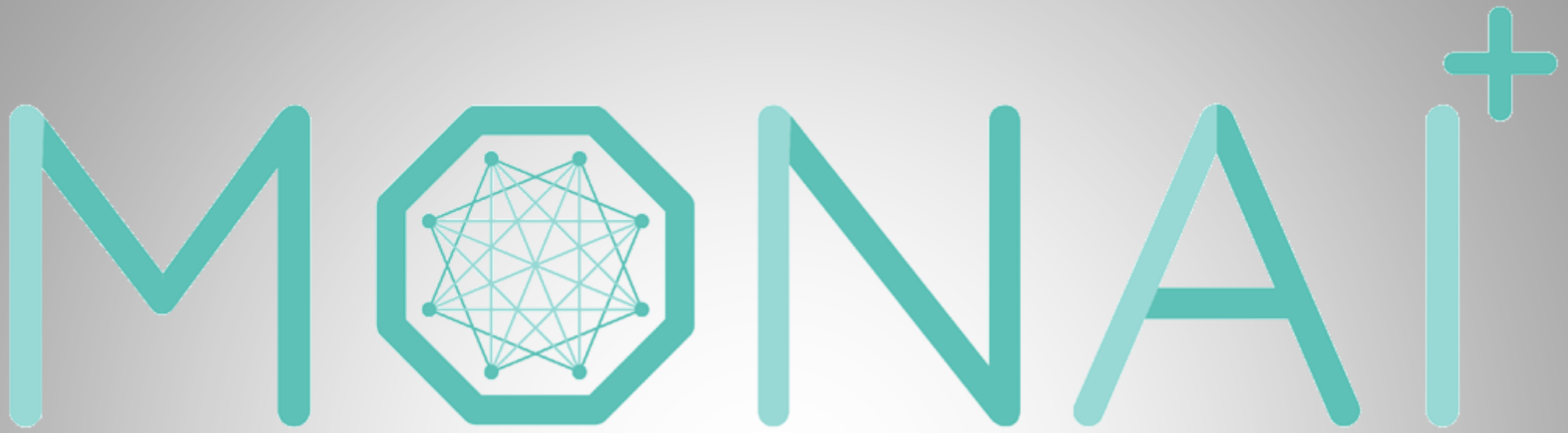

Open Science and Open Innovation for Medical Imaging AI

Stephen R. Aylward, Ph.D.
Chair of MONAI External Advisory Board
Senior Directory of Strategic Initiatives, Kitware

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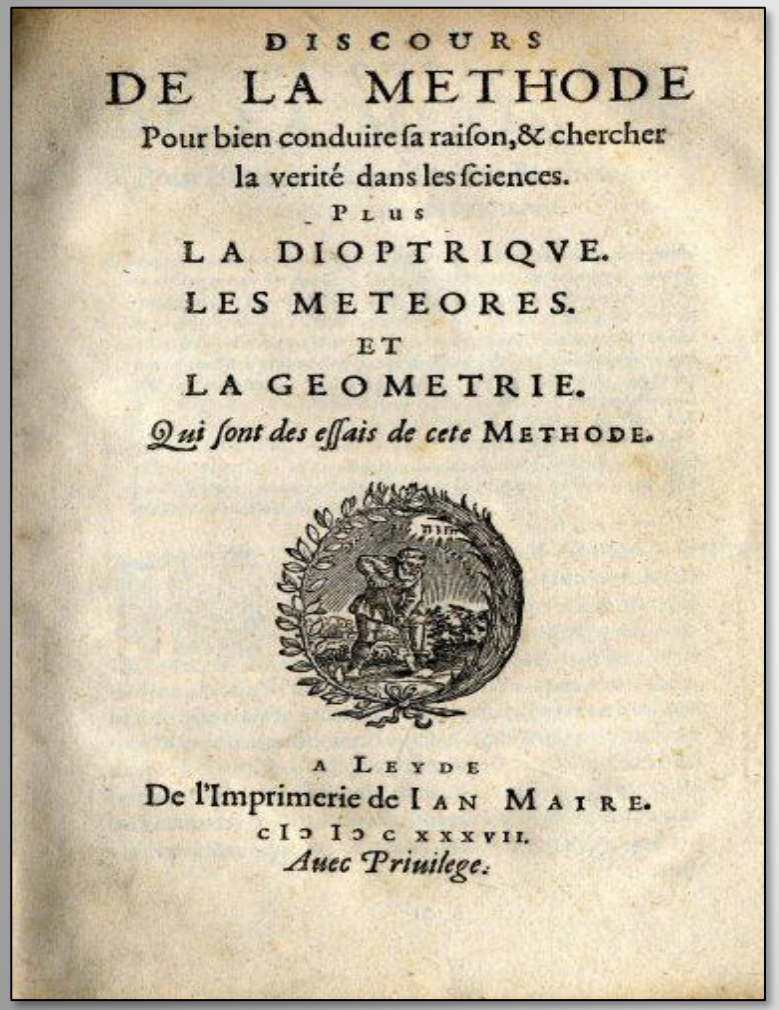
Why is Open Science Important?



DISCOURS
DE LA METHODE
Pour bien conduire ſa raiſon,& chercher
la verité dans les ſciences.
PLUS
LA DIOPTRIQVE.
LES METEORES.
ET
LA GEOMETRIE.
Qui ſont des eſſais de cete METHODE.

A LEYDE
De l'Imprimerie de IAN MAIRE.
cIↃ IↃ c xxxvii.
Auec Priuilege.

"DOUBT EVERYTHING and only believe in those things that are evidently true (reproducible)."

-- Descartes 1637
Discourse on the (Scientific) Method

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Failure of Open Science

Nature (March 2012)

-- Glenn Begley: Head of cancer research at pharma giant Amgen

-- Lee M. Ellis: Cancer researcher at the University of Texas

- Identified 53 'landmark' publications.
- Sought to double-check the findings before building on them for drug development.
- Result: 47 of the 53 could not be replicated.

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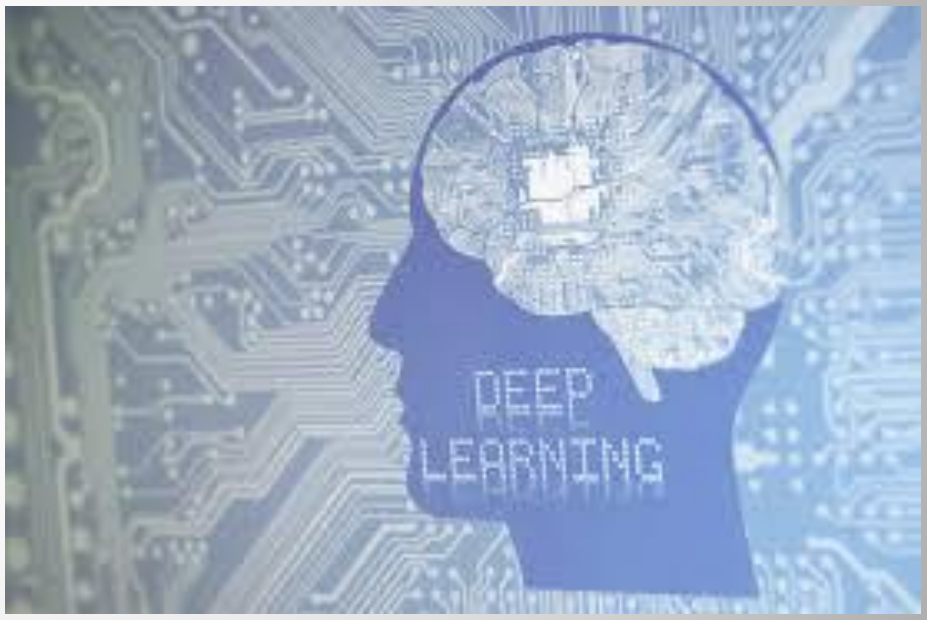
What is open science?

"Reproducible Science"

Write open-source code, share data, and publish so that others can fully replicate your work.

Why is deep learning succeeding?

- Performance
- Open Science



-- Forbes.com

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Deep Learning Success: Performance

< Left as an exercise for the audience >

Deep Learning Success: Open Science

- Open science is pervasive in deep learning
  - Open access publications: arXiv
  - Open access data: TCIA/IDC, ImageNet, DICOM, FIHR
  - Open access algorithms: Open source: PyTorch, MONAI

MONAI's open-source code

- "Code for others": commented, well organized, …
  - Readable code
  - Keep it simple
- OSF-approved license: Apache 2.0
  - Free for academic and commercial use
- Maximize impact

Project MONAI

Open Science + Open Innovation

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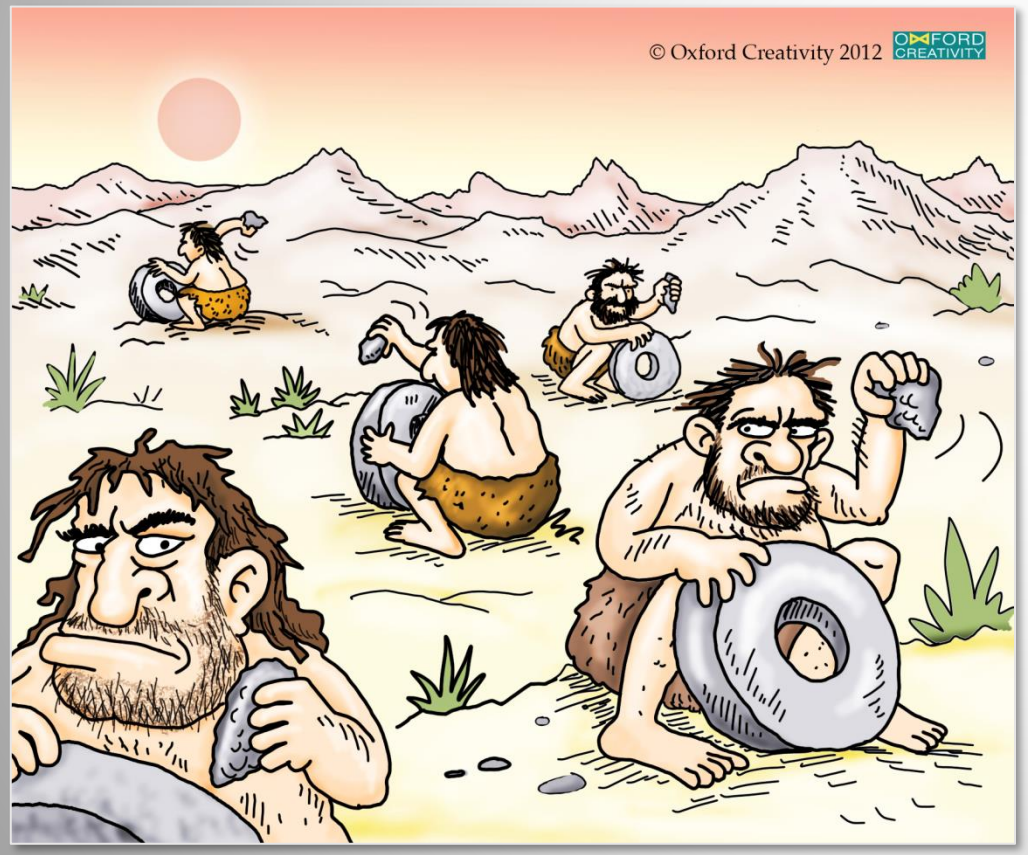
Open Innovation …

… IS NOT …



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Open Innovation …

… IS …

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Open Innovation …

… IS …

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Open Innovation …

- "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model“

-- Chesbrough, H., & Bogers, M. 2014

pecuniary = monetary = money

Project MONAI

Goal: Accelerate the pace of research and development by providing a common software foundation and a vibrant community for medical imaging deep learning.

- Began as a collaboration between Nvidia and King's College London
  - Prerna Dogra (Nvidia) and Jorge Cardoso (KCL)

- Freely available (Open-source code)
- Provides easy access to key public datasets (Open-access data)
- Community-supported (Open innovation)
- Optimized for medical imaging and reproducibility
- Reference implementation of best practices

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Project MONAI

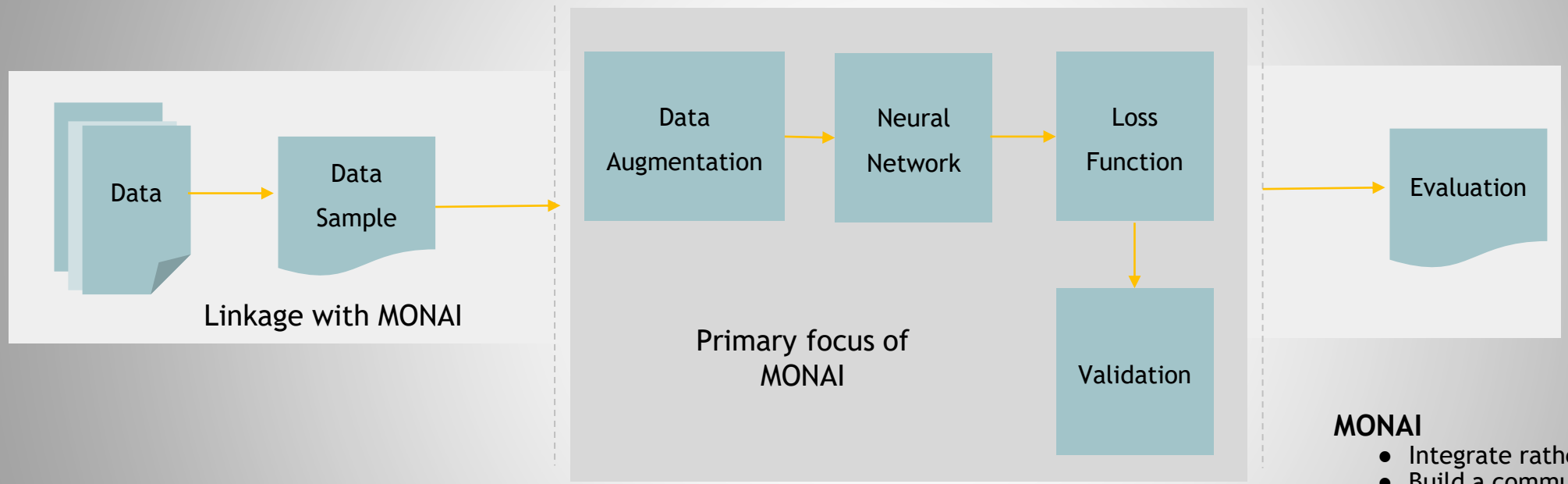
Open-Source Software

- MONAI
- MONAI Label
- MONAI Deploy
- MONAI Stream
- MONAI *<insert your idea here>*

Open-Access Data

- dataset(…)
- MedNIST, Decathlon, …
- NIH TCIA / IDC
- *<insert your data here>*

Open Science + Open Innovation



End2End workflow facilitated by MONAI

MONAI

- Integrate rather than compete
- Build a community through value

Current Conditions

- Many options
- Incompatible interfaces and formats
- Extended learning curves

NiftyNet (KCL)

DeepNeuro (Harvard)

DLTK (ICL)

TensorFlow

PYTORCH

Clara Train (NVIDIA)

Why is MONAI Needed?

- Biomedical applications have specific requirements
- Image modalities require specific processing methods: MRI, CT, etc.
- Image formats require special support: DICOM, NIfTI, etc.
- Image meta-data must be considered: voxel spacing, HU, etc.
- Certain network architectures are designed for, or are highly suitable for, biomedical applications
- Problem prioritization is domain specific: sample size limitations, annotation uncertainties, etc.

Why is MONAI Needed?

Reproducibility is vital to clinical decision support

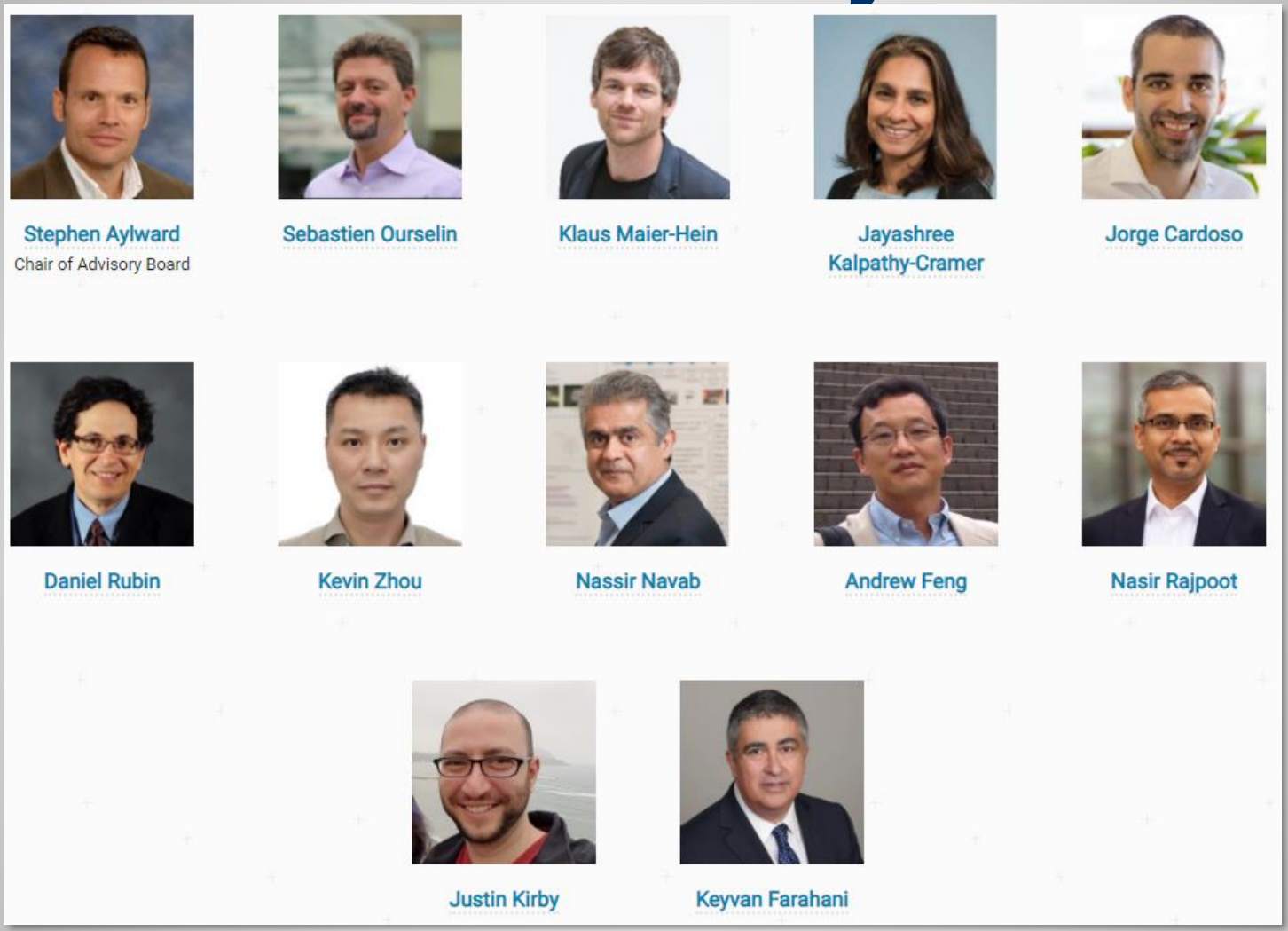
- Reduce re-implementation
- Provide baseline implementations
- Demonstrate best practices
- Facilitates open innovation

How Does MONAI Address These Needs?

- MONAI provides flexible yet reproducible Pytorch-compatible methods
  - Deterministic and validated modules
    - Medical data I/O
    - Data transforms to process, regularize, and augment image data
    - Metrics, Loss Functions
    - Checkpointing
  - Standardized networks and training paradigms

- Support for multi-GPU and multi-node multi-GPU training
- Tutorials and documentation: Jupyter Notebooks and Ignite Workflows

MONAI Advisory Board



Stephen Aylward
Chair of 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

Working Groups of MONAI

Liaison with the community:
Recommend policies and priorities to development team

1. *IMAGING I/O* – *Stephen Aylward (Kitware)*
2. *DATA DIVERSITY* – *Brad Genereaux (Nvidia)*
3. *CHALLENGES* – *Lena Maier-Hein (DKFZ)*
4. *TRANSFORMATIONS* – *Jorge Cordoso (KCL)*
5. *FEDERATED LEARNING* – *Jayashree Kalapathy (MGH) and Daniel Rubin (Stanford)*
6. *ADVANCED RESEARCH* – *Paul Jaeger (DKFZ)*
7. *INTEGRATION AND DEPLOYMENT* – *David Bericat (Nvidia)*
8. *PATHOLOGY* – *Nasir Rajpoot (Warwick)*
9. *COMMUNITY ADOPTION* – *Prerna Dogra (Nvidia)*

https://github.com/Project-MONAI/MONAI/wiki

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MONAI is Open Source

Ignite

Catalyst

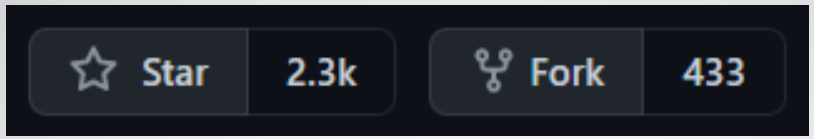
ITK

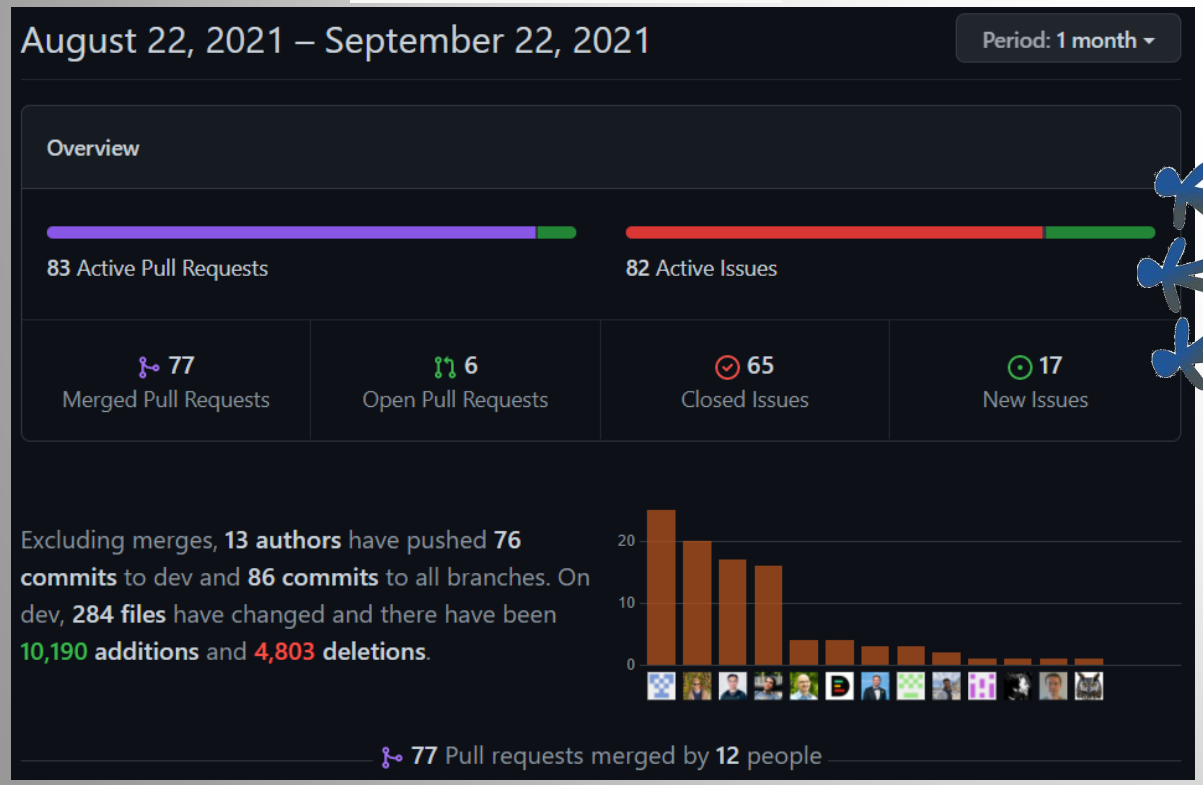
Massachusetts Institute of Technology

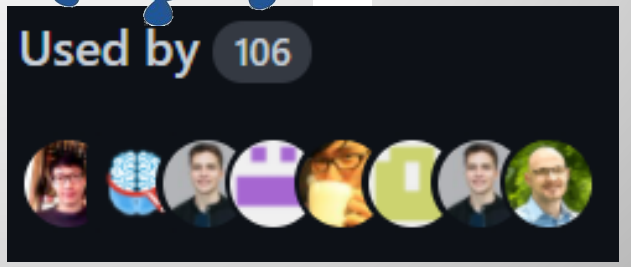
The University of Iowa

中国科学技术大学
University of Science and Technology of China

kornia







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Open Innovation

Novograd optimizer
LearningRateFinder
Unet
DynUNet
DenseNet
GAN
AHNet
Vnet
SENet / SEResNet, SEResNeXt
SegResNet
EfficientNet
Attention-based networks
Sliding window inference
Mean Dice
AUC
Confusion Matrices

Hasudorff Distance
Surface Distance
Occlusion Sensitivity
DICOM
NIFTI
NRRD
PNG
JPEG
20+ other file formats
Checkpointing for Transfer Learning
Multi-GPU, Multi-Node support
CUDA Optimized
MONAI Research Repository
  * COPLE-Net, LAMP, …
MONAI Data Portal
  * MedNIST, Decathlon, TCIA
Pre- and Post-processing filters
DeepGrow
…

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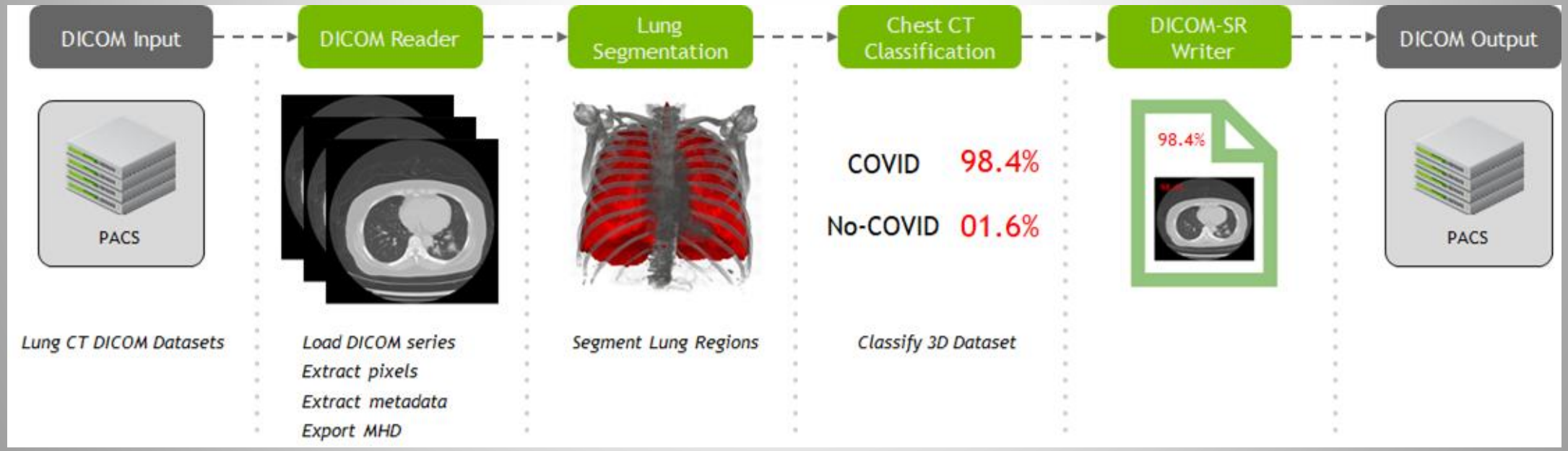
Nvidia = First Commercial Adopter: Nvidia CLARA

Encapsulating a COVID-19 Algorithm into an Integrated AI Application

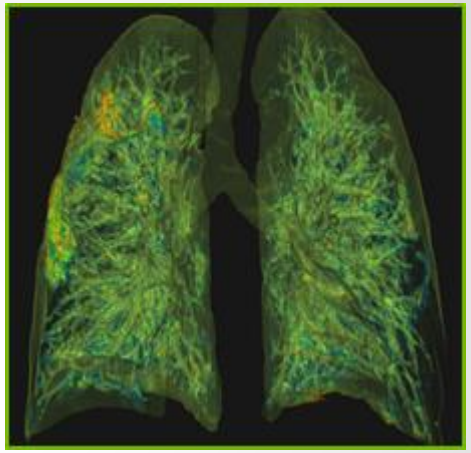


Nvidia CLARA PRE-TRAINED MODELS

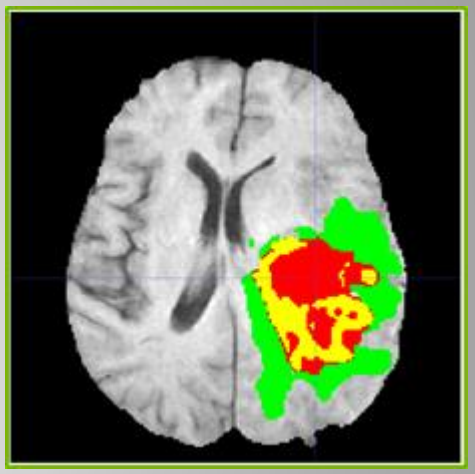
Packaged as Medical Models ARchive (MMARs)

Liver Tumor Segmentation

Lung Segmentation



Chest CT Classification



Brain Tumor Segmentation

Model	Medical Task	Data	Network
Brain tumor segmentation	3D Segmentation	MR (BraTS 2018)	Res-UNet
Liver and tumor segmentation	3D Segmentation	CT (medical Decath)	Anisotropic Hybrid Network (AH-Net)
COVID-19 Lung segmentation	3D Segmentation	CT NIH + global	
COVID-19 Chest CT classification	3D Classification	NIH dataset	DenseNet121
Chest X-ray classification	2D Classification	PLCO	

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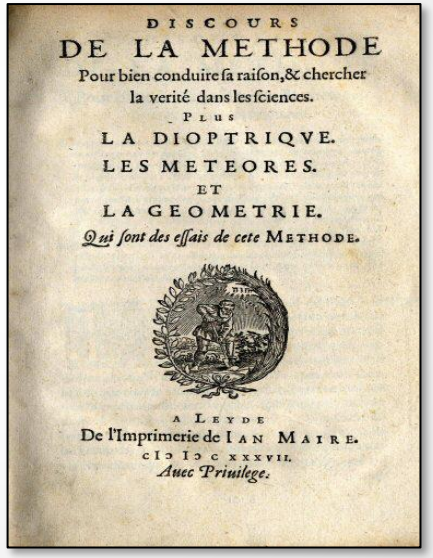
Conclusion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