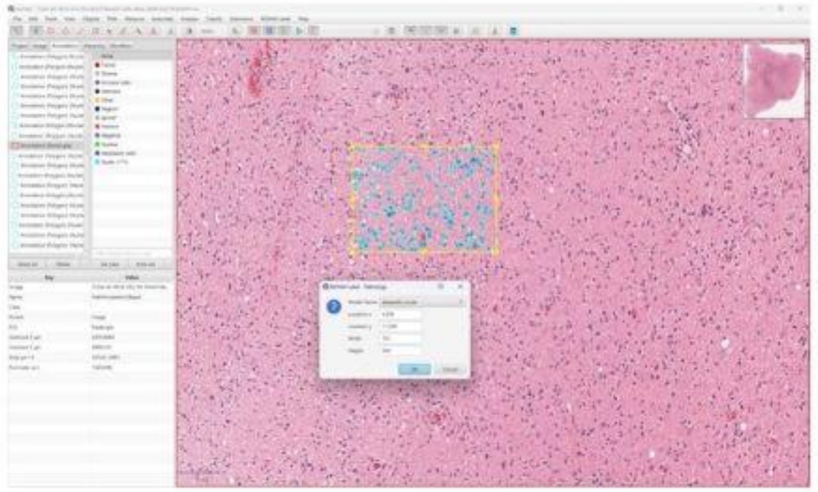
Labeling App for **Radiography Imaging**



Interactive and automated segmentation over radiology images for 2D and 3D volumes.

Pathology

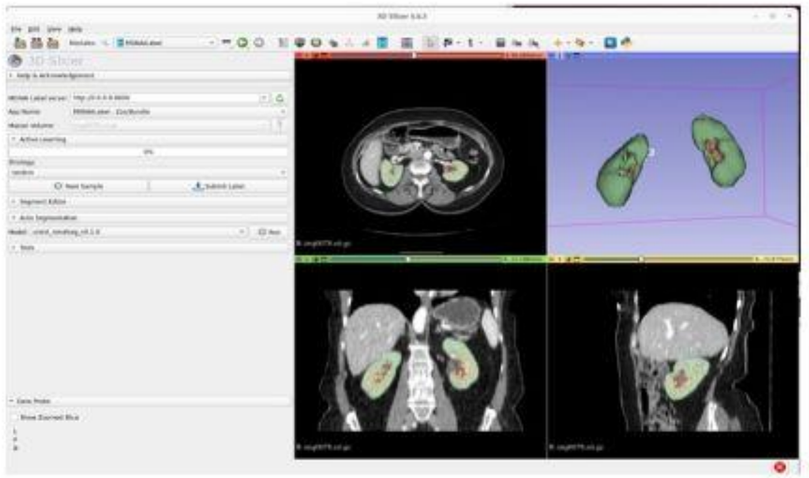
Labeling App for **Microscopy Imaging**



Interactive and automated segmentation over pathology whole-slide images (WSI).

Bundle

Flexible Labeling with **Customized Models**



Integrating customized models for inference, training or processing any target anatomies.

Endoscopy

Labeling App for **Endoscopy Images**

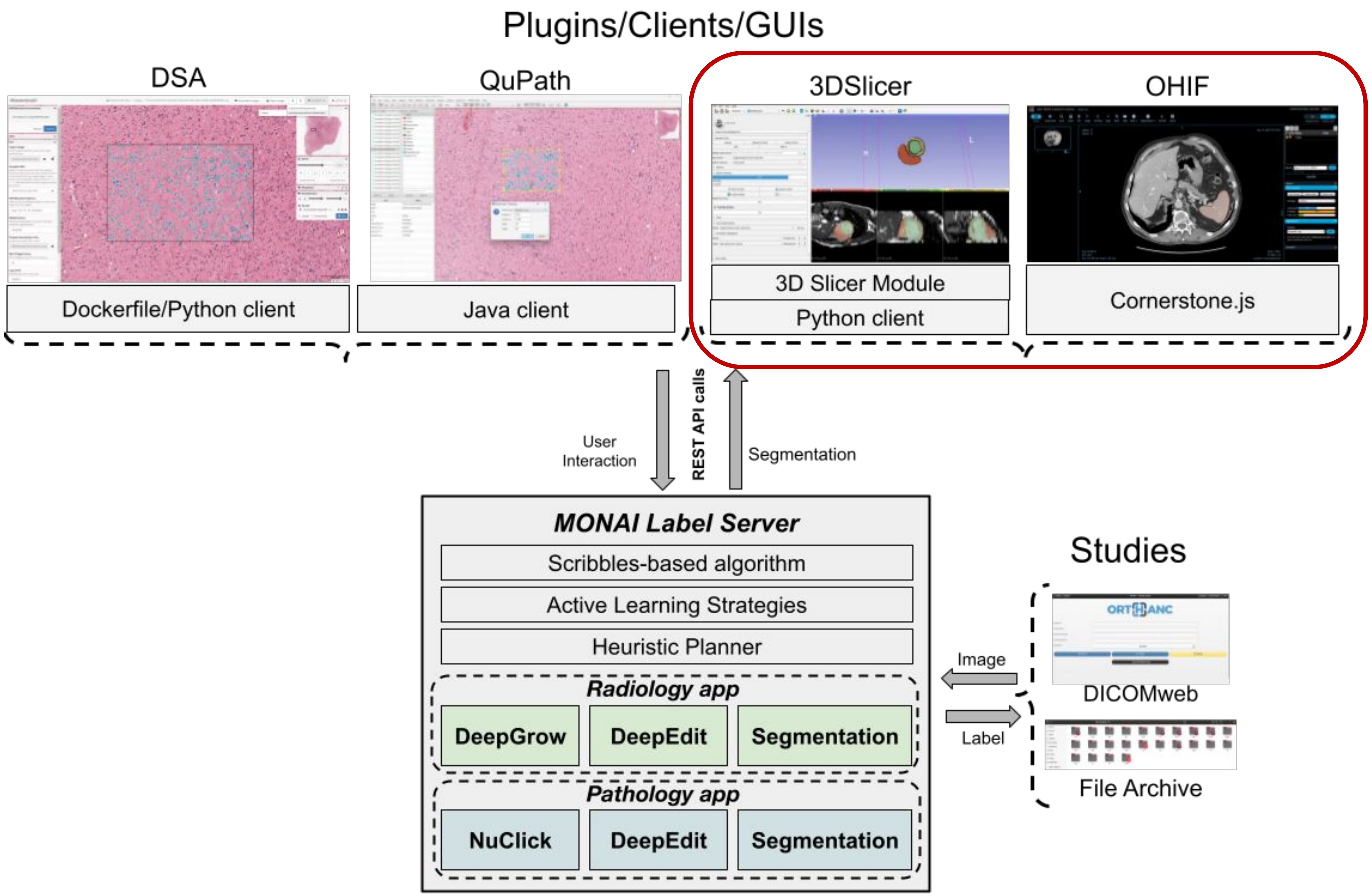
Interactive/automated segmentation, detection, classification for endoscopy images.

What is MONAI Label?

MONAI Label Infrastructure: server-client system

Three main parts:

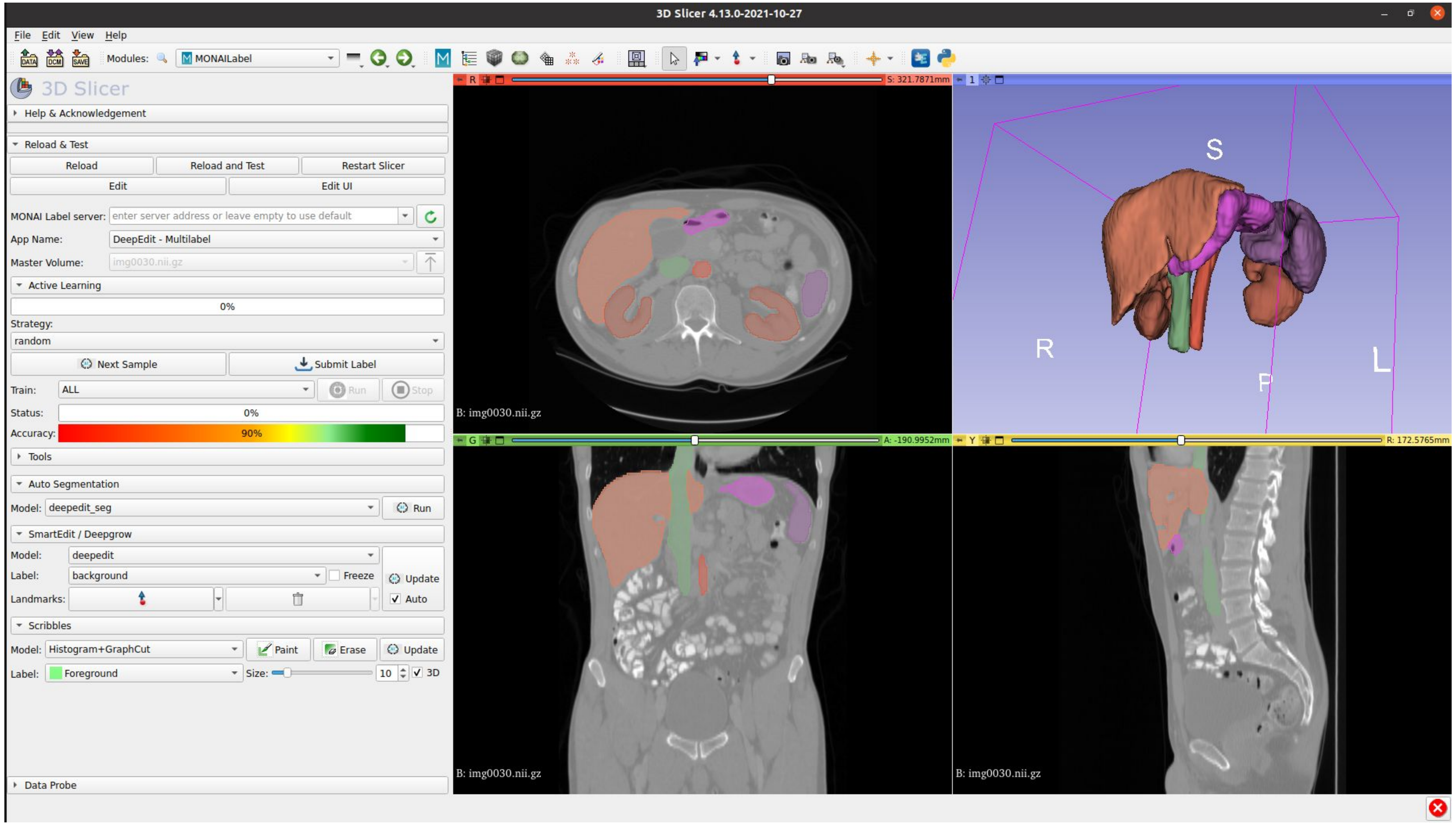
- MONAI Label server
- Datastore
- Clients/GUIs



What is MONAI Label?

Client - 3D Slicer

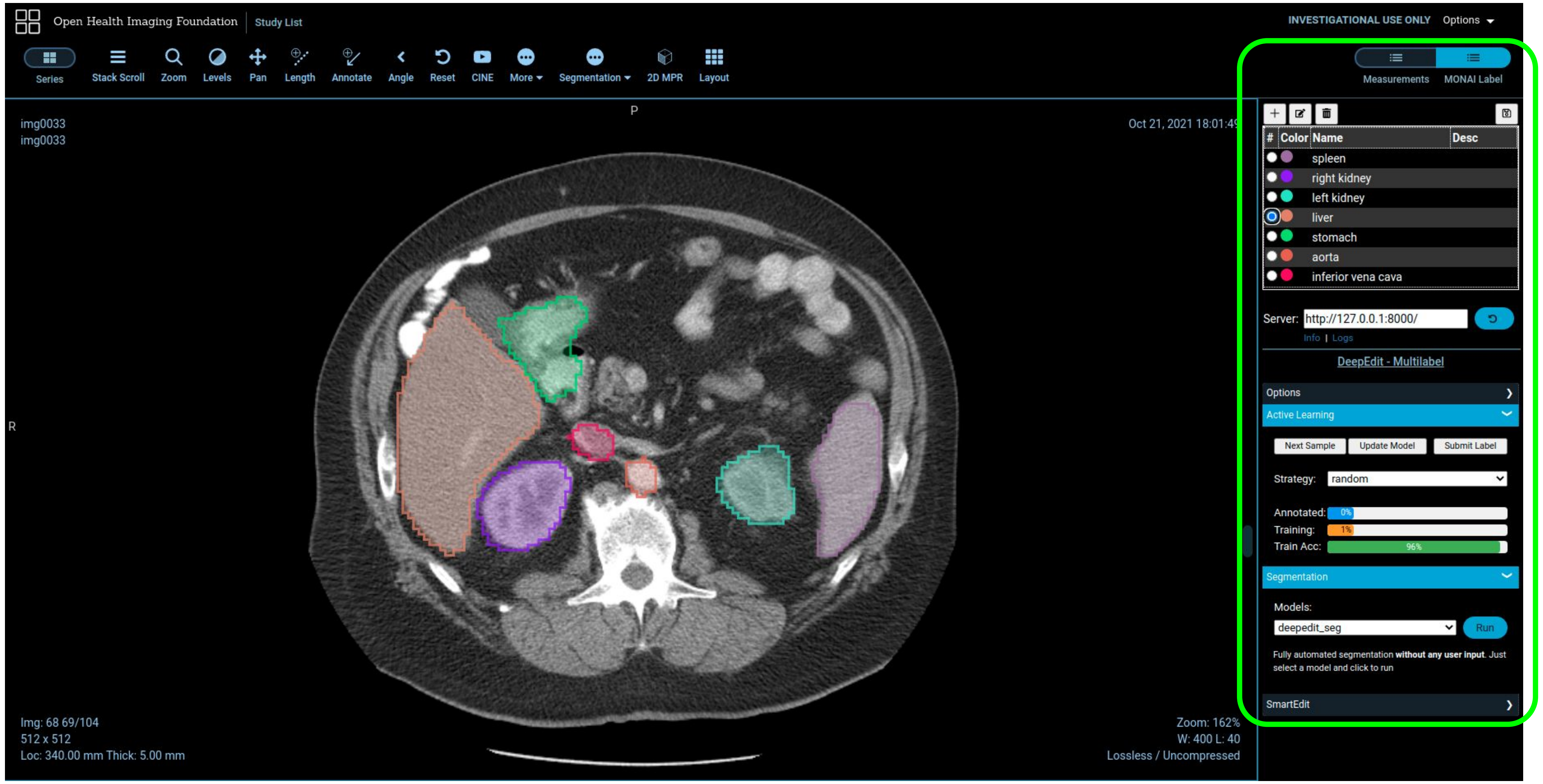
- Supportive community
- User-friendly
- Easy to customise
- Many manual annotation tools
- Image Registration



What is MONAI Label?

Client - OHIF

MONAI Label

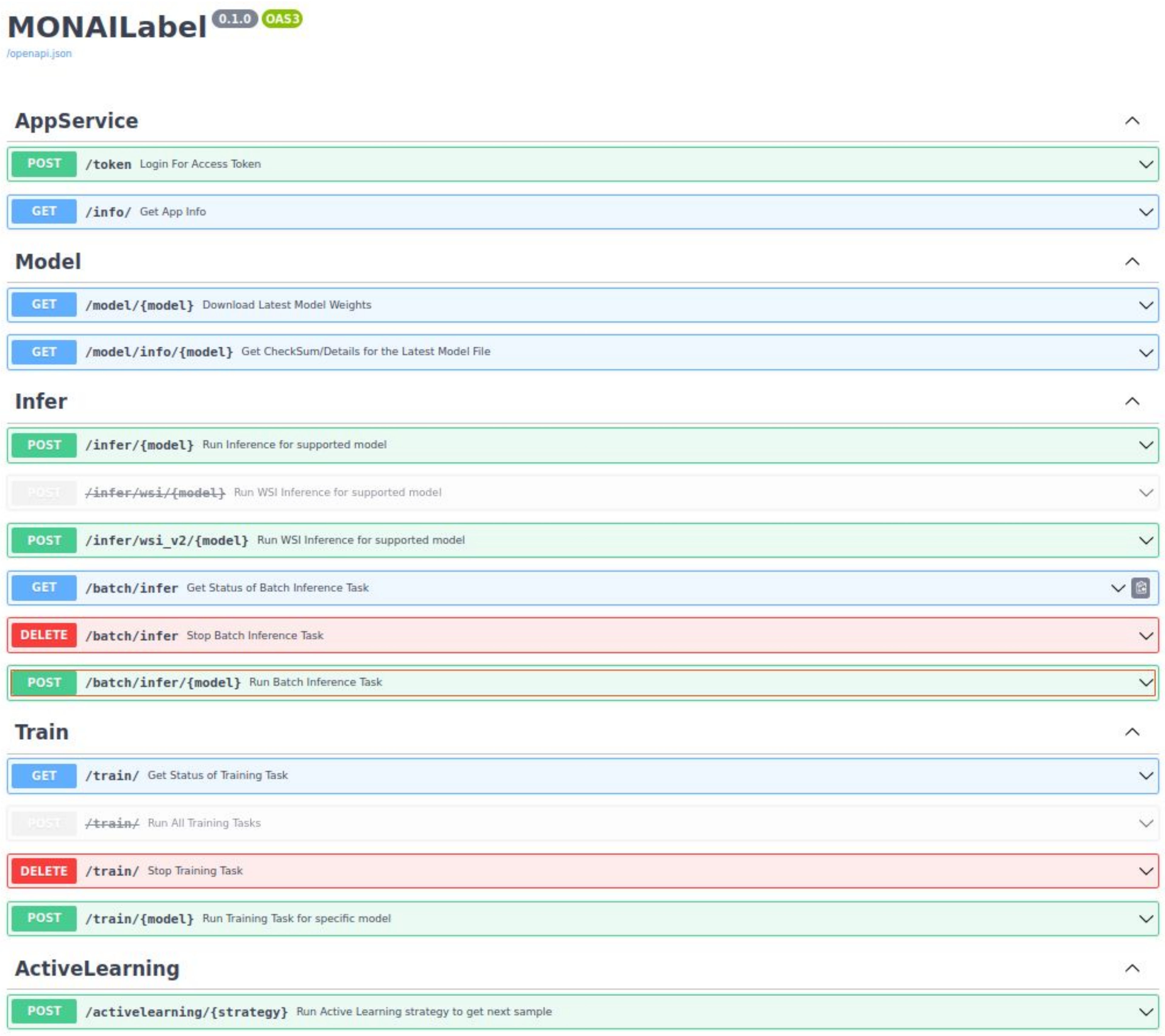


- Works out-of-the-box with Image Archives that support DICOMWeb.
- http://127.0.0.1:8000/ohif
- Web-based viewer.
- Beautiful user interface (UI) designed with extensibility in mind.

What is MONAI Label?

Client - REST API

REST API at http://127.0.0.1:8000/



Why use MONAI Label?

What is MONAI Label?

- Researcher Perspective: MONAI Label allows researchers to

  Create new annotation methods
  Rapid App prototyping
  Implement active learning techniques
  Verify their effectiveness in real-world scenarios
  Make incremental improvements
  Readily deploy labeling apps to wider audiences

- Clinician user in a research setting perspective: MONAI Label reduces the time and effort of annotating new datasets

  Ready-to-use viewers:

  Radiology: 3D Slicer, OHIF Viewer
  Pathology: DSA and QuPath
  Endoscopy: CVAT

How to create a MONAI Label App?

How to create a MONAI Label App?

- ***Select an app*** (i.e. radiology, pathology or endoscopy) and model to use (i.e. deepedit, segmentation, nuclick)
- ***Prepare the dataset*** - Labels with the same name as images
- ***Define the label names and label numbering*** in configs file accordingly

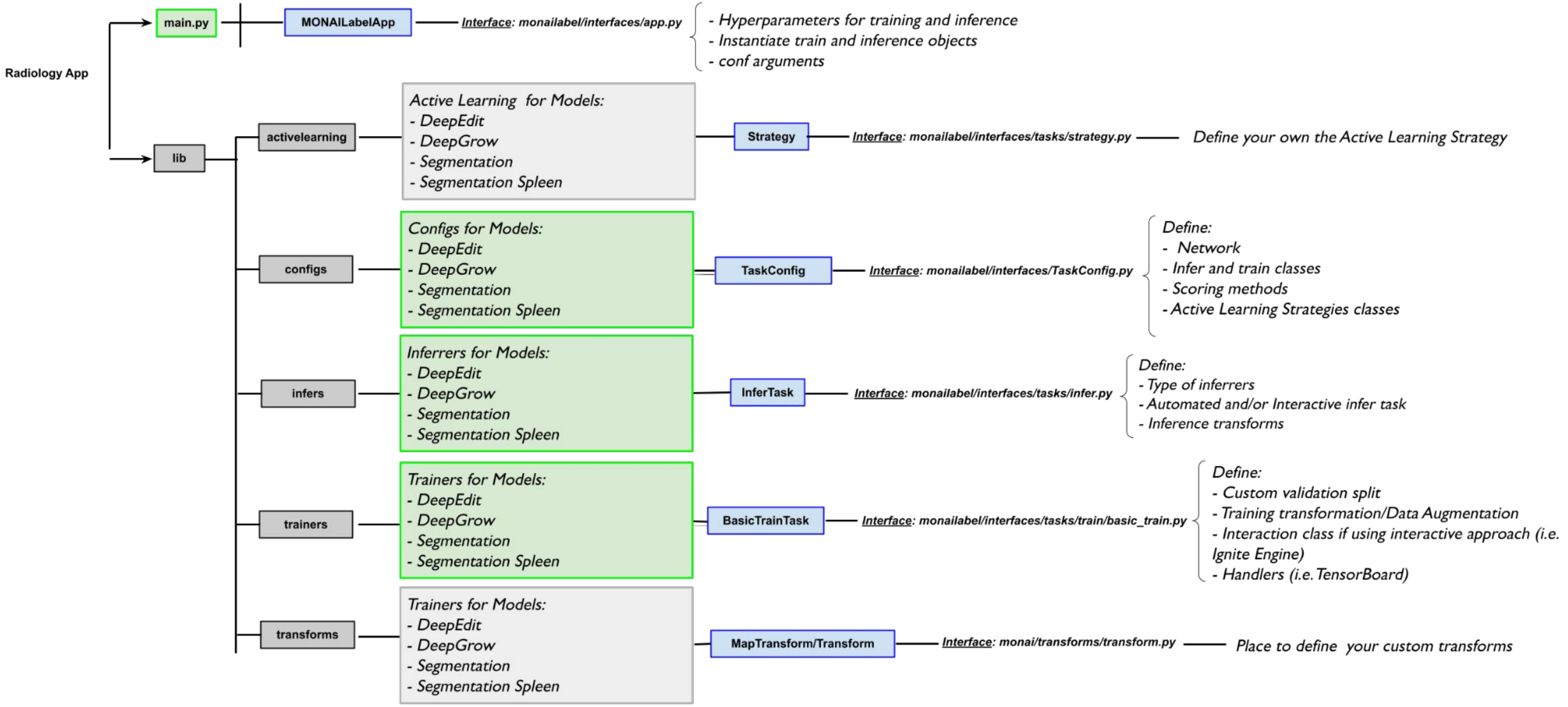
Advanced changes:

- ***Select the spatial/intensity transforms*** to preprocess images for training and inference
- ***Define the active learning*** technique use in the labeling app
- ***Define neural network architecture***
- ***Upgrade interactions:*** Preprocess ROI, closed curve, or any input sent to the MONAI Label server through the REST API

Users can directly use samples models (i.e. DeepGrow, DeepEdit and Segmentation) to jumpstart the development of their own custom labeling apps

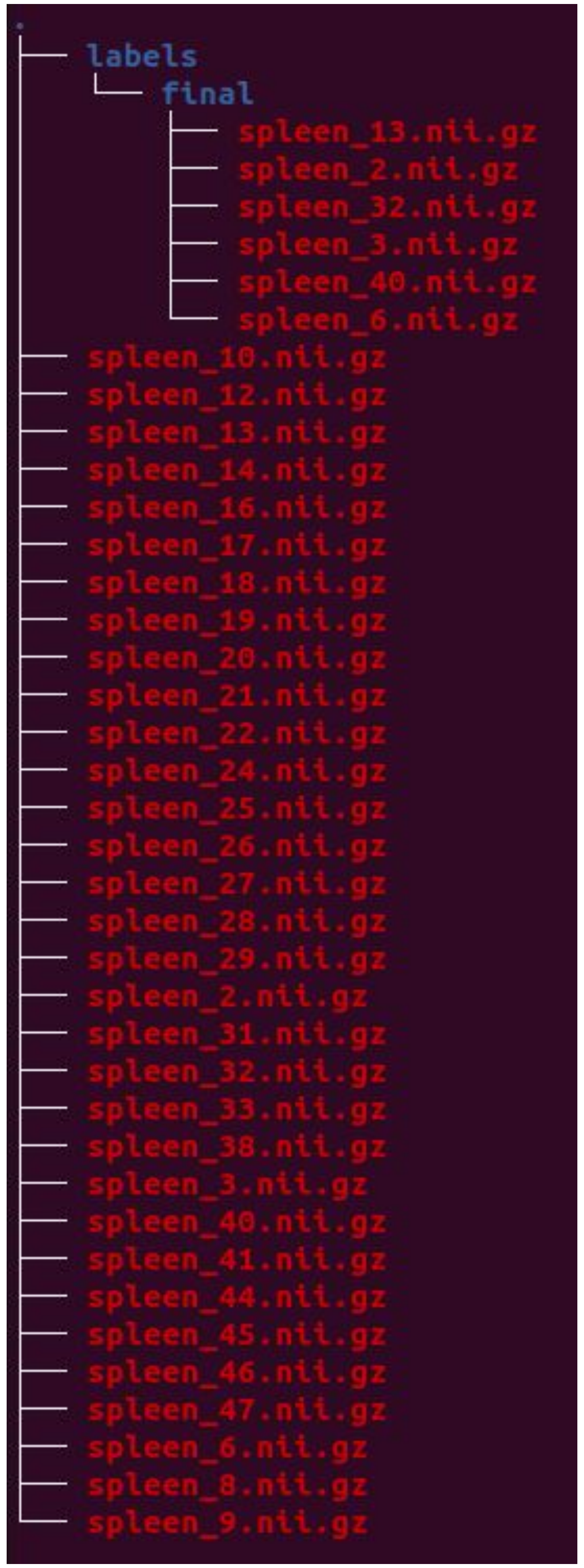
How to create a MONAI Label App?

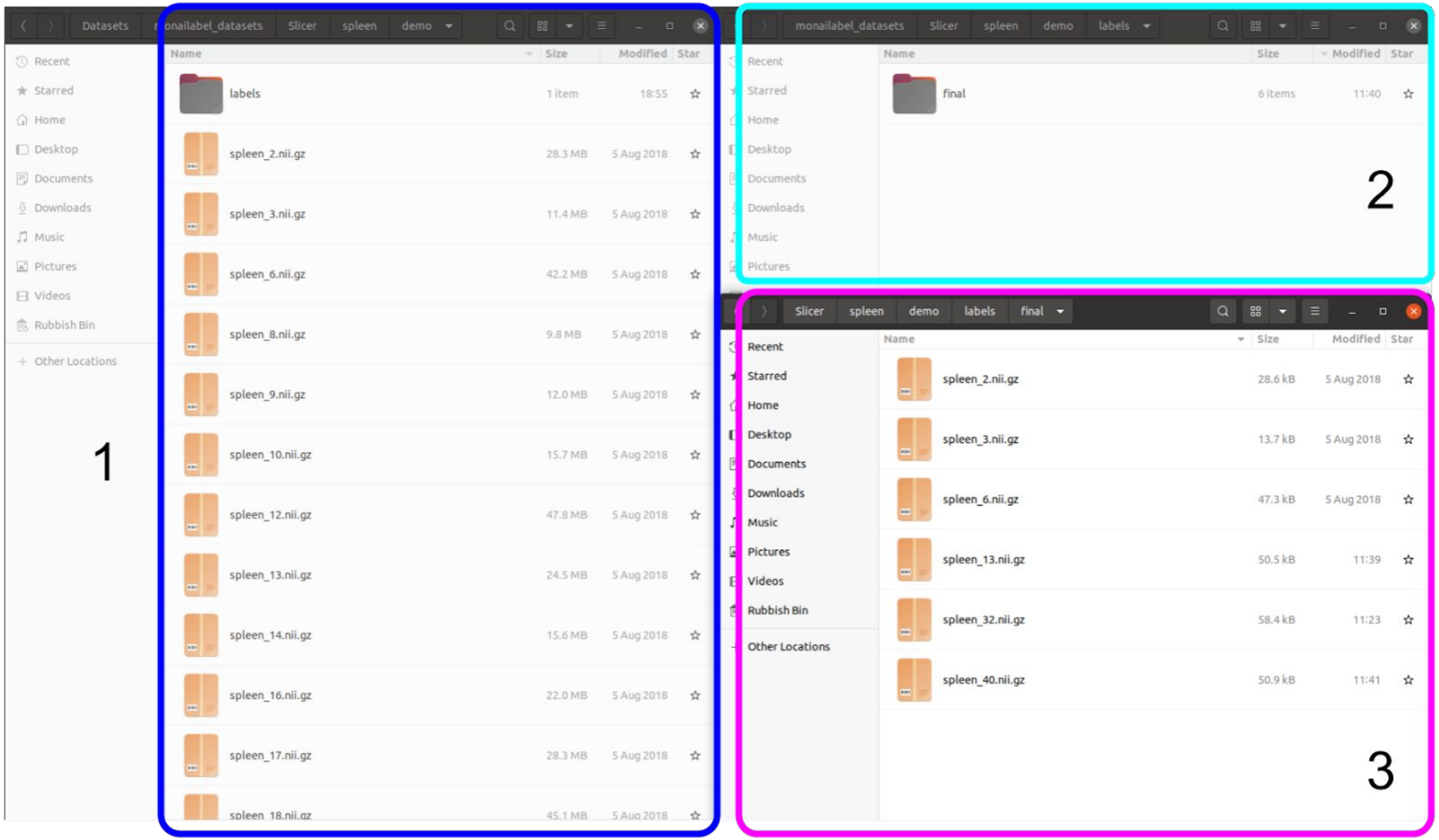
MONAI Label App Structure



How to create a MONAI Label App?

Datastore in file archive



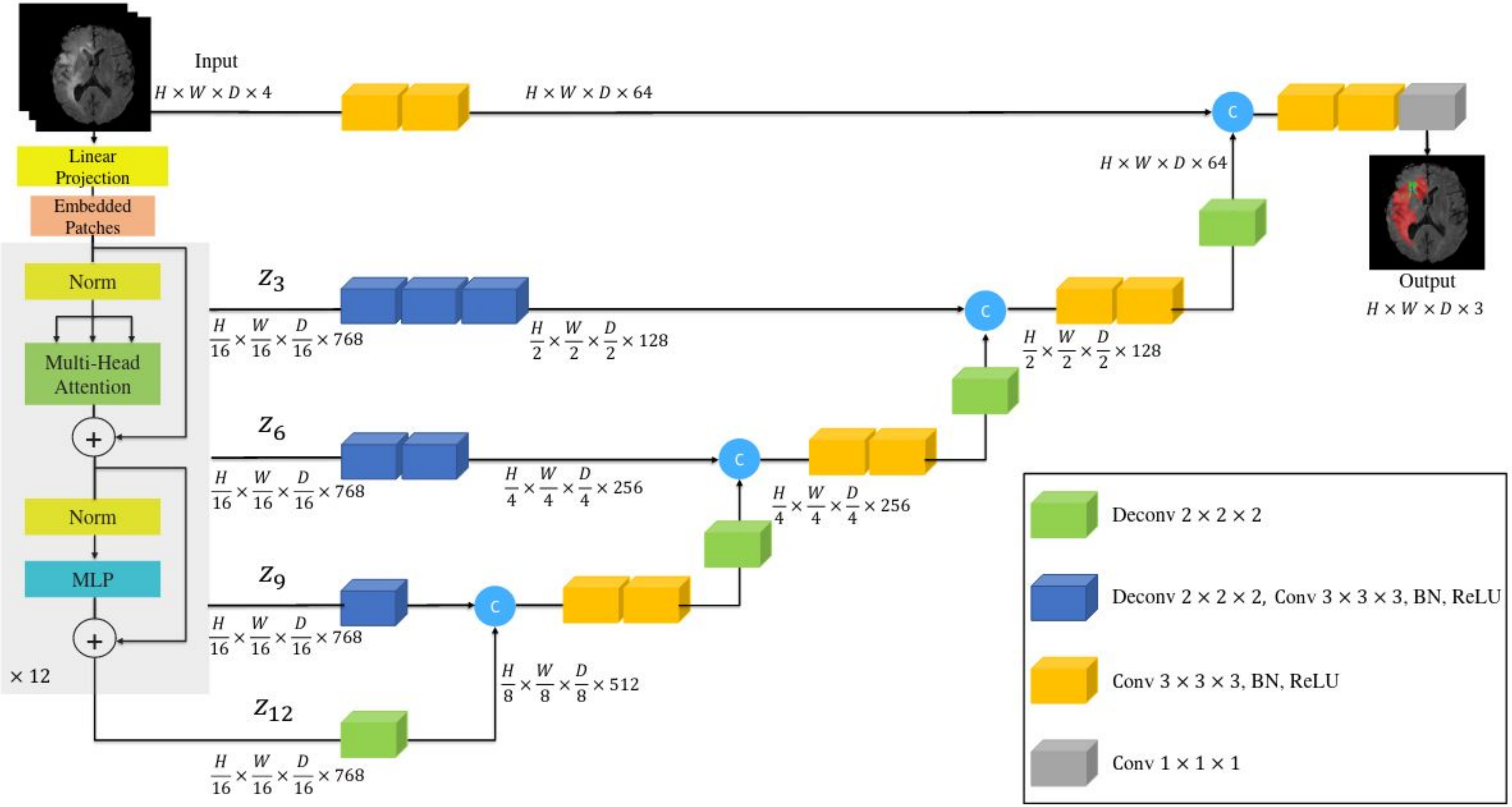


For the cases on which labels are available

How to create a MONAI Label App?

Possible backbones

- UNET
- UNETR
- DynUNet
- Any PyTorch CNN

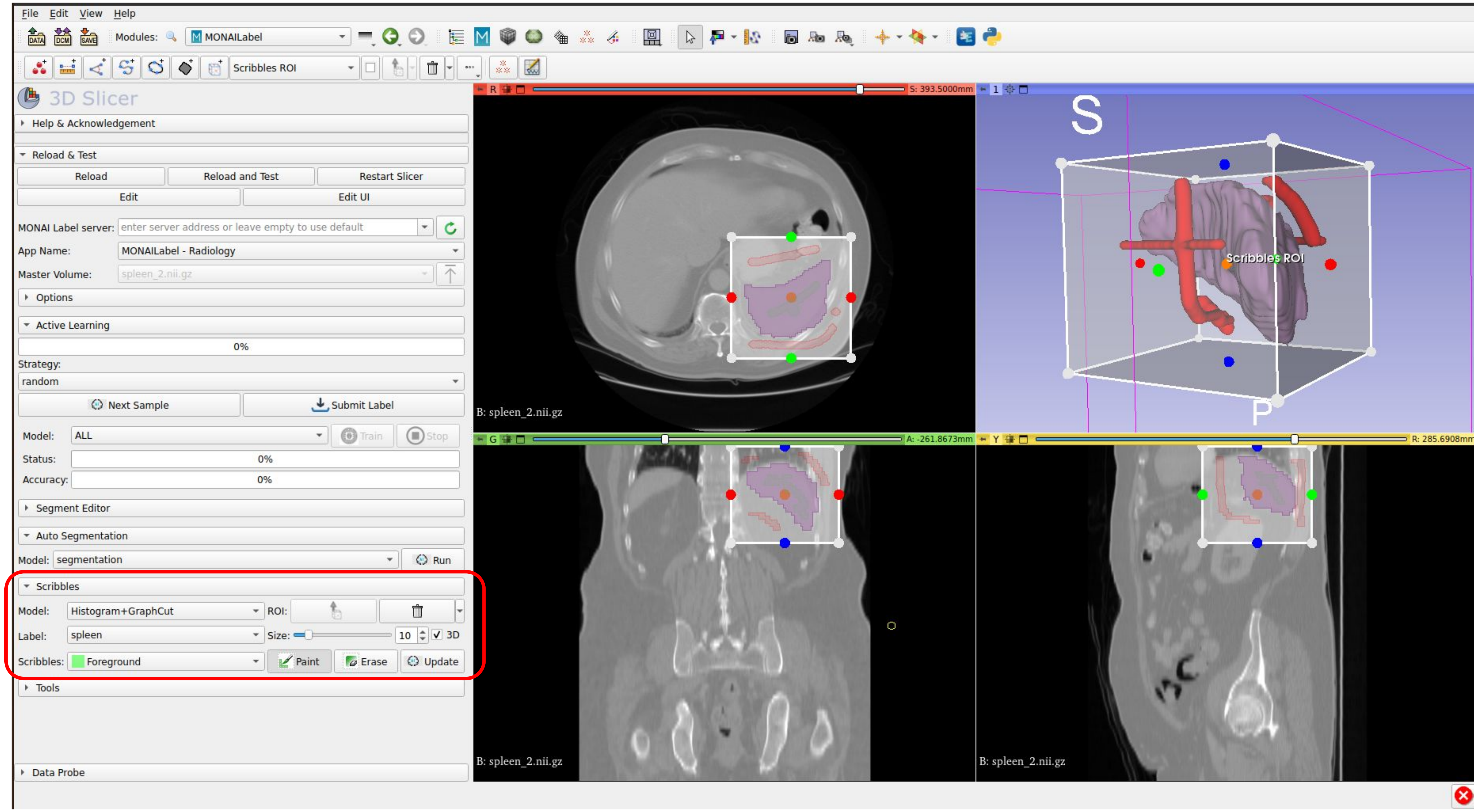


Hatamizadeh A. et al., **UNETR: Transformers for 3D Medical Image Segmentation**. 2021

How to create a MONAI Label App?

Create your customised Slicer Module

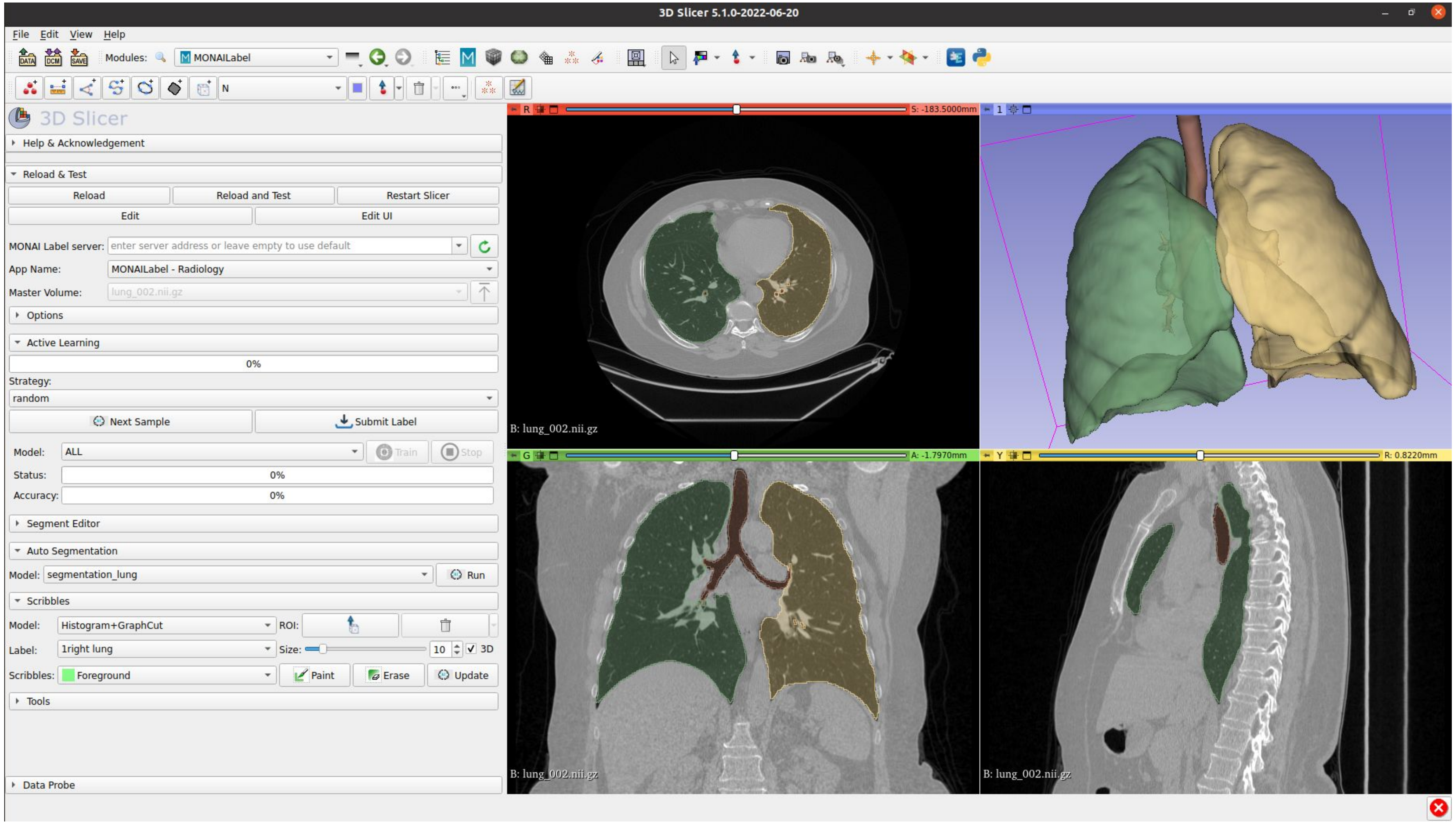
- More dynamic extensions! Support different types of interactions such as closed curves.
- MONAI Label backend APIs can support those interactions (i.e. text input, binary input)



Radiology Use cases

Lung & Airway Segmentation

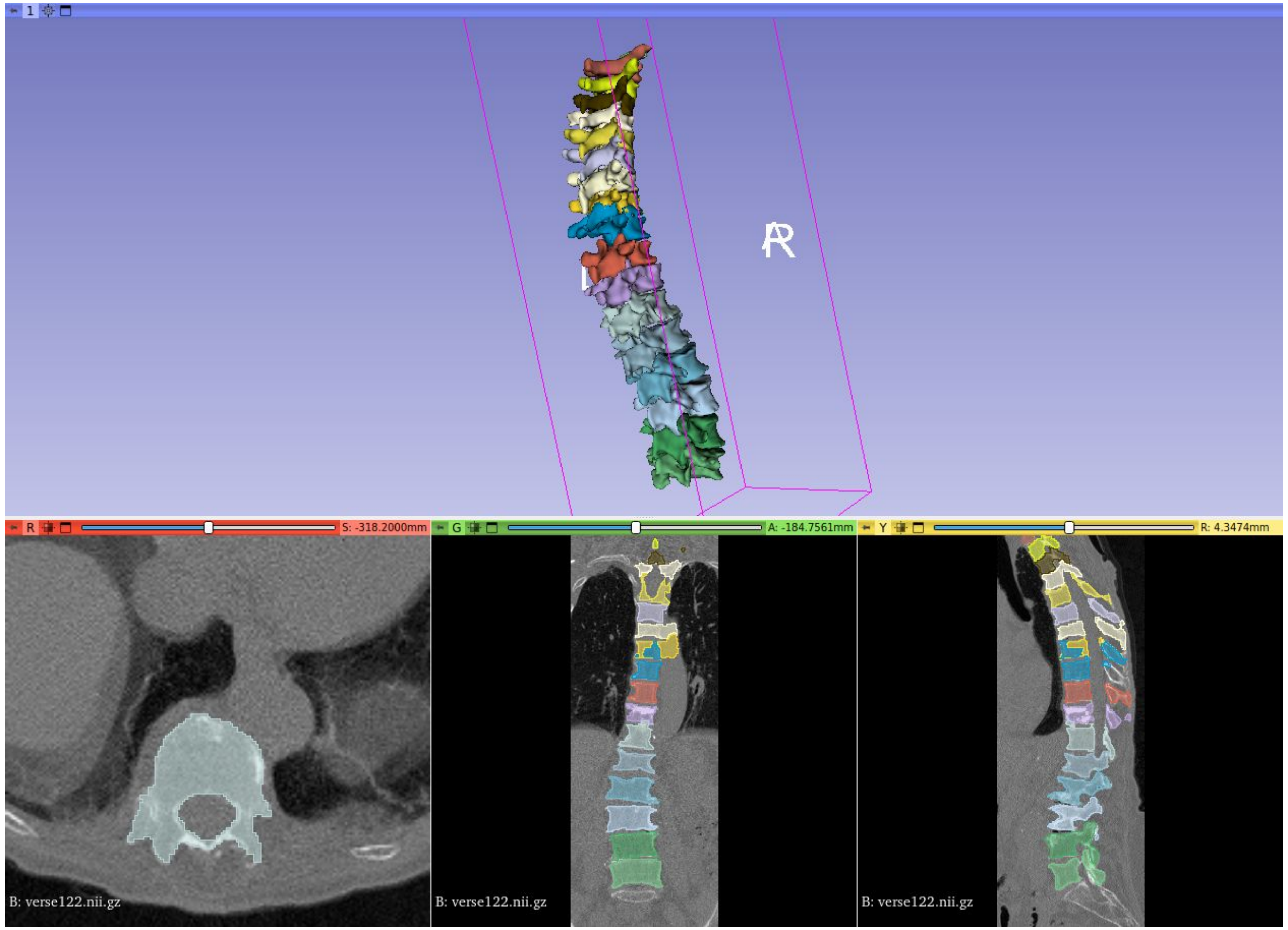
Results obtained after training on **Task06_Lung** dataset from the Medical Segmentation Decathlon (http://medicaldecathlon.com/).



Lung labels have been created by Dr Rudolf Bumm as part of the Slicer Hackathon project: https://projectweek.na-mic.org/PW37_2022_Virtual/Projects/MONAILabelLung/

Spine & Vertebra Segmentation

Results obtained after training on **VerSe** dataset (https://github.com/anjany/verse).

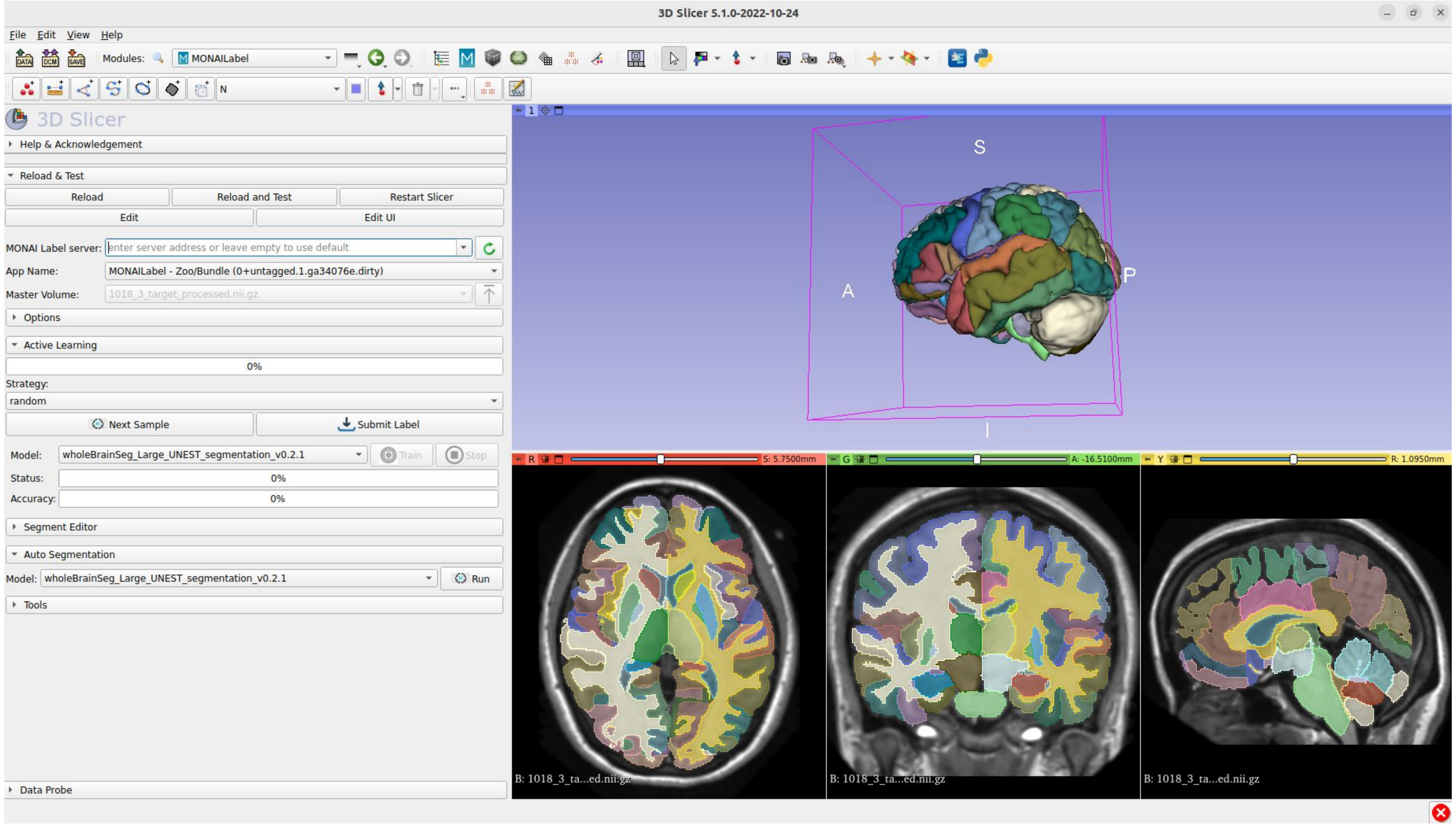


Whole brain Segmentation

Results obtained after training on **OASIS and CANDI datsets.**

Training and testing data are MRI T1-weighted (T1w)

https://github.com/Project-MONAI/model-zoo/tree/dev/models/wholeBrainSeg_Large_UNEST_segmentation



Scribbles in MONAI Label

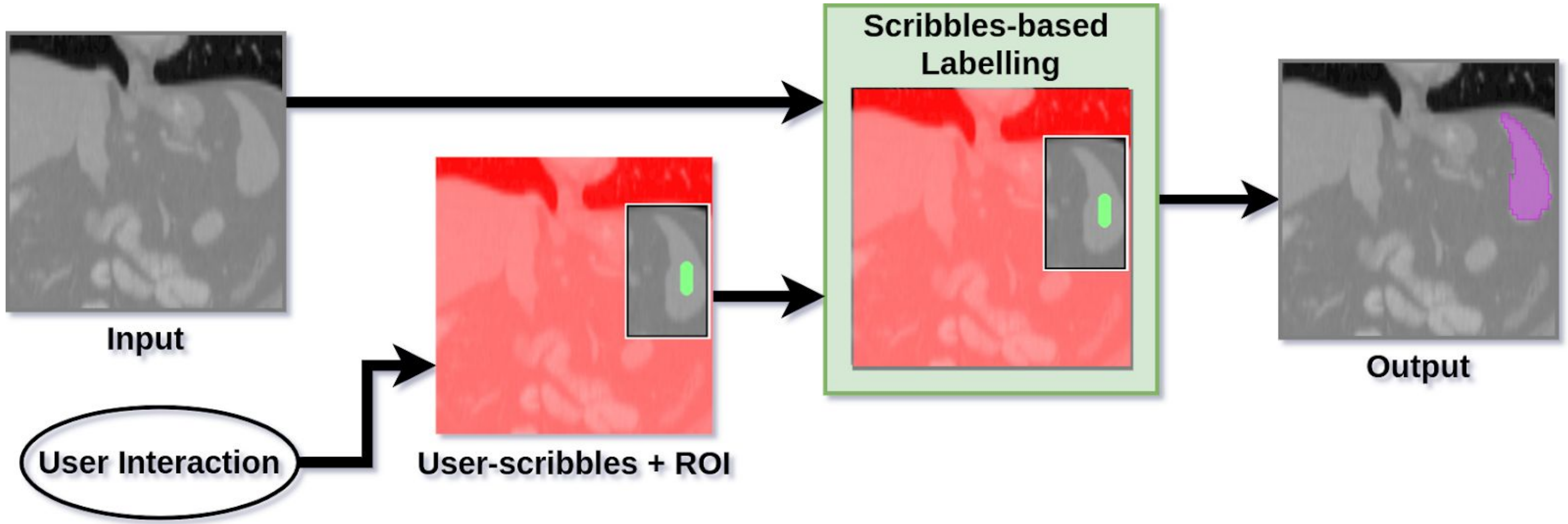
Scribbles in MONAI Label

Scribbles: free-hand line drawings for minimal interaction

- MONAI Label provides two scribbles-based modes:

  Scribbles-only: uses scribbles to generate segmentation labels (demo) [1, 2]

  Scribbles-based refinement: refines labels from a deep learning model [2]

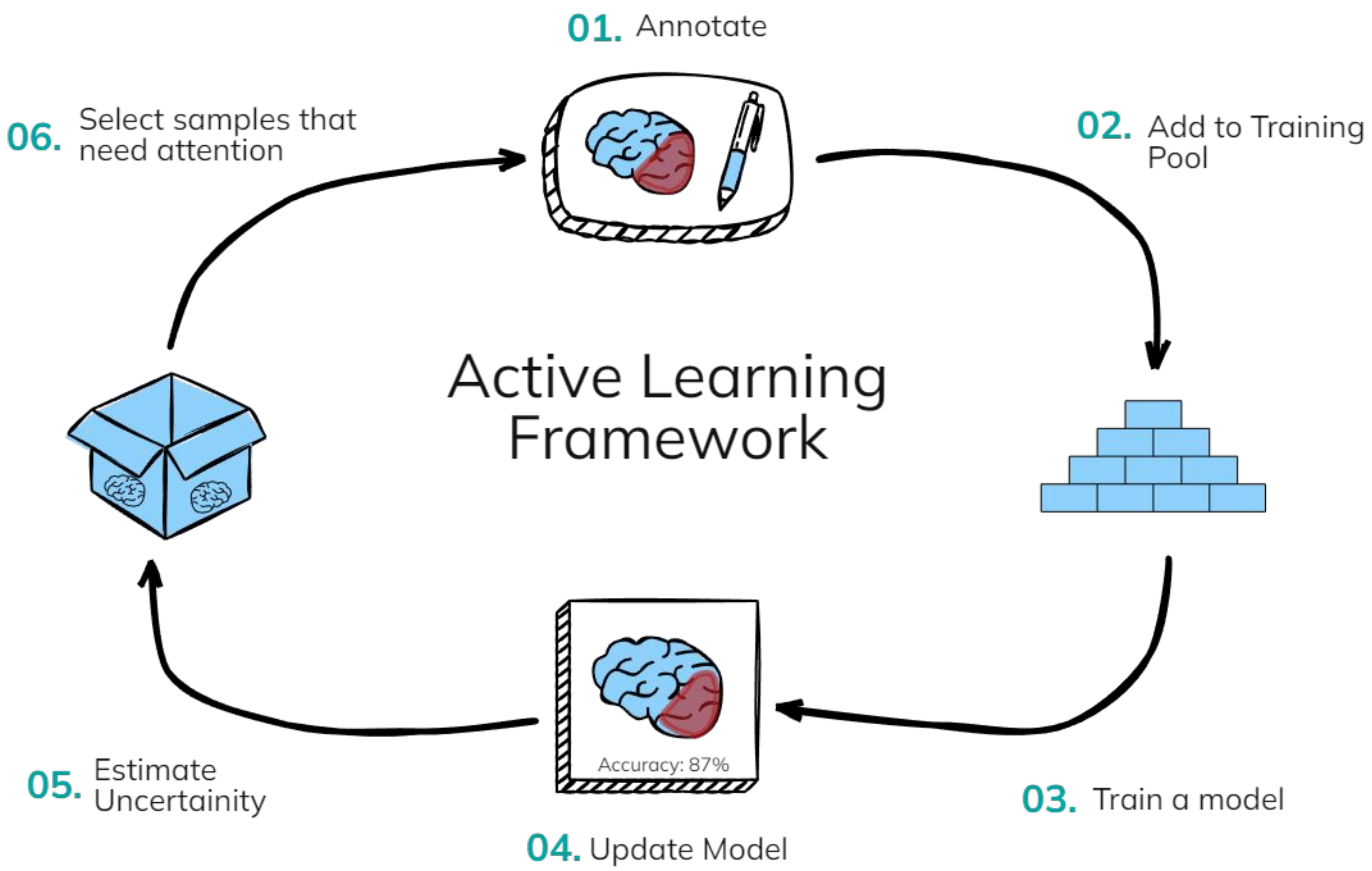


[1] Criminisi, Antonio, et al. "Geos: Geodesic image segmentation." ECCV, 2008.
[2] Wang, Guotai, et al. "Interactive medical image segmentation using deep learning with image-specific fine tuning." IEEE TMI, 2018.

Active Learning Strategies

Active Learning Strategies

- Active learning is a semi-supervised machine learning approach where the algorithm can choose which data it wants to learn from
- Available in MONAI Label: Aleatoric (Test Time Augmentation) and Epistemic (using Dropout) Uncertainty
- After having a pretrained model, uncertainty of each image can be computed. Unlabeled samples that need more attention from the clinician will be selected
- Selection of harder samples or samples that need more attention



Conclusions and future work

Conclusions and future work

- **Conclusion:**

  MONAI Label is a open source project that facilitates annotations of medical images.

  It is one of the frameworks that uses Active learning strategies to segment medical images.

- **Future Work:**

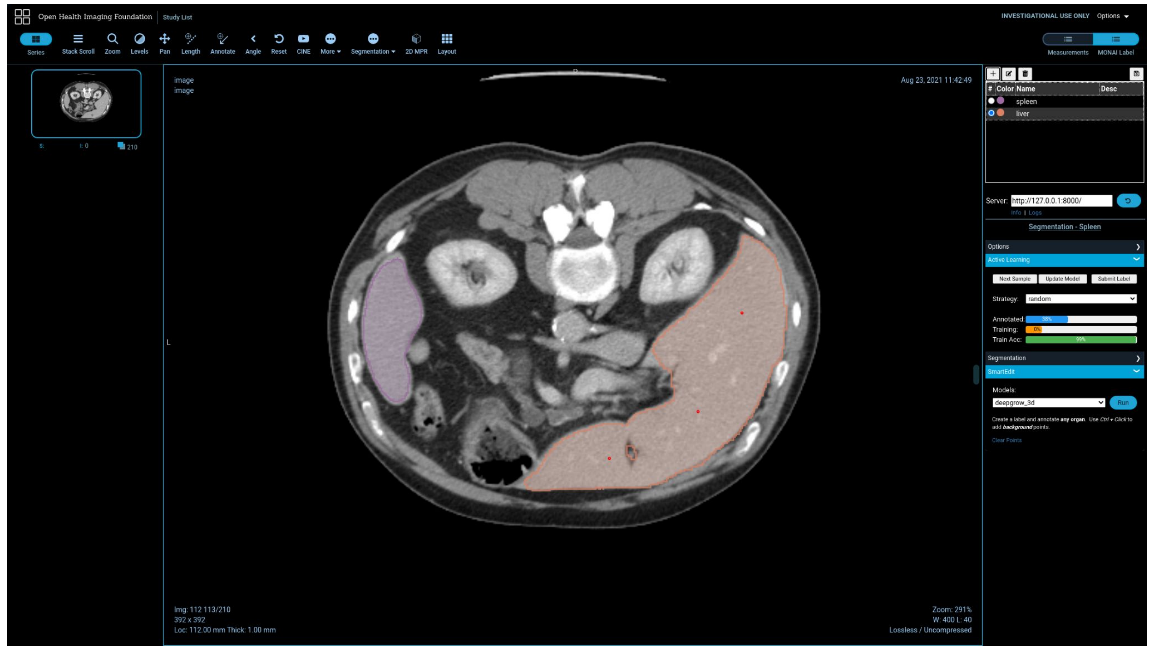
  Standalone version

  “ImageNet” pretrained model for 3D medical image segmentation

  Self-supervised learning or unsupervised learning algorithms to leverage unlabeled data for better performance.

Resources

- **MONAI Label repo**
  https://github.com/Project-MONAI/MONAILabel
- **MONAI Label wiki**
  https://github.com/Project-MONAI/MONAILabel/wiki
- **MONAI Label Deep Dive series**
  https://www.youtube.com/watch?v=8y1OBQs2wis&list=PLtoSVSQ2XzyD4lc-lAacFBzOdv5Ou-9IA
- **Quick start**
  https://github.com/Project-MONAI/MONAILabel/blob/main/README.md
- **MONAI Label + OHIF**
  https://github.com/Project-MONAI/MONAILabel/tree/main/plugins/ohif
- **Active Learning**
  https://github.com/Project-MONAI/MONAILabel/wiki/Active-Learning
- **FAQ**
  https://github.com/Project-MONAI/MONAILabel/wiki/FAQ



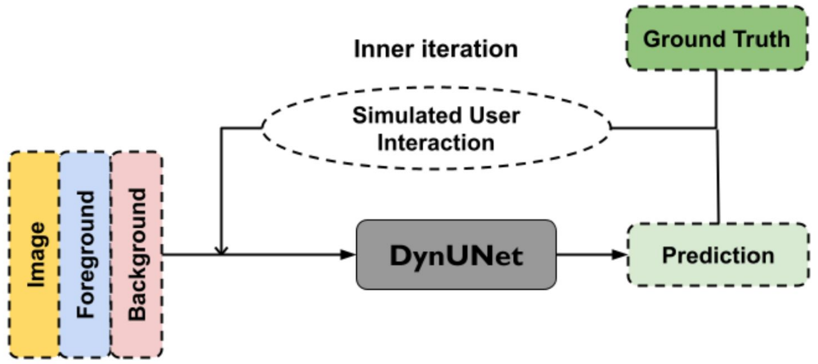
DeepEdit

Andres Diaz-Pinto edited this page on 16 Sep 2021 · 20 revisions

DeepEdit is an algorithm that combines the power of two models in one single architecture. It allows the user to perform inference, as a standard segmentation method (i.e. UNet), and also to interactively segment part of an image using clicks (Sakinis et al.). DeepEdit aims to facilitate the user experience and at the same time the development of new active learning techniques.

Training schema:

The training process of a DeepEdit App involves a combination of simulated clicks and standard training. As shown in the next figure, the input of the network is a concatenation of three tensors: image, positive (foreground) and negative (background) points or clicks. This model has two types of training: For some iterations, tensors representing the foreground and background points are zeros and for other iterations, positive and negative clicks are simulated so the model can receive inputs for interactive segmentation. For the click simulation, users can take advantage of the already developed transforms and engines in MONAI.



NVIDIA

DEEP
LEARNING
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