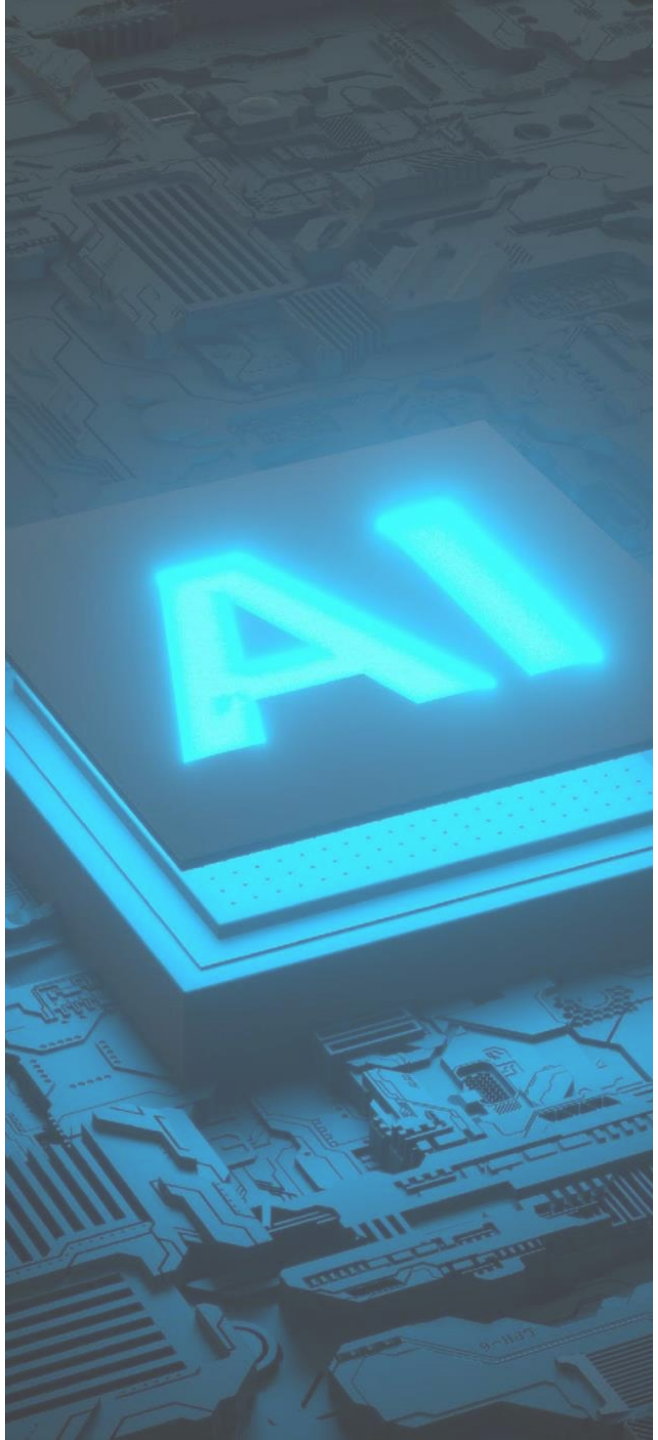
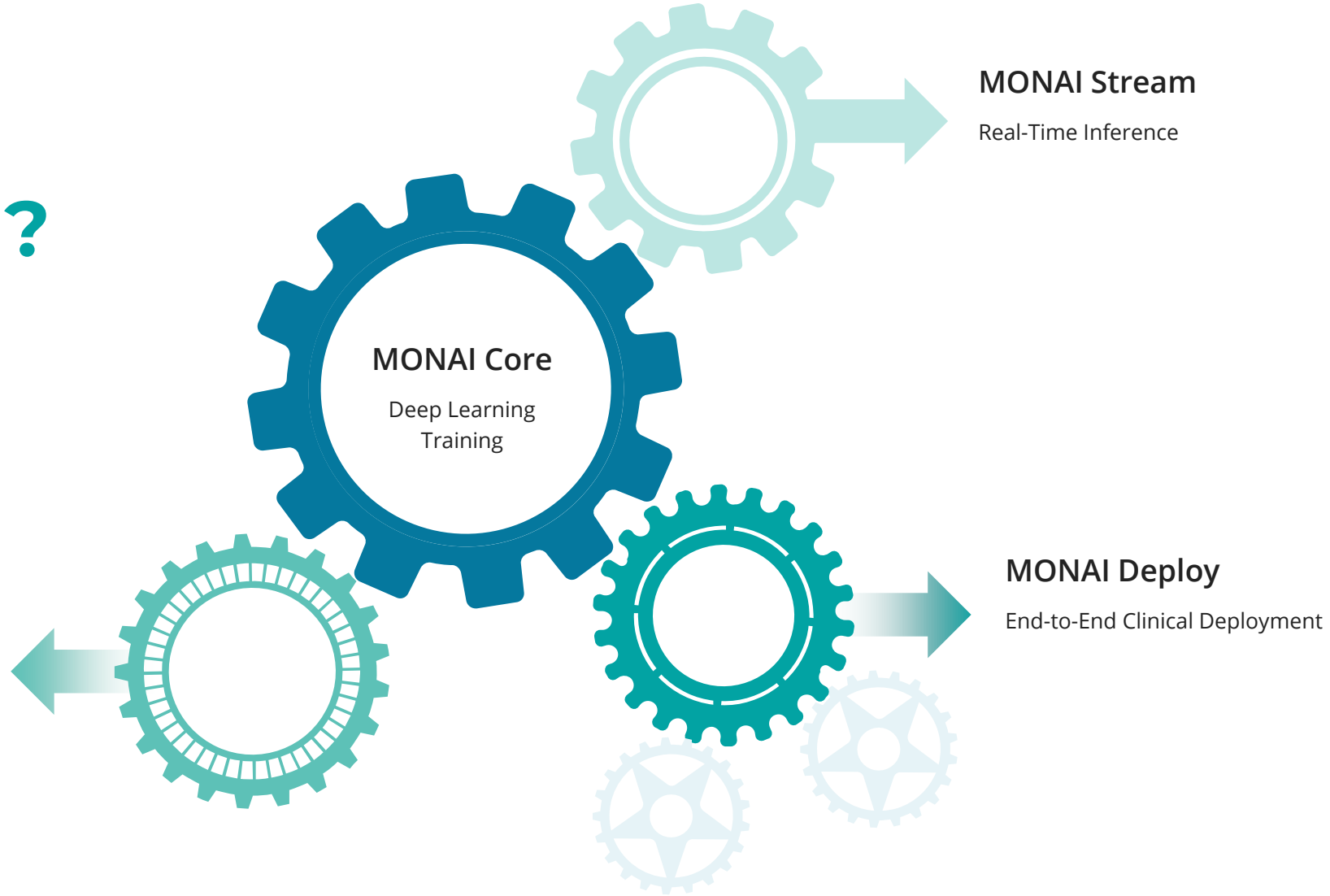
Medical Open Network for AI

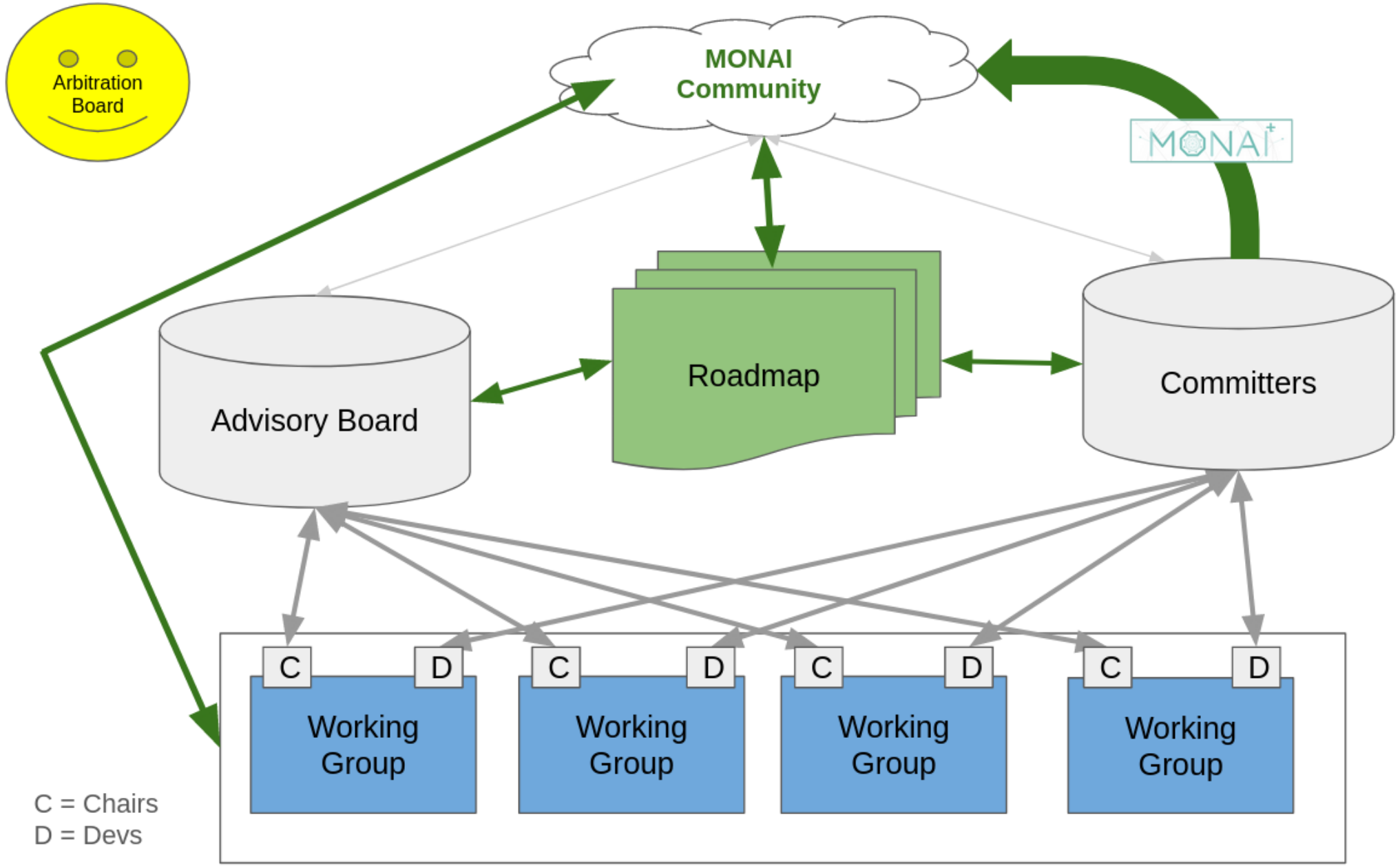


What is MONAI?

Project MONAI is a collaborative open-source initiative built by academic and industry leaders for deep learning in healthcare imaging.

What is MONAI?




Arbitration Board
MONAI Community
MONAI+
Advisory Board
Roadmap
Committers
C
D
Working Group
Working Group
Working Group
Working Group
C = Chairs
D = Devs

Stephen Aylward

Chair of the Advisory Board

Sebastien Ourselin

Klaus Maier-Hein

Jayashree Kalpathy-Cramer

Jorge Cardoso

Daniel Rubin

Kevin Zhou

Nassir Navab

Andrew Feng

Nasir Rajpoot

Justin Kirby

Keyvan Farahani

MONAI Advisory Board.

MONAI brings together the effort to build a common and open foundation. It is mission-critical for MONAI's success to be guided by thought leaders in the domain.

MONAI Working Groups.

Imaging I/O

Focus: define how data is read into and written out from memory in MONAI.

Data

Focus: Defining support for bioinformatics, biomarkers, and metadata that are in scope for MONAI.

Transformations

Focus: Topics related to data preprocessing and augmentation modules in MONAI.

Federated Learning

Focus: Unify the disparate methods of Federated Learning in a common MONAI framework.

Evaluation, Reproducibility, and Benchmarking

Focus: Provide the infrastructure and tools for quality-controlled validation and benchmarking of medical image analytics methods.

Research

Focus: Establish MONAI as a catalyst for scientific progress and real-life impact.

Community Development

Focus: Establish MONAI as a common software foundation that the medical imaging research and development community can build upon.

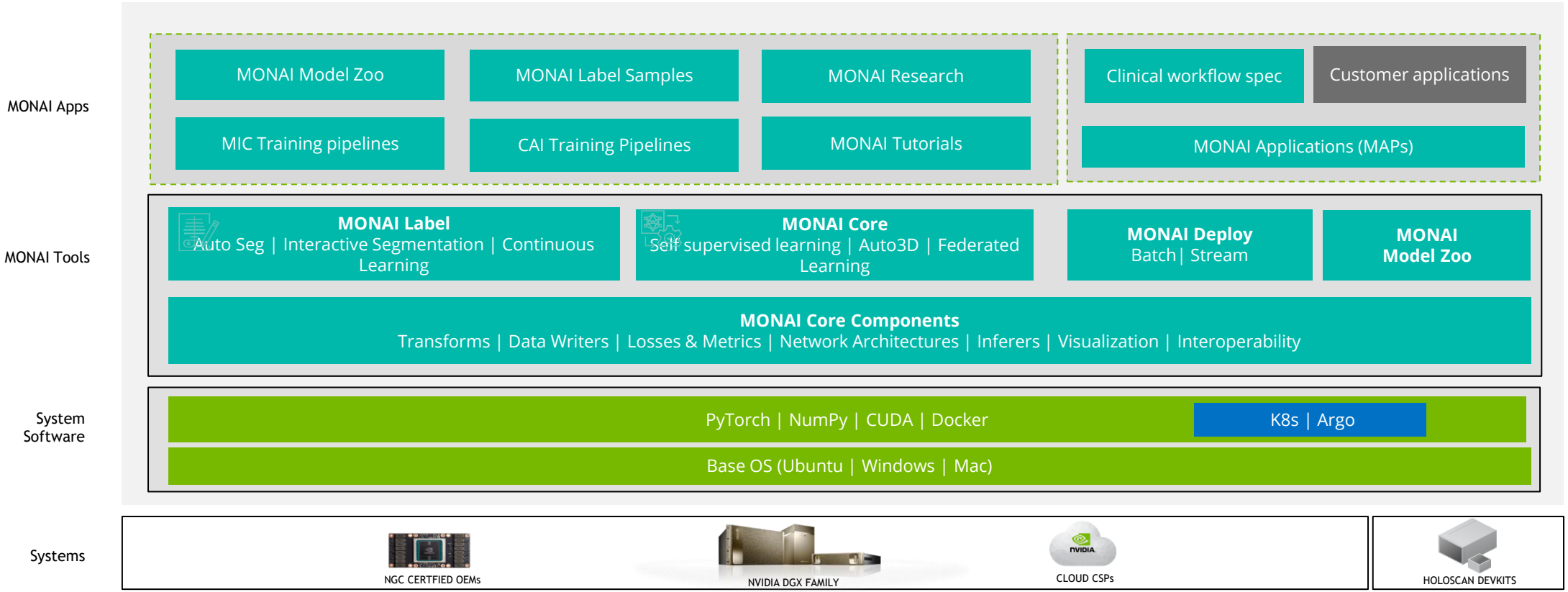
Deploy

Focus: Close the existing gap from research and development to clinical production environments by bringing AI models into the medical workflow.

Digital Pathology

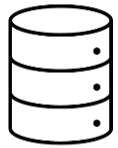
Focus: Creating a standard pipeline for preprocessing, analysis, and visualization of pathology images.

MONAI Stack.


MONAI Apps
MONAI Model Zoo
MONAI Label Samples
MONAI Research
MIC Training pipelines
CAI Training Pipelines
MONAI Tutorials
Clinical workflow spec
Customer applications
MONAI Applications (MAPs)
MONAI Tools
MONAI Label
Auto Seg | Interactive Segmentation | Continuous Learning
MONAI Core
Self supervised learning | Auto3D | Federated Learning
MONAI Deploy
Batch | Stream
MONAI Model Zoo
MONAI Core Components
Transforms | Data Writers | Losses & Metrics | Network Architectures | Inferers | Visualization | Interoperability
System Software
PyTorch | NumPy | CUDA | Docker
K8s | Argo
Base OS (Ubuntu | Windows | Mac)
Systems
NGC CERTFIED OEMs
NVIDIA DGX FAMILY
CLOUD CSPs
HOLOSCAN DEVKITS
SOTA Research to Clinical Deployments

MONAI Workflow.

00 Data



Data is the basis for all medical imaging workflows. Whether that's your data or public data, you need a way to get the data into the MONAI as quickly as possible.

MONAI provides easy access to datasets like the Medical Segmentation Decathlon and MedNIST datasets through wrapper APIs. MONAI also provides easy methods to load your data with performant libraries for most common medical image formats.

01

Labeling

MONAI Label is an intelligent open-source image labeling, and learning tool that helps researchers and clinicians collaborate, create annotated datasets and build AI models in a standardized MONAI paradigm.

MONAI Label v0.8

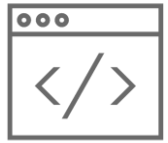
02

Training

MONAI is the flagship PyTorch-based library for deep learning in healthcare imaging. It provides domain-optimized foundational capabilities for developing healthcare imaging training workflows

MONAI Core v1.3

03



App Development

MONAI Deploy App SDK enables developers to take an AI model and turn them into AI applications.

MONAI Deploy App SDK v0.6

04

Deployment

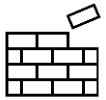
MONAI Deploy is also building open reference implementations of an inference orchestration engine, informatics gateway, and a workflow manager to help drive clinical integration.

MONAI Workflow Manager v0.1.29
MONAI Informatics Gateway v0.4.1
MONAI Deploy Express v0.5.0

MONAI Design Goals.

Customizable

Abstracted for customizable design for varying user expertise

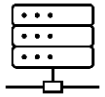


Composable

Portable with ease of Integration into existing workflows

Domain Specialized

3D Transformations, Network Architectures, and workflows for Medical Imaging



GPU Optimized

Multi-GPU CUDA accelerated data and model parallel processing

Reproducible

Built for reproducibility and comparison with state of the art

High Quality

Tutorials for getting started, robust validation, and documentation

What is MONAI Label?

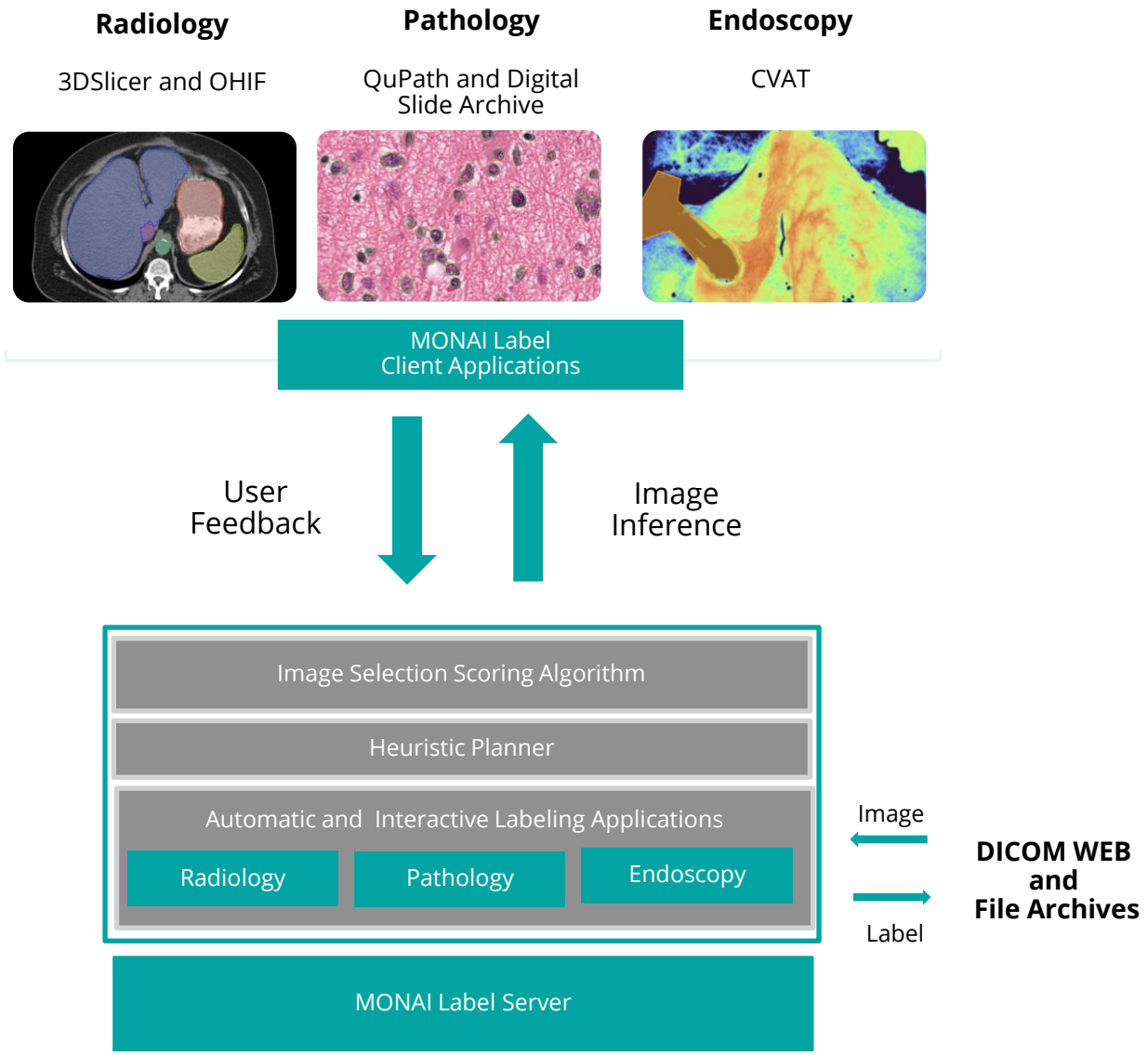
An intelligent image labeling and learning tool that uses AI assistance to reduce the time and effort of annotating new datasets.

NEXT

MONAI Label Overview.

Save time with an intelligent data labeling tool

- Created annotated datasets and build AI annotation models for clinical evaluation
- Support for 3D segmentation (radiology), pathology (nuclei detection), and 2D segmentation (endoscopy video).
- Client Viewer Integrations: 3DSlicer, OHIF, PAIR, Digital Slide Archive, QuPath, CVAT (MONAI Label is a plug in into other viewers, not a viewer)
- MONAI Label Server makes applications ready to deploy and serve as a service



MONAI Label Client.

3D Slicer

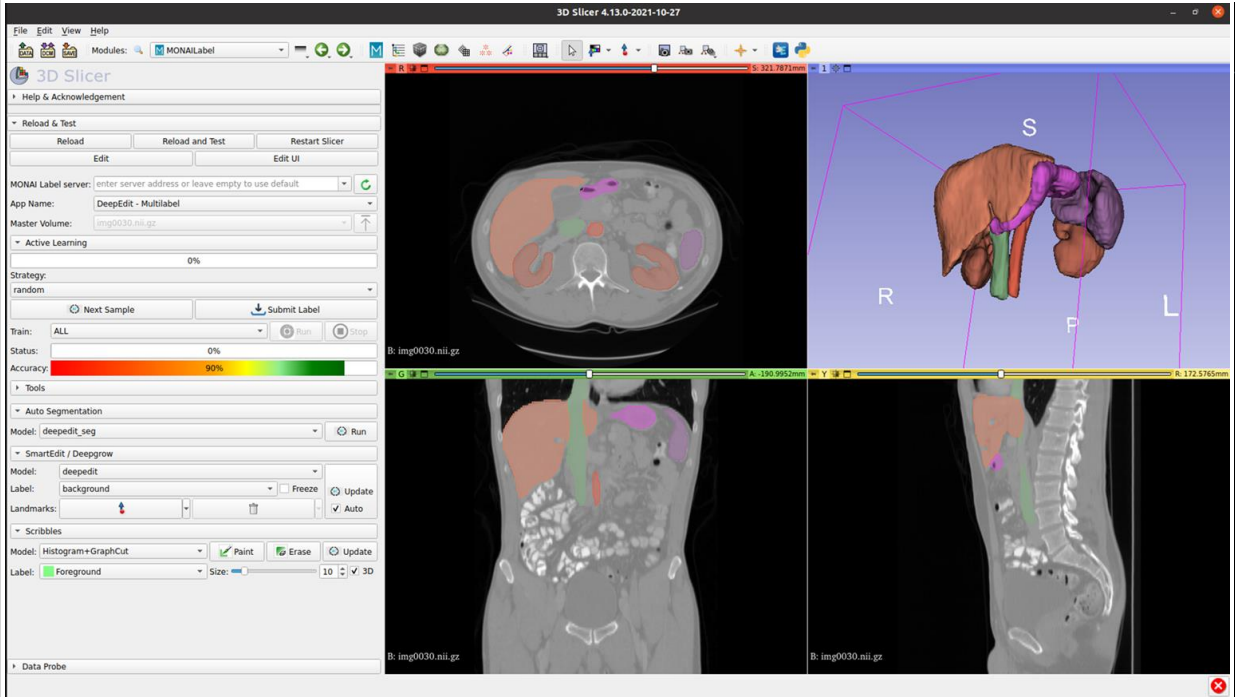
A free, open source and multi-platform software package widely used for medical, biomedical, and related imaging research.

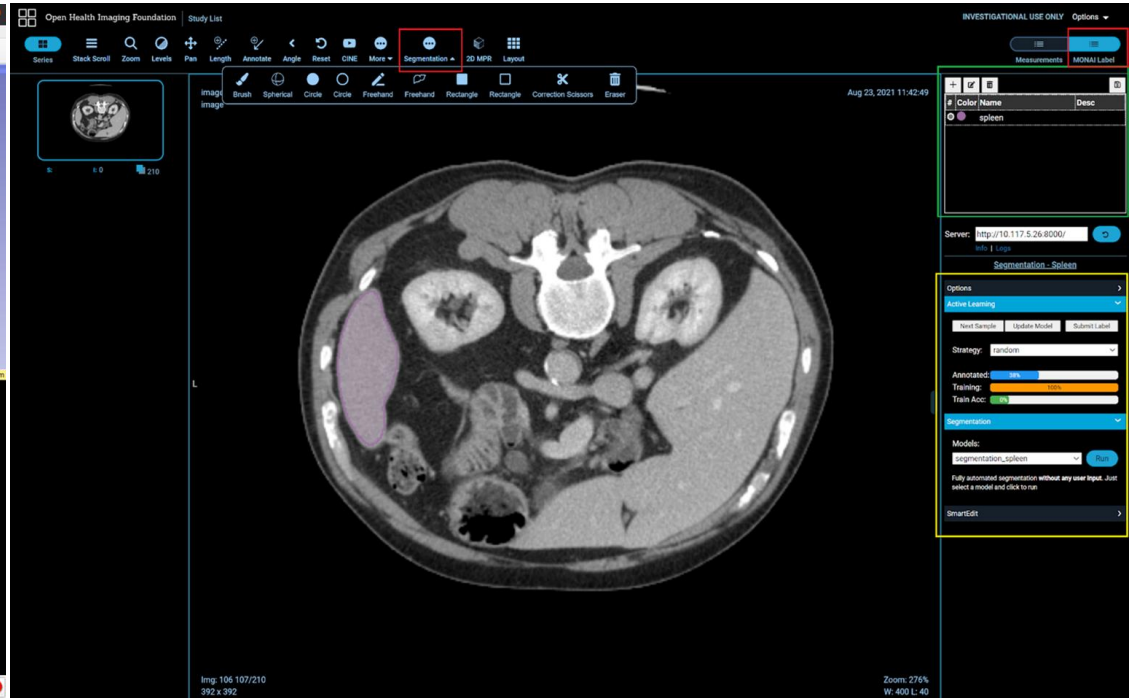
- Supportive community
- User-friendly
- Easy to customise
- Many manual annotation tools
- Image Registration

OHIF

The Open Health Imaging Foundation (OHIF) Viewer is an open source, web-based, medical imaging platform. It aims to provide a core framework for building complex imaging applications.

- 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.





Why MONAI Label?

For Clinician

Radiology: X-Ray, CT, and MRI
Pathology: Whole Slide Images

Viewer Integration

Existing viewer integration with common applications in both radiology and pathology workflow including 3D Slicer and DSA.

Multiple Annotation Methods

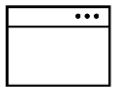
Start by using traditional annotation methods like Scribbles or use an interactive algorithm like DeepEdit.

Sample Apps and Pretrained Models

MONAI Label includes sample applications for both radiology and pathology. You can also use the our pretrained models or start from scratch.

For Researcher and Data Scientists

Quickly get started with a common framework



Rapid App Prototyping

Use a sample app to jumpstart the development of your own custom labeling app.

Active Learning Techniques

Use existing Active Learning strategies or implement your own.

Easy Integration

MONAI Label exposes a REST API that you can use to integrate in to your own viewer or workflow.

What is MONAI Core?

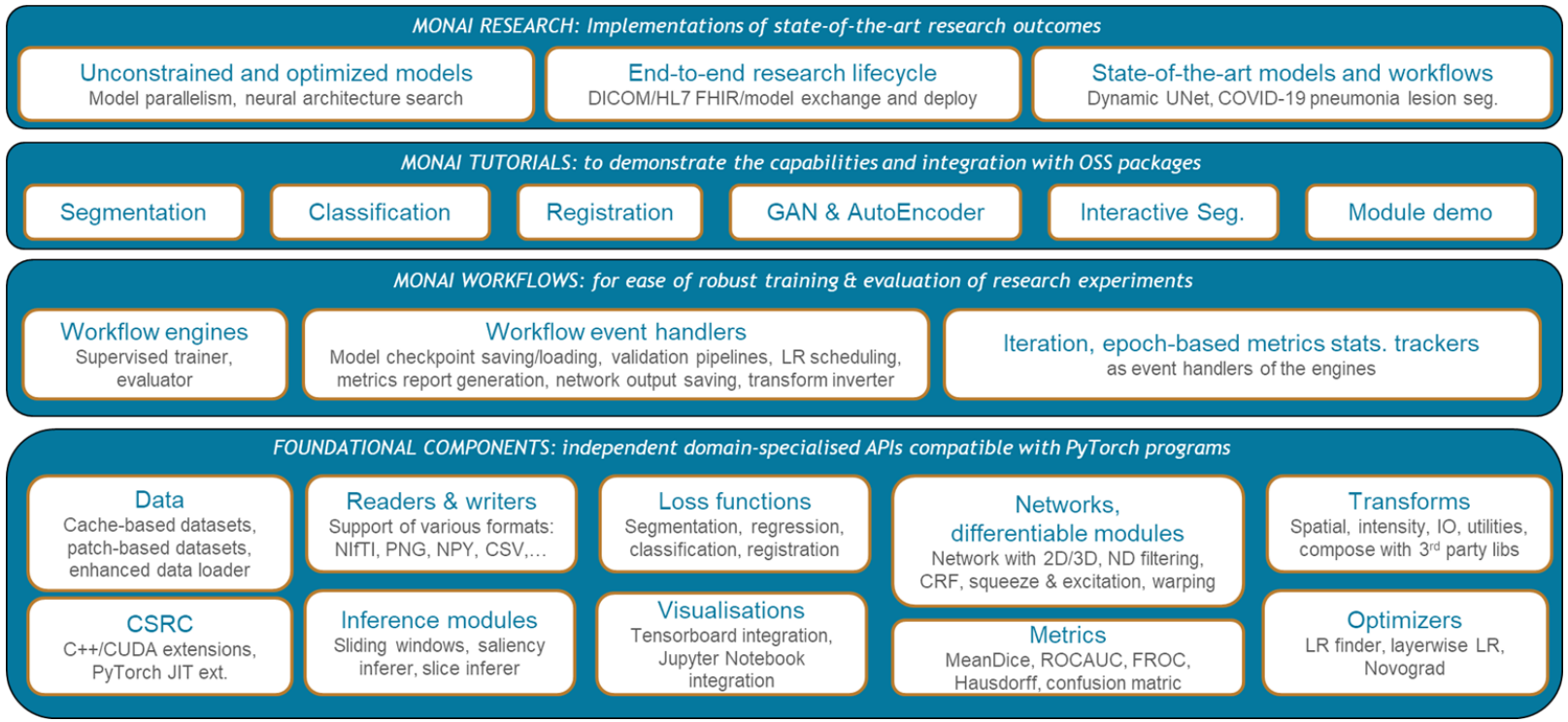
A framework that provides domain-specific capabilities for training AI models for healthcare imaging.

NEXT

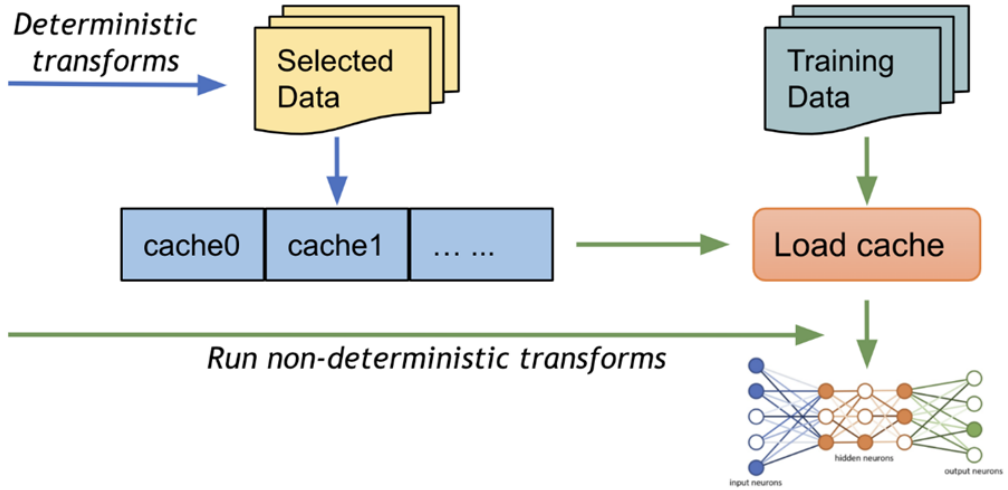
What is MONAI Core.

MONAI Core Component Basics

- Transformations
- Dataset APIs
- Sliding Window Methods
- Other (differentiable) modules



```
Train_transforms = Compose([
    LoadNiftid(),
    AddChanneld(),
    Spacingd(),
    Orientationd(),
    ScaleIntensityRanged(),
    RandCropByPosNegLabeld(),
    ToTensord()
])
```



(1) Define a chain of transforms

(2) Run deterministic transforms on selected data before training

(3) Load cached data and run random transforms in training

MONAI Core Transformations.

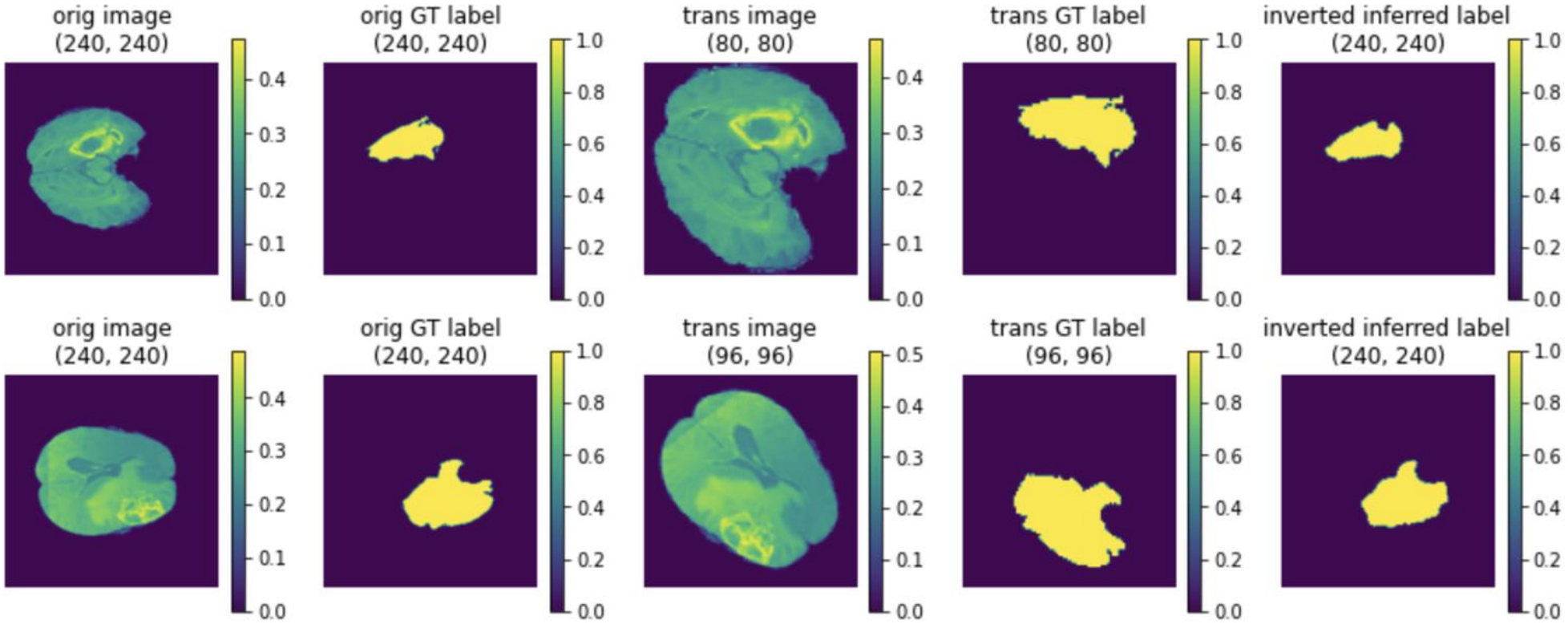
Types of Transforms

- Medical domain specific
  - LoadImage | Spacing | Orientation
  - Intensity-based data augmentation
- Image/patch transforms and GPU optimization
  - Spatial transforms
  - Patch-based sampling
  - Deterministic training
- Composable pipelines
  - CopyItem, ConcatItem, DeleteItem
  - De-collate, post-processing

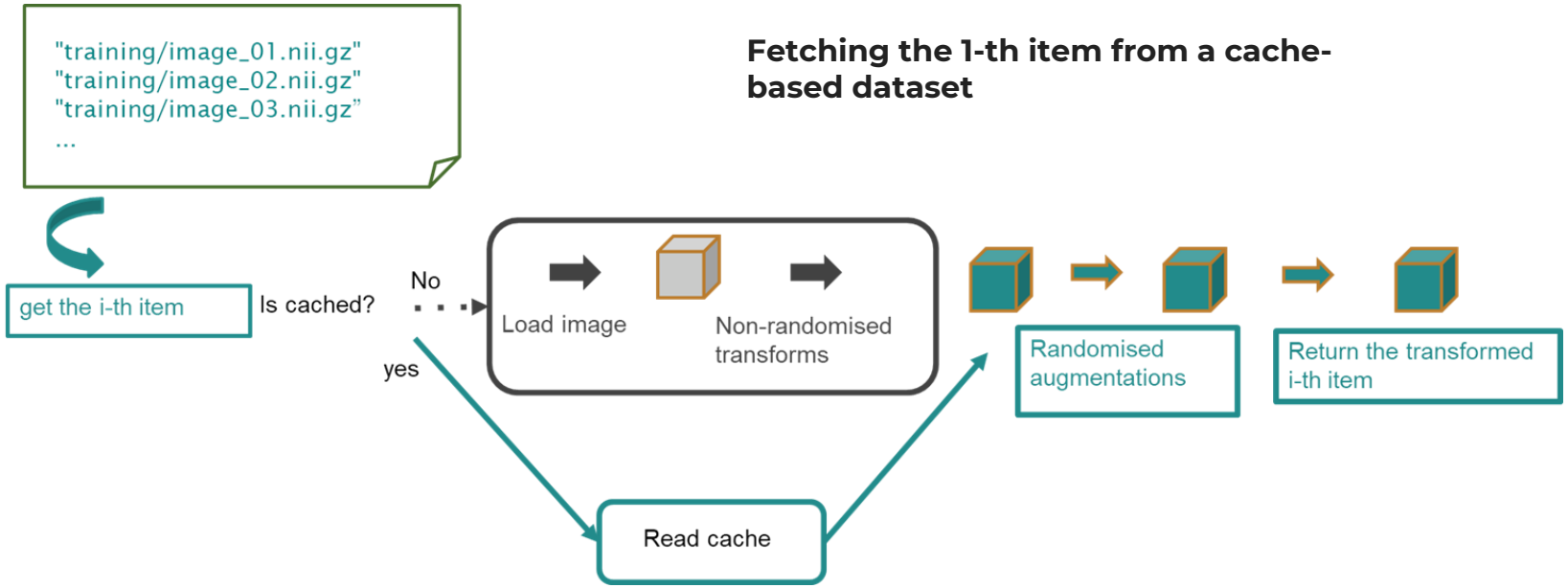
Invertible Transforms.

Why Invertible Transforms?

- Randomly augment the test case
- Track the transform parameters
- Run model inferences (segmentation)
- Resume to the original image space
- Compute ensemble/uncertainties

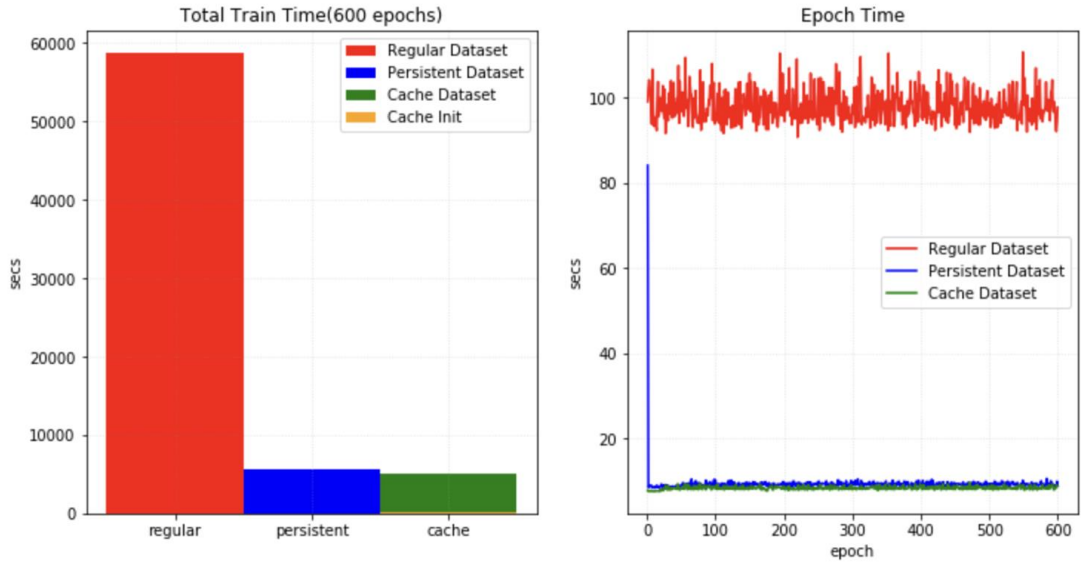


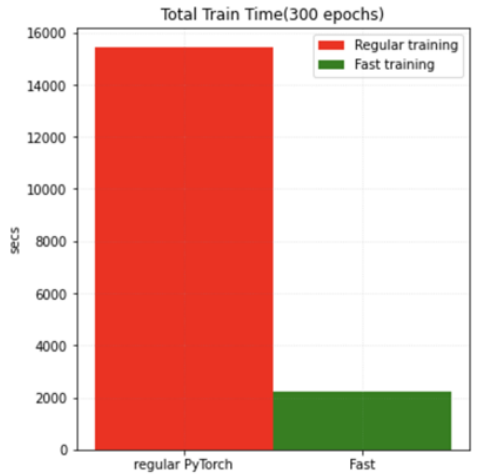
Dataset and Caching APIs.

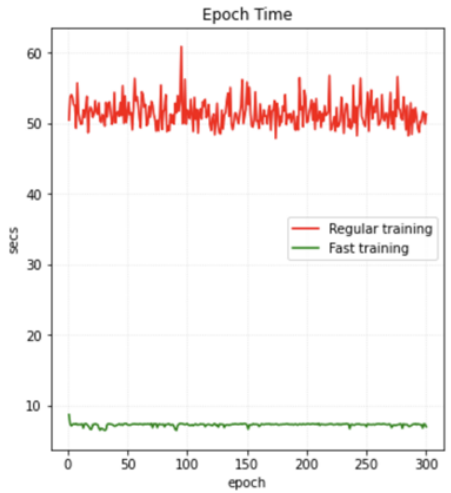


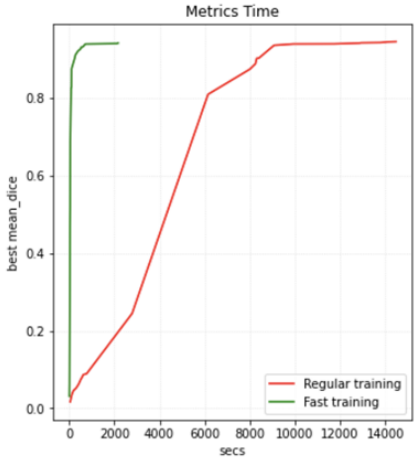
Fetching the 1-th item from a cache-based dataset

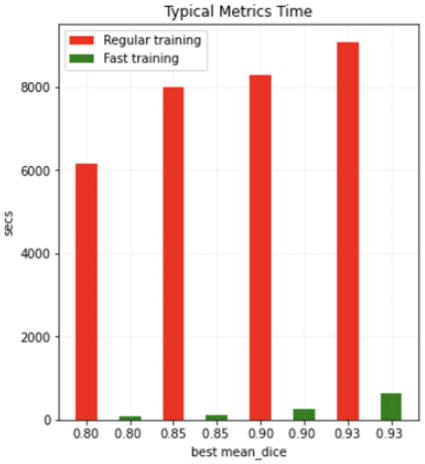
Caching Performance

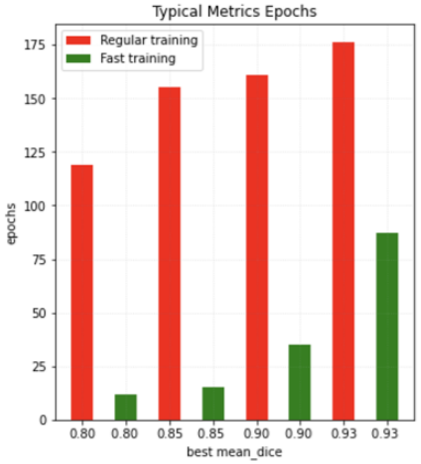












Efficient Training in MONAI.

Fast Training

- Parameters:
  - Auto Mixed Precision (AMP)
  - CacheDataset
  - Novograd Optimizers
- Takes fewer epochs to achieve a typical model quality
- About 12x speedup compared with native PyTorch implementation
- Fast Training Tutorial Available on GitHub
  - https://github.com/Project-MONAI/tutorials/blob/master/acceleration/fast_training_tutorial.ipynb

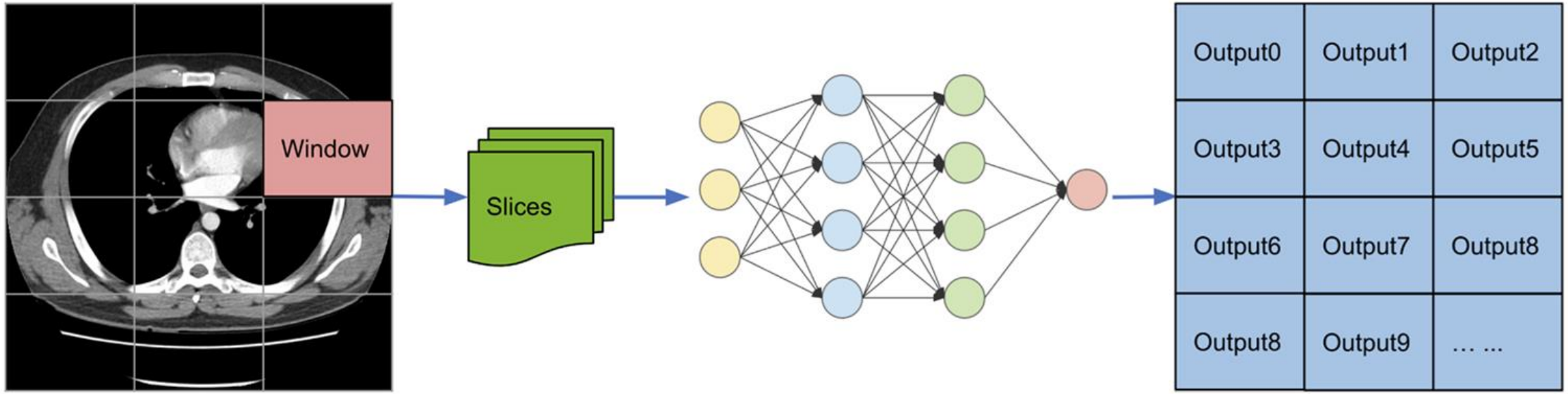
Sliding Window Inference and Evaluation.

Metrics

- Mean Dice
- Area under the ROC curve
- Confusion matrix
- Hausdorff distance
- Average surface distance
- Peak signal to noise ratio
- ...

Metrics APIs

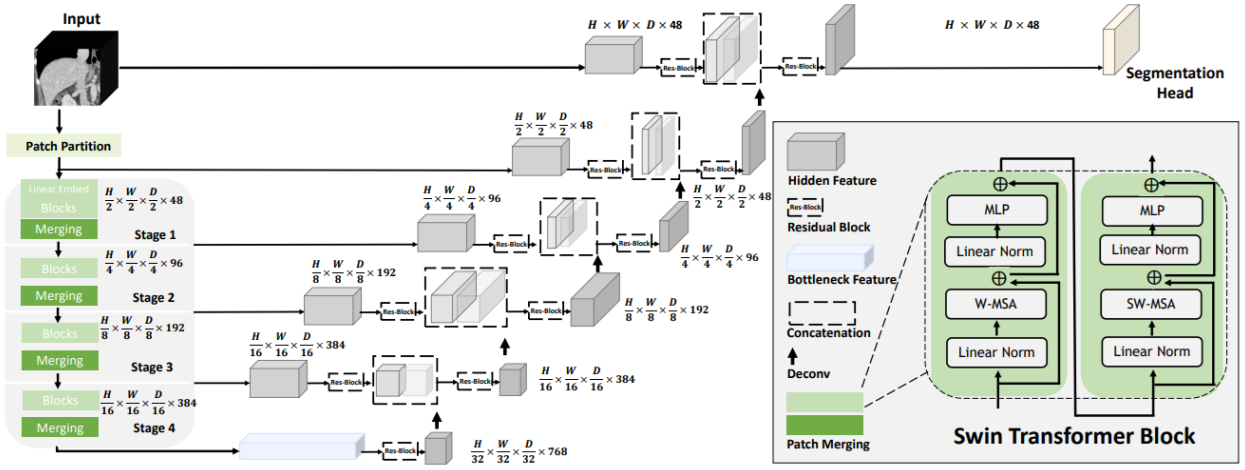
- Iterative Metric
- Cumulative
- Cumulative Average
- ...

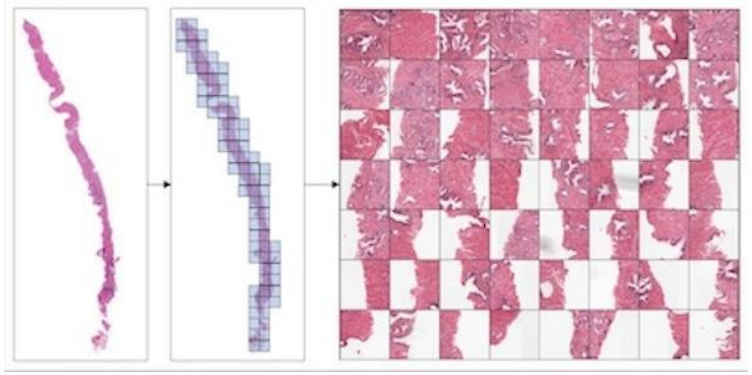


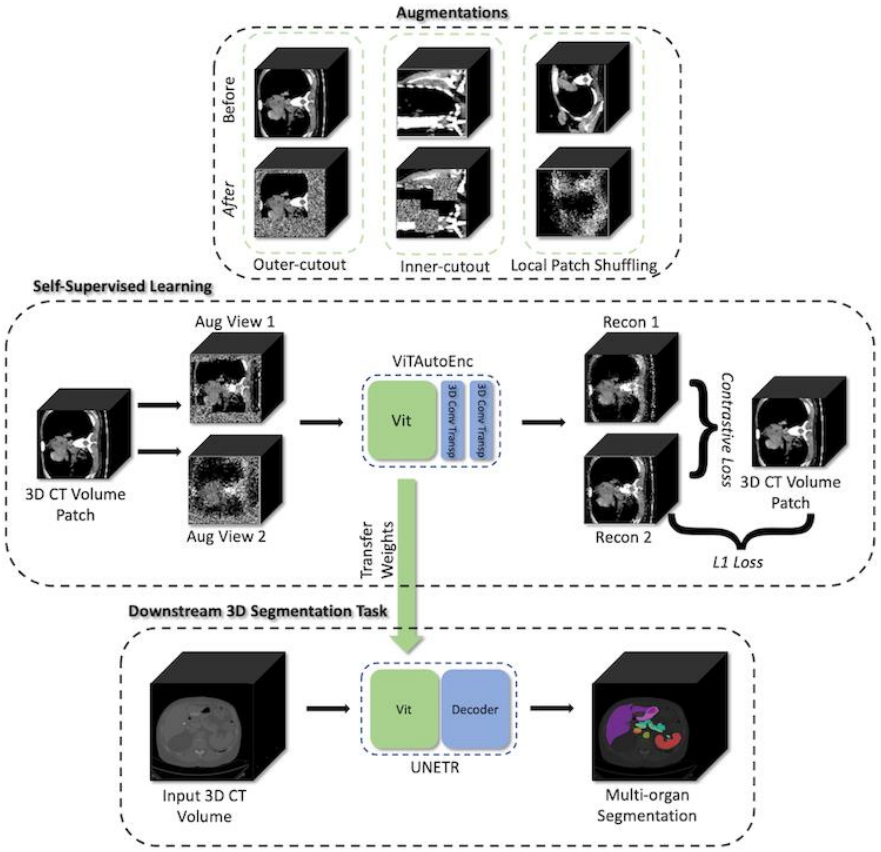
Network Architecture and Building Blocks.

Using MONAI Networks

- Predefined Layers and Blocks
- Implementation of generic 2D and 3D networks
- Network adapter to finetune final layers
- SoTA Architectures like: DiNTS, SSL, and Swin UNETR







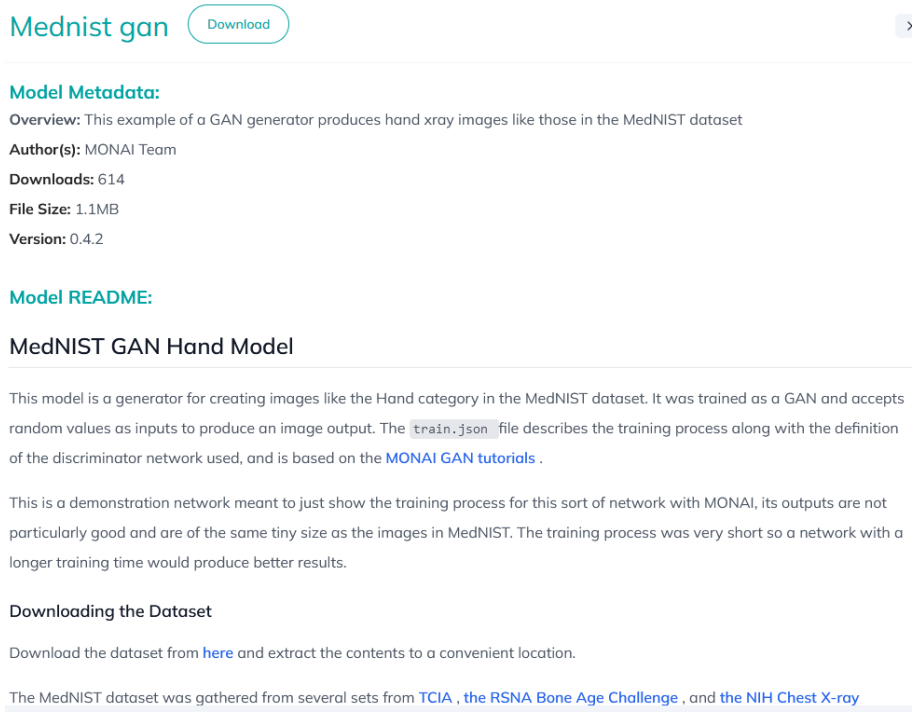
What is MONAI Model Zoo?

Repository of pre-trained models stored in a semantically-rich format

NEXT

Model Zoo

- MONAI-specific repository of pre-trained models
- Represented as bundles which include semantic and other information
- Represent many basic models, bundle templates, outputs from research, etc.
- Open to new contributors



Mednist gan Download

Model Metadata:

Overview: This example of a GAN generator produces hand xray images like those in the MedNIST dataset

Author(s): MONAI Team

Downloads: 614

File Size: 1.1MB

Version: 0.4.2

Model README:

MedNIST GAN Hand Model

This model is a generator for creating images like the Hand category in the MedNIST dataset. It was trained as a GAN and accepts random values as inputs to produce an image output. The `train.json` file describes the training process along with the definition of the discriminator network used, and is based on the MONAI GAN tutorials .

This is a demonstration network meant to just show the training process for this sort of network with MONAI, its outputs are not particularly good and are of the same tiny size as the images in MedNIST. The training process was very short so a network with a longer training time would produce better results.

Downloading the Dataset

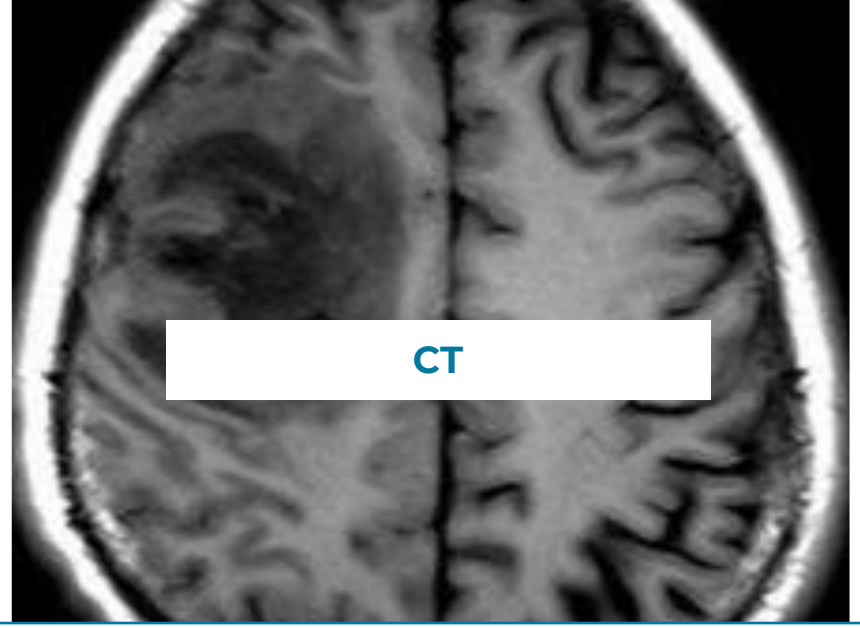
Download the dataset from here and extract the contents to a convenient location.

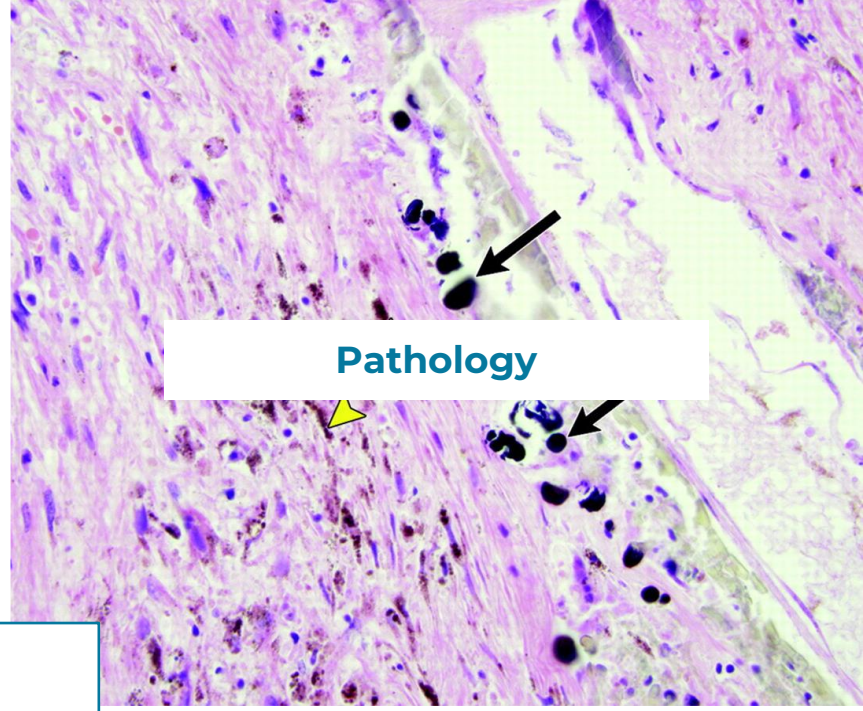
The MedNIST dataset was gathered from several sets from TCIA , the RSNA Bone Age Challenge , and the NIH Chest X-ray

```
├── brats_mri_axial_slices_generative_diffusion
├── brats_mri_generative_diffusion
├── brats_mri_segmentation
├── breast_density_classification
├── classification_template
├── endoscopic_inbody_classification
├── endoscopic_tool_segmentation
├── lung_nodule_ct_detection
├── mednist_gan
├── mednist_reg
├── multi_organ_segmentation
├── pancreas_ct_dints_segmentation
├── pathology_nuclei_classification
├── pathology_nuclei_segmentation_classification
├── pathology_nuclick_annotation
├── pathology_tumor_detection
├── prostate_mri_anatomy
├── renalStructures_CECT_segmentation
├── renalStructures_UNEST_segmentation
├── segmentation_template
├── spleen_ct_segmentation
├── spleen_deepedit_annotation
├── swin_unetr_btcv_segmentation
├── valve_landmarks
├── ventricular_short_axis_3label
├── wholeBody_ct_segmentation
└── wholeBrainSeg_Large_UNEST_segmentation
```

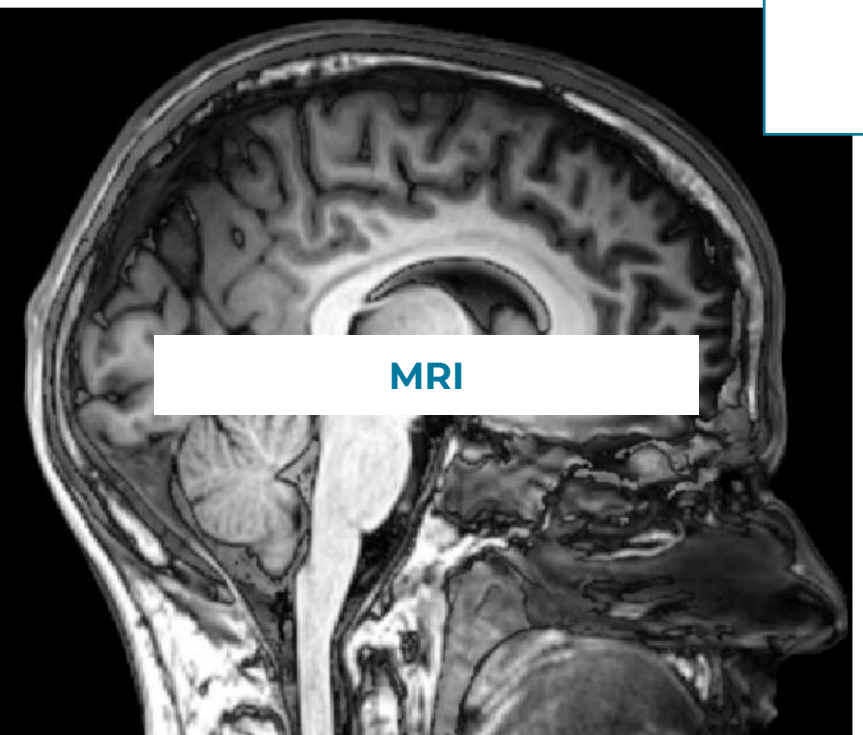
MONAI Model Zoo.

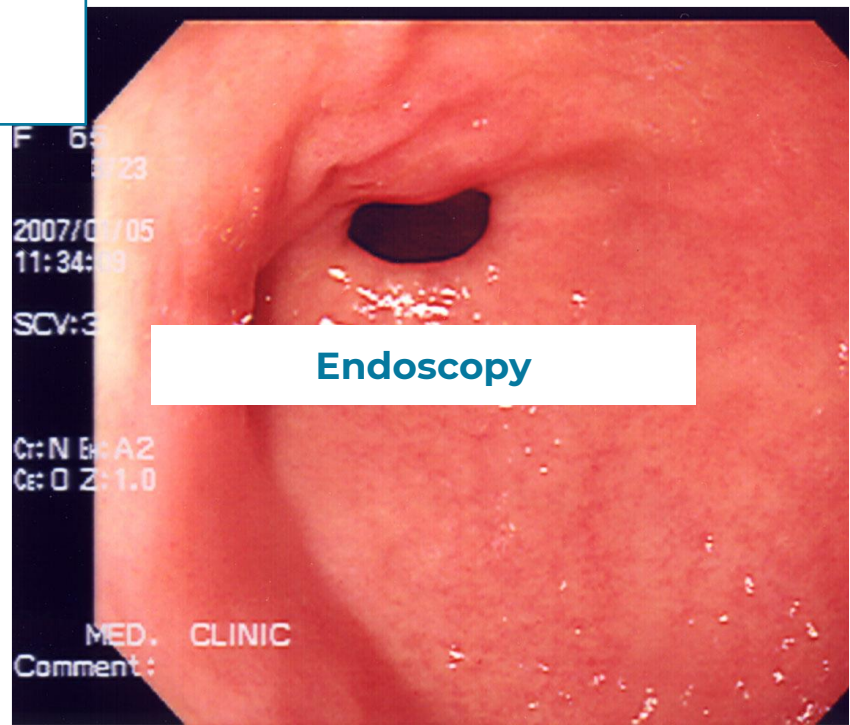
Use pre-trained models to jumpstart AI development for all organs and disease types





Modalities





Model Zoo Contributors.

CHARITÉ UNIVERSITÄTSMEDIZIN BERLIN

MAYO CLINIC

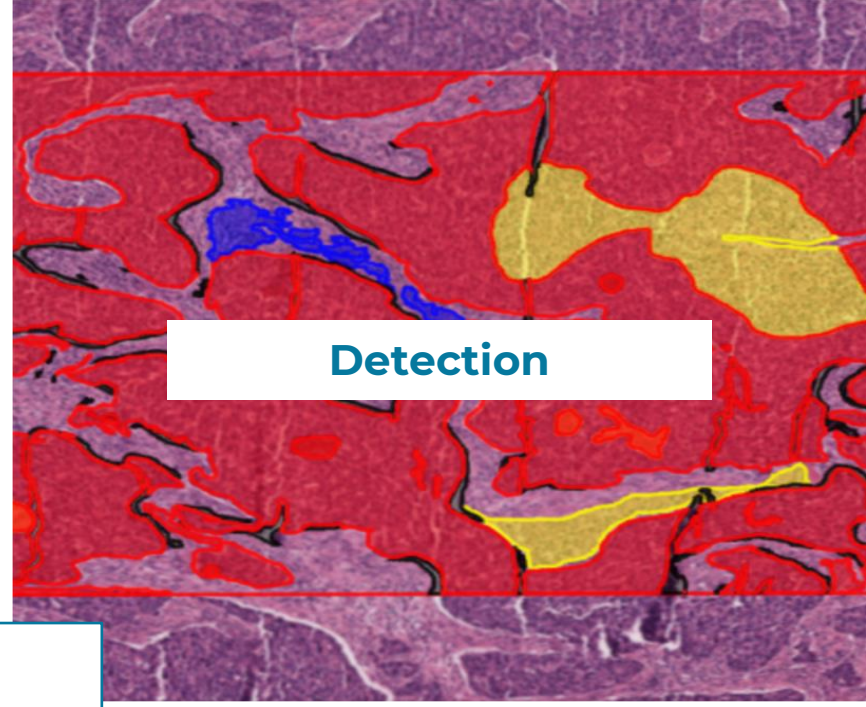
VANDERBILT UNIVERSITY

KING'S College LONDON

NVIDIA

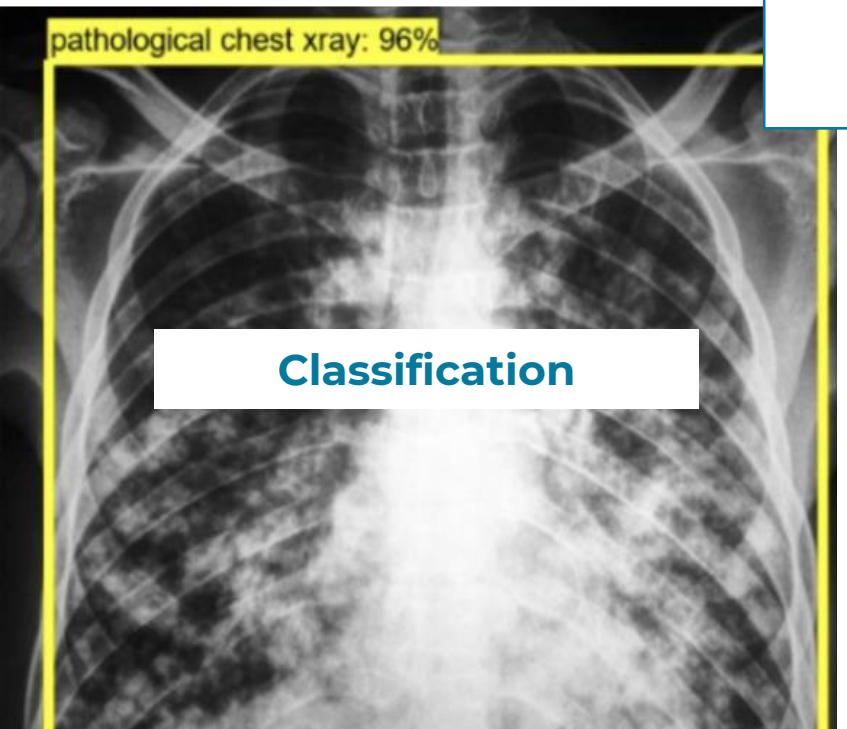
WARWICK THE UNIVERSITY OF WARWICK

Segmentation

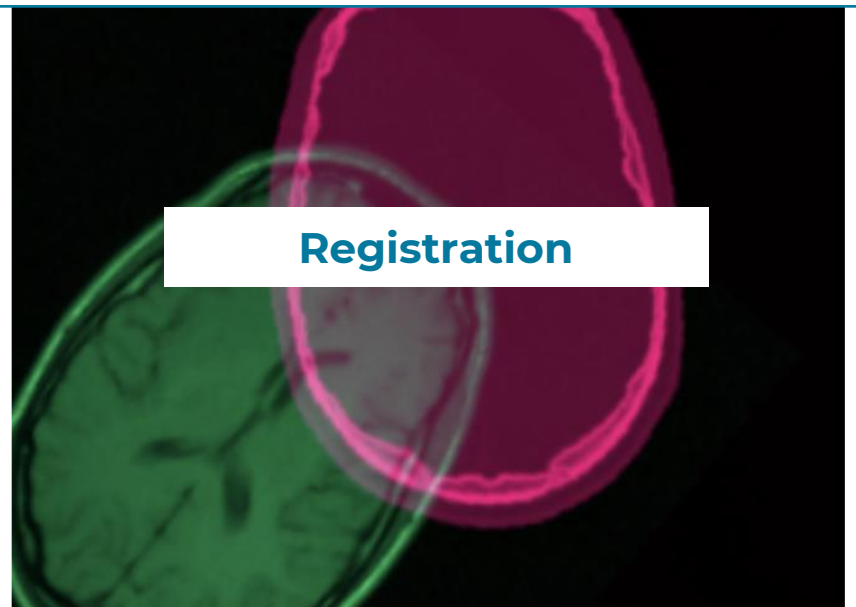


Detection

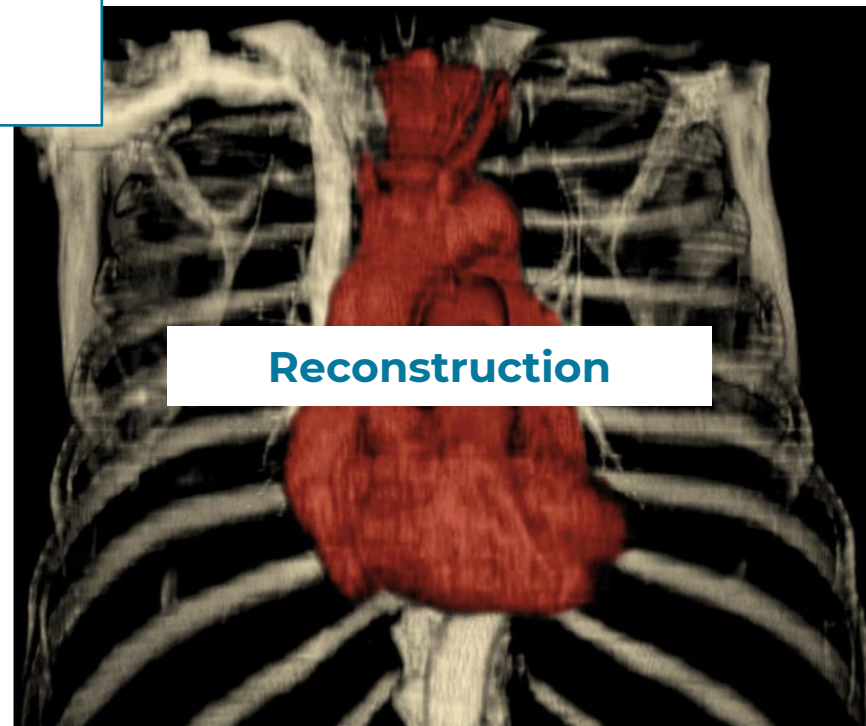
Applications



Classification



Registration



Reconstruction

MONAI Bundles

- Model are defined as bundles in Model Zoo
- Encapsulates model definition with metadata describing model, such as input/output format, usage, plain language description, etc.
- Defines a standard directory structure with metadata JSON files
- Further JSON/YAML files can define scripts or programs using syntax for describing object instantiations
- These are used by other applications, like Label or Deploy, to interface with a model
- Other items, such as license files, shell scripts, Python code, etc., can be included

Example: **mednist_gan**

```
├── LICENSE
├── configs
│   ├── inference.json
│   ├── logging.conf
│   ├── metadata.json
│   └── train.json
├── docs
│   ├── README.md
│   └── data_license.txt
├── models
│   └── model.pt
└── scripts
    ├── __init__.py
    └── losses.py
```

```
{
    "imports": [
        "$import functools",
        "$import glob",
        "$import scripts"
    ],
    "bundle_root": ".",
    "ckpt_path": "$@bundle_root + '/models/model.pt'",
    "dataset_dir": "./MedNIST/Hand",
    "latent_size": 64,
    "discriminator": {
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        "channels": [8, 16, 32, 64, 1],
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        "num_res_units": 1,
        "kernel_size": 5
    },
    ...
    "trainer": {...},
    "training": [
        "$@trainer.run()"
    ]
```

What is MONAI Deploy?

A framework for developing packaging, testing, deploying, and running medical AI applications in clinical production.

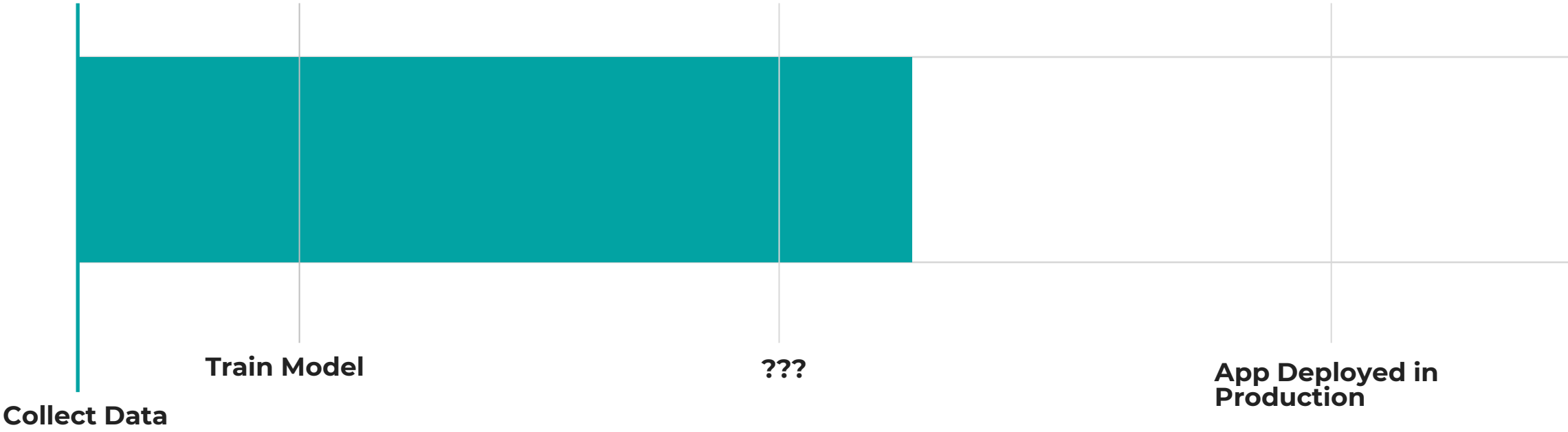
NEXT

Why is it hard?

More than 87% of data science projects never make it to production.

Why?

- Selecting the right DICOM datasets
- Loading DICOM Datasets
- Pre / Post processing Input Images
- Performing Inference
- Exporting AI results to DICOM
- Visualizing inference results
- Performance Optimization
- Resource Utilization
- Monitoring



What is MONAI Deploy?

End-to-End workflow to deploy AI< from bench to bedside

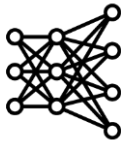
For Researchers and Developers

MONAI Deploy provides an easy way to develop MONAI Deploy Application Packages (MAPs).

For Hospital Operations

MONAI Deploy will define what a clinical infrastructure to run AI should look like, and how to interoperate with medical imaging systems over standards like DICOM and FHIR.

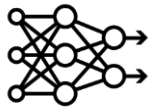
AI Research and Development



Trained Model (MONAI Bundle)

MONAI Deploy App SDK

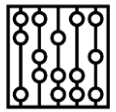
MONAI Application Package (MAP)



Inference Engine

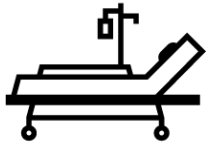
Clinical Production

MONAI Deploy Workflow Manager



Medical Imaging Standards DICOM, FHIR, HL7

MONAI Deploy Informatics Gateway



PACs, EHRs, Viewers

Accelerate Application Development

Build AI applications with few lines of code and package into a MONAI Application Package (MAP) in < 20 min.

Run Anywhere

Integrate into health IT standards and deploy across data center, cloud and edge environments.

Streamline Hospital Operations

Maintain AI governance for Hospital IT

MONAI Deploy Subsystems.

MONAI Deploy App SDK

What is it?

A Pythonic SDK to build deploy-ready AI Apps in Healthcare

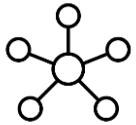
Developing, Packaging and Testing

MONAI Deploy Informatics Gateway

What is it?

Connects AI Applications to Healthcare Information Systems

Deploying and Running



MONAI Deploy Workflow Manager

What is it?

Central hub for the MONAI Deploy Platform

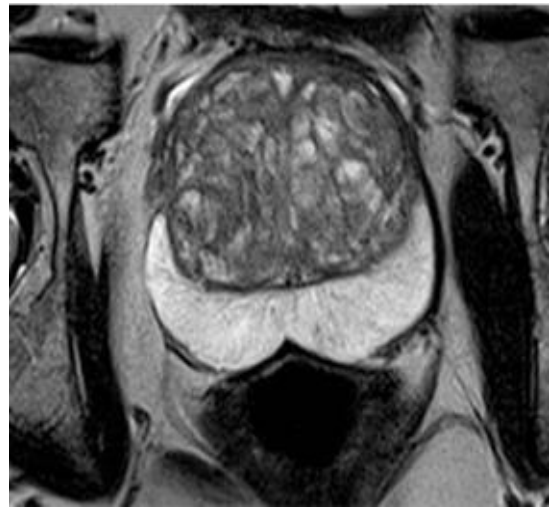
Deploying and Running

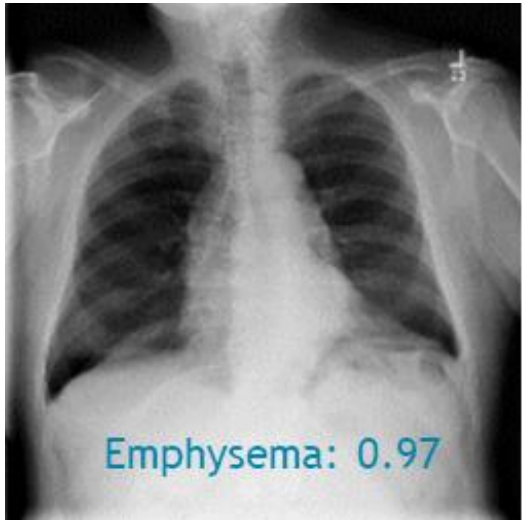
What is MONAI Deploy App SDK?

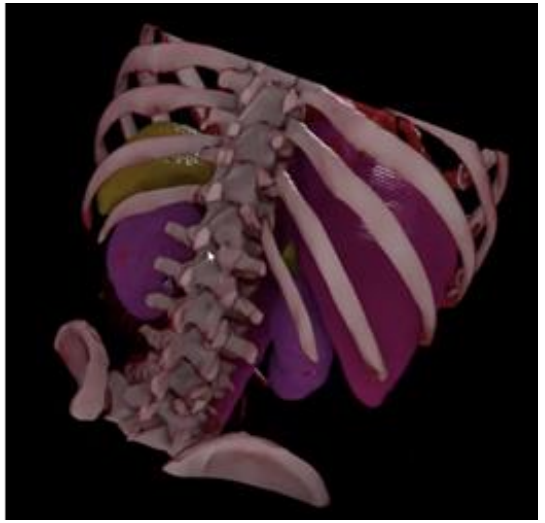
Design Goals:

- Focus on usability
- Enables composability
- Facilitates portability
- Ready for production

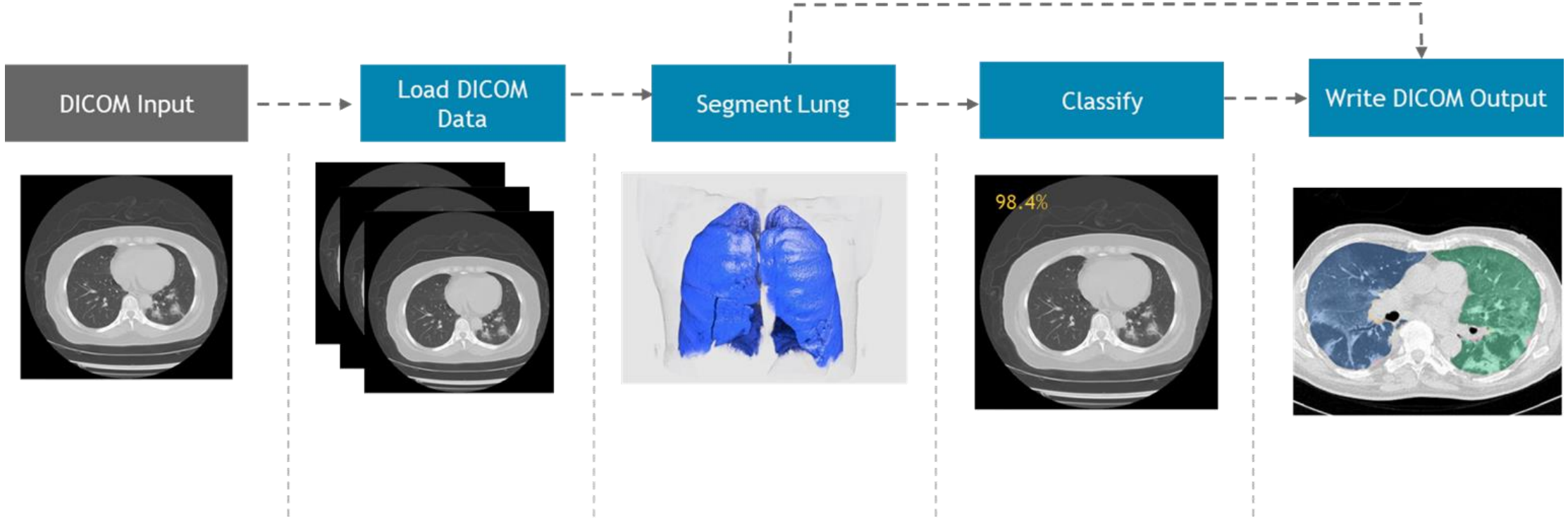
MONAI Deploy includes the MONAI Deploy App SDK, a simple python environment that builds containerized applications from pre-trained models in under 20 minutes. The resulting containerized application is called a MONAI Application Package (MAP).



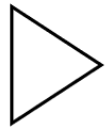




Typical Application in Medical Imaging AI.



Getting involved in the MONAI Community.



Start using MONAI!

How?

Start with tutorials in whichever piece of MONAI fits your current workflow.

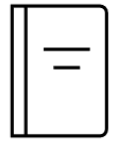
Get started with MONAI

Submit Issues or Bugs

How?

You've been using MONAI and found an issue or think we could write a tutorial? Tell us!

Contribute to MONAI



Contribute code, features, or research

How?

You've submitted a paper or trained a model? Start a discuss to integrate it into MONAI

Commit to MONAI

MONAI Resources.

- 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

Q/A