Tutorial: MONAI Core

Huiwen Ju

hju@nvidia.com

Solutions Architect, Higher Education & Research

03/01/2022

@ University of Florida

Agenda

- What is MONAI?
- What is MONAI Core & Why use it?
- MONAI Core local success story
- How to use MONAI Core on HiperGator? +demo
- Resources

WHAT IS MONAI?

Medical Open Network for AI

Project MONAI

- a collaborative open-source initiative
- founded at MICCAI 2019
- establish and standardize the best practices for deep learning in healthcare imaging to accelerate the pace of innovation.

WHAT IS MONAI?

Accelerate Pace of Research Innovation With a Common Foundation

AI-assisted image labeling tool

MONAI Label v0.3

deep learning training

MONAI Core v0.8

create applications from models
in minutes

MONAI Deploy App SDK v0.2

Coming Soon!

MONAI Stream

MONAI Core

Medical-imaging PyTorch.

MONAI Core

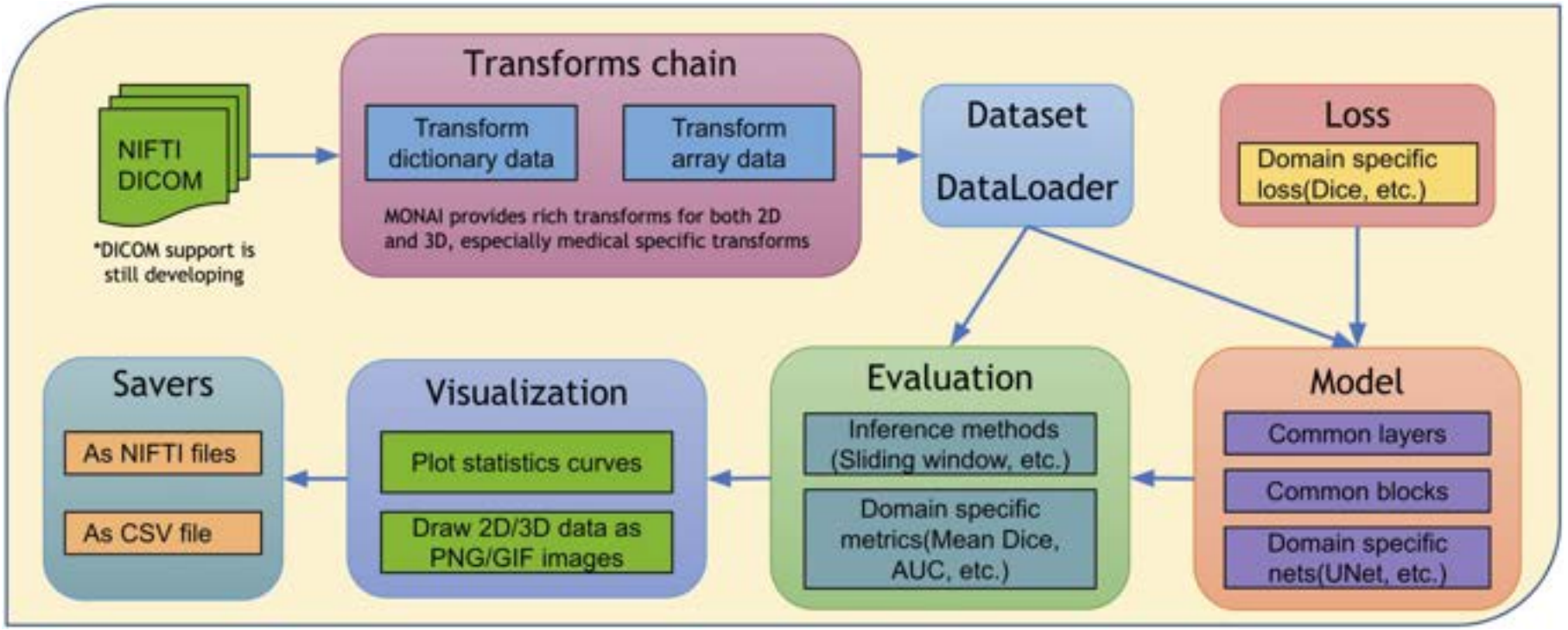
1. Medical-imaging-specific AI framework

2. Superior performance

3. Friendly community

MONAI Core

1. Medical imaging specific AI framework – ***comprehensive & flexible***
2. Superior performance
3. Friendly community



MONAI website https://monai.io/

MONAI Core

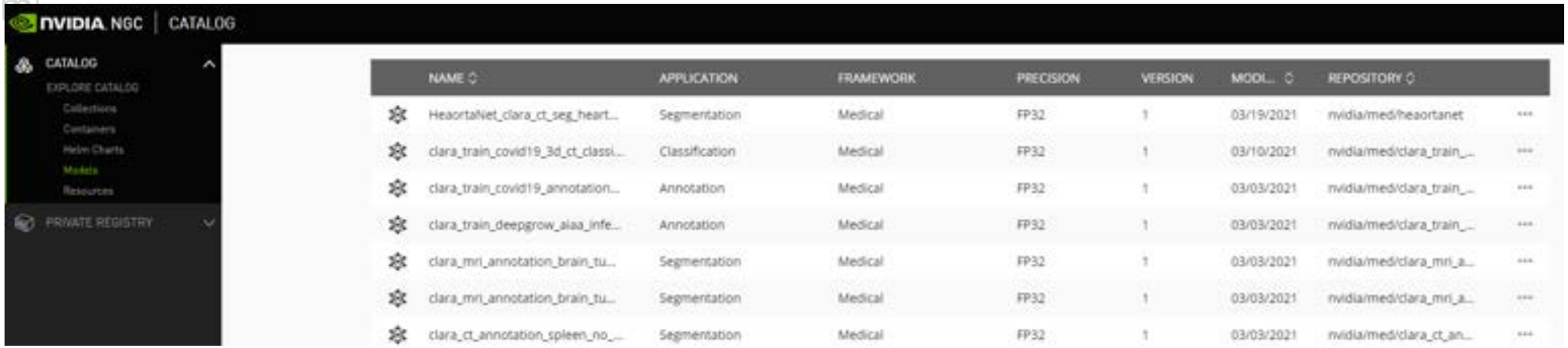
1. Medical imaging specific AI framework – ***comprehensive & flexible***

PRE-TRAINED models

2. Superior performance

Download from NGC 20+ Pre-Trained Models: CT, MRI, X-Ray, Digital Pathology
https://ngc.nvidia.com/catalog/models?orderBy=modifiedDESC&pageNumber=0&query=clara&quickFilter=models&filters=

3. Friendly comm



MONAI Core

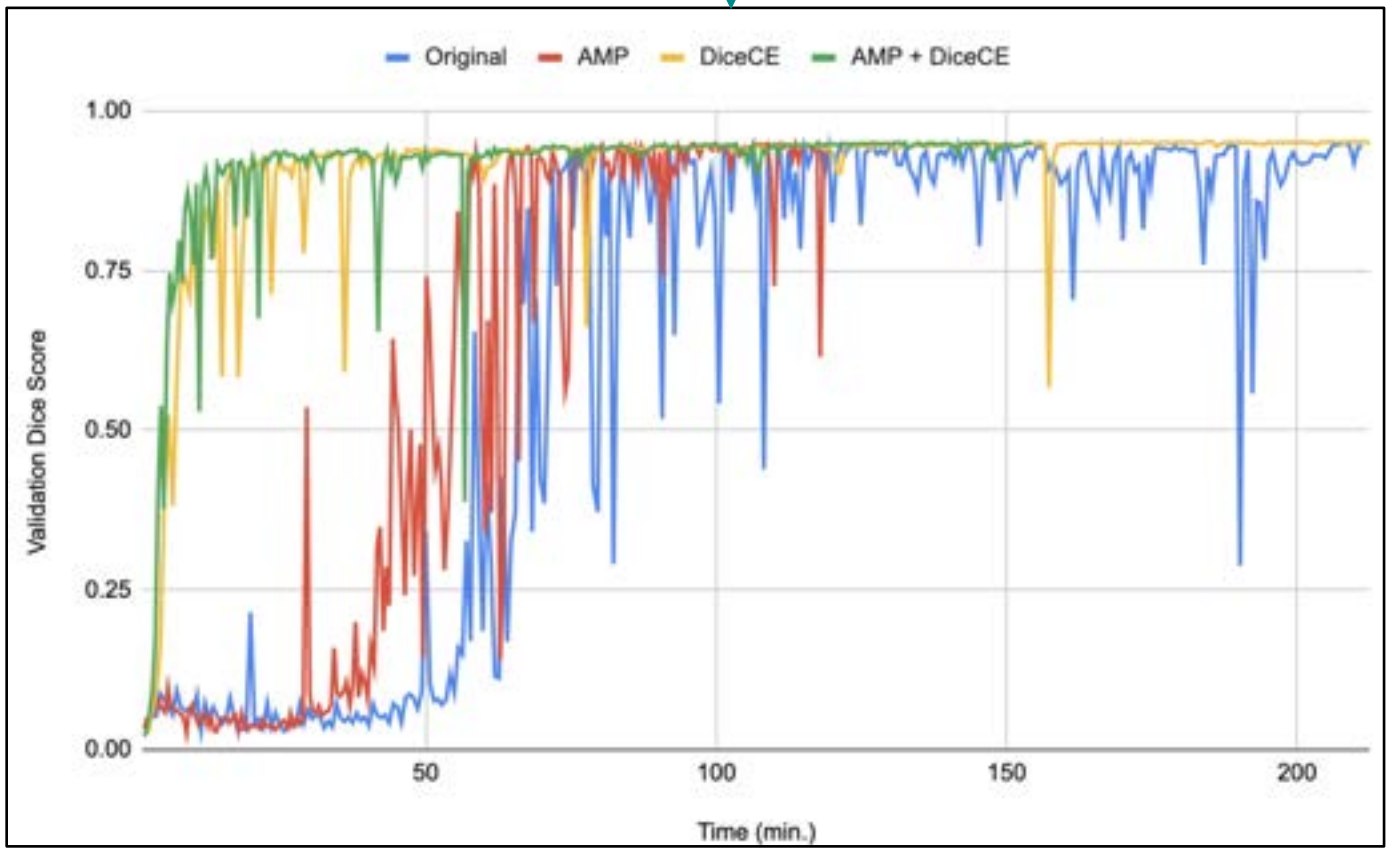
1. Medical imaging specif

2. Superior performance

3. Friendly community

Improve AI algorithms

- *Network architecture - UNETR*…*
- *Optimizer - Novograd …*
- *Loss function - DiceCELoss …*



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

MONAI Core

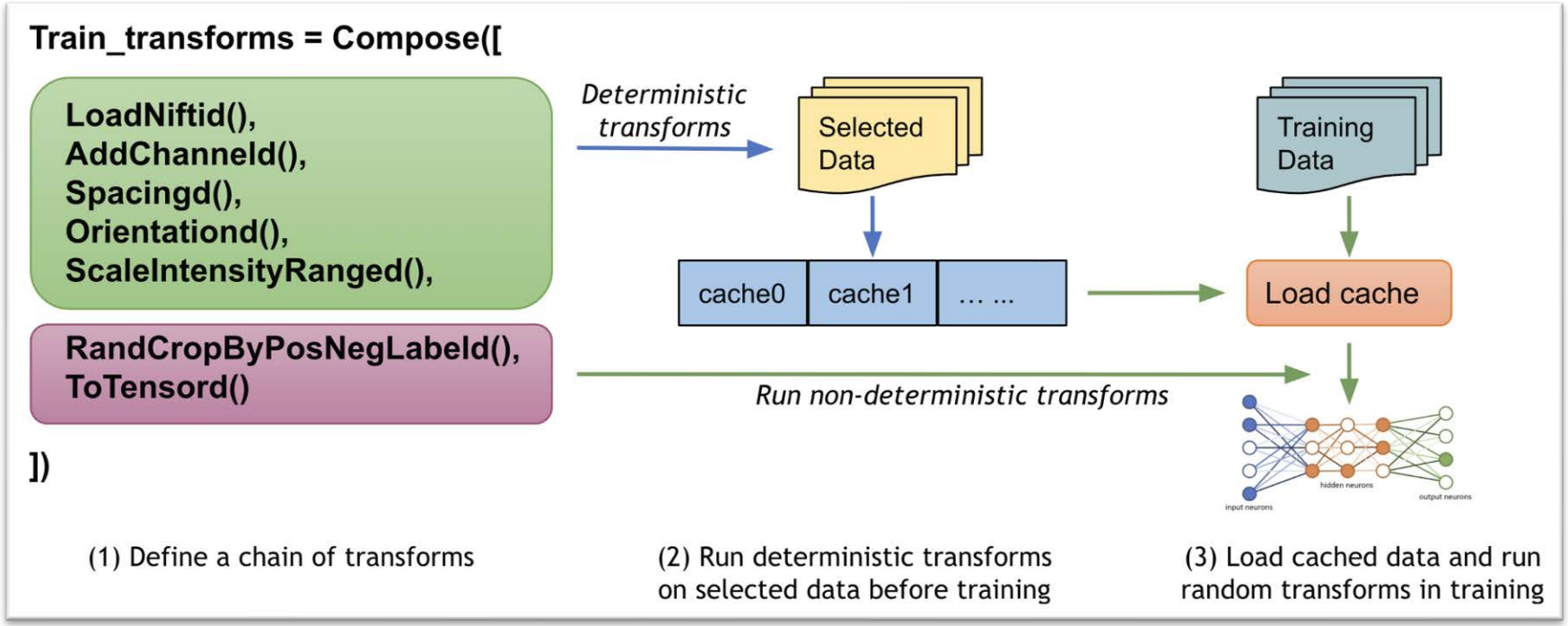
1. Medical imaging specif

2. Superior performance

3. Friendly community

Optimize data loading

Dataset Caching - 10X speed up



MONAI Core

1. Medical imaging specif

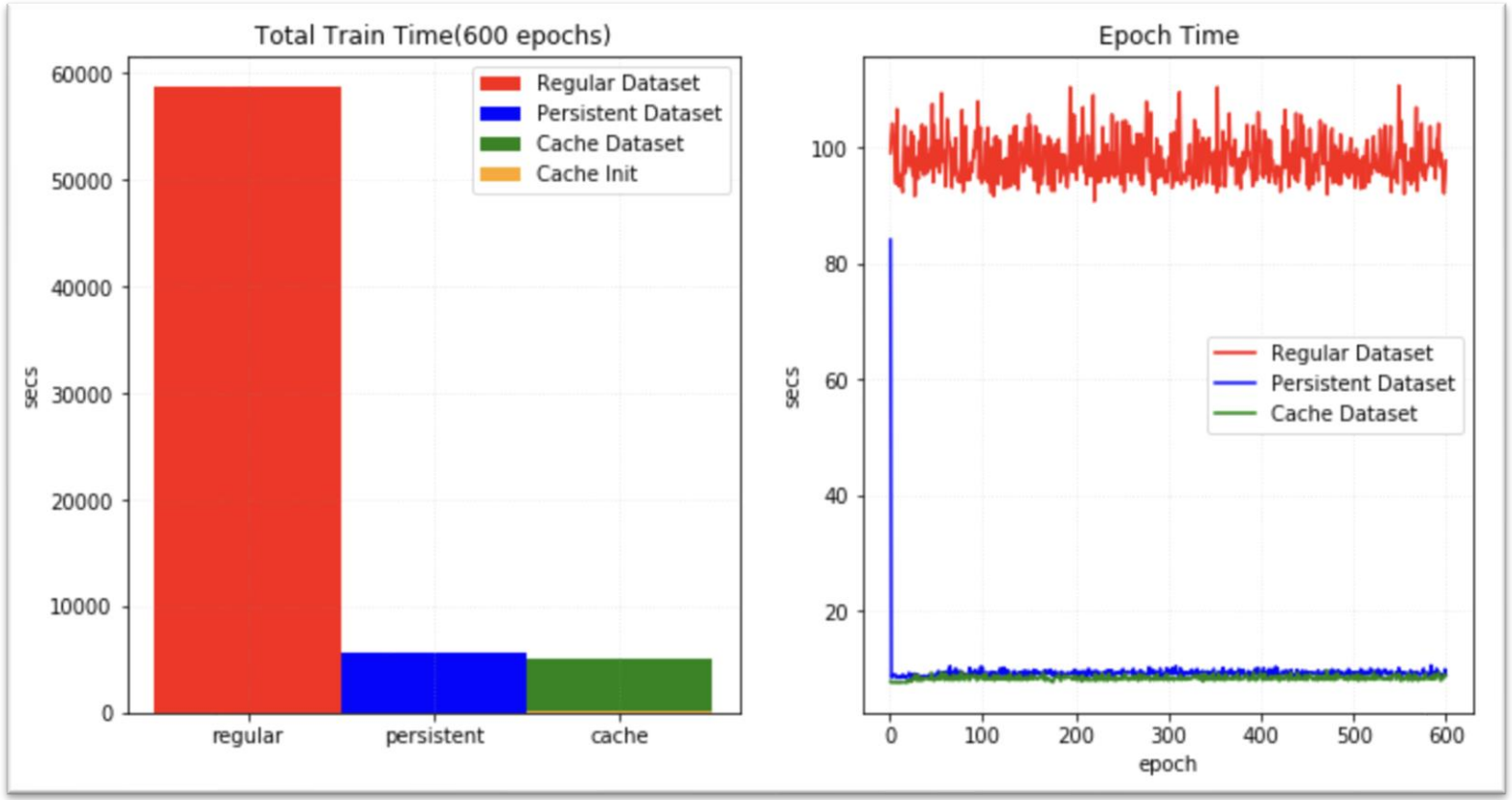
2. Superior performance

3. Friendly community

Optimize data loading

Dataset Caching - 10X speed up

e.g. CacheDataset, PersistentDataset, SmartCacheDataset

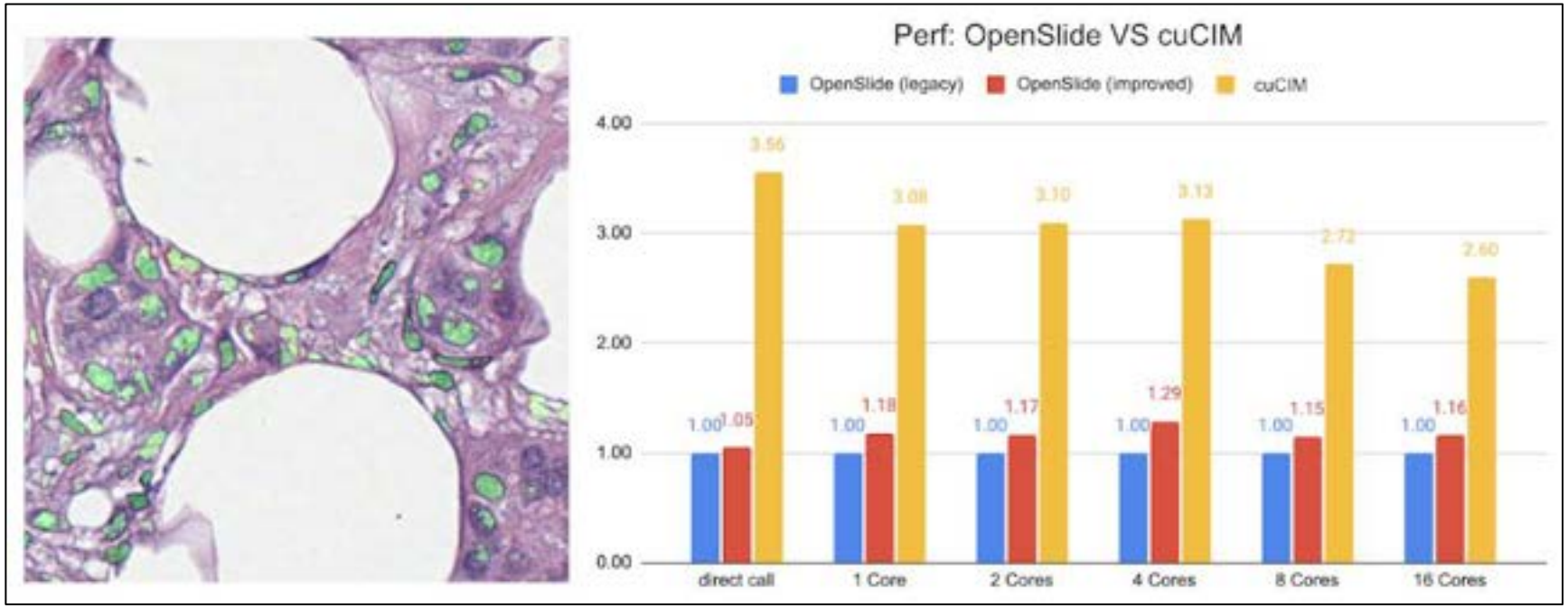


MONAI Core

1. Medical imaging specif
2. Superior performance
3. Friendly community

Optimize data loading

cuCIM – Whole Slide Imaging (digital pathology)



MONAI Core

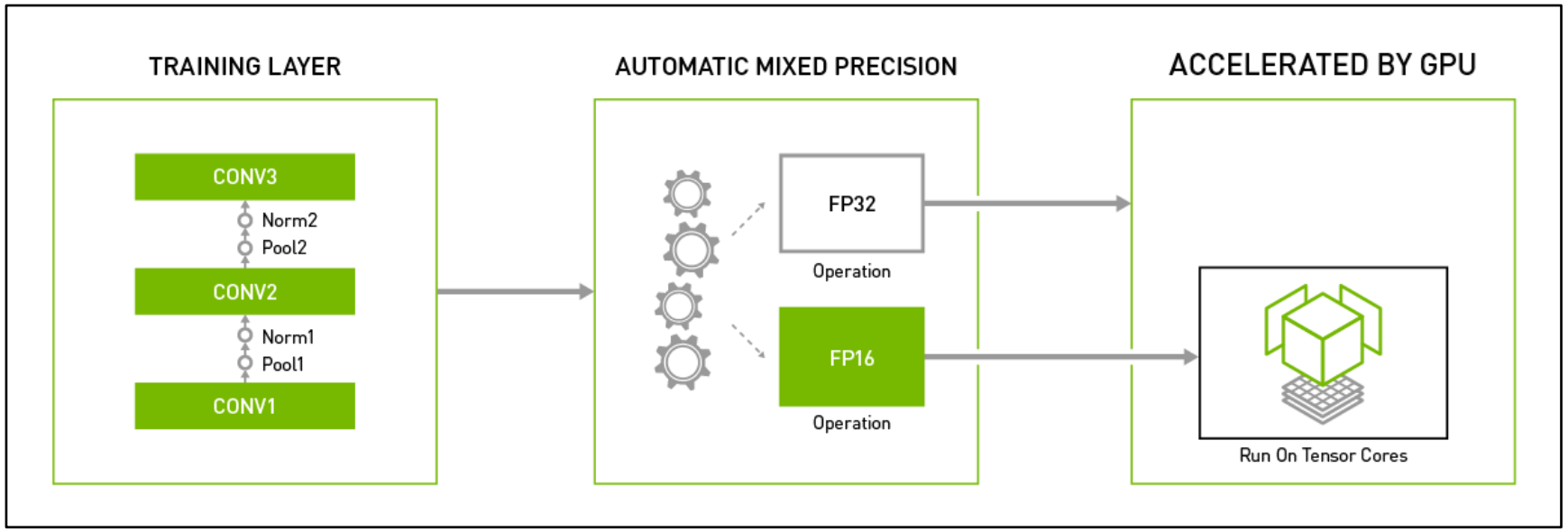
Optimize GPU utilization

AMP (Automatic Mixed Precision) - 2X speed up

1. Medical imaging specif

2. Superior performance

3. Friendly community



MONAI Core

1. Medical imaging speci

2. Superior performance

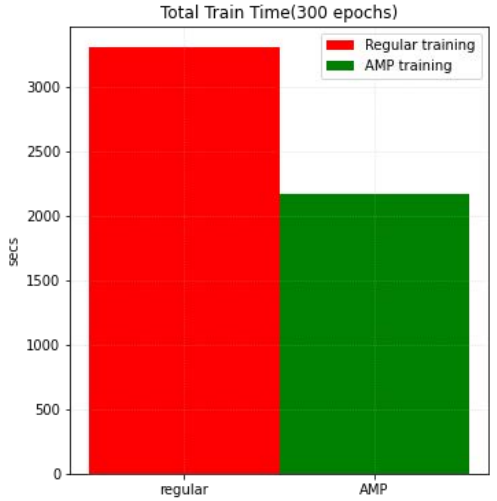
3. Friendly community

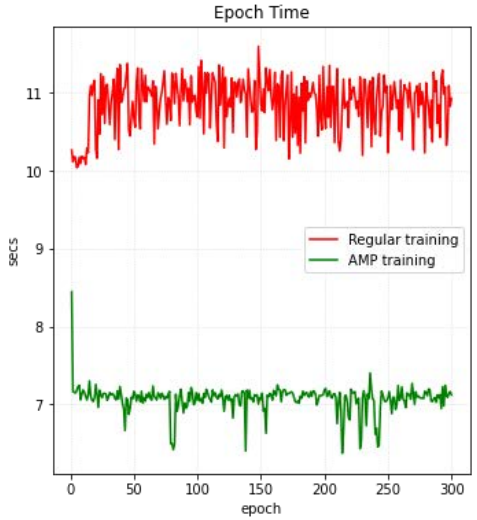
Optimize GPU utilization

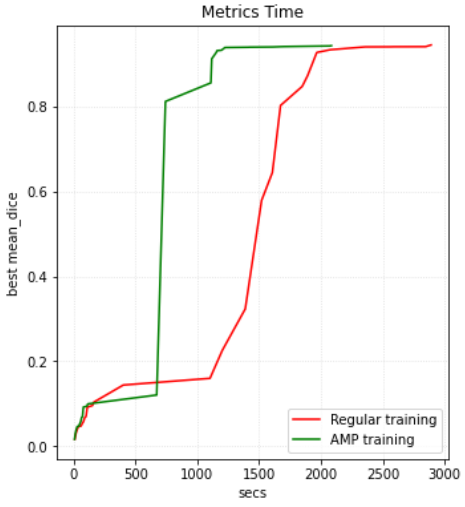
AMP (Automatic Mixed Precision) - 2X speed up

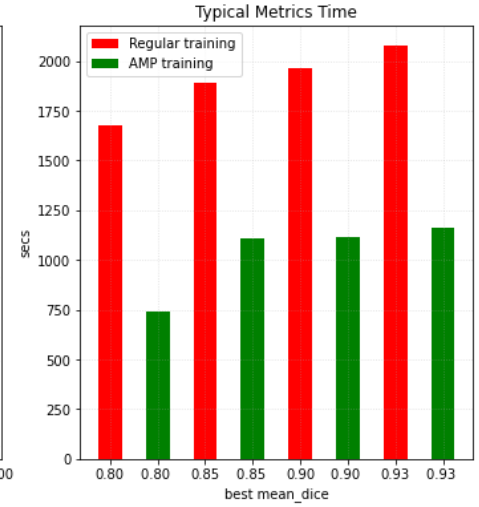
V100

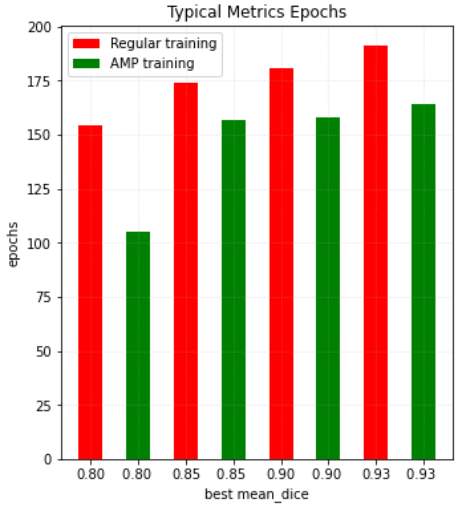
*A100 - **another 2X***











MONAI Core

1. Medical imaging speci

2. Superior performance

3. Friendly community

Optimize GPU utilization

AMP (Automatic Mixed Precision) - 2X speed up

Easy to enable in MONAI workflow

```
trainer = SupervisedTrainer(
    device=device,
    max_epochs=100,
    train_data_loader=train_loader,
    network=net,
    optimizer=opt,
    loss_function=loss,
    inferer=SimpleInferer(),
    post_transform=train_post_transforms,
    key_train_metric={"train_acc": Accuracy()},
    train_handlers=train_handlers,
    amp=True,
)

evaluator = SupervisedEvaluator(
    device=device,
    val_data_loader=val_loader,
    network=net,
    inferer=SlidingWindowInferer(),
    post_transform=val_post_transforms,
    key_val_metric={"val_mean_dice": MeanDice()},
    additional_metrics={"val_acc": Accuracy()},
    val_handlers=val_handlers,
    amp=True,
)
```

MONAI Core

1. Medical imaging speci

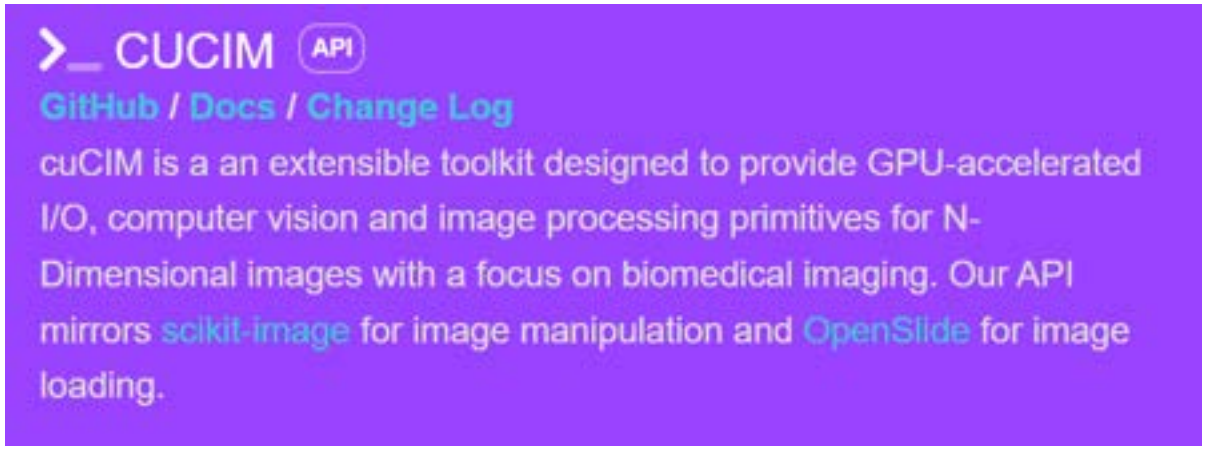
2. Superior performance

3. Friendly community

Optimize GPU utilization

Do transforms on GPU

cuCIM -> common transforms in digital pathology



https://rapids.ai/

MONAI Core

1. Medical imaging speci

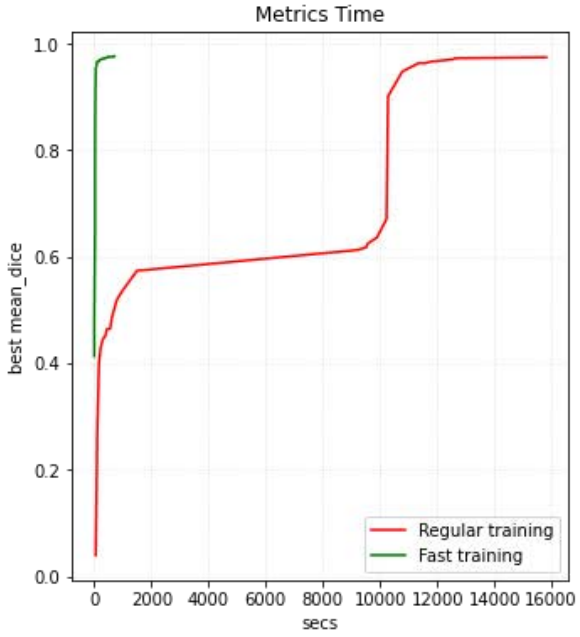
2. Superior performance

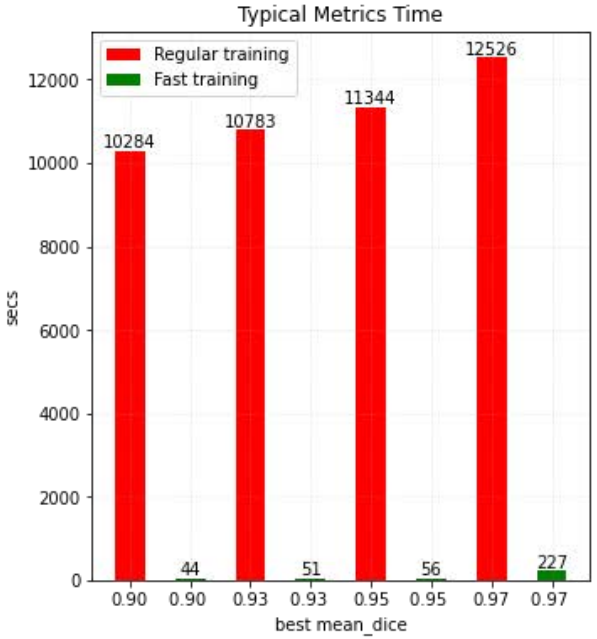
3. Friendly community

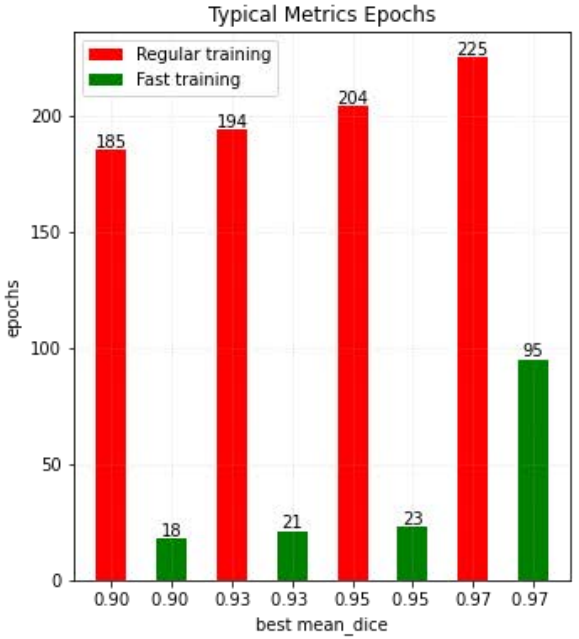
Combine previous techniques: 3D spleen segmentation

Novograd optimizer + DiceCELoss + CacheDataset + ThreadDataLoader + AMP

*A100 - **200X** native PyTorch*







MONAI Core

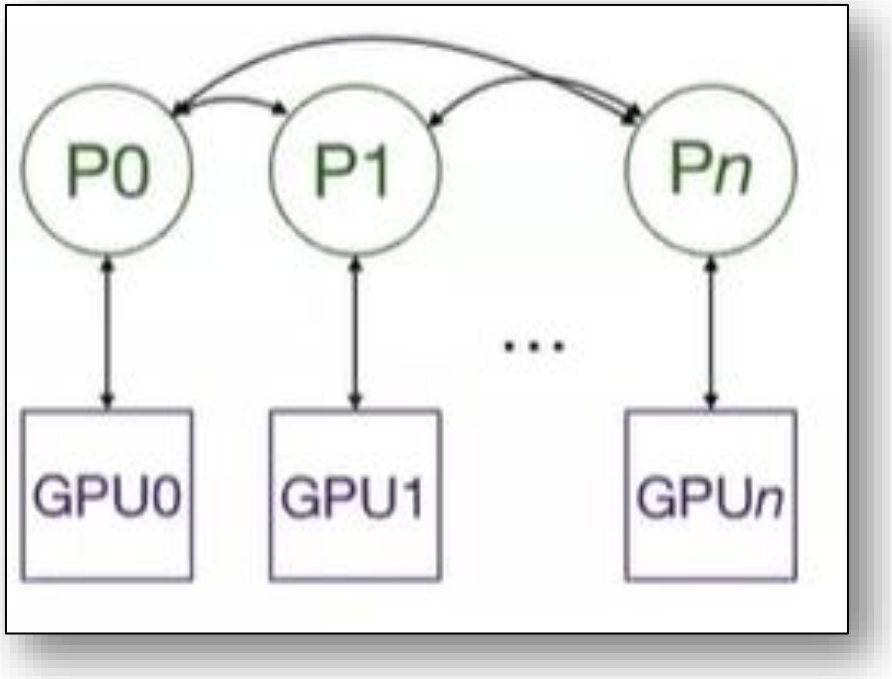
1. Medical imaging specif

2. Superior performance

3. Friendly community

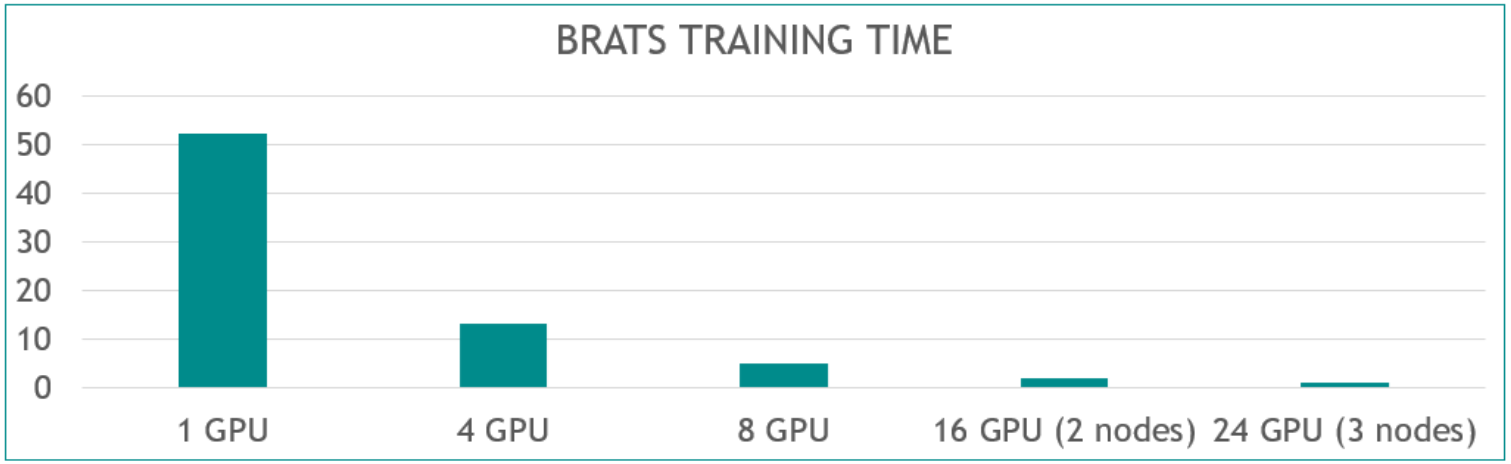
Leverage multi-GPU multi-node training

DDP (Distributed Data Parallel)



RSNA-ASNR-MICCAI BRAIN TUMOR SEGMENTATION (BRATS) CHALLENGE 2021

3 / top10 models were built by MONAI Core



BRATS'21 workloads executed on DGX A100 320GB systems.

https://developer.nvidia.com/blog/nvidia-data-scientists-take-top-spots-in-miccai-2021-brain-tumor-segmentation-challenge/

UFResearchComputing github:

sample scripts for using multi-node multi-GPU MONAI Core on HiperGator

MONAI Core

1. Medical imaging specific AI framework

2. Superior performance

Learn more [Tutorial: Fast Model Training Guide]

3. Friendly community

MONAI Core

1. Medical imaging specific AI framework

2. Superior performance

3. Friendly community – ***learn***, ***ask***, ***contribute***, ***guide***

MONAI Core

1. Medical imaging specific AI framework – ***comprehensive & flexible***

2. Superior performance – ***improve algorithms, optimize data loading & GPU utilization, multi-GPU***

3. Friendly community – ***learn, ask, contribute, guide***

MONAI Core for High-Fidelity Head Image Segmentation for Precision Intervention in Cognitive Aging

UF BME

UF College of Public Health & Health Professions UNIVERSITY of FLORIDA

UF Center for Cognitive Aging and Memory Clinical Translational Research
EVELYN F. AND WILLIAM L. MCKNIGHT BRAIN INSTITUTE


Dr. Ruogu Fang, Ph.D.


Skylar Stolte


Dr. Adam Woods Ph.D.

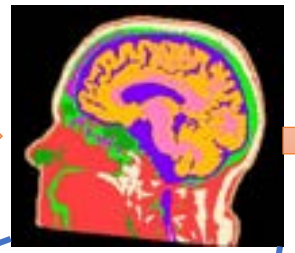

Dr. Aprinda Indahlastari, Ph.D.

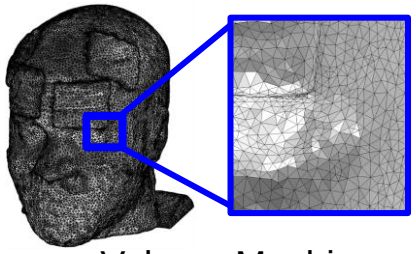

Alejandro Albizu

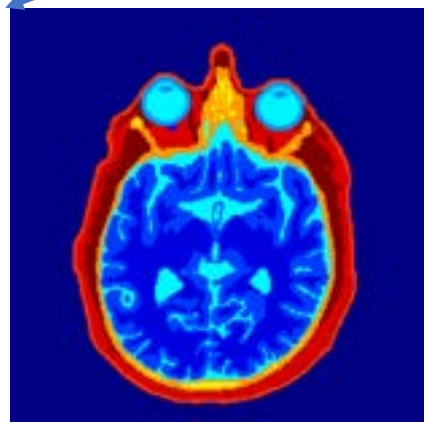
- **MONAI** offers **modular**, **open-source**, and **state-of-the-art** deep learning frameworks for versatile medical image analysis applications.
- MONAI Core accelerates our investigation and development of a **high-fidelity head image segmentation** tool from structural MRI images.
- This tool potentiates a **fully-automatic, high-precision, and personalized intervention** system using non-invasive brain stimulation to remediate cognitive aging and prevent dementia.
- **Next steps:** Build an interactive app using MONAI Label and package using MONAI Deploy where researchers can obtain fast high-fidelity head image segmentation and improve the model using direct interaction.

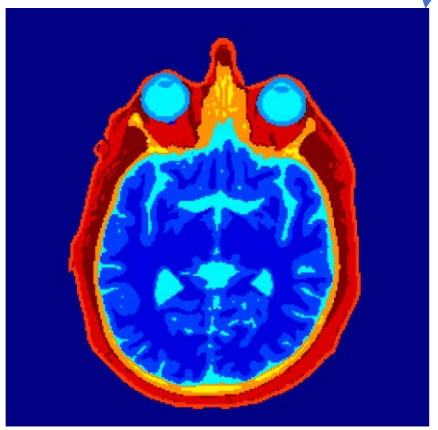

tDCS Stimulation

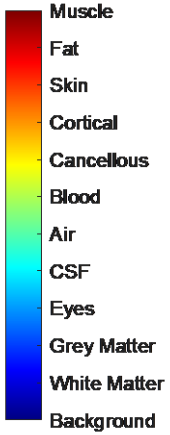

T1 MRI

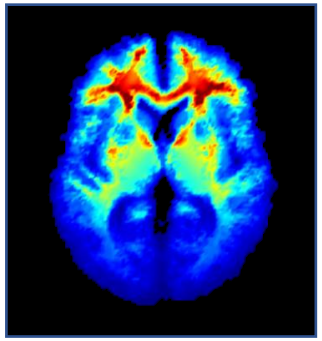

Head tissue segmentation


Volume Meshing


Ground Truth Manual Segmentation (~20 hours)


MONAI-Enabled Auto-Segmentation (3 s)




Electrical Current Map

How to use MONAI Core on HiperGator?

Major Steps Overview

0. Login HiperGator

1. Build a Singularity container for MONAI Core (or use prebuilt one)

2. Download tutorial repository

3. Run tutorial scripts - Python scripts (.py) & Jupyter Notebooks (.ipynb)

Why use MONAI Core container?

- Clean developing environment
  - easy to maintain dependencies of specific version
  - easy to debug
- Portable(reproducible)
- Scalable
- Based on NGC PyTorch containers (NVIDIA GPU CLOUD https://ngc.nvidia.com/catalog/)
  - optimized performance, keep updating

Why build your own MONAI Core container?

- Use your preferred MONAI Core version (weekly release vs milestone release 2~3 months)
- Bring your own environment (vs read-only prebuilt container)

How to use MONAI Core on HiperGator?

Major Steps

0. Login HiperGator

Your terminal or Open OnDemand https://ood.rc.ufl.edu/

1. Build a Singularity container for MONAI Core (or use prebuilt one)

Build based on MONAI Core docker images https://hub.docker.com/r/projectmonai/monai

sbatch build_container.sh

Check the SLURM job output file. If no error, then the container is built successfully.

cat SLURM_job_output_file (e.g. build_container.sh.12345.out)

How to use MONAI Core on HiperGator?

Major Steps

2. Download tutorial repository

Go to your home directory
cd ~

Clone MONAI Core tutorial repository into a directory. The default name of the directory is “tutorials”.
git clone https://github.com/Project-MONAI/tutorials.git

Make all files in the directory executable
chmod -R +x tutorials

How to use MONAI Core on HiperGator?

Major Steps

3. Run tutorial scripts - Python scripts (.py)

- batch mode

sbatch run_container.sh

cat run_container.sh.12345.out

- interactive mode

start an interactive session

srun --nodes=1 --partition=gpu --gpus=1 --ntasks=1 --cpus-per-task=1 --mem-per-cpu 3gb -t 10:00:00 --pty /bin/bash -i

go inside container

module load singularity

singularity shell --nv /blue/vendor-nvidia/hju/monaicore

run a python script

python3 /home/hju/tutorials/2d_segmentation/torch/unet_training_array.py

How to use MONAI Core on HiperGator?

Major Steps

3. Run tutorial scripts - Jupyter Notebooks (.ipynb)

launch a jupyter lab server (make sure you're in the directory which will be used in Jupyter Lab)
cd ~/tutorials
sbatch launch_jupyter_lab.sh

Once the job starts, look at the jupyter_lab_$SLURM_JOBID.log SLURM job output file, we will need the hostname (e.g., c1000a-s17) and token in next steps.
cat launch_jupyter_lab.sh.12345.out

Open another local terminal, SSH to the server host
ssh -NL 8888:c45a-s29:8888 hju@hpg.rc.ufl.edu

In a web browser, go to
http://localhost:8888/
You might be prompted to authenticate. Copy paste token from the SLURM job output above in the prompt box. Note: if you do not want to go through copying/pasting the token for every jupyter job, you can set a default password, see https://help.rc.ufl.edu/doc/Remote_Jupyter_Notebook)

Open any jupyter notebooks (.ipynb) in the directory "tutorials" on the left pane.

End-to-end MONAI Core workflow jupyter notebook from MICCAI 2021 MONAI Bootcamp

Resources

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

- MONAI wiki page https://help.rc.ufl.edu/doc/Monai

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

Resources

MONAI sessions @GTC 2022

- AI-assisted Annotation for Continuous Learning with MONAI Label [DLIT2098]
- Developing for the AI Medical Project Life Cycle: MONAI Community Developer Meetup [SE2174]
- Accelerate your research with MONAI on AWS [S42397]
- Design, Train, and Evaluate Domain-specialized Health-care Imaging AI Models with MONAI [DLIT2097]
- Creating Inference Applications for the Medical AI Project Life Cycle using MONAI Deploy [DLIT2099]
- HCLS Dev Summit: Building an Open-source Foundation to Fuel R&D Innovation [S42639]
- Experiences in Algorithm Deployment in Large Healthcare Settings and Continuous Learning [S41923] Mayo Clinic
- Scientific Process of Building AI Models (Presented by Quantiphi, Inc.) [S42426] Quantiphi, Inc.
- AI Building Blocks for Industry 4.0 (Presented by Supermicro) [S42564] Super Micro Computer, Inc.

Resources

MONAI

1. **Get Started with MONAI**

- Homepage (Doc & Github links on top right) https://github.com/Project-MONAI
- YouTube Channel https://www.youtube.com/c/Project-MONAI
- MONAI Bootcamp 2021 at MICCAI
  - GitHub https://github.com/Project-MONAI/MONAIBootcamp2021
  - Bootcamp Recording Playlist (sessions for MONAI Label, MONAI Core, MONAI Deploy, MONAI Federated Learning) https://www.youtube.com/playlist?list=PLtoSVSQ2XzyCobzE6NvwjNpITsQyPUtfs
- MONAI Bootcamp 2020
  - Github https://github.com/Project-MONAI/MONAIBootcamp2020
- MONAI Label – Annotate datasets & interactively create AI models for annotation
  - Github https://github.com/Project-MONAI/MONAILabel
  - Doc (please explore the top menu bar What's New, Installation, Quickstart [step-by-step tutorials], Modules Overview, Application Deployment, API Reference) https://docs.monai.io/projects/label/en/latest/whatsnew.html
  - Recording from MONAI Bootcamp 2021 (please try to repeat the two demos, see attached *demos_monailabel.docx* for steps used in the demos) https://www.youtube.com/watch?v=o8HipCgSZIw&list=PLtoSVSQ2XzyCobzE6NvwjNpITsQyPUtfs&index=11&t=1819s
  - To learn more about 3D Slicer basics, see Getting Started section in its doc https://slicer.readthedocs.io/en/latest/user_guide/getting_started.html
- MONAI Core - Create AI models
  - Tutorials (for almost all common tasks) https://github.com/Project-MONAI/tutorials
  - Fast Model Training Guide https://github.com/Project-MONAI/tutorials/blob/4735dd0387db0aa8c37729ec7b6261ba1b52b6a2/acceleration/fast_model_training_guide.md
  - Github https://github.com/Project-MONAI/MONAI
  - Doc (please explore the top menu bar What's New, Installation, etc) https://docs.monai.io/en/stable/whatsnew.html
  - Recordings from MONAI Bootcamp 2021 (many sessions in the playlist below) https://www.youtube.com/playlist?list=PLtoSVSQ2XzyCobzE6NvwjNpITsQyPUtfs
  - End-to-End MONAI Core Workflow Google Colab jupyter notebook from MONAI Bootcamp 2020 https://colab.research.google.com/github/Project-MONAI/MONAIBootcamp2020/blob/master/day1notebooks/lab2_end_to_end.ipynb

Resources

MONAI

- MONAI Deploy - Create an application from an AI model
  - Github https://github.com/Project-MONAI/monai-deploy-app-sdk
  - Doc (please explore the top menu bar, the Getting Start tab has multiple tutorials) https://docs.monai.io/projects/monai-deploy-app-sdk/en/latest/release_notes/index.html
  - Recording from MONAI Bootcamp 2021 (please try to repeat the demos, step-by-step tutorials for the demos are within the Getting Start tab of the Doc listed above) https://www.youtube.com/watch?v=pS68i8ShoOk&list=PLtoSVSQ2XzyCobzE6NvwjNpITsQyPUtfs&index=12
- MONAI Federated Learning – use MONAI within NVIDIA Flare
  - Tutorials https://github.com/Project-MONAI/tutorials/tree/master/federated_learning
- Report bugs\ask questions\request new features\provide any feedback: Issues & Discussion tabs within each repo (they always reply promptly). E.g., for MONAI Core
  - Issues tab https://github.com/Project-MONAI/MONAI/issues
  - Discussion tab https://github.com/Project-MONAI/MONAI/discussions
- **Digital Pathology** (please do more thorough exploration by yourself, search `pathology` within Doc &Project-MONAI Github repo should be helpful)
  - Tutorials https://github.com/Project-MONAI/tutorials/tree/master/pathology
  - From the doc
    https://docs.monai.io/en/stable/whatsnew_0_5.html?highlight=pathology#lesion-detection-in-digital-pathology
    https://docs.monai.io/en/stable/whatsnew_0_8.html?highlight=pathology#multiple-instance-learning-for-digital-pathology-wsi-analysis
    https://docs.monai.io/en/stable/highlights.html?highlight=pathology#integrate-third-party-transforms

2. Contribute to MONAI

- GitHub
  - Community Guide: https://github.com/Project-MONAI/MONAI#community
  - Contributing Guide: https://github.com/Project-MONAI/MONAI#contributing
- Join the Slack Channel. Fill out the Google Form here https://forms.gle/QTxJq3hFictp31UM9

Thanks

Q&A

Huiwen Ju
Solutions Architect, Higher Education & Research
hju@nvidia.com

NVIDIA