Tutorial: MONAI LABEL

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Agenda

- What is MONAI?

- What is MONAI Label?

- How to create a MONAI Label App?

- MONAI Label Success Story

- Demo: Radiology & Pathology Sample Applications

- Resources

- MONAI Label on HiperGator

WHAT IS MONAI?

Medical Open Network for AI
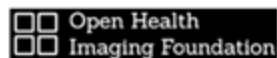
Project MONAI

- a collaborative open-source initiative

- founded at MICCAI 2019

- <u>establish and standardize</u> the best practices for deep learning in healthcare imaging to <u>accelerate</u> the pace of innovation.
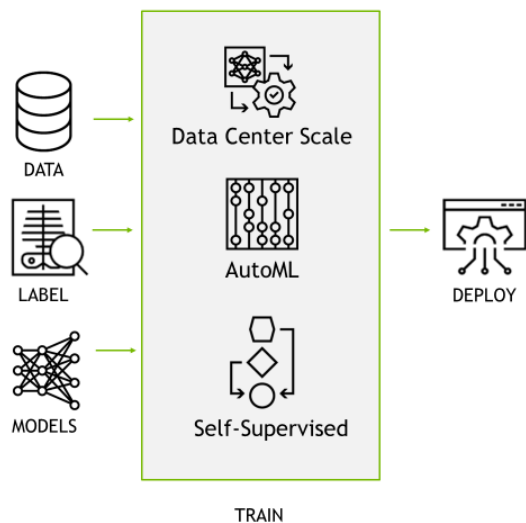
MONAI+

World's Most Advanced Framework for Medical AI
600K Downloads of MONAI Core

STATE-OF-THE-ART AI
From Data to Deployment Dev Tools

DATA → Data Center Scale
LABEL → AutoML
MODELS → Self-Supervised
→ DEPLOY

TRAIN

GLOBAL ECOSYSTEM
Community Lead | Accessibility

World Leading Contributors

AI CENTRE for Value Based Healthcare · dkfz. German Cancer Research Center · Frederick National Laboratory for Cancer Research · IOWA

King's College London · kitware · MAYO CLINIC · Mass General Brigham

Guy's and St Thomas' NHS Foundation Trust · NVIDIA · TUM Technische Universität München · UCSF · ci² center for intelligent imaging

Universitätsklinikum Essen · Vanderbilt University · WARWICK The University of Warwick

Integration Partners

Amazon SageMaker · Microsoft · Google Cloud Platform · mlflow

3DSlicer · Open Health Imaging Foundation · Answer · quantiphi Solving What Matters

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EXPONENTIAL GROWTH
Accelerating Open Research

50K MONTHLY DOWNLOADS

MONAI Monthly Downloads

50K, 45K, 40K, 35K, 30K, 25K, 20K, 15K, 10K, 5K, 0K

11/2020 02/2021 05/2021 08/2021 11/2021 05/2022
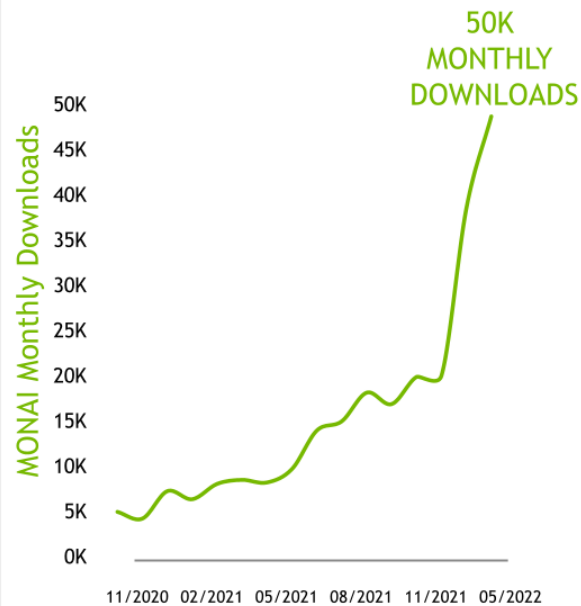
R&D MOMENTUM
Publishing to Production

Top 30+
Research Medical Centers Published over 150 papers

AI CENTRE for Value Based Healthcare — **AIDE: A NEW OPERATING SYSTEM FOR THE HOSPITAL**
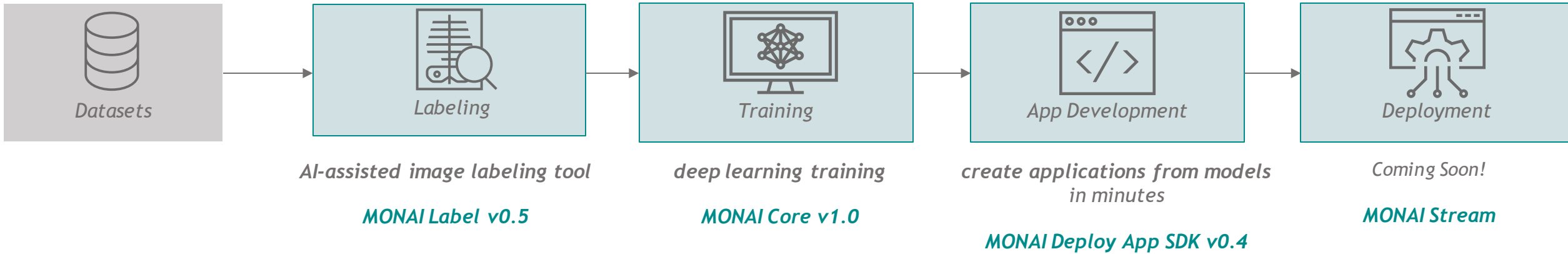
MAYO CLINIC — **EXPERIENCES WITH ALGORITHM DEPLOYMENT IN HEALTHCARE SETTINGS**

aws — **ACCELERATE YOUR MEDICAL IMAGING RESEARCH WITH MONAI ON AWS**

WHAT IS MONAI?

## Accelerate Pace of Research Innovation With a Common Foundation

Datasets

Labeling

AI-assisted image labeling tool

MONAI Label v0.5

Training

deep learning training

MONAI Core v1.0

App Development

create applications from models
in minutes

MONAI Deploy App SDK v0.4

Deployment

Coming Soon!

MONAI Stream

MONAI Label

AI-assisted image labeling tool

What is MONAI Label?

Infrastructure: client-server system

Endoscopy viewer: CVAT
Pathology viewers: QuPath, DSA, CVAT
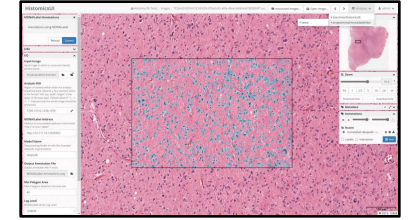
Three main parts
- MONAI Label server
- Datastore
- Clients/GUIs

Annotator / Clinician / Researcher
- Annotate datasets by sample apps, w/wo pre-trained model
  - Build AI annotation models by just submitting labels
  - Less time and effort

- Pre-built plugins for image viewers

Developer / Researcher
- Create new MONAI LABEL apps, e.g.,
  - Implement new annotation methods
  - Implement new active learning techniques

- Rapid app prototyping
  - Make incremental improvements to sample apps
  - Verify effectiveness in real-world scenarios
  - Deploy MONAI Label Apps to wider audiences

Clients/GUIs

3DSlicer

3D Slicer Module

Python client

OHIF

Cornerstone.js

User Interaction   REST API calls   Segmentation

MONAI Label Server

Scribbles-based algorithm

Active Learning Strategies

Heuristic Planner

DeepGrow   DeepEdit   Automatic Segmentation

Studies

Image

DICOMweb

Label

File Archive
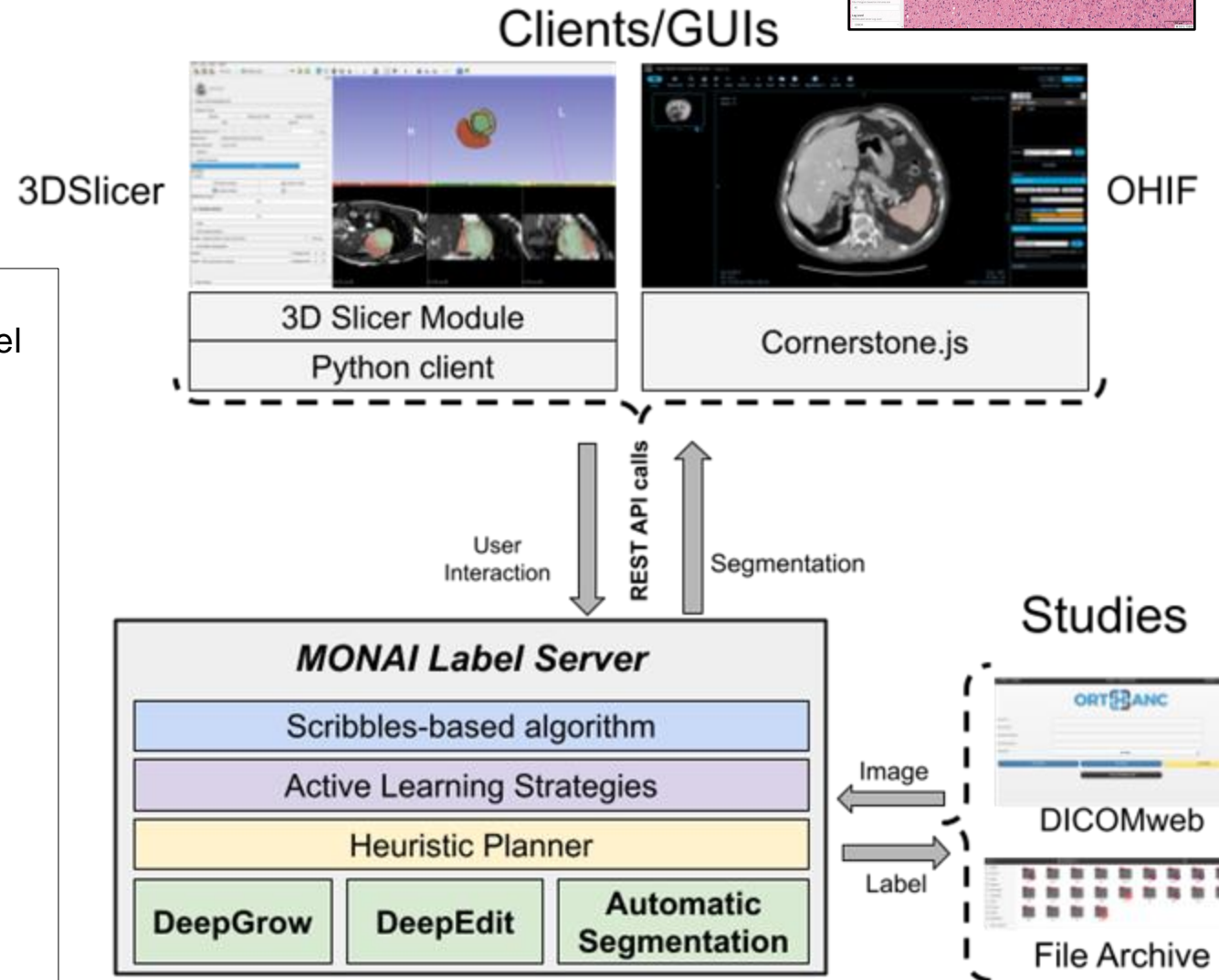
What is MONAI Label?

Server: Active Learning Strategies

- **Why use Active Learning Strategies?**
- o Random selection is not always the most efficient.
- o A semi-supervised machine learning approach where the algorithm can choose which data it wants to learn from
- o E.g., train on <u>harder/more uncertain</u> ones first.

- **Strategies available in MONAI Label**
- o Aleatoric Uncertainty (based on Test-Time Augmentation)
- o Epistemic Uncertainty

- **After having a pretrained model**
- o Uncertainty of each image is computed.
- o Unlabeled samples that are <u>harder/need more attention from the clinician</u> will be selected.

What is MONAI Label?

Server: Active Learning Strategies

Rinse N' Repeat

MONAI Label Server → Unlabeled Pool → Select Top 'K' For Annotation → Push Annotation Task to CVAT → Annotate via CVAT → Train a new model

More Unlabeled Data Can Be Easily Added

MONAI Label Offers Multiple Active Learning Strategies
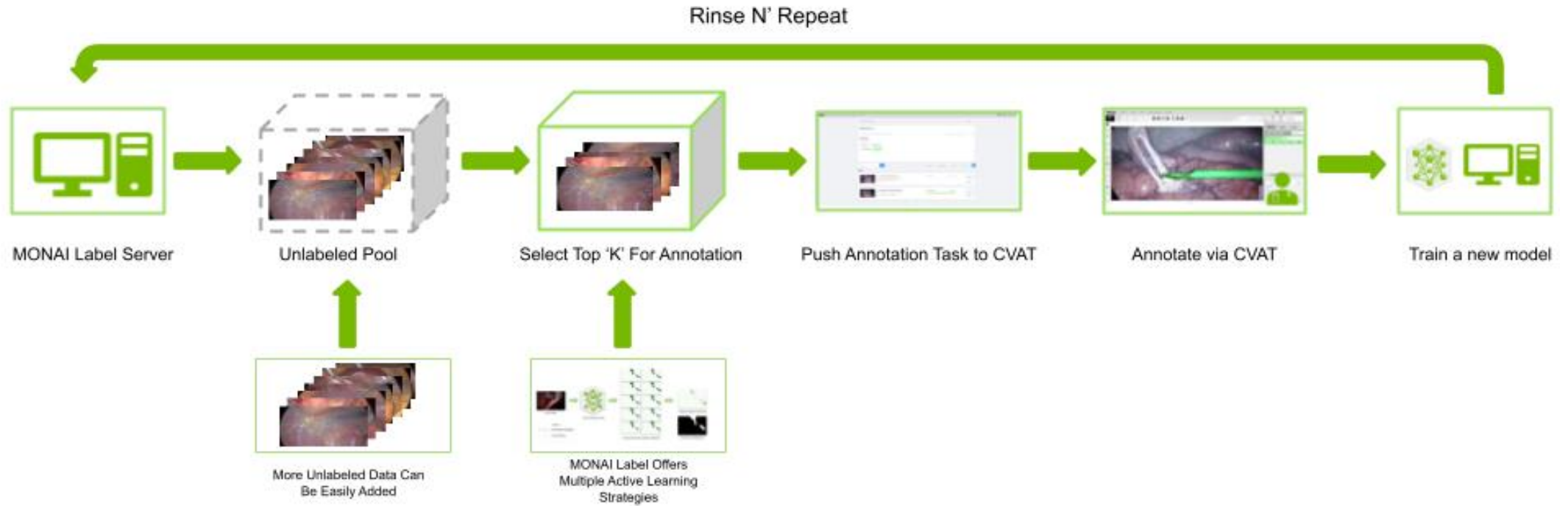
Initial Pool: 50 & Samples Added: 50

- Random
- Variance
- Entropy

----- Test Score (trained on all data)
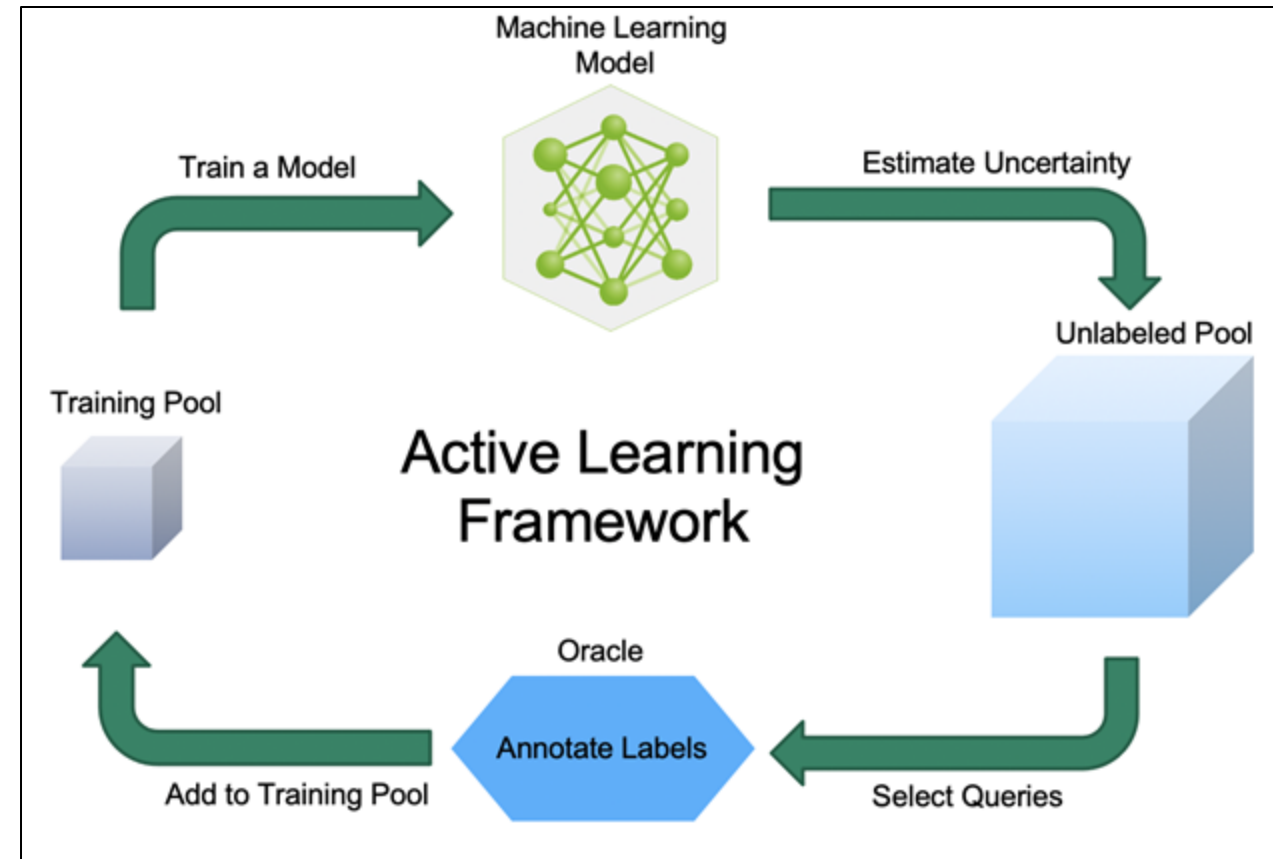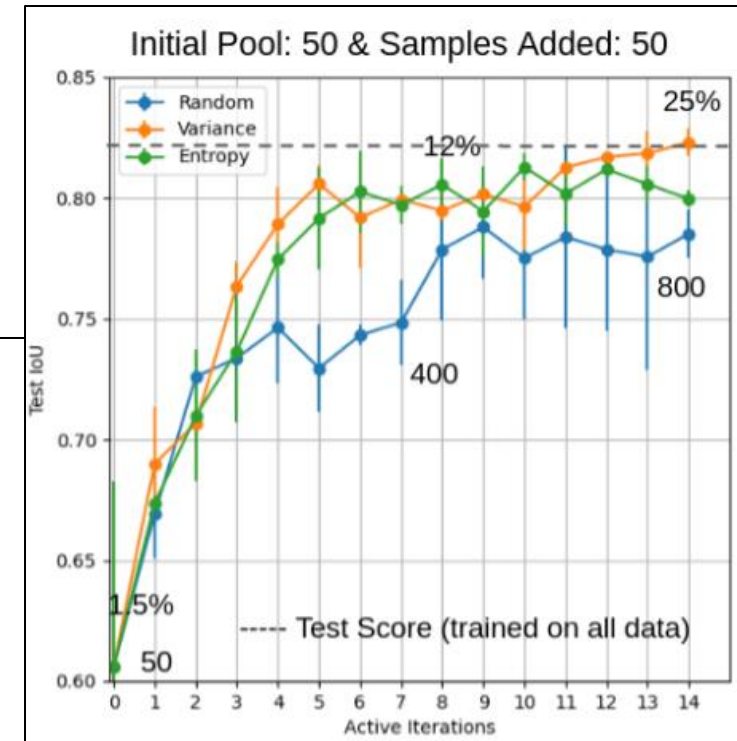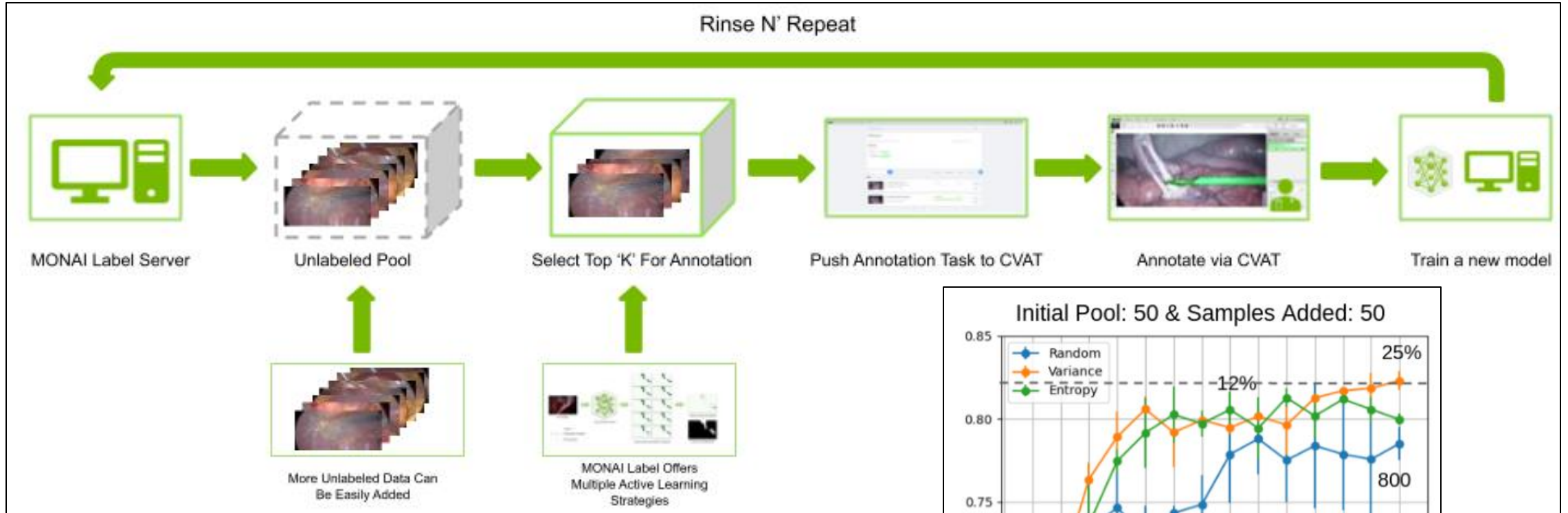
What is MONAI Label?

Server: Heuristic Planner

- Defines image spatial size based on available GPU memory.
- Defines training transforms based on GPU memory, average spatial size and spacing of datastore.
- Performs sanity checks before starting training.
- Shows warning in case images are multimodality or multilabel.
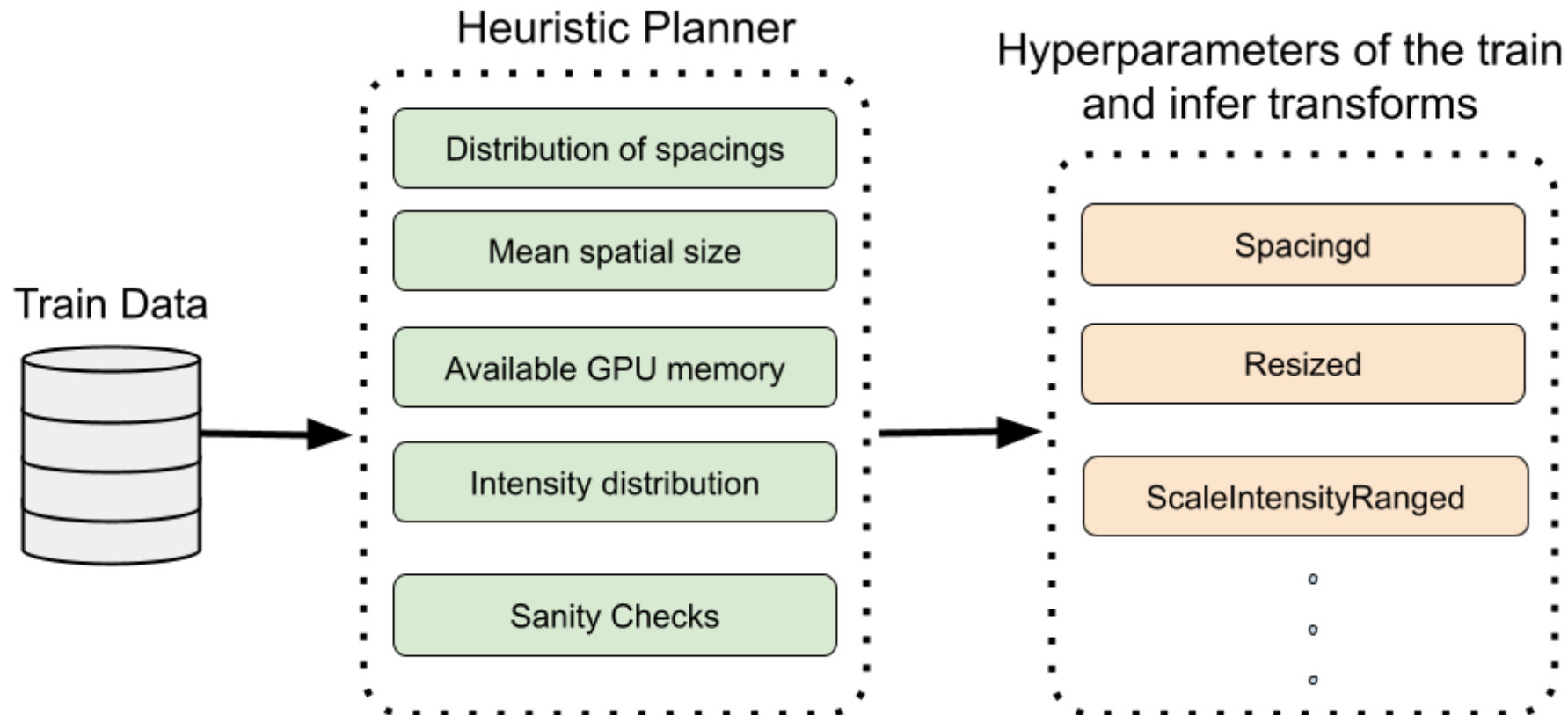
What is MONAI Label?

Server: Scribbles-based algorithms

- **Scribbles:** free-hand line drawings for minimal interaction

- **Two scribbles-based modes in MONAI Label**
  - Scribbles-only: uses scribbles to generate segmentation labels [1, 2]
  - Scribbles-based refinement: refines labels inferred by 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.
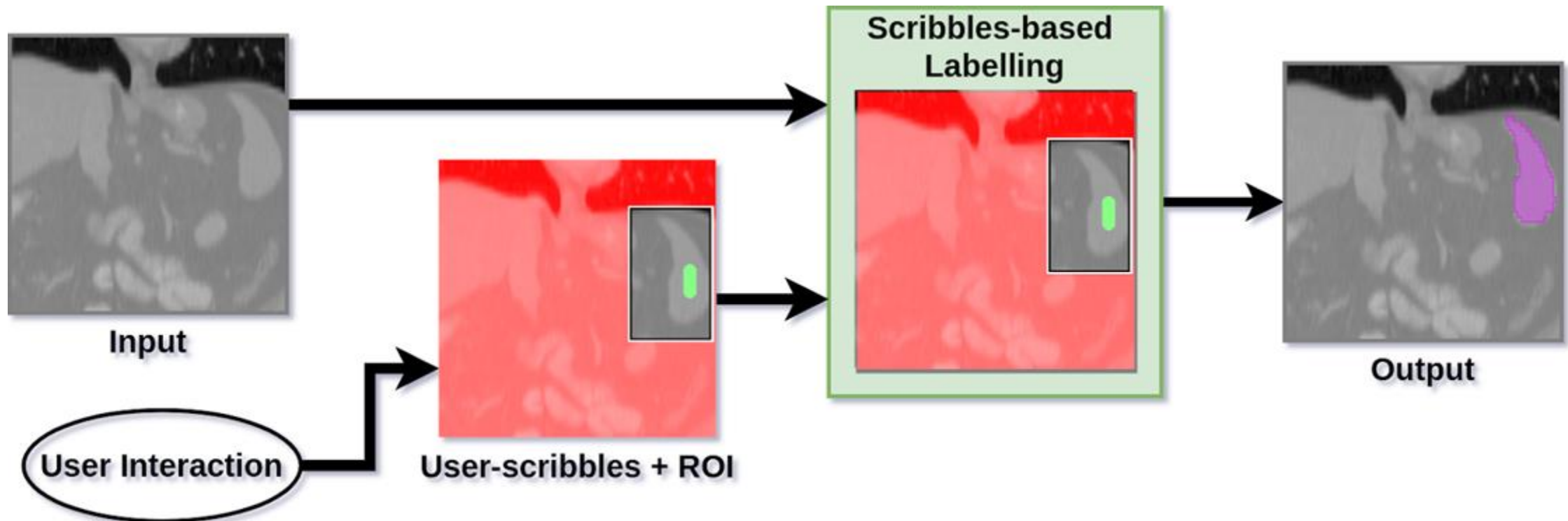
What is MONAI Label?

Datastore
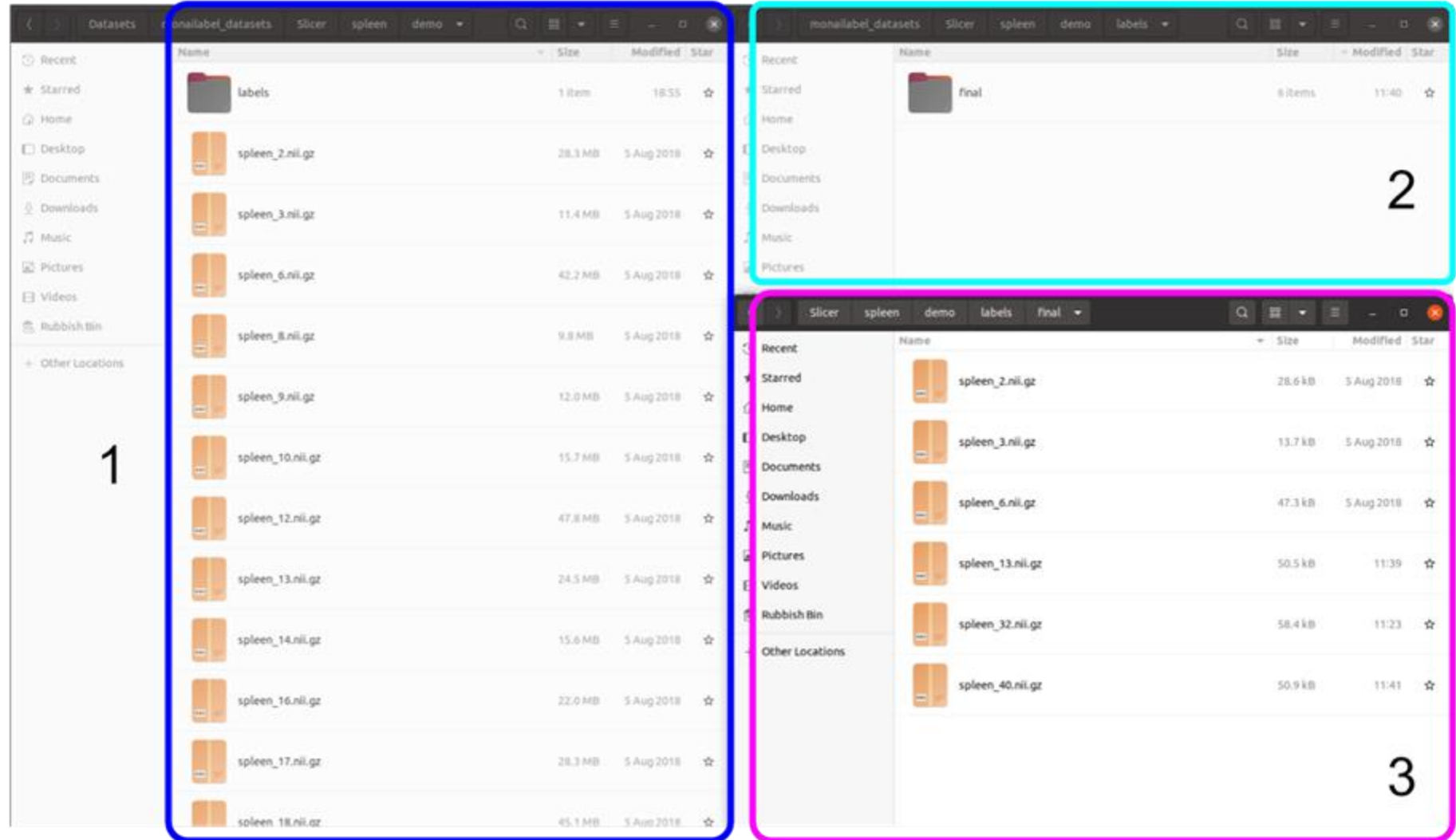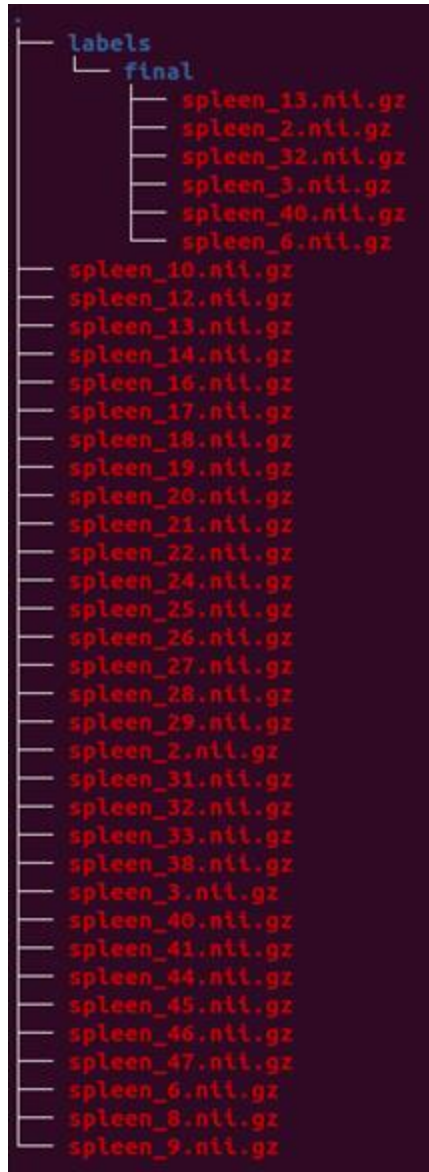
What is MONAI Label?

Client: 3DSlicer

- Open-source

- User-friendly

- Supportive community

- Many manual annotation tools

- Easy to customize

- Ready-to-use MONAI Label plugin
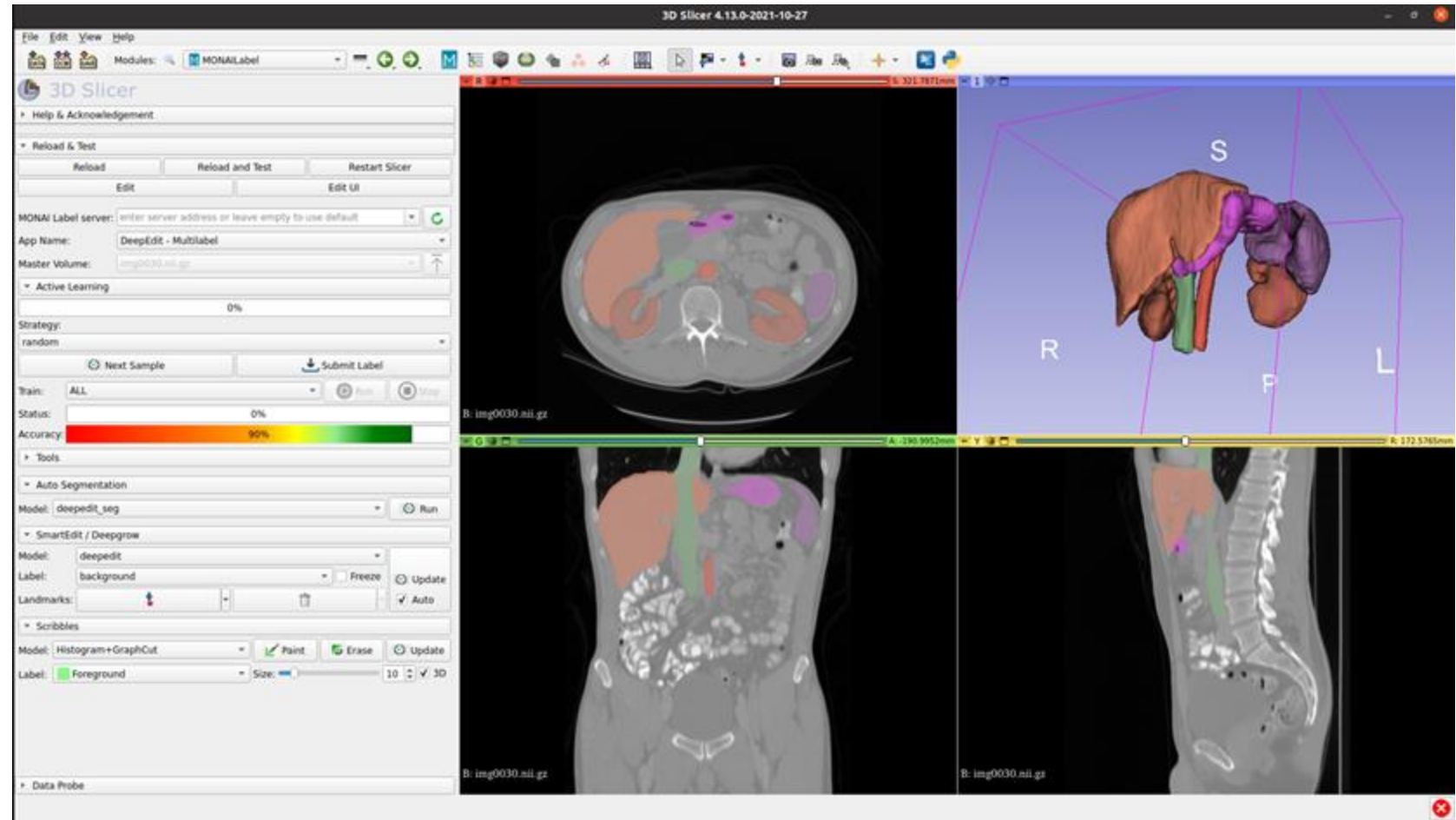
What is MONAI Label?

Client: OHIF viewer (Open Health Imaging Foundation)

- Open-source

- Web-based viewer

- Works out-of-the-box with Image Archives that support DICOMWeb, e.g., Orthanc.

- Beautiful user interface (UI) designed with extensibility in mind.

- Pre-built with MONAI Label

- accessible at http://127.0.0.1:8000/ohif/ when you start monailabel server connecting to local/remote dicom-web storage.
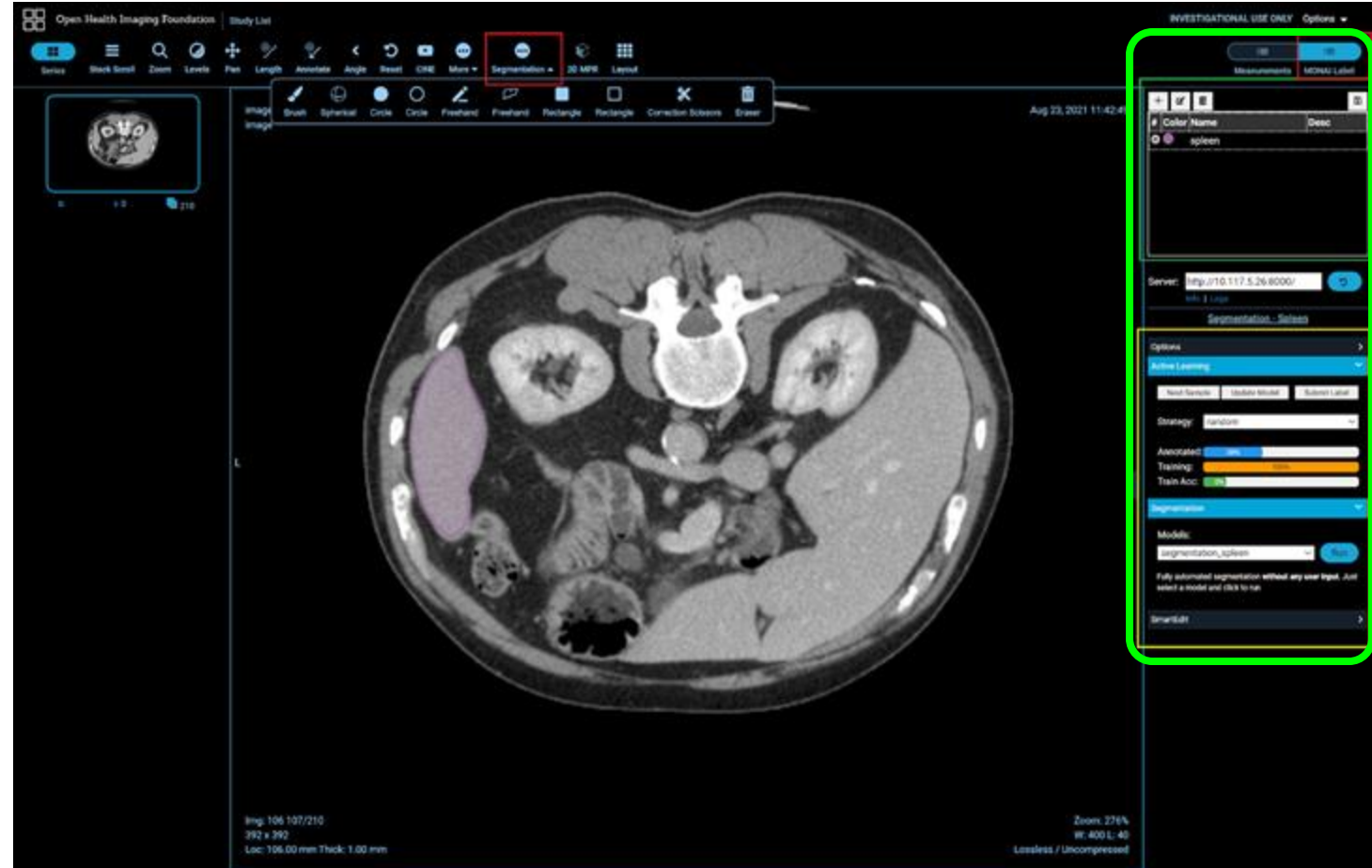
What is MONAI Label?

Client: pathology – QuPath, DSA, CVAT

QuPath
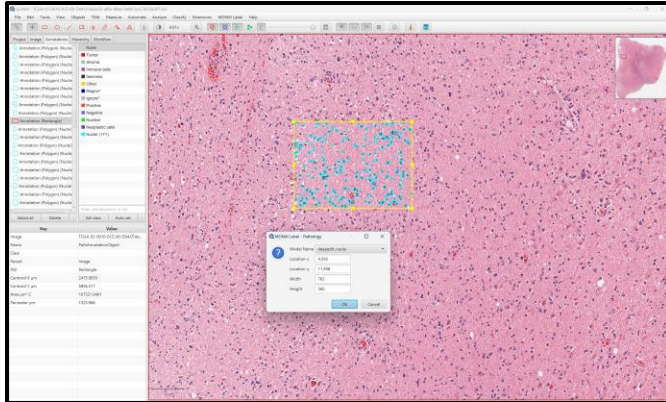
DSA
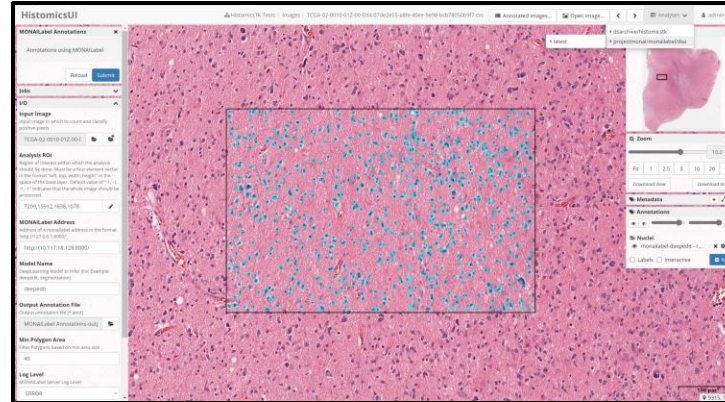
CVAT
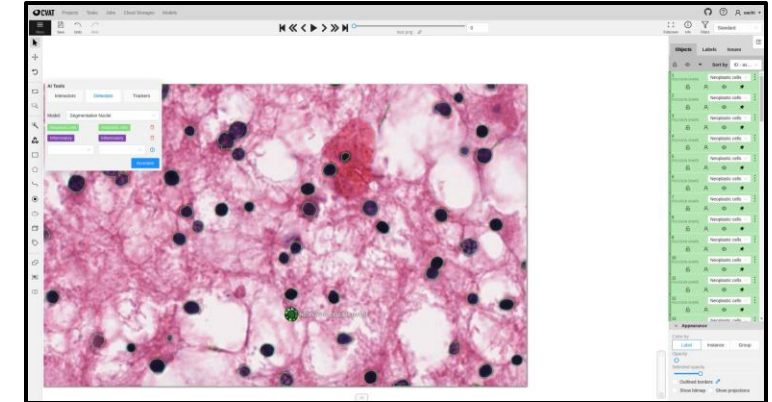
What is MONAI Label?

Client: endoscopy – CVAT

How to create a MONAI Label App?

Start from sample apps

How to create a MONAI Label App?

MONAI Label App Structure

Note: might be small changes of the app structure over versions
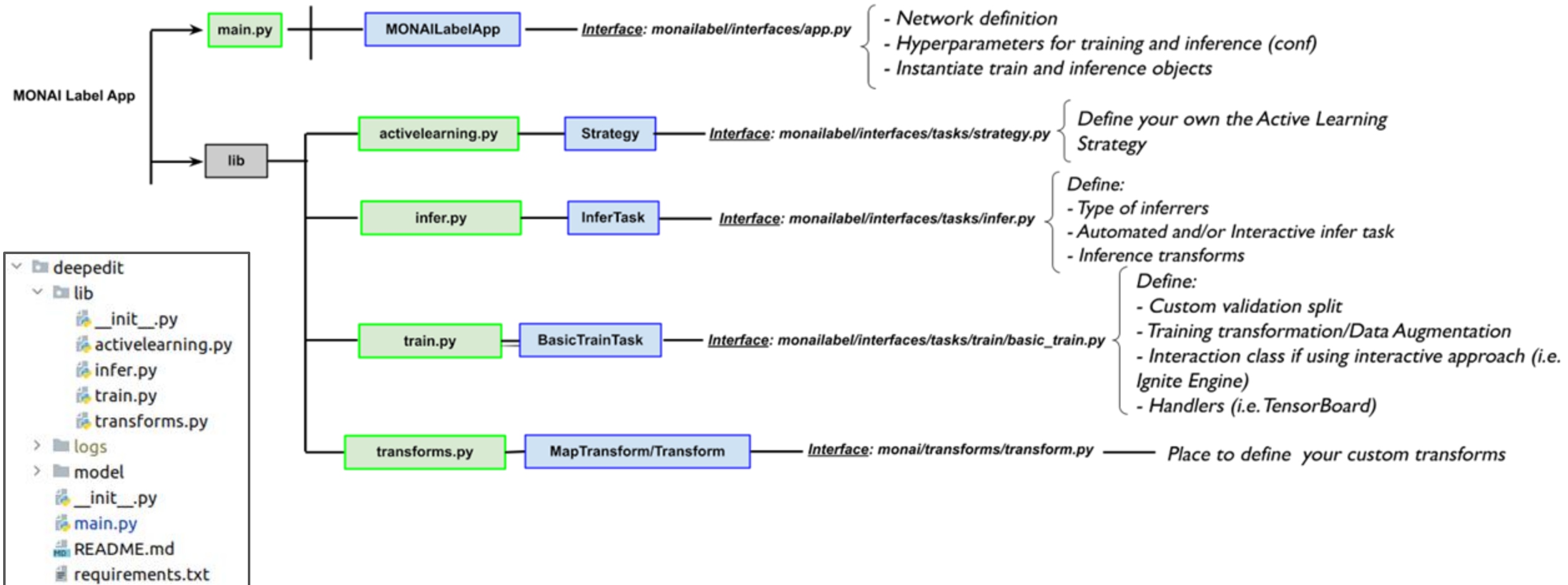
How to create a MONAI Label App?

Create interactions in client plugin

Can support different types of interactions, e.g., **closed curves**.
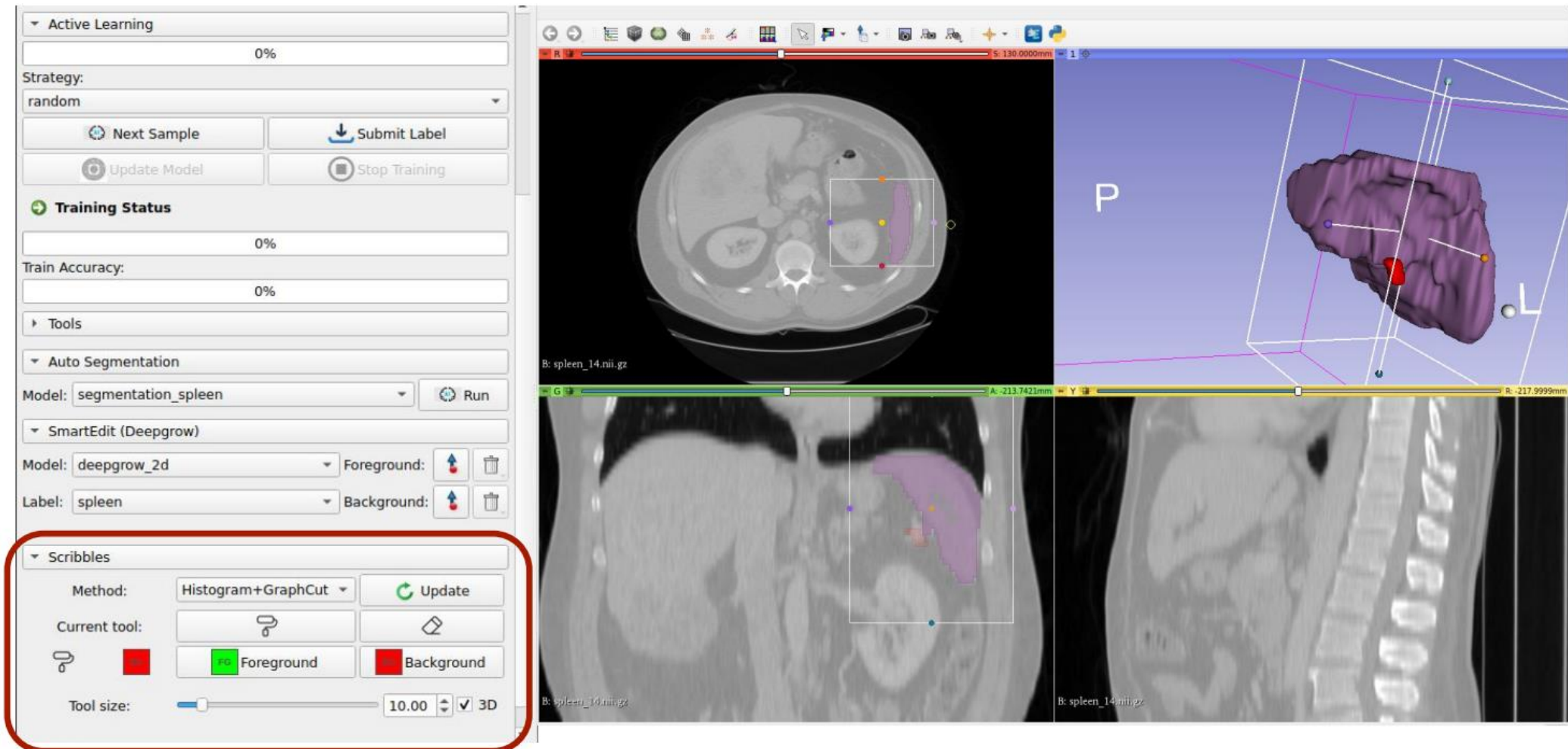
How to create a MONAI Label App?

Integrate to other viewers

- REST API for Clients http://127.0.0.1:8000/

- Requirement for the viewer:
- ○ can REST API calls to the server
- ○ commercial viewers might not allow you to modify

AppService

| GET | /info/ Get App Info |
| GET | /download/{image} Download Image |

Infer

POST	/infer/{model} Run Inference for supported model
GET	/batch/infer Get Status of Batch Inference Task
DELETE	/batch/infer Stop Batch Inference Task
POST	/batch/infer/{model} Run Batch Inference Task

Train

GET	/train/ Get Status of Training Task
POST	/train/ Run Training Task
DELETE	/train/ Stop Training Task

MONAI Label Success Story

Children's Hospital of Philadelphia

"Open-source frameworks like Project MONAI provide a **standardized, transparent, and reproducible template** *for the creation of, and deployment of medical imaged-focused machine learning models, potentiating efforts such as ours. They allow us to* **focus on investigating novel algorithms and their application, rather than developing and maintaining software infrastructure.** *This in turn has* **accelerated research progress** *which we are actively translating into tools of practical relevance to the pediatric community we serve"* – Dr. Matthew Jolley, MD, CHOP
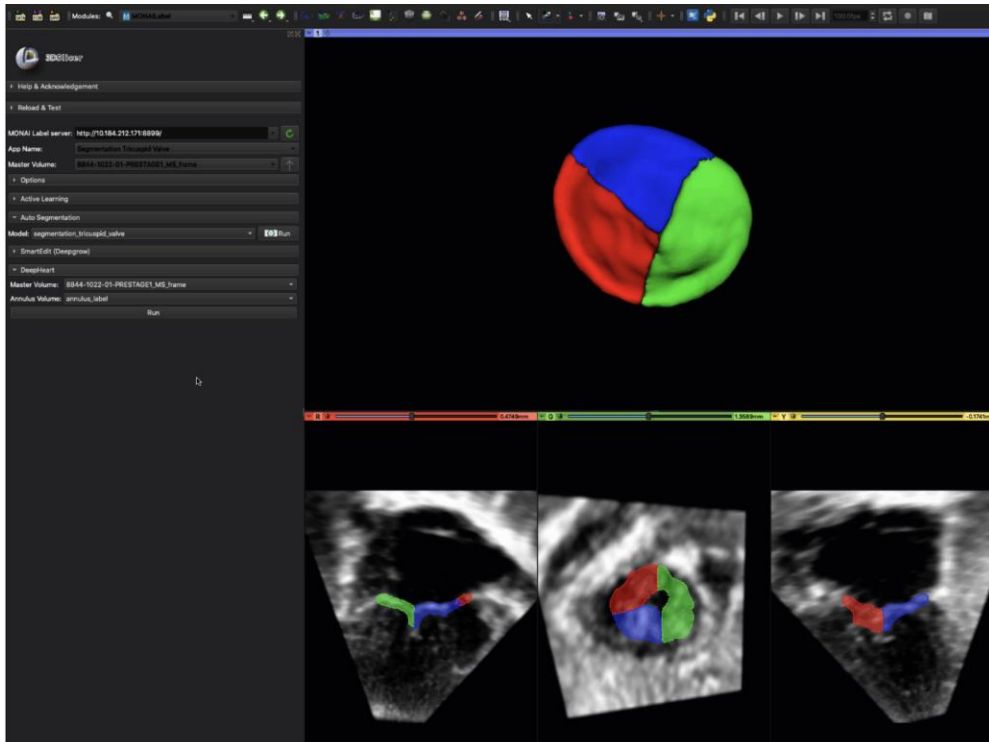
- Creation of a MONAI Label app for leaflet segmentation of heart valves in 3D echocardiographic (3DE) images.

- Require standardized way of collaborating between clinical and research teams.

- Next steps: Deploy this model as a MONAI Label application on a public facing server at CHOP where clinicians can directly interface with the model and trigger a training loop for adaptation.

Radiology Demo
Client: 3DSlicer

Stage 1 - cold start (no labels/pretrained models available), manual from-scratch annotation

   Use active learning strategy
   Annotate - Slicer's internal tools (e.g., Grow-from-Seeds) / MONAI Label plugin's Scribbles
   Start training in the background
   Demo - annotate & train a model for liver segmentation

Stage 2 - decent model, faster annotation

   Use the just-trained model to do auto-segmentation/inference, then refine it interactively
   Demo - start from auto-segmentation predicted by a MONAI Label's pretrained model for multi-organ segmentation

Stage 3 - good model, even faster annotation
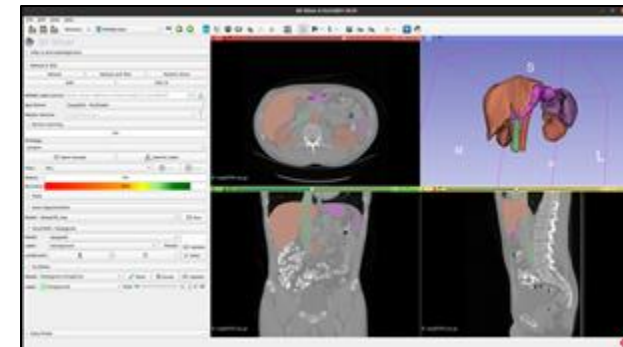
Pathology Demo
Client: Digital Slide Archive

- Auto-segment nuclei by a MONAI Label's pretrained model
- Trigger training a model

- Use NuClick model to segment nuclei

Resources
MONAI Label

MUST WATCH DEEP DIVE series!
Keep adding new tutorials!

- **MONAI Label Deep Dive series** (e.g., multi-label, 3DSlicer plugin settings) https://www.youtube.com/playlist?list=PLtoSVSQ2XzyD4lc-lAacFBzOdv5Ou-9IA

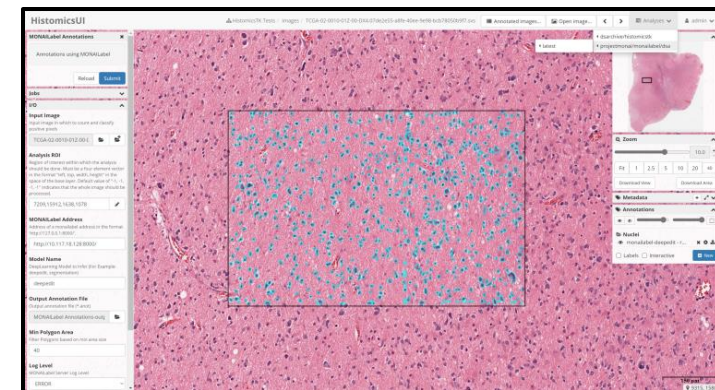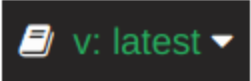- Doc https://docs.monai.io/projects/label/en/latest/whatsnew.html (choose the correct version at the lower-right button) [v: latest]

- MONAI Label repo https://github.com/Project-MONAI/MONAILabel (ask questions & make suggestions at `Discussion` tab)
- MONAI Label wiki https://github.com/Project-MONAI/MONAILabel/wiki
- Quick start https://github.com/Project-MONAI/MONAILabel/blob/main/README.md
- Active Learning https://github.com/Project-MONAI/MONAILabel/wiki/Active-Learning
- FAQ https://github.com/Project-MONAI/MONAILabel/wiki/FAQ
- Report bugs\ask questions\request new features\provide any feedback
  Issues tab https://github.com/Project-MONAI/MONAILabel/issues
  Discussion tab https://github.com/Project-MONAI/MONAILabel/discussions

- MONAI Label session recording from MICCAI MONAI Bootcamp 2021
  https://www.youtube.com/watch?v=o8HipCgSZIw&list=PLtoSVSQ2XzyCobzE6NvwjNpITsQyPUtfs&index=11&t=1819s

- 3DSlicer doc for the basics https://slicer.readthedocs.io/en/latest/user_guide/getting_started.html
- 3DSlicer doc for module Segment Editor https://slicer.readthedocs.io/en/latest/user_guide/modules/segmenteditor.html
- 3DSlicer 10min segmentation tutorial https://www.youtube.com/watch?v=BJoIexIvtGo&t=2s

Want to use MONAI LABEL on HiperGator?

- HiperGator demo at MONAI LABEL BoF July 2022

- Can run MONAI LABEL server and 3DSlicer on the same GPU-accelerated node

- A step-by-step tutorial to repeat the demo: https://github.com/hw-ju/monai_uf_tutorials/tree/main/monailabel

- Please let me know and help you as it's still in early stage

New to HiperGator?

- Become a HiperGator user (request HiperGator accounts, trials, submit purchase forms, etc)
https://www.rc.ufl.edu/get-started/hipergator/

- How to use HiperGator?
  - UFRC wiki https://help.rc.ufl.edu/doc/UFRC_Help_and_Documentation
  - Open OnDemand https://help.rc.ufl.edu/doc/Open_OnDemand

- Need more help?
  - Submit a ticket https://support.rc.ufl.edu
  - Doc on getting help https://help.rc.ufl.edu/doc/Get_Help

Thanks for your attention!
Q & A

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