



Tutorial: MONAI Core

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@ 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
- Data analytics: CuPy, RAPIDS

WHAT IS MONAI?

Medical Open Network for AI

Project MONAI

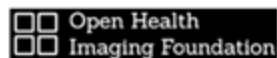
- a collaborative open-source initiative
- founded at MICCAI 2019
- establish and standardize the best practices for deep learning in healthcare imaging to accelerate the pace of innovation.



VANDERBILT
UNIVERSITY



ACR AI-LAB™



Frederick National Laboratory
for Cancer Research



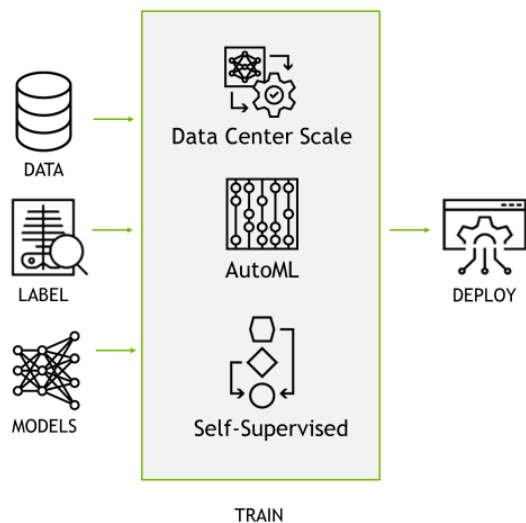


World's Most Advanced Framework for Medical AI

600K Downloads of MONAI Core

STATE-OF-THE-ART AI

From Data to Deployment Dev Tools



GLOBAL ECOSYSTEM

Community Lead | Accessibility

World Leading Contributors

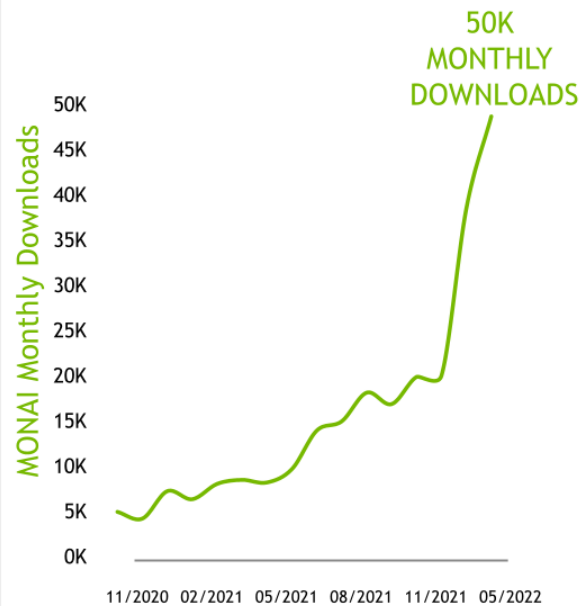


Integration Partners



EXPONENTIAL GROWTH

Accelerating Open Research



R&D MOMENTUM

Publishing to Production

Top 30+

Research Medical Centers
Published over 150 papers



AIDE: A NEW OPERATING
SYSTEM FOR THE HOSPITAL



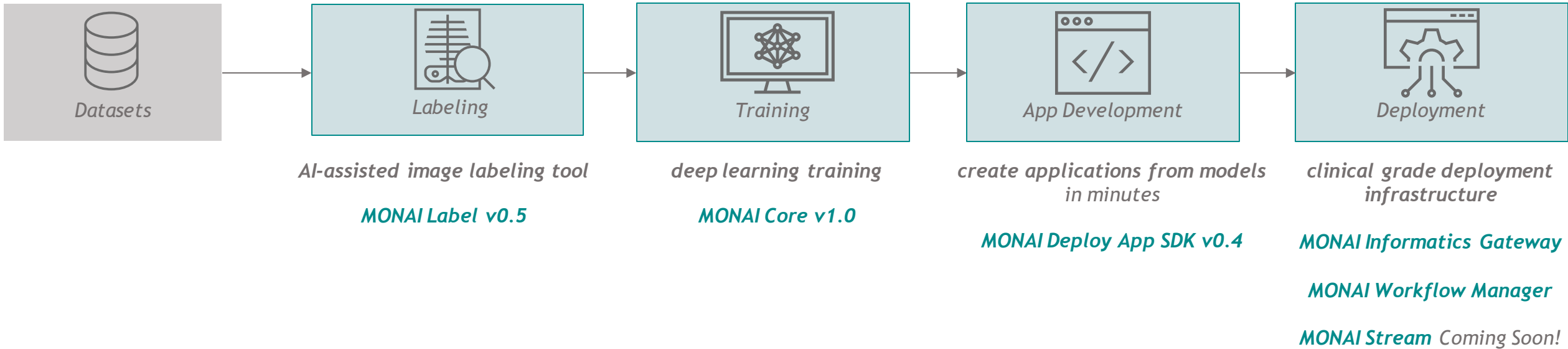
EXPERIENCES WITH ALGORITHM
DEPLOYMENT IN HEALTHCARE SETTINGS



ACCELERATE YOUR MEDICAL IMAGING
RESEARCH WITH MONAI ON AWS

WHAT IS MONAI?

Accelerate Pace of Research Innovation With a Common Foundation



MONAI Core

Medical-imaging PyTorch.

MONAI Core

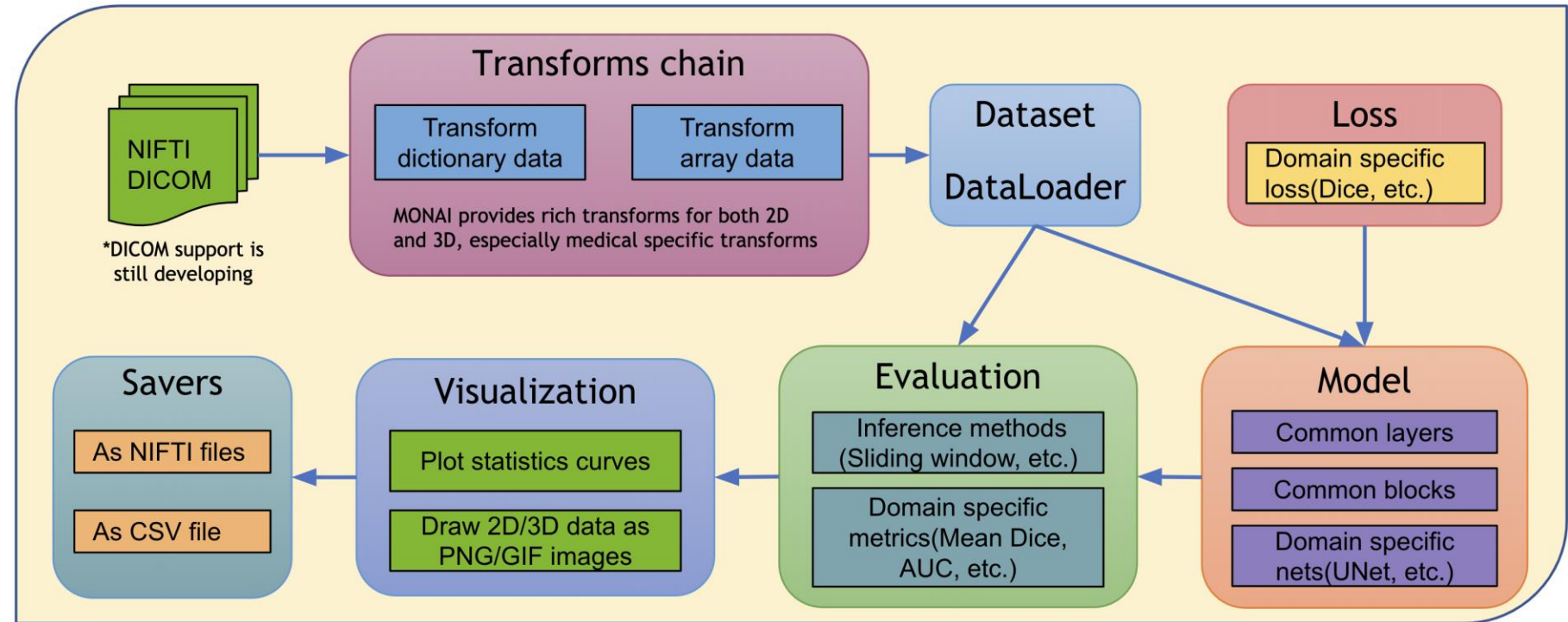
1. Medical-imaging-specific AI framework
2. Superior performance
3. Friendly community

MONAI Core

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

2. Superior performance

3. Friendly community



MONAI website <https://monai.io/>

MONAI Core

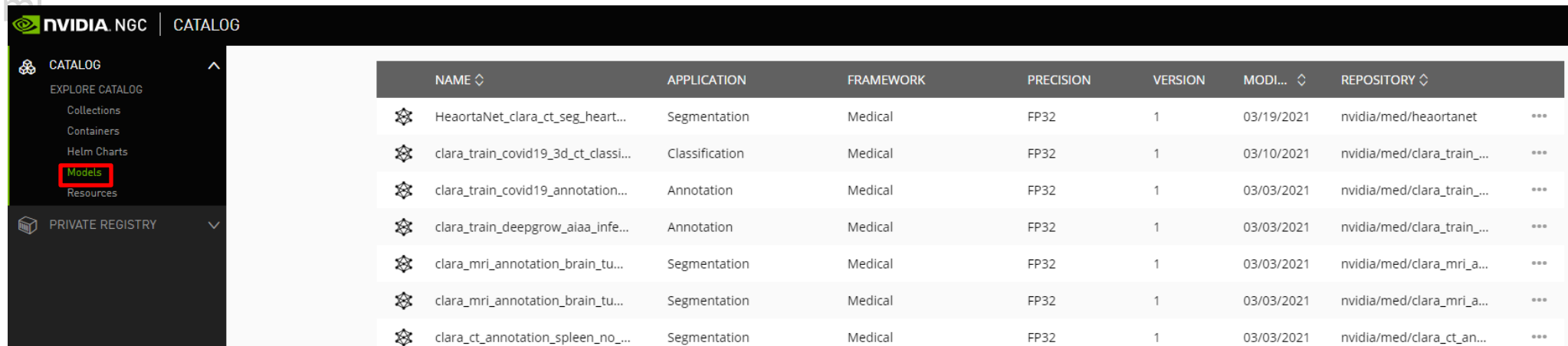
1. Medical imaging specific AI framework - ***comprehensive & flexible***

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PRE-TRAINED models

Download from NGC 20+ Pre-Trained Models: CT, MRI, X-Ray, Digital Pathology
<https://catalog.ngc.nvidia.com/> go to CATALOG/Models, then search `clara`



The screenshot shows the NVIDIA NGC CATALOG interface. On the left is a dark sidebar with navigation options: CATALOG, EXPLORE CATALOG, Collections, Containers, Helm Charts, Models (highlighted with a red box), Resources, PRIVATE REGISTRY, and a dropdown arrow. The main content area displays a table of pre-trained models.

NAME ↕	APPLICATION	FRAMEWORK	PRECISION	VERSION	MODI... ↕	REPOSITORY ↕	
HeaortaNet_clara_ct_seg_heart...	Segmentation	Medical	FP32	1	03/19/2021	nvidia/med/heaortanet	***
clara_train_covid19_3d_ct_classi...	Classification	Medical	FP32	1	03/10/2021	nvidia/med/clara_train_...	***
clara_train_covid19_annotation...	Annotation	Medical	FP32	1	03/03/2021	nvidia/med/clara_train_...	***
clara_train_deepgrow_aiaa_infe...	Annotation	Medical	FP32	1	03/03/2021	nvidia/med/clara_train_...	***
clara_mri_annotation_brain_tu...	Segmentation	Medical	FP32	1	03/03/2021	nvidia/med/clara_mri_a...	***
clara_mri_annotation_brain_tu...	Segmentation	Medical	FP32	1	03/03/2021	nvidia/med/clara_mri_a...	***
clara_ct_annotation_spleen_no_...	Segmentation	Medical	FP32	1	03/03/2021	nvidia/med/clara_ct_an...	***

MONAI Core

Improve AI algorithms

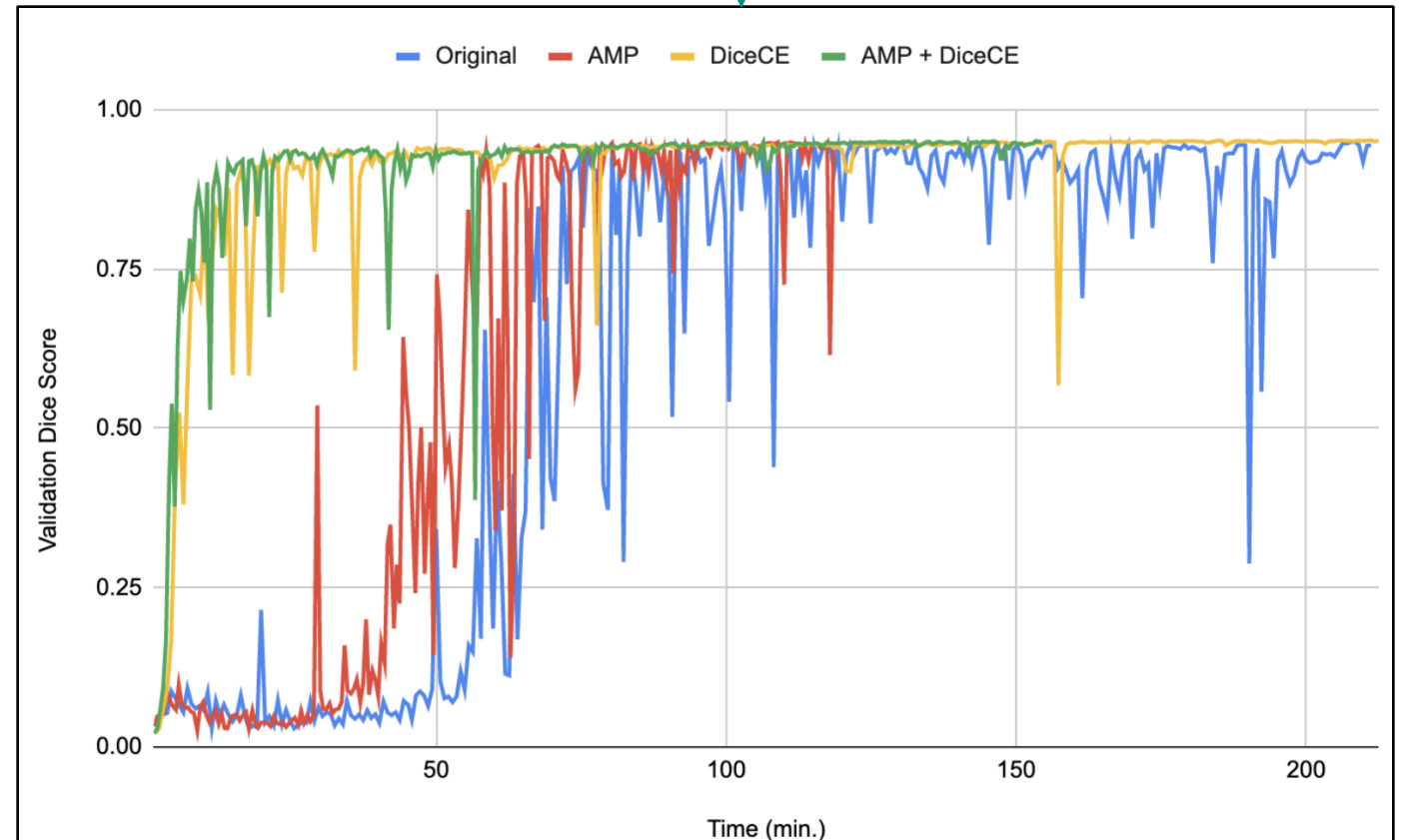
- *Network architecture* - *UNETR**, *Swin UNETR* ...
- *Optimizer* - *Novograd* ...
- *Loss function* - *DiceCELoss* ...

- Self-supervised pretraining
- ranked 1st on the public test leaderboards of both MSD and BTCV datasets

1. Medical imaging specif

2. Superior performance

3. Friendly community



* [Hatamizadeh et al., UNETR: Transformers for 3D Medical Image Segmentation](#)

MONAI Core

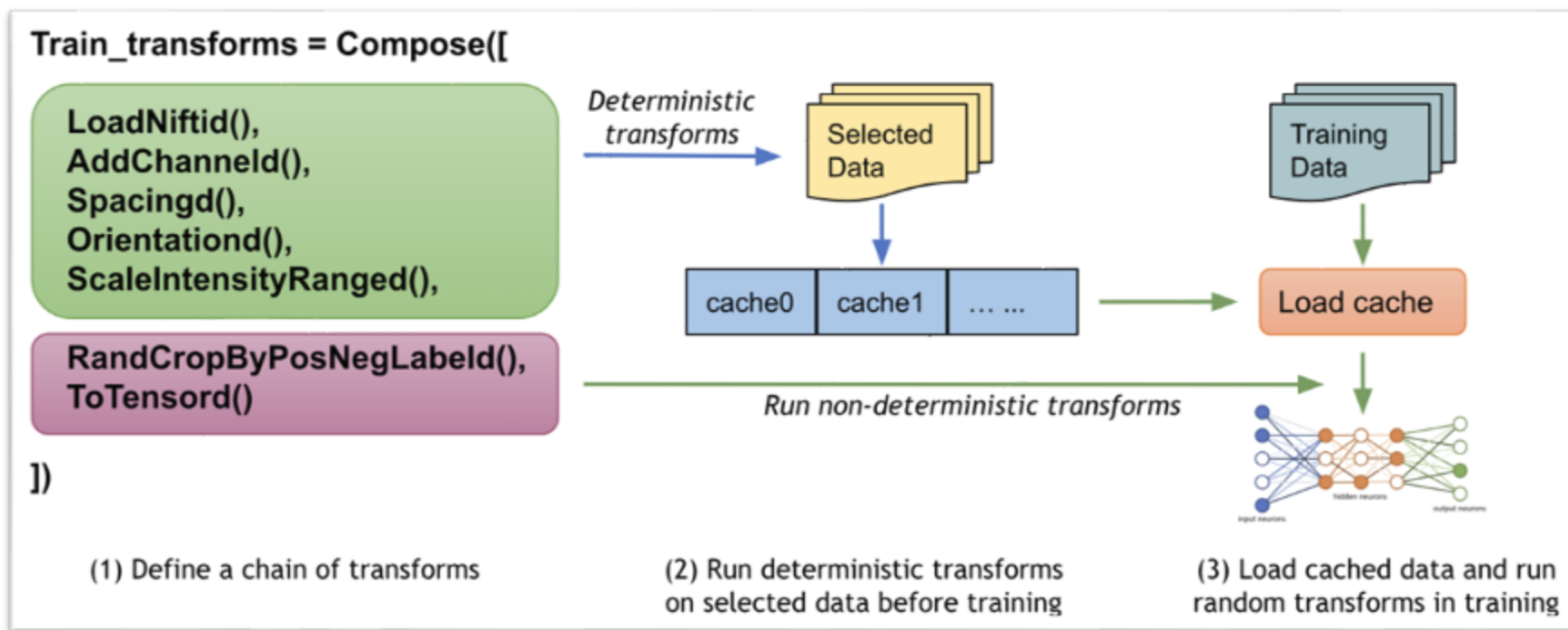
1. Medical imaging specif

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Optimize data loading

Dataset Caching - 10X speed up



MONAI Core

Optimize data loading

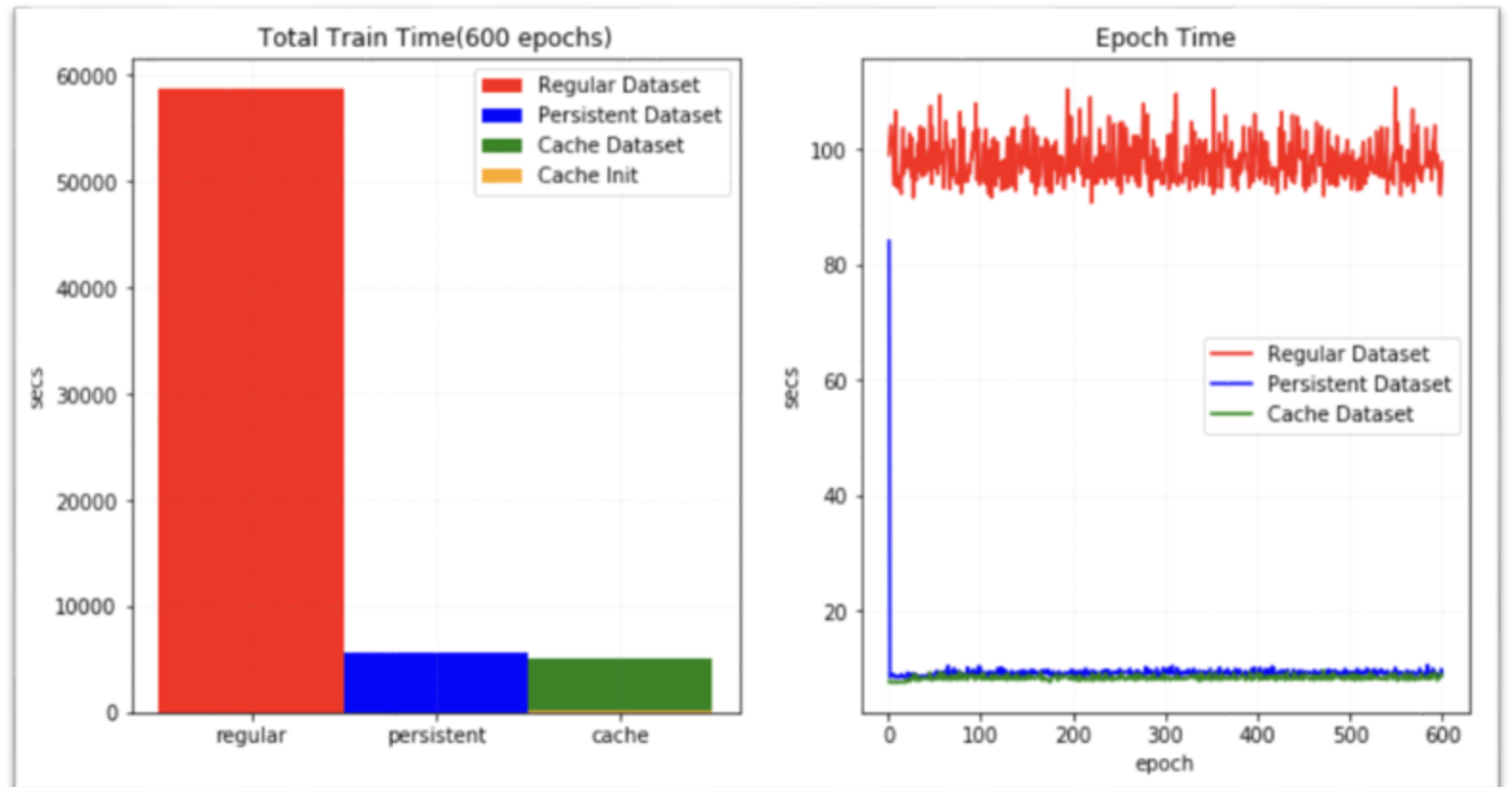
1. Medical imaging specif

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3. Friendly community

Dataset Caching - 10X speed up

e.g. CacheDataset, PersistentDataset, SmartCacheDataset



MONAI Core

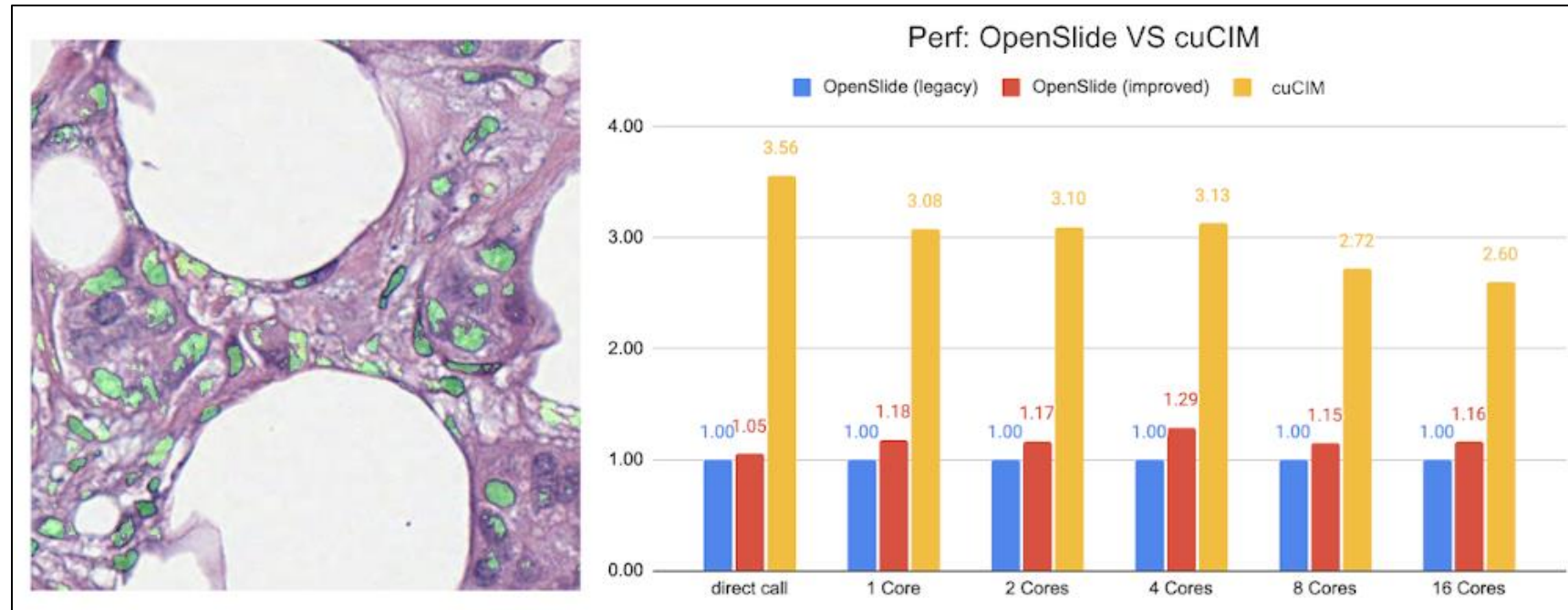
Optimize data loading

cuCIM - Whole Slide Imaging (digital pathology)

1. Medical imaging specif

2. Superior performance

3. Friendly community



> **CUCIM** (API)
[GitHub](#) / [Docs](#) / [Change Log](#)
cuCIM is an extensible toolkit designed to provide GPU-accelerated I/O, computer vision and image processing primitives for N-Dimensional Images with a focus on biomedical imaging. Our API mirrors [scikit-image](#) for image manipulation and [OpenSlide](#) for image loading.

cuCIM - a toolkit within [RAPIDS](#)

MONAI Core

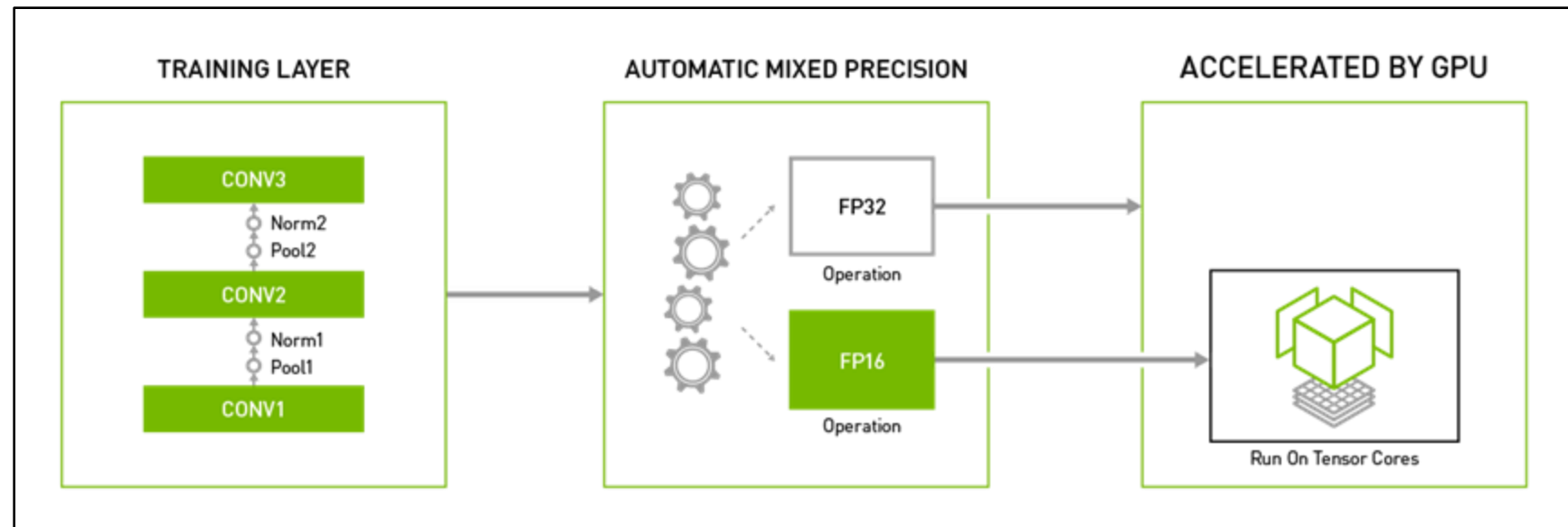
Optimize GPU utilization

AMP (Automatic Mixed Precision) - 2X speed up

1. Medical imaging specif

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MONAI Core

Optimize GPU utilization

AMP (Automatic Mixed Precision) - 2X speed up

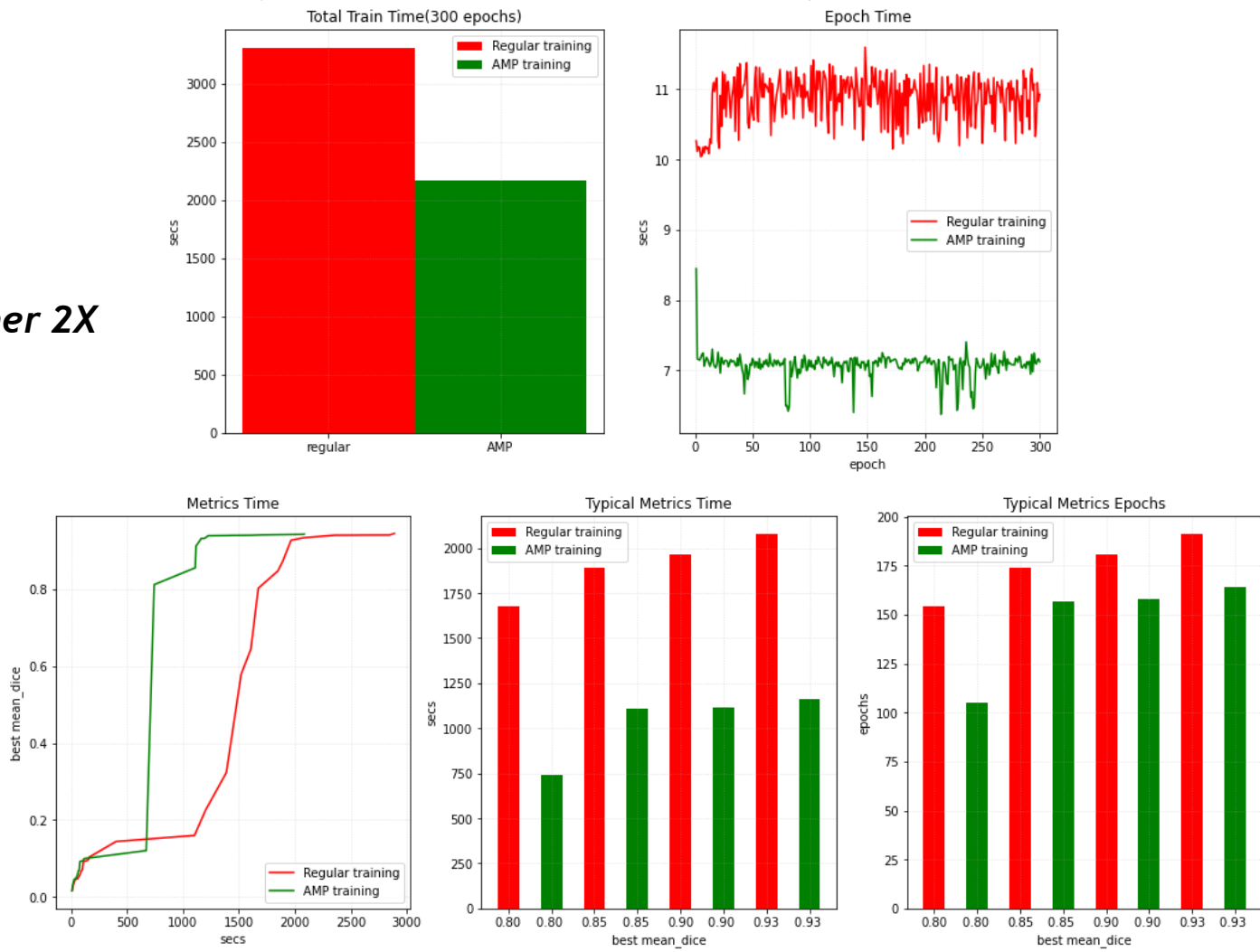
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V100

A100 - another 2X



MONAI Core

Optimize GPU utilization

AMP (Automatic Mixed Precision) - 2X speed up

Easy to enable in MONAI workflow

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2. Superior performance

3. Friendly community

```
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

Optimize GPU utilization

Do transforms on GPU

cuCIM -> common transforms in digital pathology

1. Medical imaging speci

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```
13 from monai.transforms import (  
14     Activations,  
15     AsDiscrete,  
16     CastToType,  
17     CastToTyped,  
18     Compose,  
19     CuCIM,  
20     GridSplitd,  
21     Lambdad,  
22     RandCuCIM,  
23     RandFlipd,  
24     RandRotate90d,  
25     RandZoomd,  
26     ScaleIntensityRanged,  
27     ToCupy,  
28     ToNumpyd,  
29     TorchVisiond,  
30     ToTensor,  
31     ToTensord,  
32 )
```

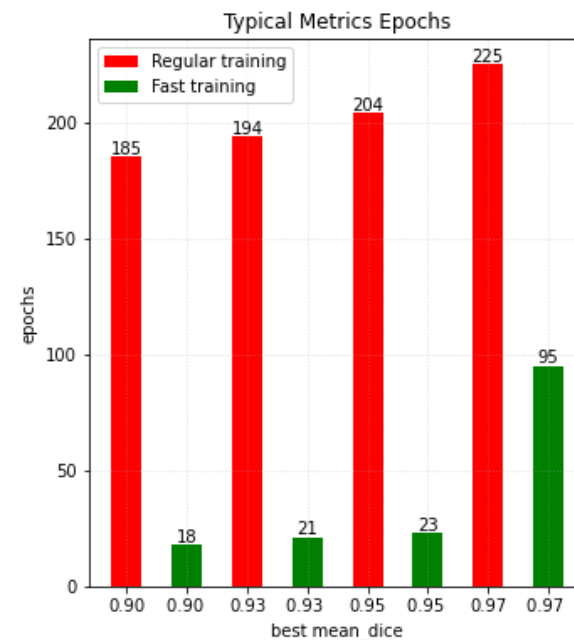
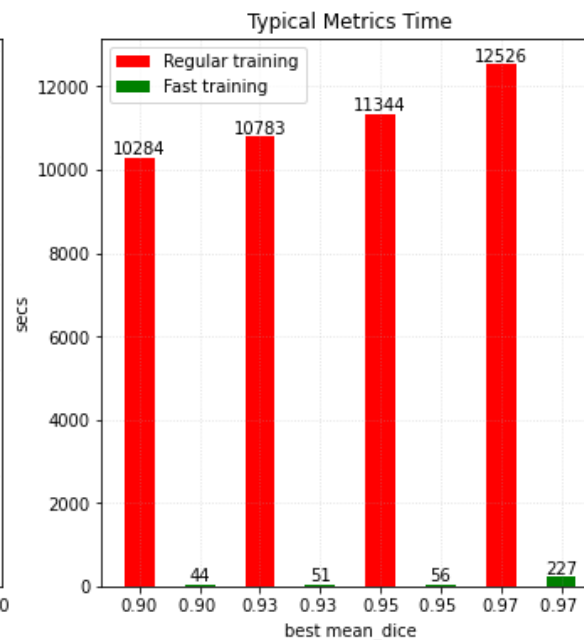
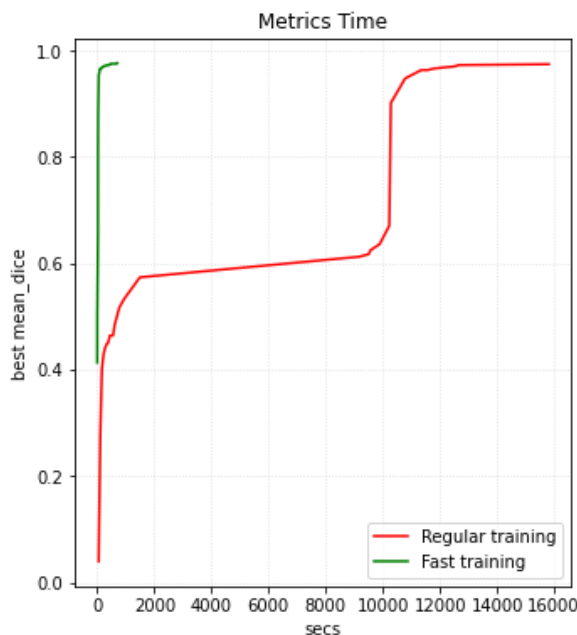
[Pathology tutorials](#)

MONAI Core

Combine previous techniques: 3D spleen segmentation

Novograd optimizer + DiceCELoss + CacheDataset + ThreadDataLoader + AMP

A100 - 200X native PyTorch



1. Medical imaging speci

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MONAI Core

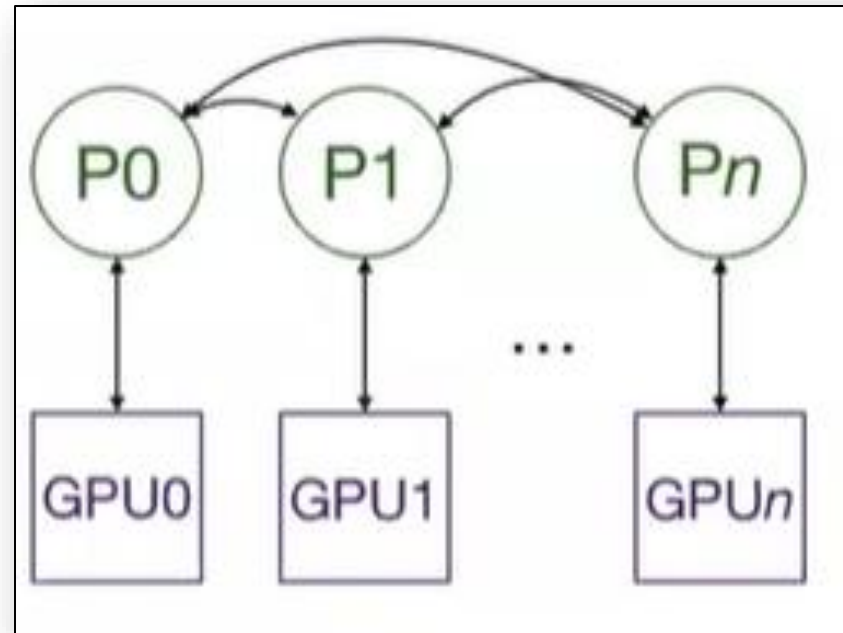
Leverage multi-GPU multi-node training

DDP (Distributed Data Parallel)

1. Medical imaging specif

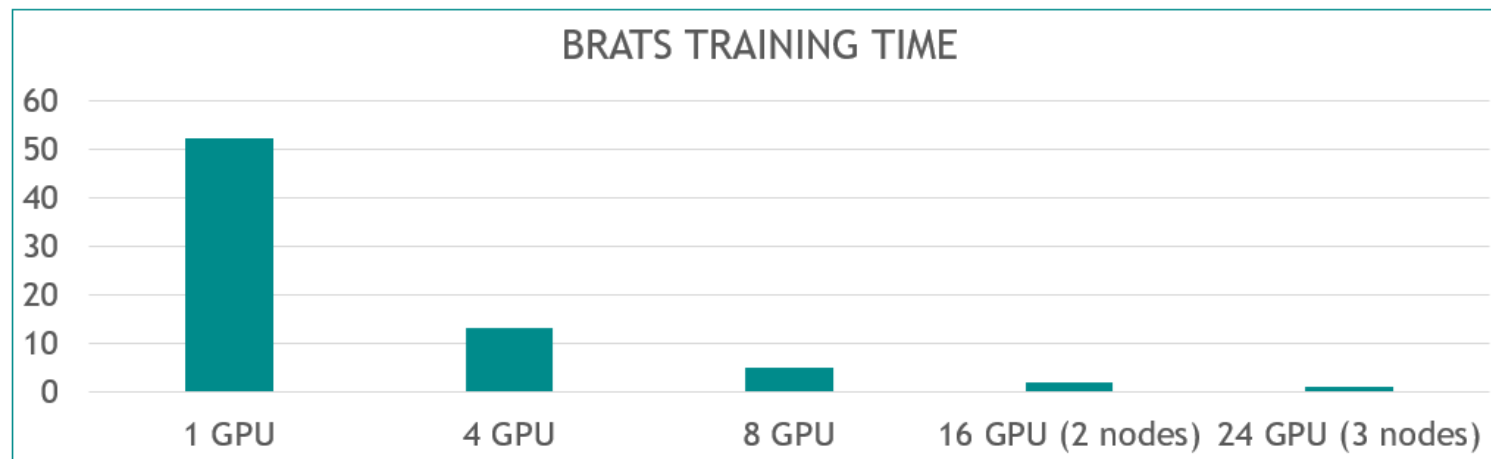
2. Superior performance

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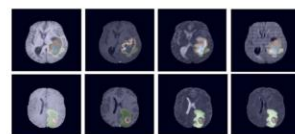
RSNA-ASNR-MICCAI BRAIN TUMOR SEGMENTATION (BRATS) CHALLENGE 2021

3 / top10 models were built by MONAI Core



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

DEVELOPER BLOG



AI / DEEP LEARNING | DATA SCIENCE

Sep 30, 2021

NVIDIA Data Scientists Take Top Spots in MICCAI 2021 Brain Tumor Segmentation Challenge

By Vanessa Braunstein

Tags: Computer Vision / Video Analytics, DALI, Healthcare & Life Sciences, Medical Imaging, MONAI, News

[Discuss](#)

NVIDIA data scientists this week took three of the top 10 spots in a [brain tumor segmentation challenge](#) validation phase at the prestigious [MICCAI 2021](#) medical imaging conference.

Now in its tenth year, the BraTS challenge tasked applicants with submitting state-of-the-art AI models for segmenting heterogeneous brain glioblastomas sub-regions in multi-parametric magnetic resonance imaging (mpMRI) studies, which is an extremely challenging task.

Participants could also focus on a second task of classification methods to predict the MGMT promoter methylation status.

More than 2,000 AI models were submitted to the challenge, which is jointly organized by the Medical Image Computing and Computer Assisted Interventions society, the Radiological Society of North America and the American Society of Neuroradiology.

[link](#)

MONAI Core

1. Medical imaging specific AI framework

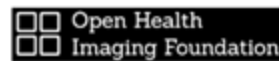
2. Superior performance

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



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

- **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** system using 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.



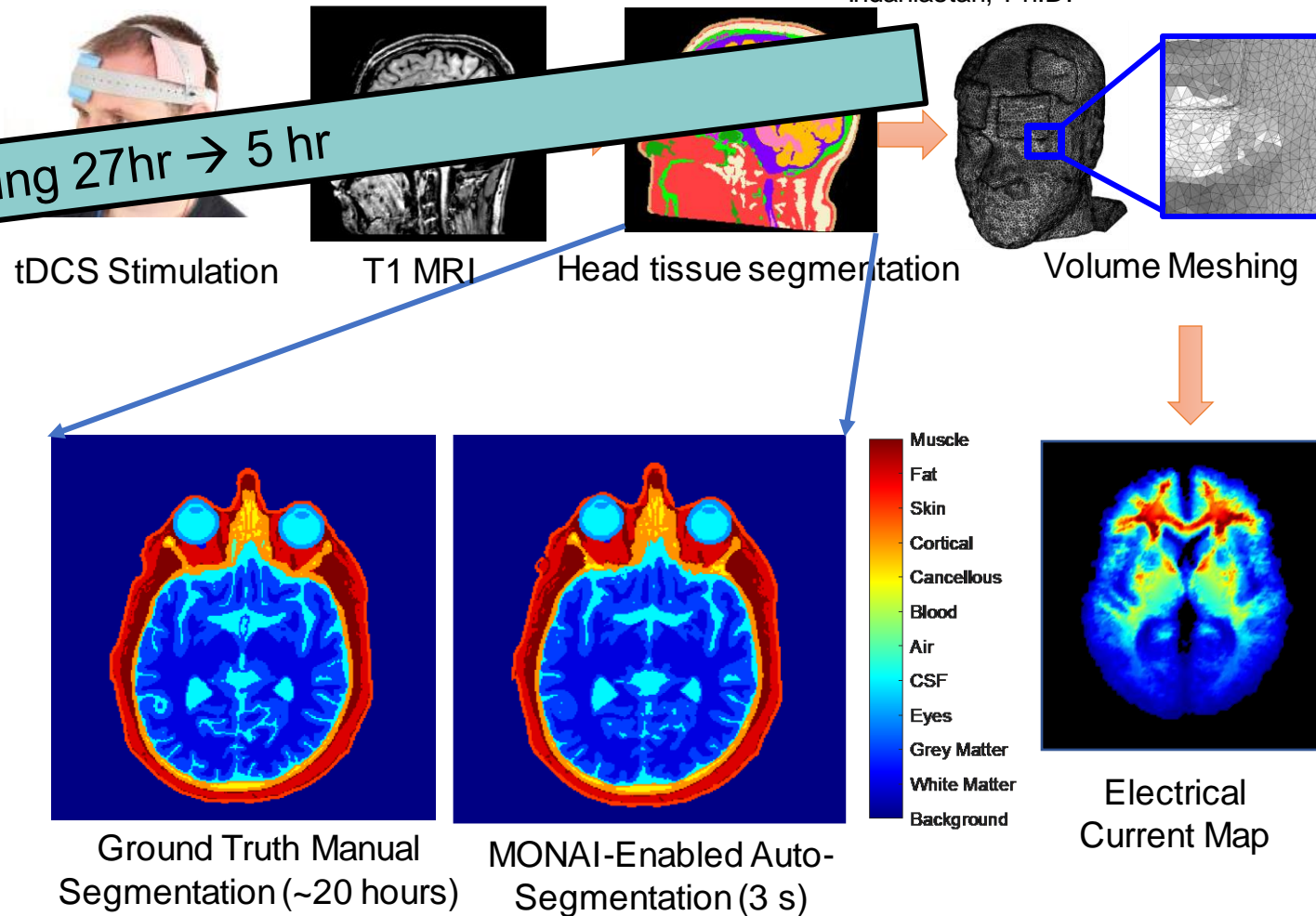
Dr. Ruogu Fang, Ph.D. Skylar Stolte



Dr. Adam Woods Ph.D. Dr. Aprinda Indahlastari, Ph.D.



Alejandro Albizu



How to use MONAI Core on HiperGator?

Demo

https://github.com/hw-ju/monai_uf_tutorials

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 recorded sessions @GTC 2022

- [Take Medical AI from Research to Clinical Production with MONAI and Clara Holoscan \[A41149\]](#)
- [Developing for the AI Medical Project Life Cycle: MONAI Community Developer Meetup \[SE2174\]](#)
- [Accelerate your research with MONAI on AWS \[S42397\]](#)
- [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=o8HipCgSZlw&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>








Federated Learning using MONAI Core





Based on NVIDIA Flare (open-source SDK)





<https://nvidia.github.io/NVFlare/>





 Project-MONAI / **tutorials** Public

 Edit Pins  Watch 20  Fork 358  Star 683

 Code  Issues 39  Pull requests 11  Discussions  Actions  Security  Insights

 main **tutorials / federated_learning /**  Go to file  Add file 

 holgerroth and wyli fix debug dataset path (#772)   e2afddf 16 hours ago  History

..		
 breast_density_challenge	fix debug dataset path (#772)	16 hours ago
 nvflare/nvflare_spleen_example	Bump nvflare from 2.0.2 to 2.0.16 in /federated_learning/nvflare/nvfl...	4 months ago
 openfl/openfl_mednist_2d_registration	master -> main (#718)	2 months ago
 substra	master to main urls (#720)	2 months ago

https://github.com/Project-MONAI/tutorials/tree/master/federated_learning

TOWARDS MULTI-OMICS / MULTIMODAL DATA

```
class CSVDataset(Dataset):
```

```
    """
```

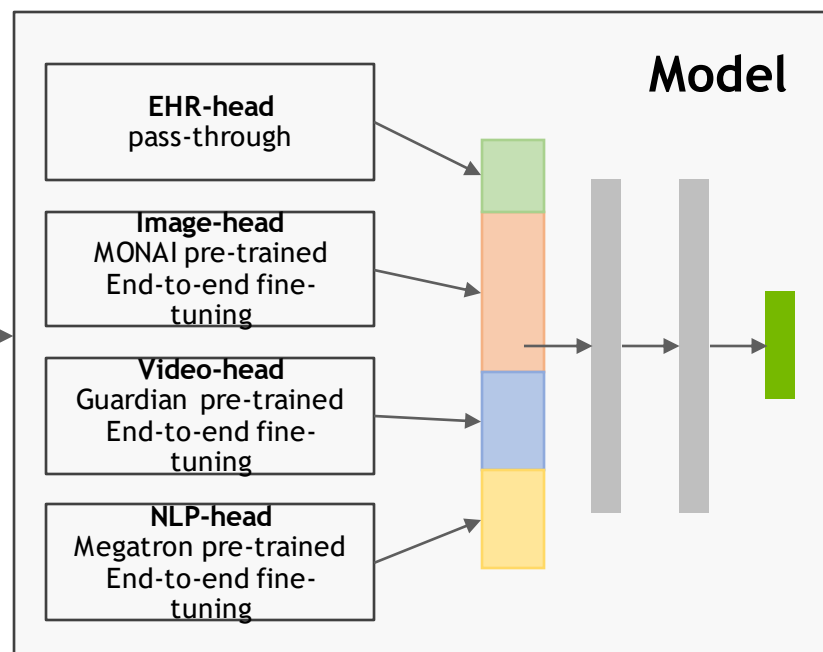
```
    Dataset to load data from CSV files and generate a list of dictionaries,
    every dictionary maps to a row of the CSV file, and the keys of dictionary
    map to the column names of the CSV file.
```

patient_id	age	sex	kg	image	video	letter
Subject_01	34	M	75	./imgs/01.nii.gz	./vid/01.mp4	./letters/01.doc
Subject_02	62	F	84	./imgs/02.nii.gz	./vid/02.mp4	./letters/02.doc
Subject_03	57	M	112	./imgs/03.nii.gz	./vid/03.mp4	./letters/03.doc
...						

				EHR	Image	Video	Letter
--	--	--	--	-----	-------	-------	--------

```
batch = {'ehr': ...,
        'image': ...,
        'video': ...,
        'letter': ...
        }
```

Modality-specific transforms



Tutorial notebook:

- CSVDataset and HuggingFaceTransform: [\[notebook\]](#)
- Multimodal transformer model TransCheX: [\[notebook\]](#)

Classes:

- [CSVDataset](#)
- [TransCheX](#)

Data Analytics: CuPy

Drop-in replacement for Numpy

CUPY

A NumPy like interface to GPU-acceleration ND-Array operations

BEFORE

```
import numpy as np

size = 4096
A = np.random.randn(size, size)

Q, R = np.linalg.qr(A)
```

AFTER

```
import cupy as cp

size = 4096
A = cp.random.randn(size, size)

Q, R = cp.linalg.qr(A)
```



52x Speedup!

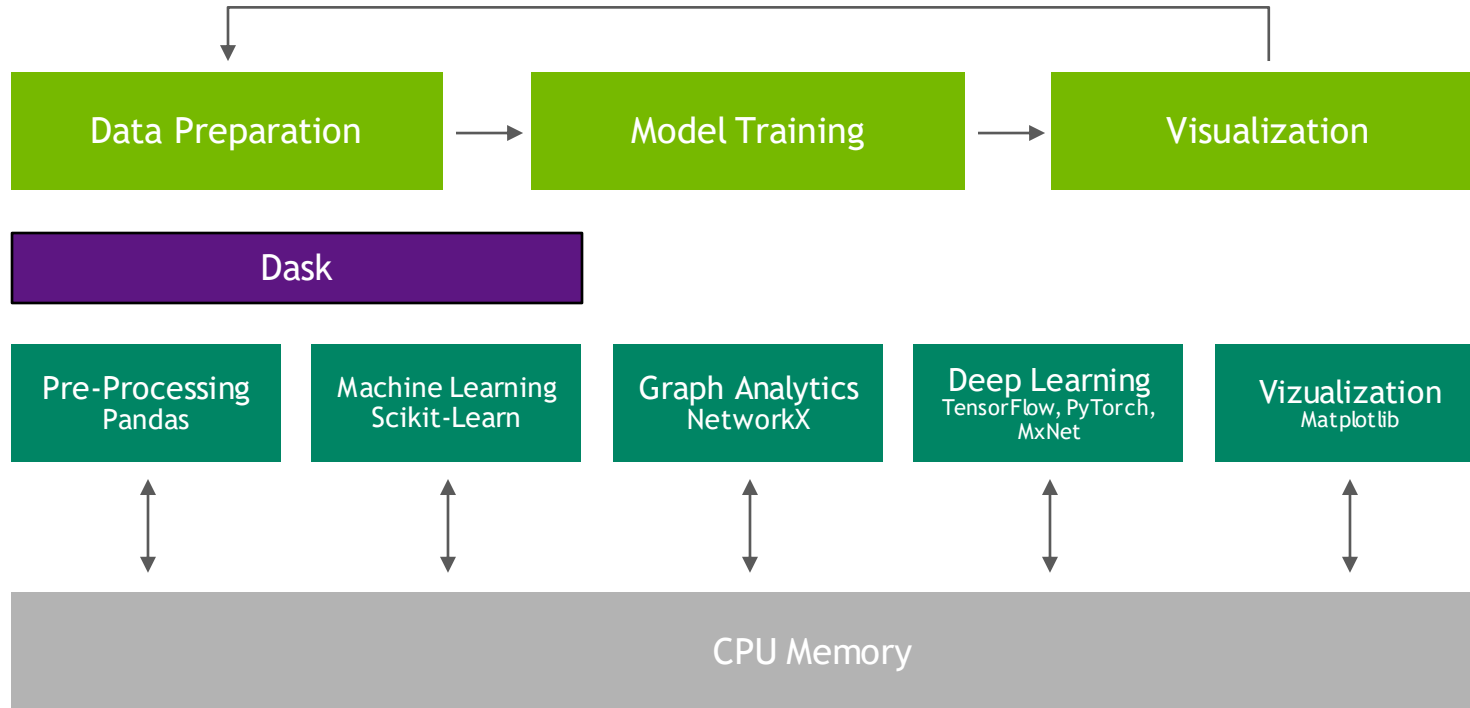


CuPy

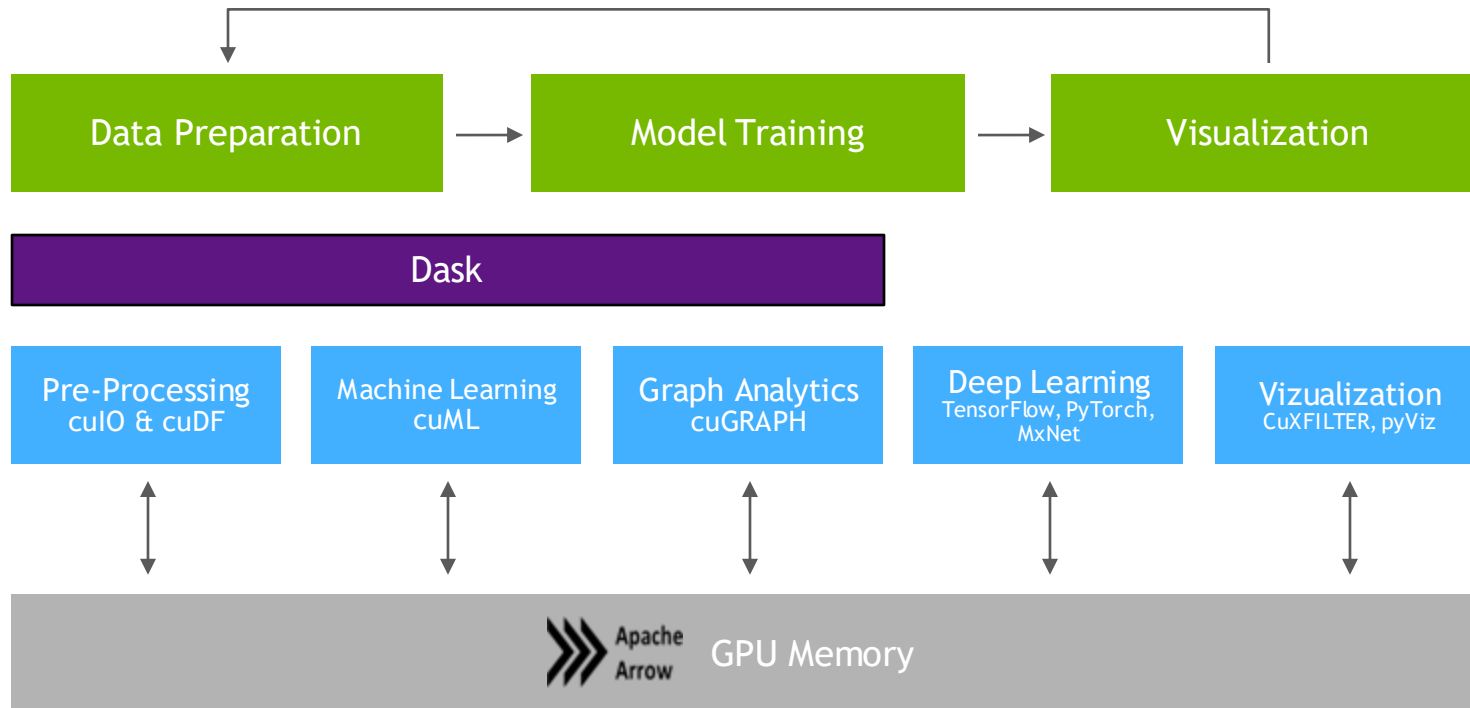
Data Analytics: RAPIDS

GPU-accelerated data science with API alignment

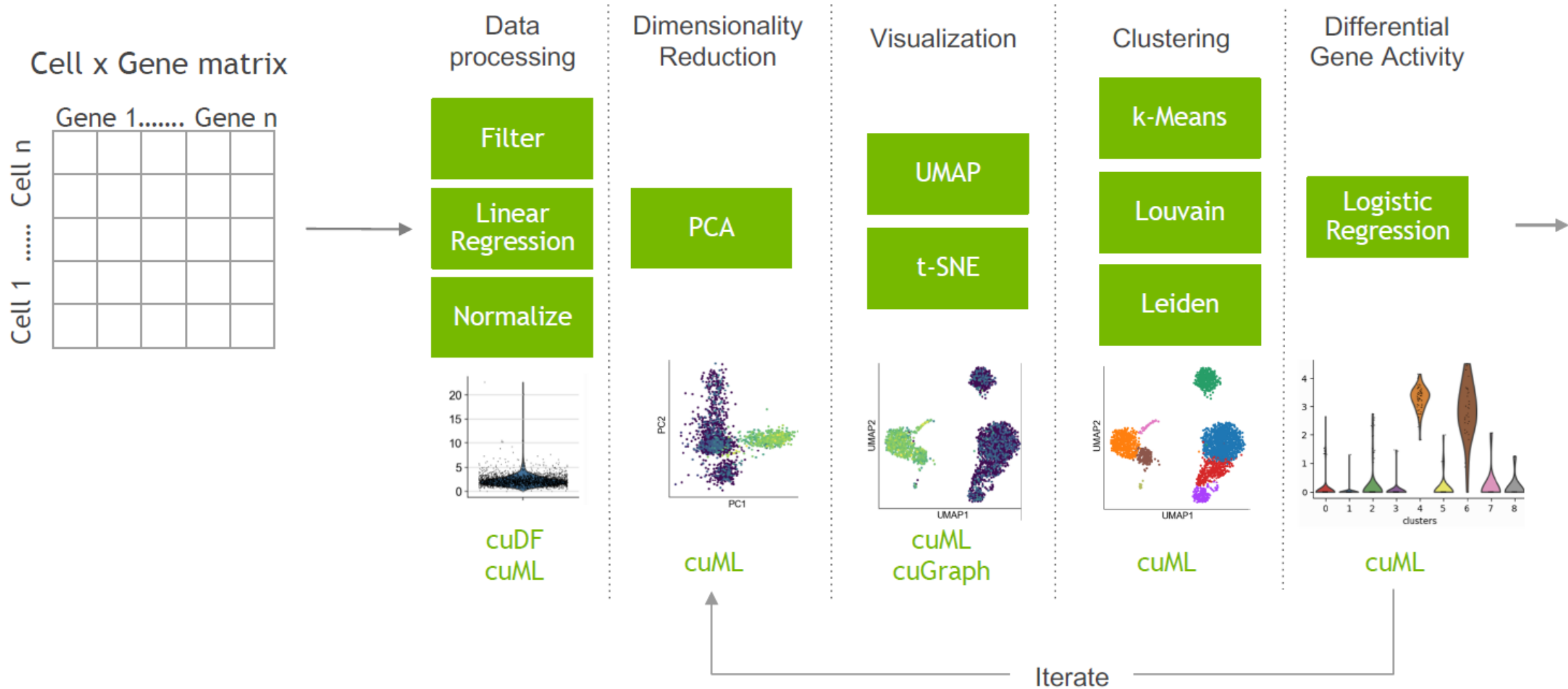
TRADITIONAL DATA SCIENCE APPLICATIONS



RAPIDS: GPU-ACCELERATED DATA SCIENCE *WITH API ALIGNMENT*



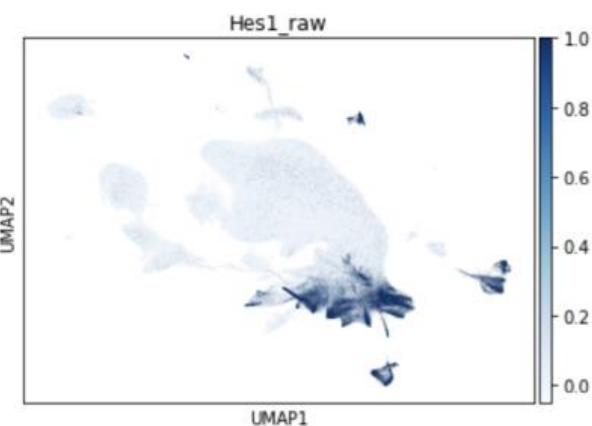
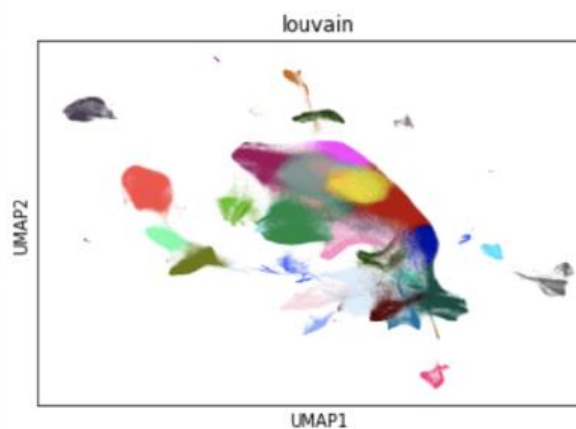
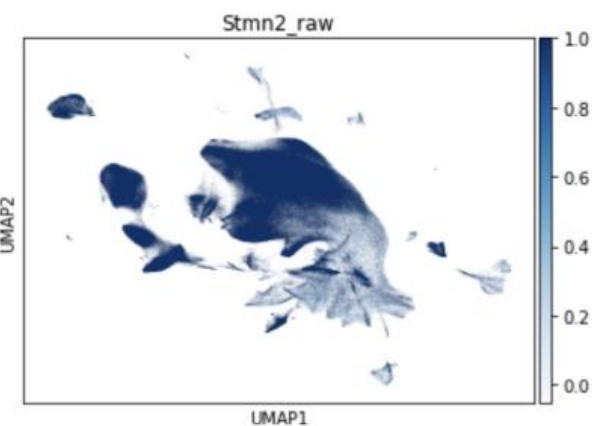
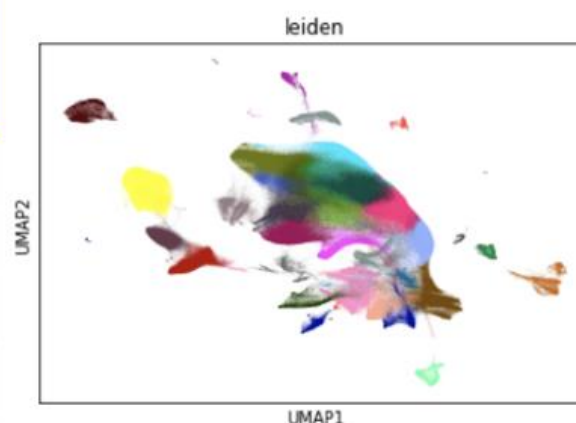
SINGLE-CELL RNA-SEQ ANALYSIS USING RAPIDS



GPU ANALYSIS OF 1 MILLION CELLS

From 3.5 hours to 8 minutes

	CPU Runtime n1-highmem-32 32 vCPUs	GPU runtime a2-highgpu-1g Tesla A100 40GB GPU	GPU acceleration
Preprocessing	28m35s	3m21s	9x
PCA	29.2s	11.4s	2.6x
t-SNE	1hr23m10s	28s	178x
KNN	3m5s	46s	4x
UMAP	21m47s	13.4s	98x
k-means clustering	2m6s	1.9s	66x
Louvain clustering	15m5s	1.9s	476x
Leiden clustering	51m1s	1.4s	2186x
End-to-end runtime	3hr31m48s	8m22s	25x
End-to-end cost	\$6.682	\$0.553	



Thanks

Q&A

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