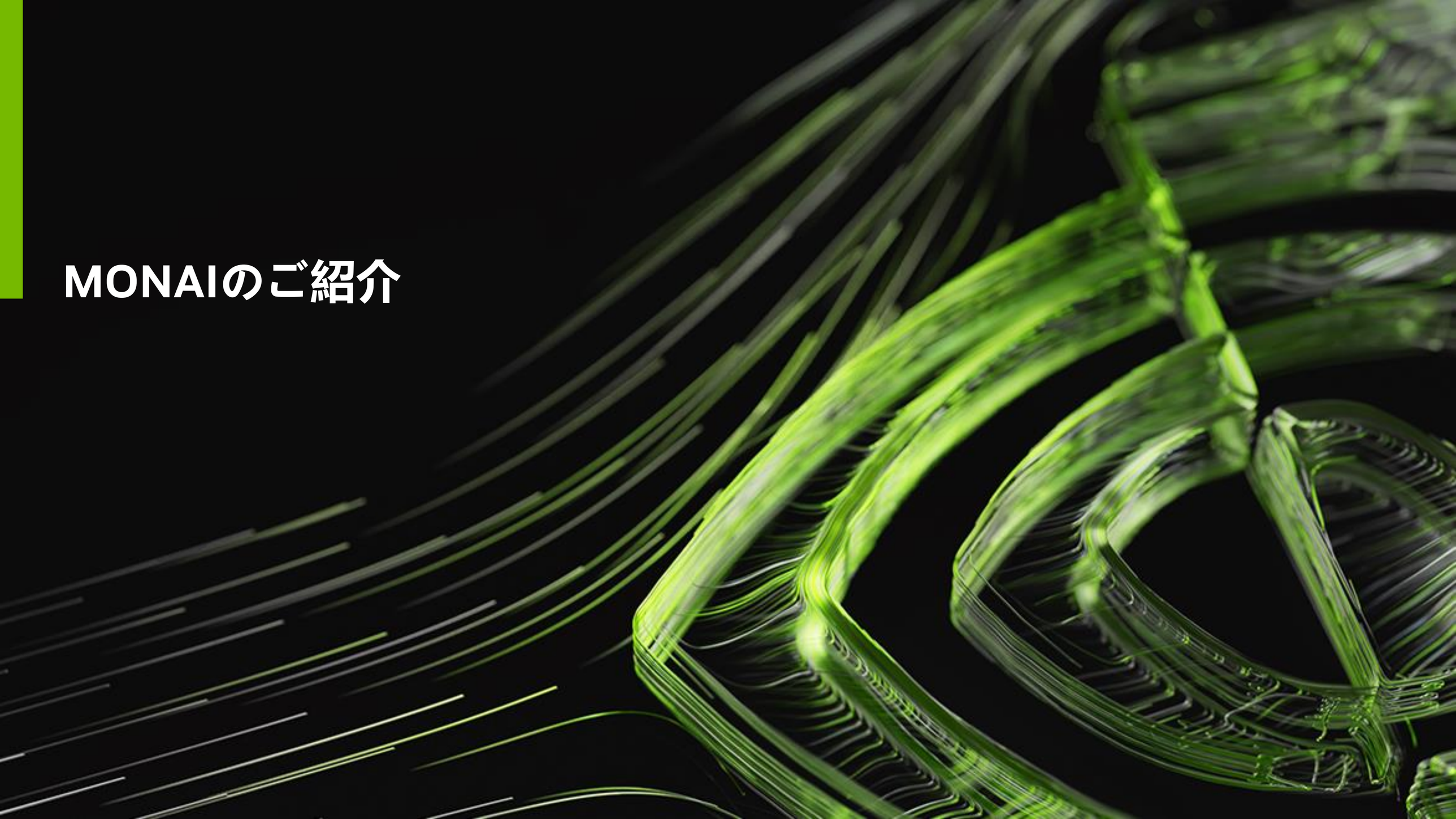
MONAI ハンズオンセミナー

Colleen Ruan, Senior Solution Architect, Healthcare, Japan

Outline

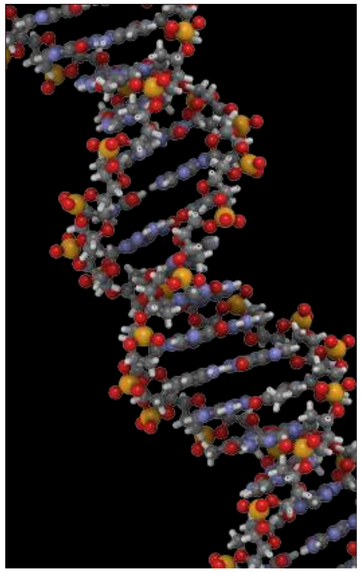
- MONAIのご紹介（30分頃）
- MONAI Coreを利用して前処理、モデル学習を行う（1時間—2時間）
- MONAI Labelを利用してデータの自動アノテーションのデモンストレーション（30分頃）
- Q＆A（15分）

MONAIのご紹介



NVIDIA CLARA

GENOMICS



NLP

Fever PROBLEM and urinary symptoms PROBLEM : A preliminary diagnosis of pyelonephritis PROBLEM was established. Other causes of fever PROBLEM were possible but less likely. The patient was hypotensive PROBLEM on initial assessment TEST with a blood pressure TEST of 80/40. Serum lactate TEST was elevated PROBLEM at 6.1. A bolus of IV fluid TREATMENT was administered (1.5L) but the patient remained hypotensive PROBLEM . Our colleagues from ICU were consulted. An arterial line TREATMENT was inserted for hemodynamic monitoring TEST . Hemodynamics were supported with levophed TREATMENT and crystalloids TREATMENT . Piptazo TREATMENT was started after blood and urine cultures TEST were drawn. After 12 hours serum lactate TEST had normalized and hemodynamics TEST had stabilized. Blood cultures TEST were positive for E Coli PROBLEM that was sensitive to all antibiotics TREATMENT . The patient was stepped down to oral ciprofloxacin TREATMENT to complete a total 14 day course of antibiotics TREATMENT .

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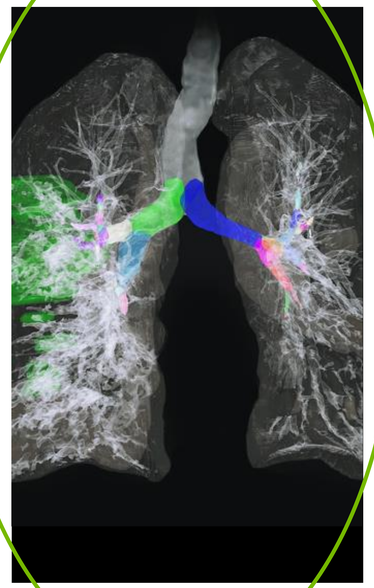
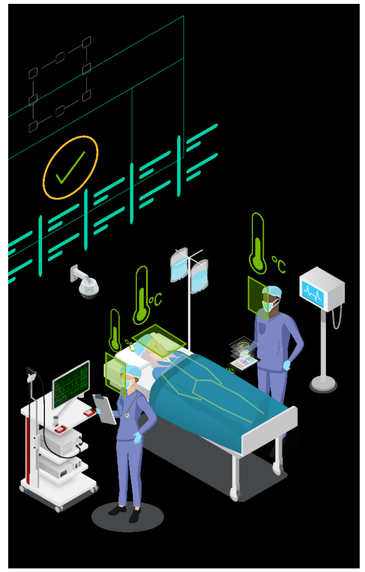
IMAGING

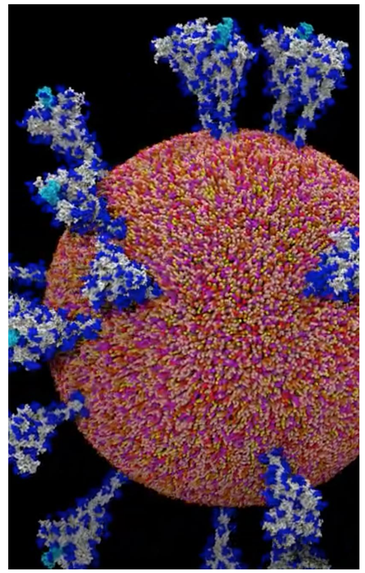


INSTRUMENTS

CONVERSATIONAL AI



DRUG DISCOVERY



NVIDIA

Medical Imaging is the essential instrument for Healthcare

2,000,000 Devices | 16,000 Companies | 10,000 Modalities

SCREENING

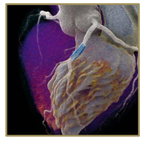
Mammo

X-RAY

Endoscopy

Detect

3D & 4D
DIAGNOSIS



MRI

Photon

Motion

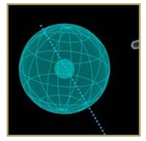
CT

PET

Segment

5D
TREATMENT

Surgery



Track

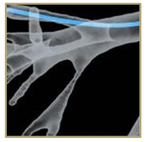
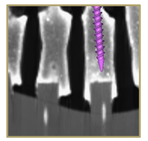


Image-
Guided

Navigate

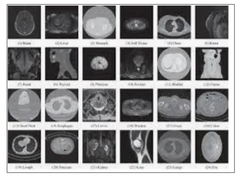


Hyper-
Spectral

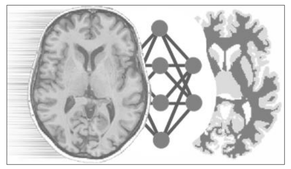
Adaptive
Therapy

30% of World’s Data is Healthcare |90% of healthcare data is from medical imaging

MONAI: THE ESSENTIAL FRAMEWORK FOR THE MEDICAL AI ECOSYSTEM



MONAI Datasets



MONAI Model Zoo

1

MONAI Label
(Annotation & Active Learning)

MONAI

2

MONAI Core
(Model Training)

MONAI Bundle
(Trained Model)

PACS
(DICOM Imaging Database)

3

MONAI Deploy
(Informatics Gateway & Workflow Manager)

MAPS
(Containerized MONAI App)

NVIDIA

MONAI Advisory Board

Bringing Together Domain Experts & Leaders

Stephen Aylward

Chair of the Advisory Board

Sebastien Ourselin

Klaus Maier-Hein

Jayashree Kalpathy-Cramer

Jorge Cardoso

Daniel Rubin

Lena Maier-Hein

Kevin Zhou

Nassir Navab

Andrew Feng

Nasir Rajpoot

Justin Kirby

Keyvan Farahani

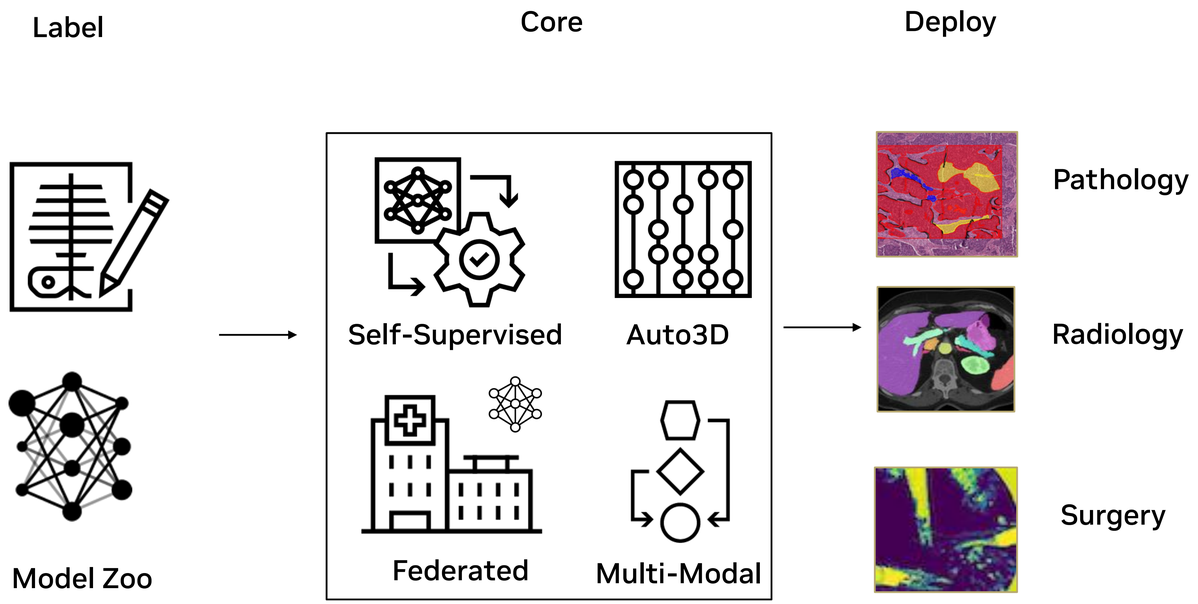
Selnur Erdal

MONAI stands for Medical Open Network for AI and is a collaborative open-source projects for building the best practices for deep learning in Medical Imaging

NVIDIA

MONAI

An AI Acceleration Framework for Medical Imaging



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SFL SCIENTIFIC DISCOVER MORE
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Frederick National Laboratory for Cancer Research
Mass General Brigham
Children's Hospital of Philadelphia
VANDERBILT UNIVERSITY
BAYER
KING'S College LONDON
AI CENTRE for Value Based Healthcare
quantiphi
Microsoft

MONAI Impact

Standard for Imaging Research and Clinical Deployment

50K
Download per Month

450+
Github Projects

150+
Papers Published

2019

MONAI Inception
MICCAI Shenzhen

NVIDIA and KCL initiate MONAI community

2020

MONAI Core 0.1
Domain specific training library

4 publications
550 Bootcamp registrants

2021

MONAI Label, MONAI Deploy
Expansion of imaging AI workflow

Won 5 challenges
709 Bootcamp registrants

2022

MONAI 1.0
Model Zoo, Active Learning, Auto3D

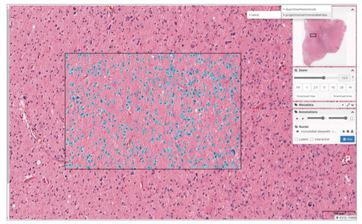
Won 6 challenges
MONAI Tutorial, MICCIA (Sept 22)

NVIDIA

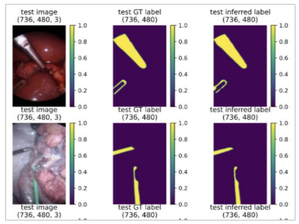
MONAI 1.0

New Features Across MONAI

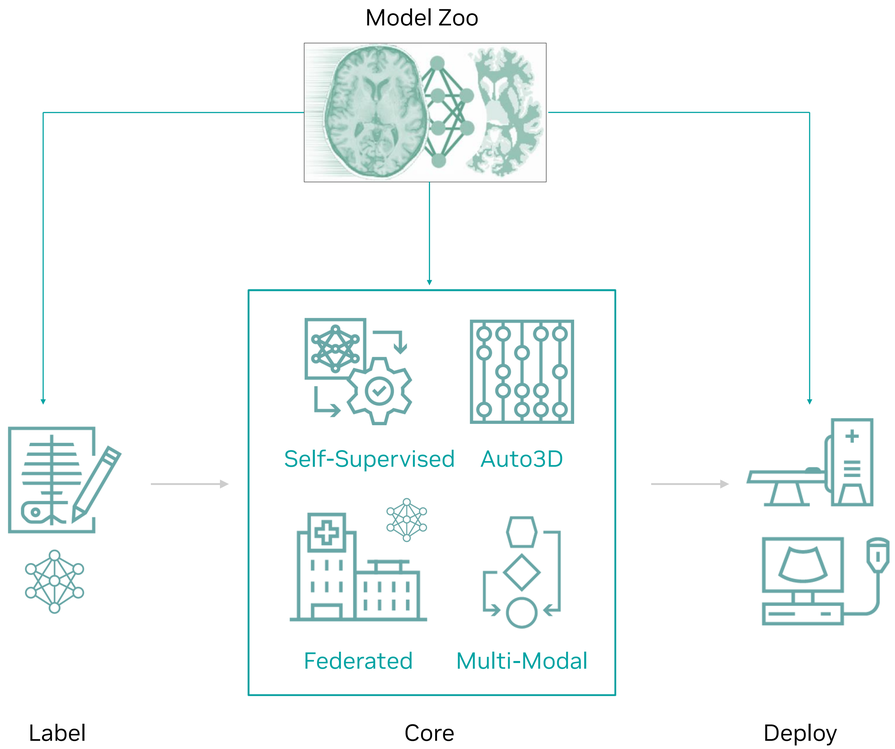
Radiology



Pathology

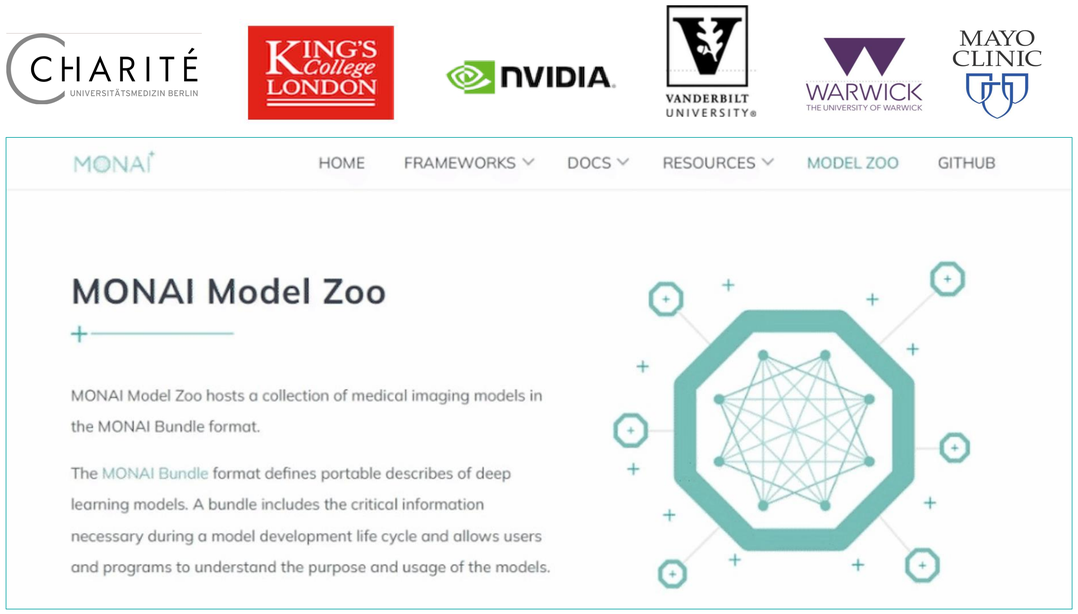


Endoscopy



MONAI MODEL ZOO NEW

A Hub for Pre-Trained Imaging AI Models



Features	Benefits
15 and growing pre-trained models across CT, MR, Pathology, Endoscopy.	Jumpstart training workflows
Packaged as MONAI Bundle for publication to Model Zoo for 1-click	Establish common standard for reproducible research & collaboration
	Broaden reach and impact of research
	Leverage the SOTA pre-trained models for downstream clinical tasks

MONAI BUNDLE NEW

Open standard for Model Definition & Package

Execute training:

```
python -m monai.bundle run training \
    --meta_file configs/metadata.json \
    --config_file configs/train.json \
    --logging_file configs/logging.conf
```

Override the `train` config to execute multi-GPU training:

```
torchrun --standalone --nnodes=1 --nproc_per_node=2 -m monai.bundle run training \
    --meta_file configs/metadata.json \
    --config_file "['configs/train.json','configs/multi_gpu_train.json']" \
    --logging_file configs/logging.conf
```

Override the `train` config to execute evaluation with the trained model:

```
python -m monai.bundle run evaluating \
    --meta_file configs/metadata.json \
    --config_file "['configs/train.json','configs/evaluate.json']" \
    --logging_file configs/logging.conf
```

Execute inference:

```
python -m monai.bundle run evaluating \
    --meta_file configs/metadata.json \
    --config_file configs/inference.json \
    --logging_file configs/logging.conf
```

Verify the metadata format:

```
python -m monai.bundle verify_metadata --meta_file configs/metadata.json --filepath eval/schema.json
```

Verify the data shape of network:

```
python -m monai.bundle verify_net_in_out network_def --meta_file configs/metadata.json --config_file configs/inference.jsc
```

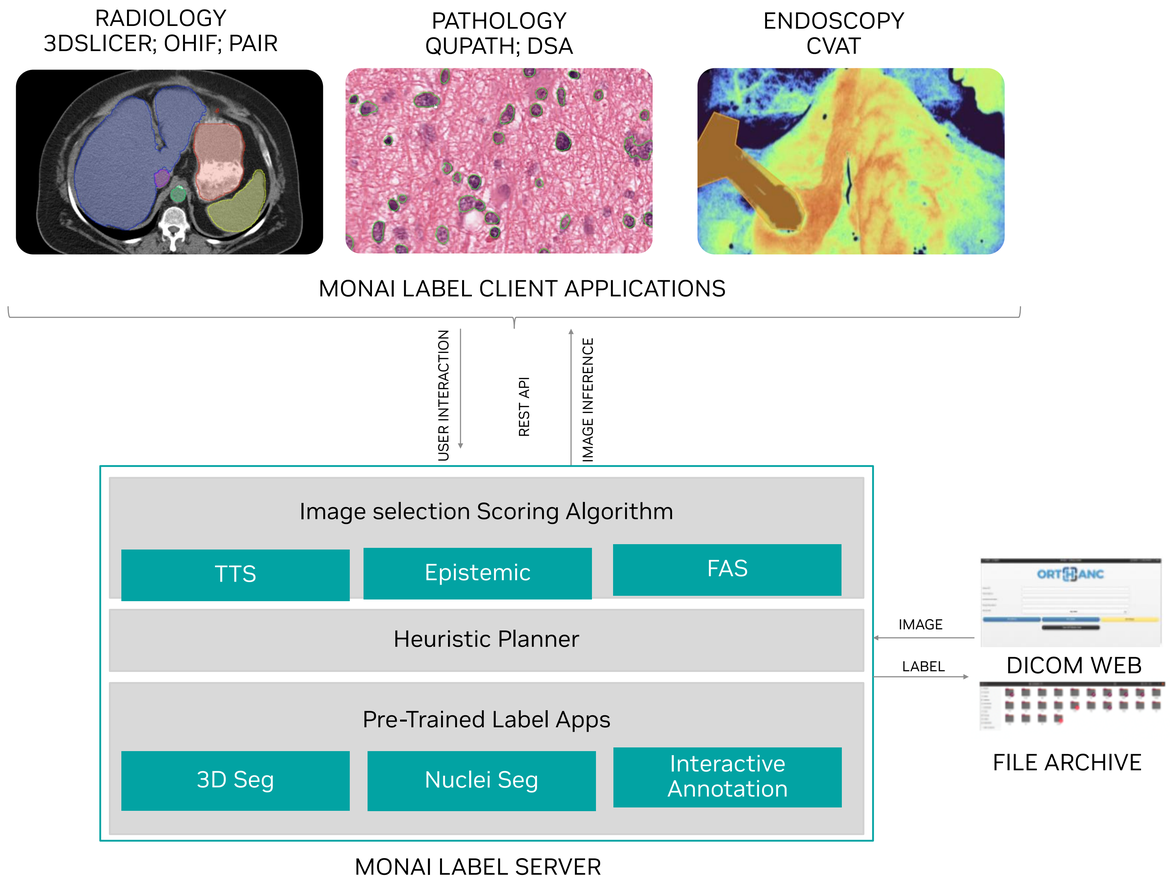
Export checkpoint to TorchScript file:

```
python -m monai.bundle ckpt_export network_def \
    --filepath models/model.ts \
    --ckpt_file models/model.pt \
    --meta_file configs/metadata.json \
    --config_file configs/inference.json
```

- MONAI Bundle is a self-contained model package with pre-trained weights and all meta data
- Build python workflows via structured configs
- Develop once and deploy anywhere
- Ease of use & flexibility to override & customize configs
- Hybrid programming with support for config to python conversion

MONAI LABEL

Intelligent Labeling & Learning Tool



- Now supports streaming modality (2D) Endoscopy New
- MONAI Label Server making application ready for deploy and serve
- Client Viewers: 3DSlicer, OHIF, PAIR, Digital Slide Archive, QuPath, CVAT New
- Data Store support DICOM & File archive
- REST APIs

インタラクティブなアノテーション機能 DEEPGROW 3D

General availability with ability to re-train the model

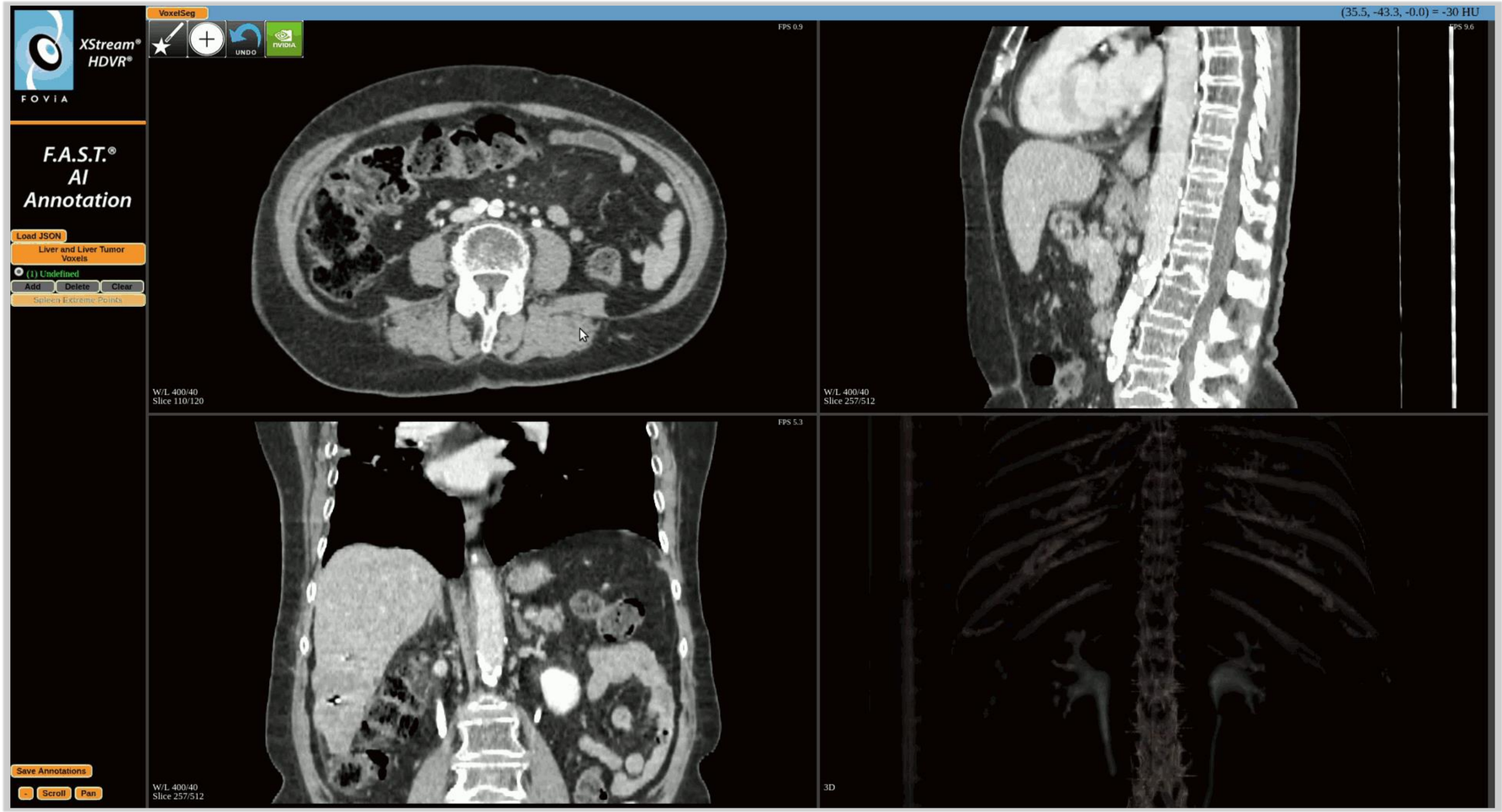
１．3Dの次世代医用画像注釈モデル

２．高品質のセグメンテーションを提供するための前景と背景のクリック

３．これまでに見られなかった画像のモデル予測が大幅に改善

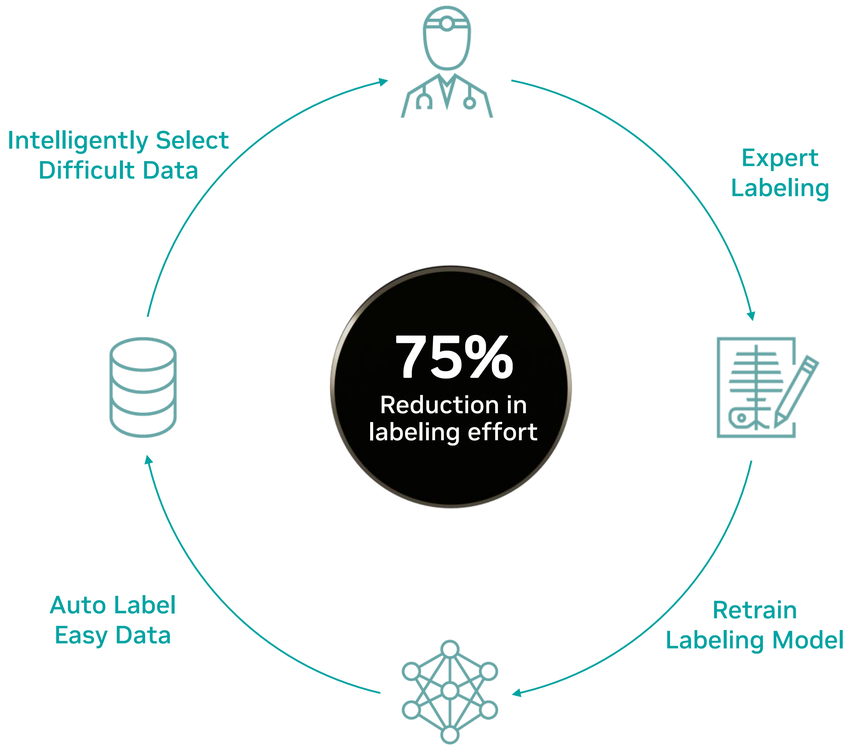
４．FoviaビューアSDKに統合され、商用の臨床統合を可能

５．3DSlicer、OHIFに統合され、オープンソースコミュニティを実現



MONAI LABEL: Active Learning

Reduce the Cost of Labeling Imaging Data



Features	Benefits
Support 3D Segmentation for Radiology & 2D Endoscopy NEW 2D Endoscopy benchmark showcase 75% reduction in need for labeled data Charite University reduced labeling cost by 50% using Epistemic algorithm	
Image selection algorithms (Aleatoric, Epistemic and FAS) intelligently chooses which data to learn from	Train models that can learn more from less data.
Human-in-the loop to annotate the most difficult images for clinical inputs	Focus on annotations that provide the highest gain in model performance and address areas where the model has uncertainty
1-click Train from Viewer UI	Seamlessly initiate training with high value annotated data bringing clinicians into data science loop

Dr. Matthew Jolley
Pediatric Cardiologist and Anesthesiologist
Children's Hospital of Philadelphia

Case Study: Researcher at AMC

*"What MONAI provides is a fundamental, scalable and powerful architecture to accelerate that process such that **we can focus on our application in a specific (clinical) domain**, rather than the creation of that fundamental architecture."*

(September 2022)

The Client

- Treats pediatric patients with congenital heart disease
- Aims to employ precision medicine from research to the OR
- Started building his own AI/ML to create patient-specific models for planning surgeries and interventions

The Problem

- No two patients and intervention are alike
- 3D Image segmentation to create patient-specific models was laborious and lengthy
- Building the homegrown infrastructure was mundane, distracting and taking many years

The Solution

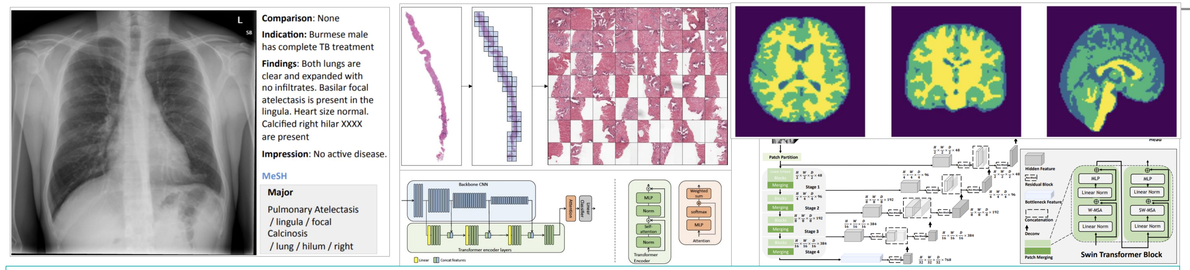
- Interact with, visualize and extract all information in patient's heart valve images
- Rapidly create models that inform the design of the correct surgical intervention the first time
- Accelerated imaging AI workflow, from labeling data, to segmenting images, and achieving the model they want

Why MONAI

- Freed his team to focus on solving clinical applications, not the infra
- Provided the boiler plates to build, scale and deploy AI faster from cardiology other surgical domains.
- Open-source community to share ideas, labels, code and implementation
- Extensible MONAI framework that integrates into 3D slicer

MONAI CORE 1.0

Standard of Imaging Research Framework



MONAI Research: implementations of state-of-the-art research outcomes

- Unconstrained and optimized models — Model parallelism, neural architecture search
- End-to-end research lifecycle — DICOM/HL7 FHIR/Model exchange and deploy
- State-of-the-art models and workflows — Dynamic UNET, COVID-19 pneumonia lesion segmentation, domain metrics

MONAI Tutorials: Demonstrate capabilities and applications of core library

- Segmentation
- Classification
- Registration
- GAN & Autoencoder
- Self Supervised Learning
- Detection
- Federated Learning

MONAI Workflows: Ease of robust training and evaluation of Research Experiments

- Workflow Engines — Supervised trainer, evaluator; Self supervised trainer, evaluator
- Workflow Event Handlers — Model checkpoint saving/loading, validation pipelines, LR Scheduling, metrics report generation, network output saving, transform inverter
- Iteration, epoch-based metrics stats, trackers — As event handlers of the engines

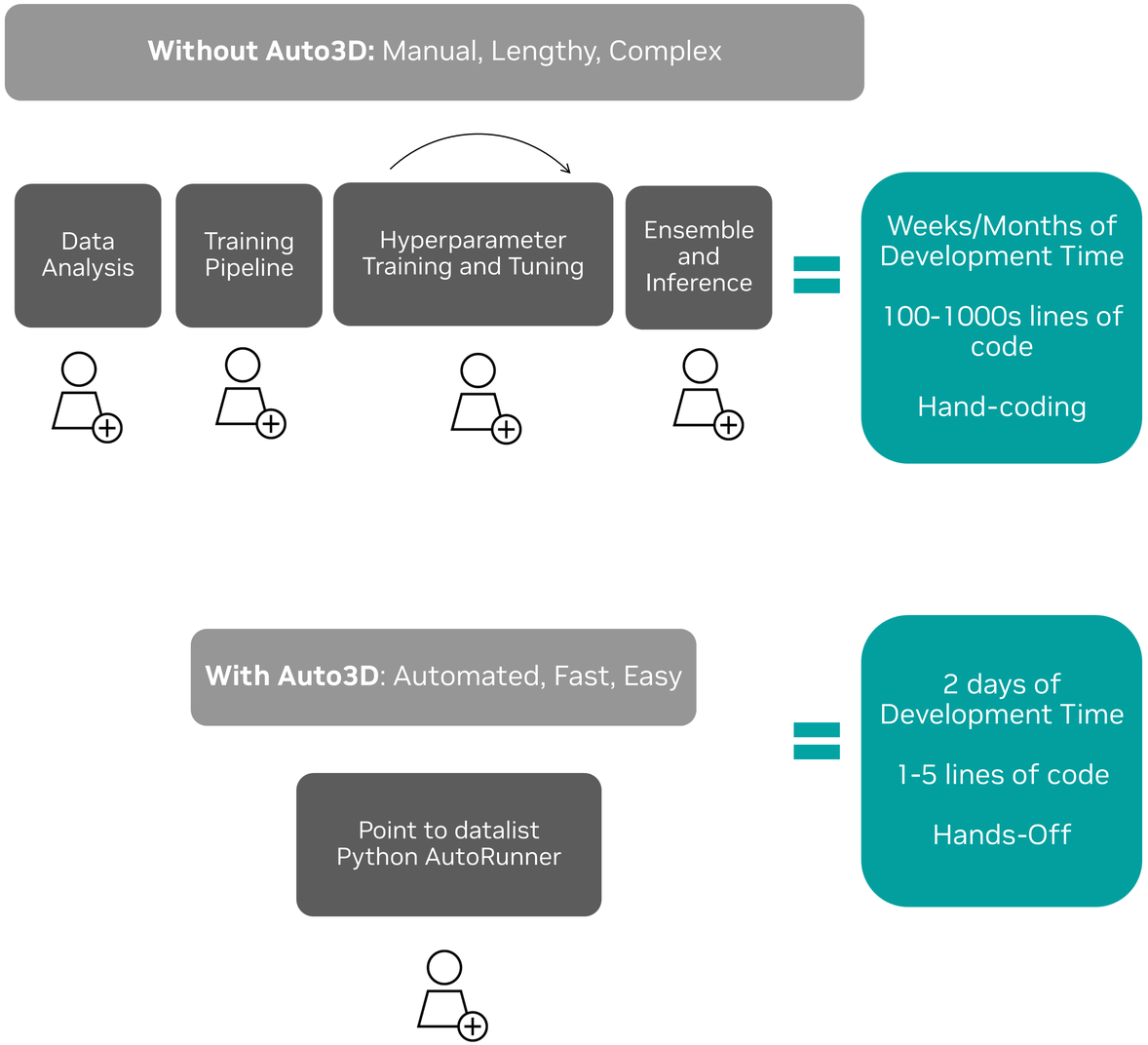
MONAI COMPONENTS: Foundational standalone domain specialized components

- Data — Cache based datasets; Patch based datasets; Enhanced data loaders
- Readers & Writers — Support various formats: NIfTI, PNG, NPY, CSV...
- Losses & Networks — Segmentation, Regression, classification, Registration, detection. Networks with 2D/3D. ND filtering, CRF, squeeze & excitation, Warping
- Transforms — Spatial, intensity, IO, utilities, compose with 3rd party
- Inference Modules — Sliding Windows, Saliency inferer, slice inferer
- Visualization — Tensorboard integration, Jypyter Notebook Integration
- Metrics — MeanDice, ROCAUC, FROC, Hausdorff, confusion matric
- Optimizers — LR finder, layerwise LR, Novograd

- Robust, backward compatible API design **New**
- Supports new MetaTensor API **New** to store Torch Tensors and meta information.
- Modular domain specialized components: network arch; transforms; losses; metrics; data handlers etc.
- Learning workflows: Supervised; Self-supervised; Federated Learning; Network architecture search
- Up to 15x faster performance as compared to vanilla implementations

AUTO3D SEGMENTATION

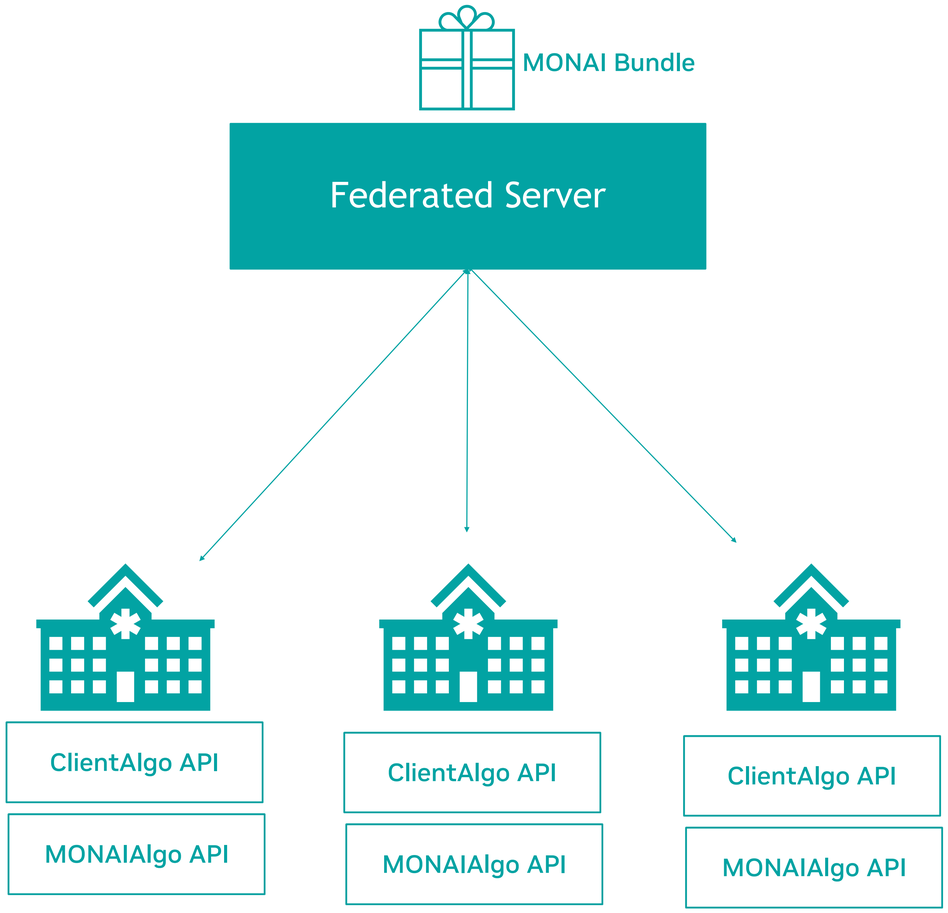
Low-code Framework to Train High-quality 3D Segmentation Models



- Auto3D is a self-contained solution to build 3D Segmentation models with minimal user inputs
- Supports state of the art algorithms: SwinUNETR; DiNTS; SegResNet out of the box and ability to customize
- Built for high Accuracy & efficiency Auto3D maximizes the productivity of data science teams.
- Auto3D based solution with no human interaction amongst MICCAI challenges winning solutions: HEKCTOR22, Instance22, ISLES22

MONAI FEDERATED LEARNING NEW

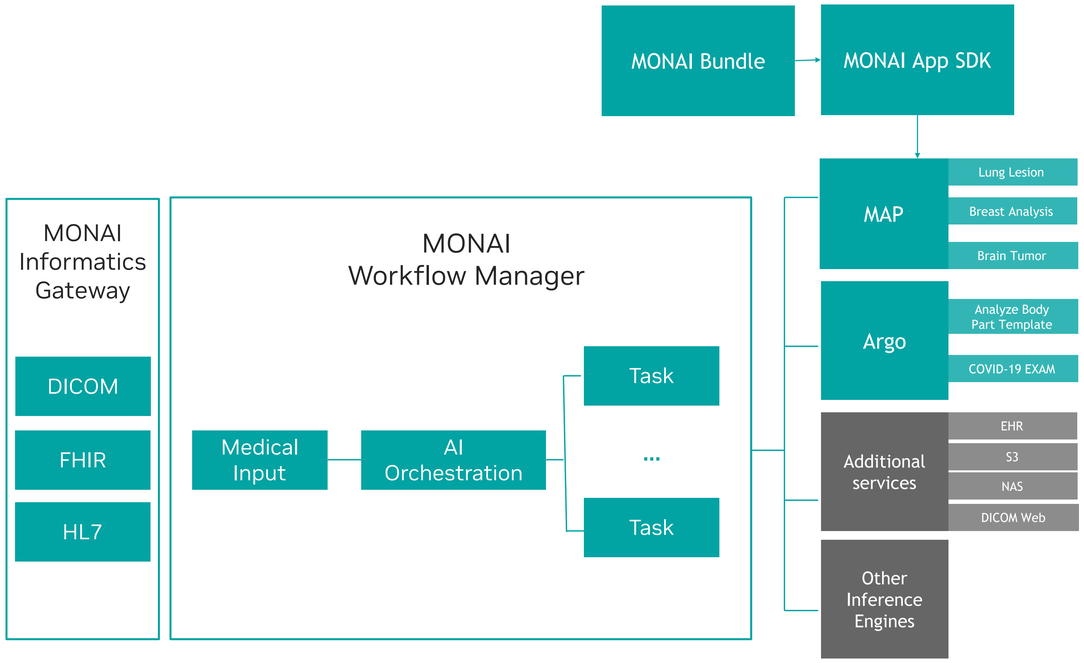
Privacy Preserving Collaborative AI development



Features	Benefits
Federated Learning Client Algo APIs	Ability to defining a MONAI client app that can run on any FL platform. Enabler for FL Toolkits interoperability.
NVIDIA FLARE Integration	Nvidia FLARE, the federated platform developed by Nvidia already integrated with MONAI FL Client APIs
MONAI Bundle compatibility	Allow for seamlessly extending any bundle from MONAI zoo to a federated paradigm

MONAI DEPLOY

End-to-End AI Clinical Workflow



Features	Benefits
MONAI App SDK	Build containerized application from pre-trained models in < 20 minutes
MONAI Informatics Gateway[NEW]	Connect hospital information systems like PACS, EHRs and viewers over DICOM, FHIR and HL7
MONAI Workflow Manager[NEW]	Maintain AI governance for Hospital IT

Jorge Cardoso
CTO at London AI Center for value-based healthcare

Case Study

*"What MONAI brings is the final layer, which is the way to **scalably apply AI** across the entire medical record **across every patient pathway.**"*

The Client

- Helps hospitals across all departments safely and effectively use and adopt AI
- Tasked with integrating trained models into hospital operations, IT systems and patient care

The Problem

- Hospital/patient information is stored in disparate systems and formats even for the same patient
- Integration of AI is difficult to do across patient pathways
- Lack of a domain-specific, easy-to-use tools, OS and software applications that helps developer productivity in the medical space

The Solution

- A platform that brings and scales data science into the clinic as insights for clinicians
- Allow clinicians to be part of the AI process, from labeling to how it is deployed and used for patient care
- Integrate all different kinds of data about a patient into a single AI platform

Why MONAI

- Open, standardized, inclusive, interoperable, scalable, improves accessibility – across every patient pathway worldwide
- Do not have to reinvent the wheel; symbiotic relationship between clinics and AI that improves patient-specific outcomes
- Foundational, pre-trained models in Model Zoo that can be used off the shelf and finetuned for specific applications

MONAI RESOURCES

Join the Growing Community Now !

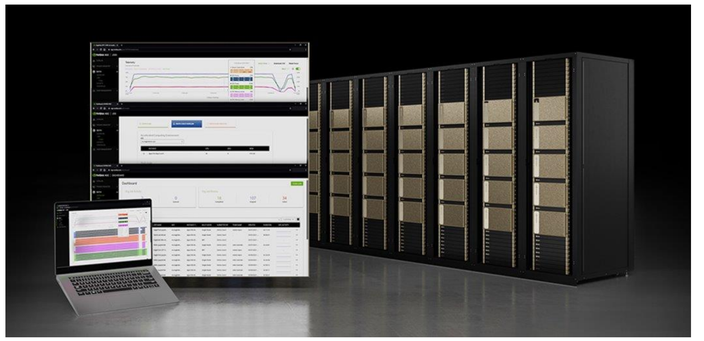
- MONAI Website: https://monai.io/
- MONAI Slack: https://forms.gle/QTxJq3hFictp31UM9
- MONAI Docs:
  - MONAI Core: https://docs.monai.io/en/stable/
  - MONAI Label: https://docs.monai.io/projects/label/en/latest/index.html
  - MONAI Deploy App SDK: https://docs.monai.io/projects/monai-deploy-app-sdk/en/latest/
- MONAI Github: https://github.com/Project-MONAI
  - MONAI Core: https://github.com/Project-MONAI/MONAI
  - MONAI Label: https://github.com/Project-MONAI/MONAILabel
  - MONAI Deploy: https://github.com/Project-MONAI/monai-deploy
- MONAI YouTube: https://www.youtube.com/c/Project-MONAI
  - Overview Videos, Deep Dive Series, Bootcamp and other event recordings
- MONAI Twitter: https://twitter.com/ProjectMONAI
  - Follow for the latest announcements
- MONAI Medium: https://monai.medium.com/
  - Read about our latest releases and our upcoming research interview series

ACCESS MONAI EVERYWHERE

Nvidia Enterprise | Cloud | Launchpad

NVIDIA Certified & DGX
Data Science at enterprise scale

Integrated for scale and ease of use across CSP

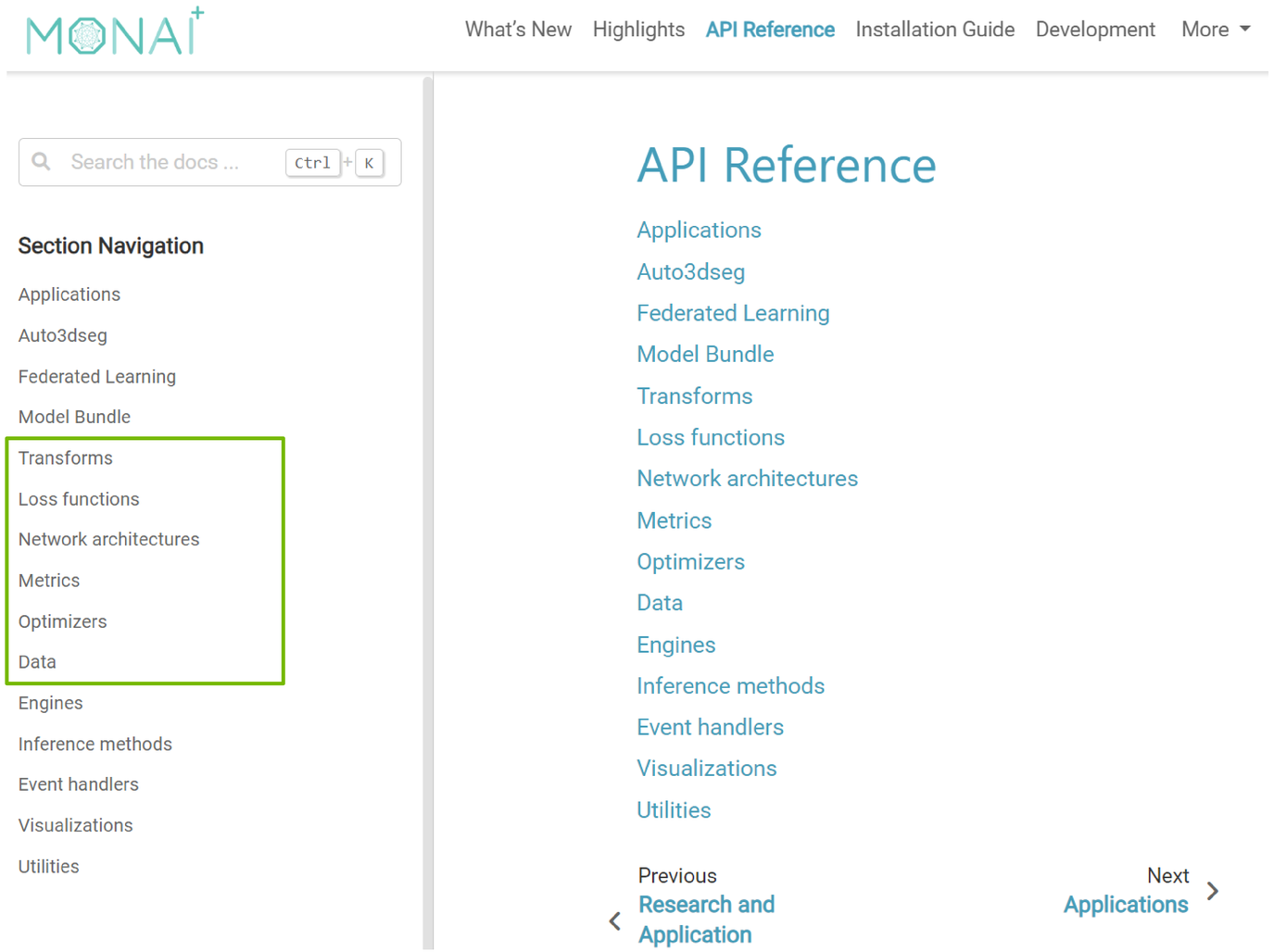


Experience MONAI on Nvidia Launchpad

MONAI Coreを利用して前処理、モデル学習を行う

MONAI CORE

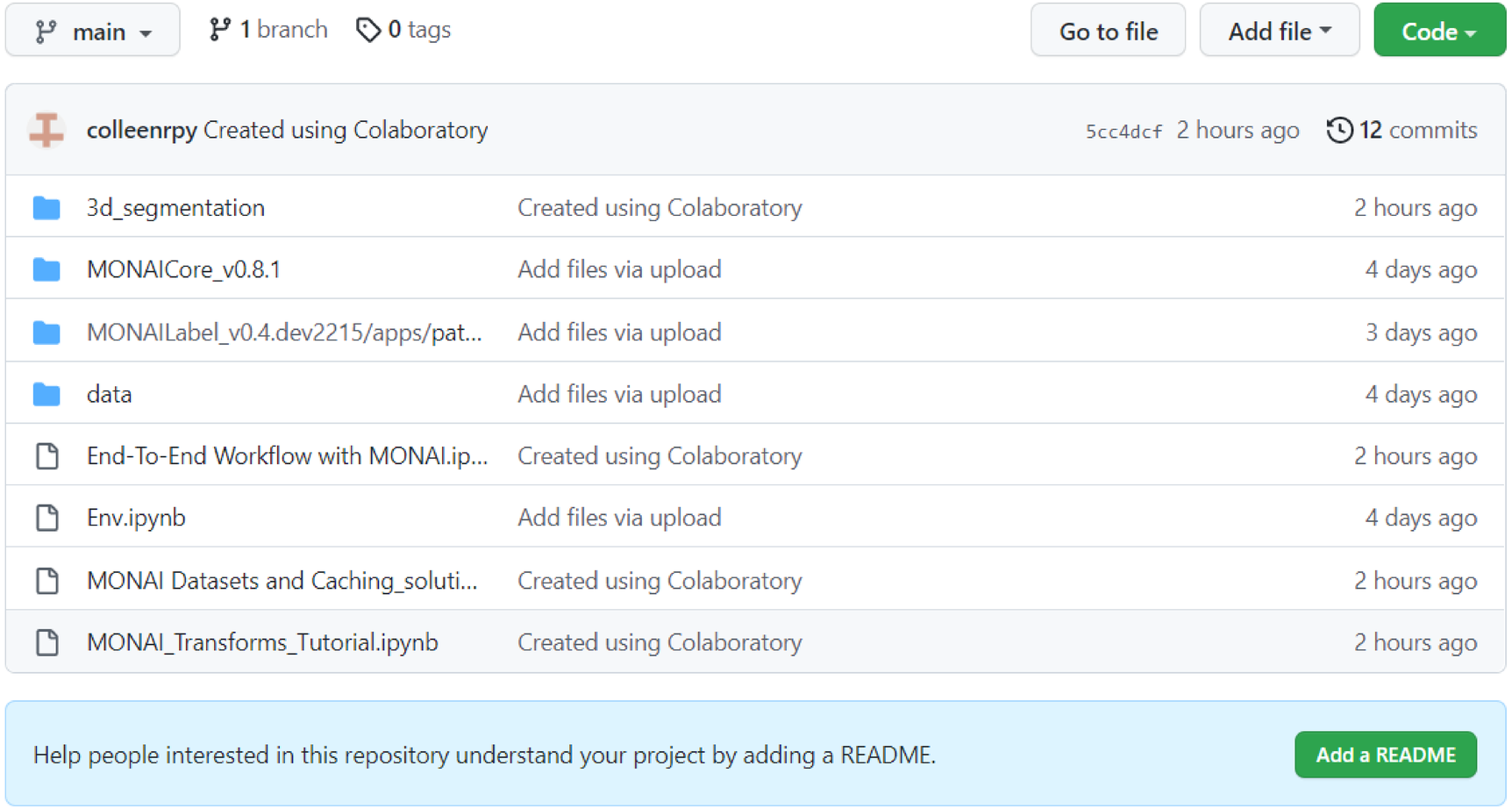
An AI Acceleration Framework for Medical Imaging



https://docs.monai.io/en/stable/api.html

MONAI COREハンズオンを開始!

https://github.com/colleenrpy/MONAI_handson



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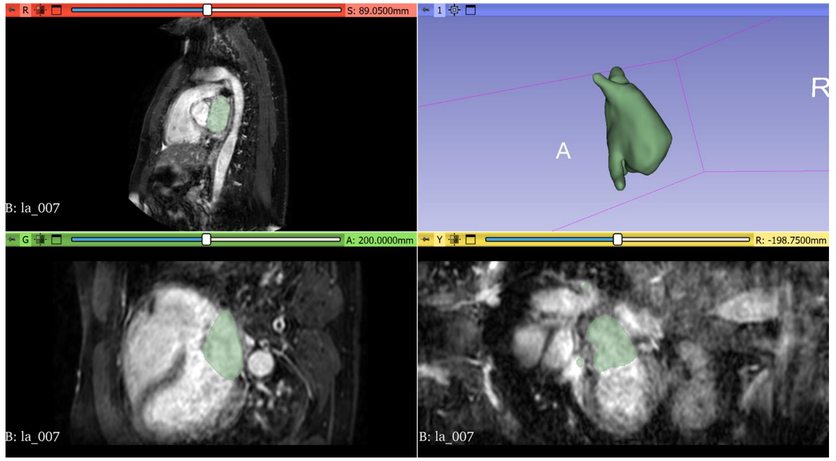
https://docs.monai.io/en/stable/api.html

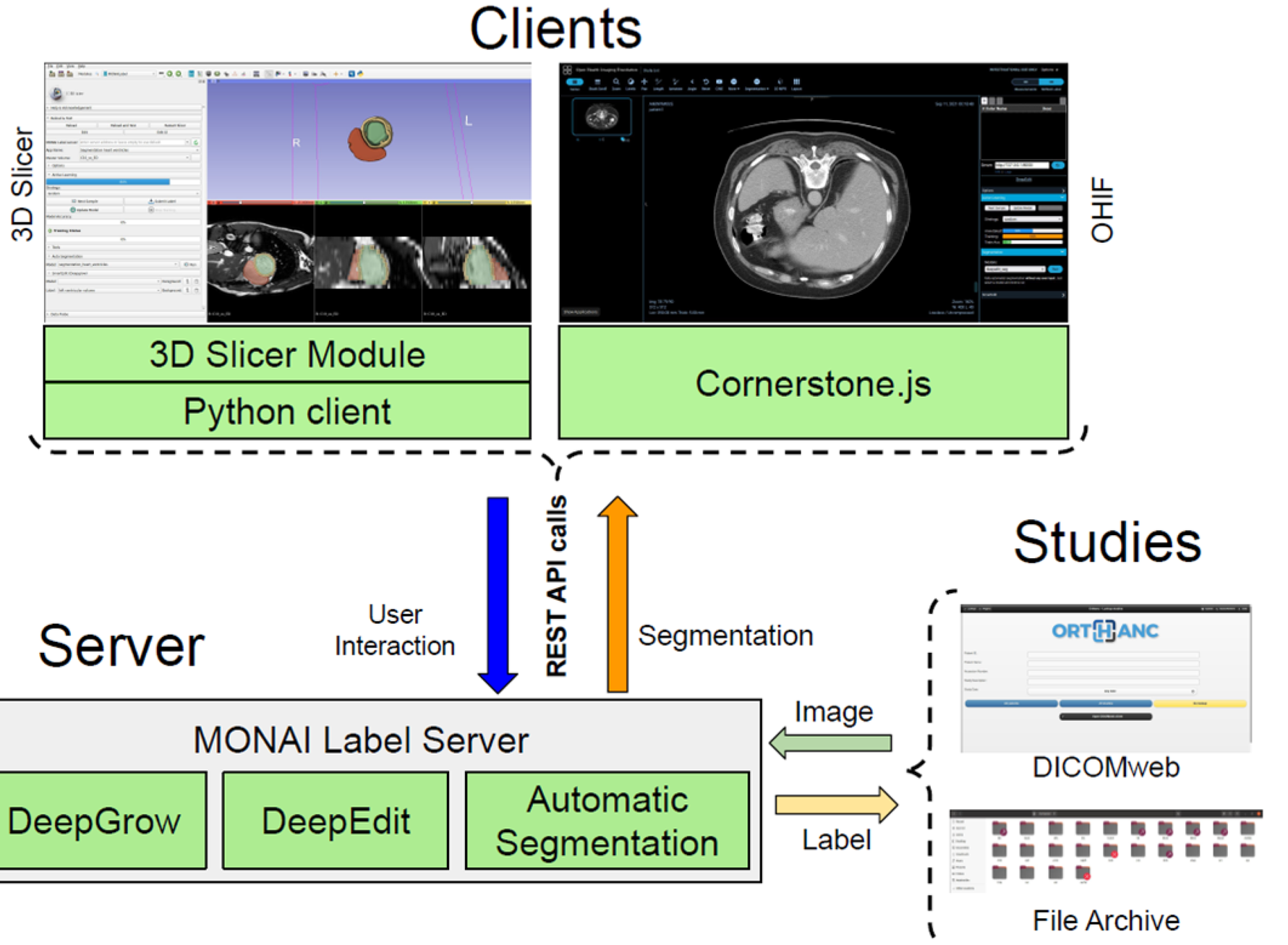
MONAI Labelを利用してデータの自動アノテーションのデモンストレーション

What is MONAI Label?

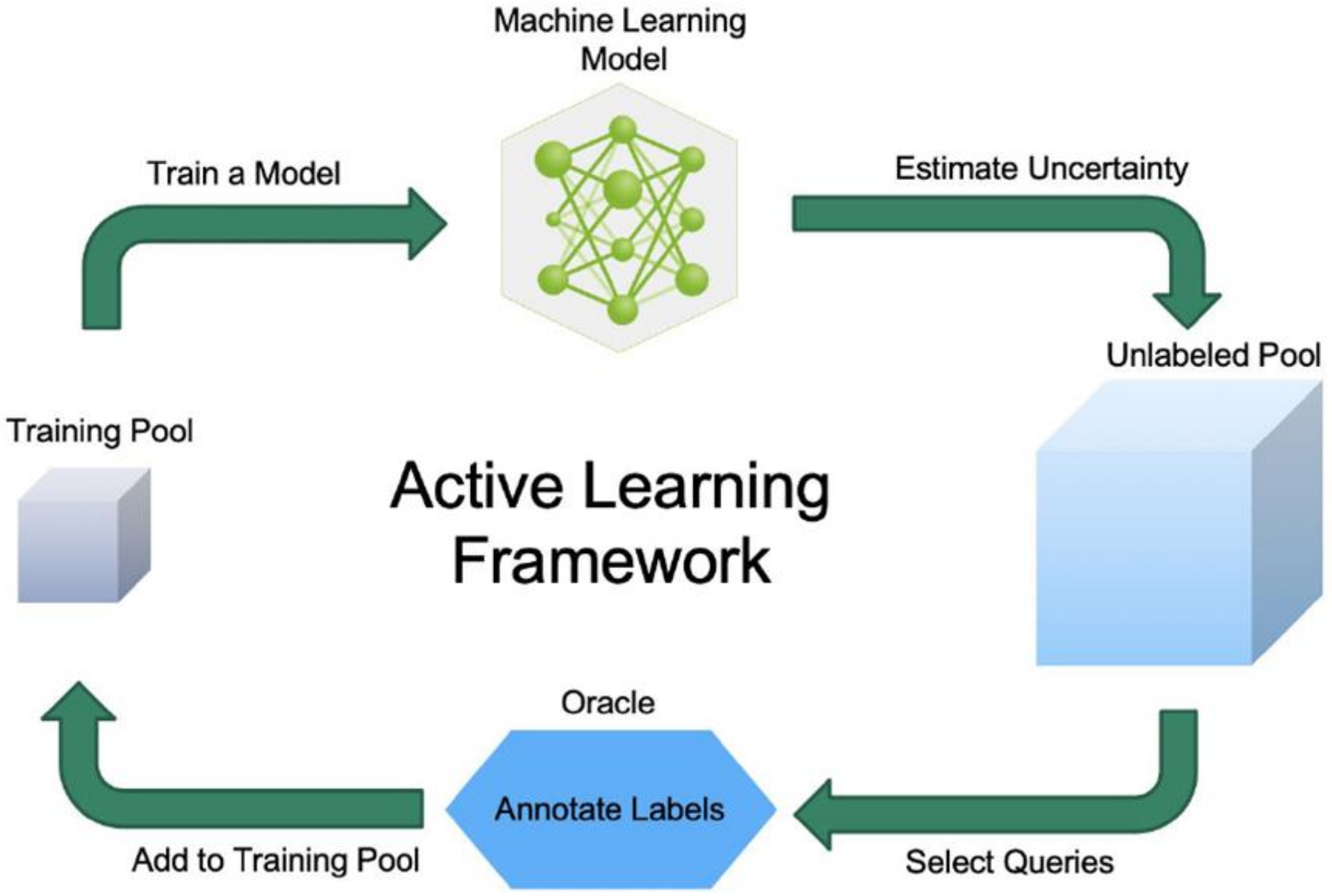
- An intelligent **open source** image labeling and learning tool that enables users to create annotated datasets and build AI annotation models for clinical evaluation
- Framework for developing and deploying **MONAI Label Apps to train and do inference using** Deep Learning models
- MONAI Label is one of the first frameworks that introduces **Active learning strategies in a software annotation setting**
- It is all Python and can be installed with simple **“pip install monailabel”**
- Supported viewers:
  - **3D Slicer**
  - **Open Health Imaging Foundation (OHIF)**



MONAI Label Infrastructure: server-client system



MONAI Label App: ***Active Learning Strategies***



- **Active learning** is a semi-supervised machine learning approach where the algorithm can choose which data it wants to learn from

- Initially, random images are selected to be labeled

  However, random is not always the most efficient.

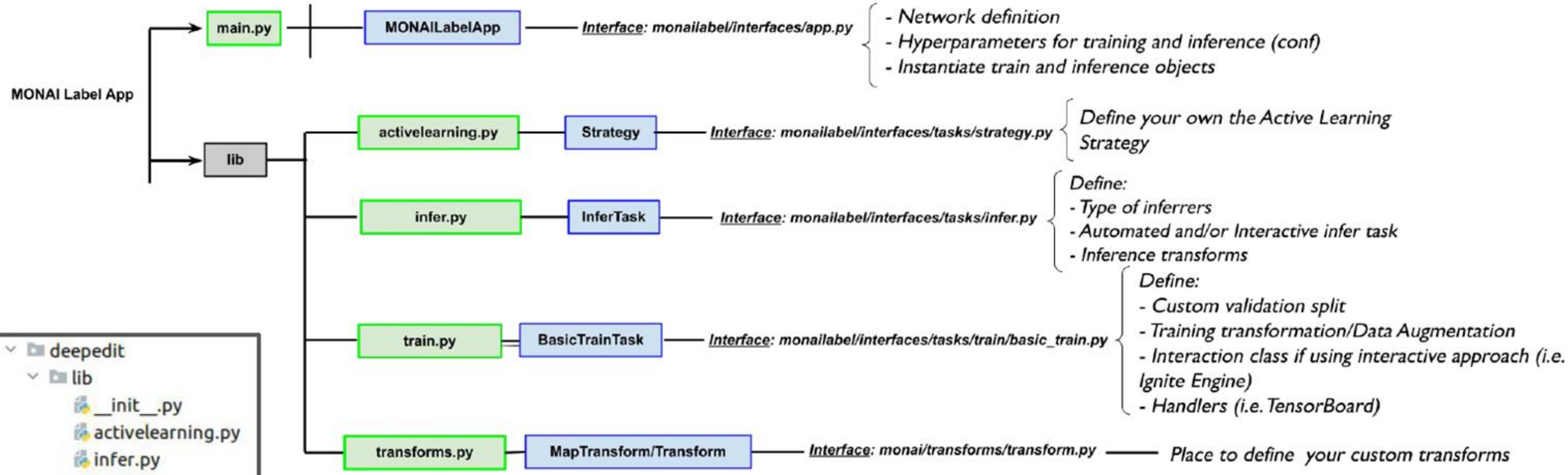
- After having a pretrained model, uncertainty of each image can be computed. Unlabeled samples that need more attention from the clinician will be selected

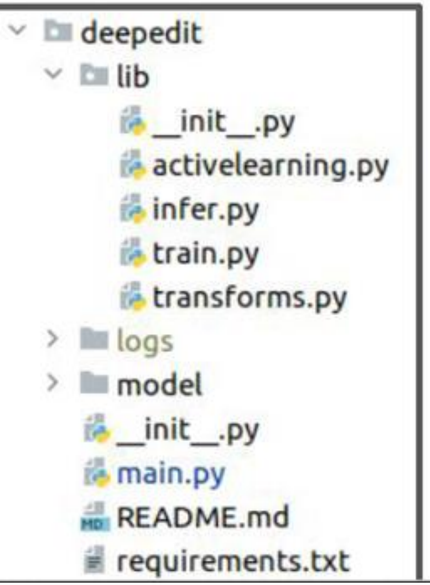
- Selection of harder samples or samples that need more attention

Why use 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 Perspective:** MONAI Label reduces the time and effort of annotating new datasets
  - Ready-to-use **3DSlicer**
  - Pre-built plugin for **OHIF Viewer**

How to create a MONAI Label App?





MONAI Label Env Setup

Server

Hardware

- GPU: Pascal or newer, RAM >= 16Gb

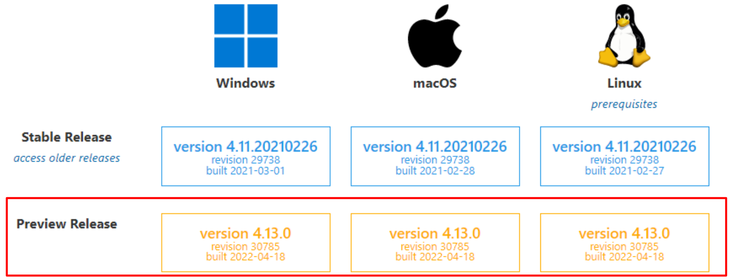
Software

- PyTorch Docker Container (NGC): https://catalog.ngc.nvidia.com/orgs/nvidia/containers/pytorch
- Steps:
  - Install MONAI Label by pip (MONAI will be installed automatically)
    `$ pip install monailabel`
  - Create your own app or download sample app by:
    `$ monailabel apps --name radiology --download --output .`
  - Create a dataset folder with your unlabeled data.
  - Start the MONAI Label server with sample app:
    `$ monailabel start_server --app radiology --studies /path/to/your/dataset --conf models deepedit`

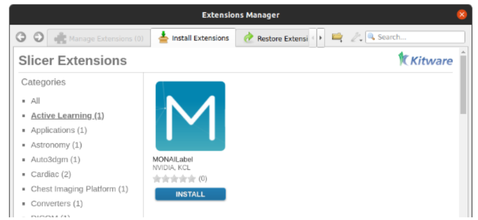
Client (3D Slicer)

https://download.slicer.org/

- 3D Slicer Installation



- MONAI Label Plugin Installation

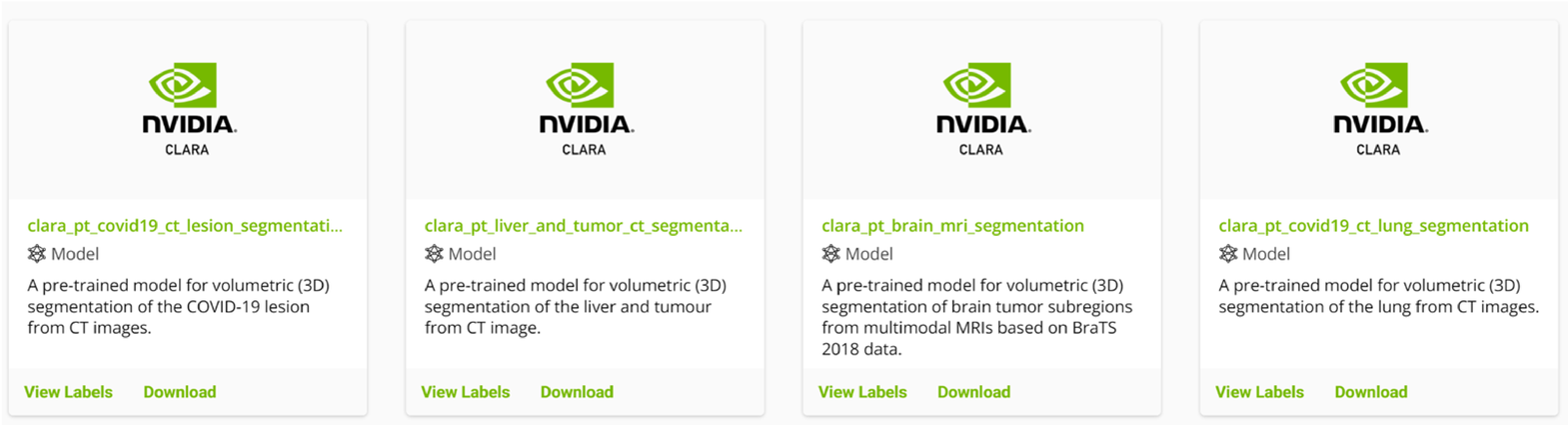


- Connect to the MONAI Label server:
  Enter the server URL including “http://”
  http://your.server.ip.address:port

MONAI Label Pre-trained Models

The default pre-trained model in the sample app is for spleen segmentation. If you want to try more pre-trained models, please follow the steps below:

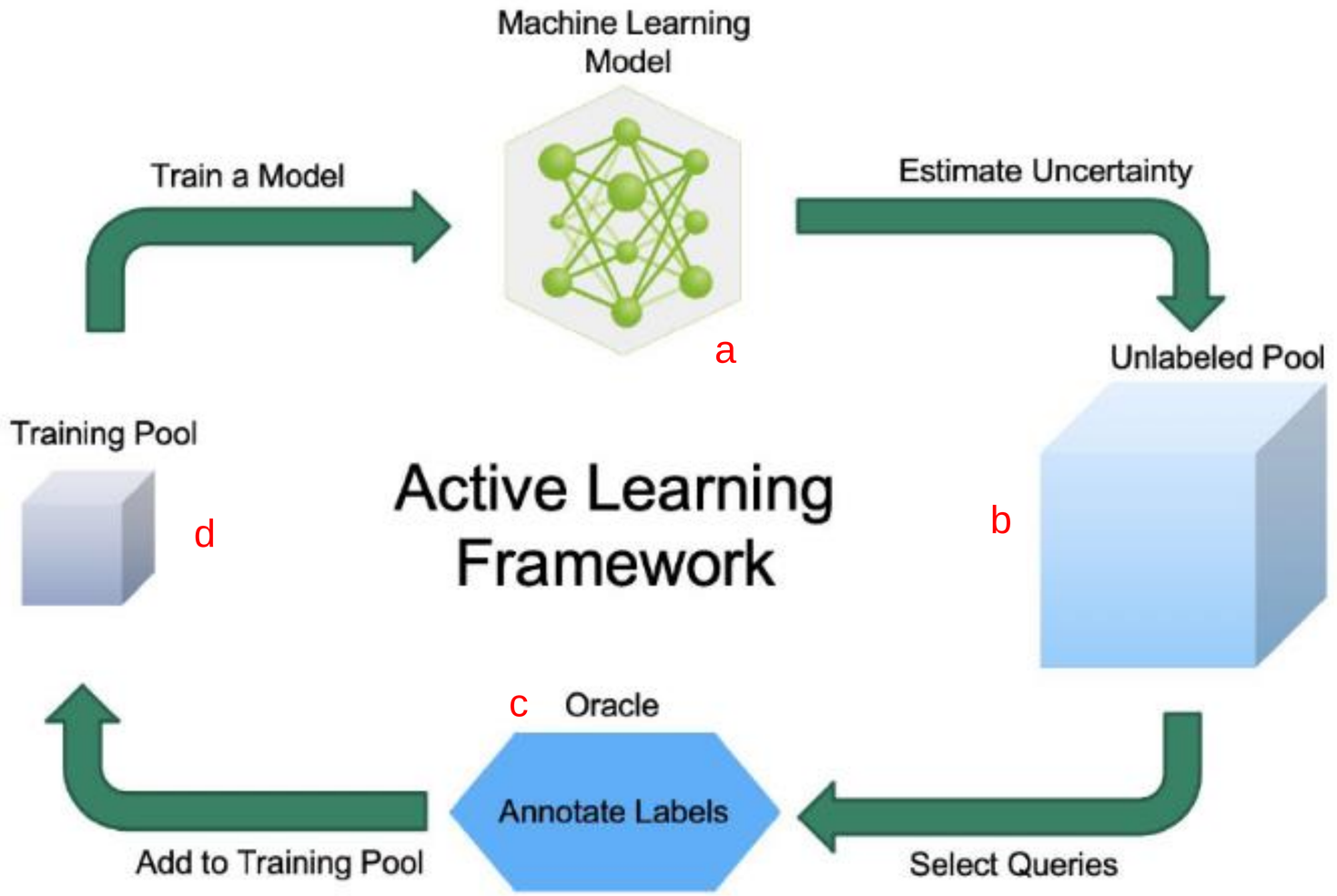
1. Select a pre-trained segmentation model from NGC:
https://catalog.ngc.nvidia.com/models?filters=&orderBy=dateModifiedDESC&query=clara



2. Copy the pre-trained weights into MONAI Label APP's model folder.

3. According to the configs of the pre-trained model, please update the APP's trainer, infer and config.

MONAI Label With Pre-trained Models



MONAI Label Without Pre-trained Models

If we don't have a pre-trained model before annotation, we can also apply MONAI Label to accelerate the annotating process.

1. Create your **custom MONAI Label app**. You should define the model architecture you want to use and the appropriate transforms. (Including pre-processing, augmentation and post-processing), then make the model to be initialized randomly.

2. Annotate a few data by yourself and submit to MONAI Label server, then train the initialized model by the annotated data.

3. Now you have a pre-trained model. Continuing looping the Active Learning Strategy to annotate your dataset.