

KING'S
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Platforms for medical AI, from prototype to clinical deployment

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JADE Day - Friday 29th September 2023

 **JADE**
Tier 2 HPC

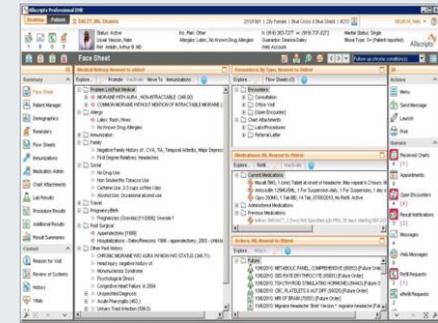
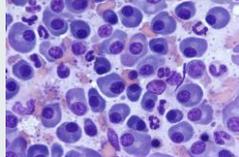
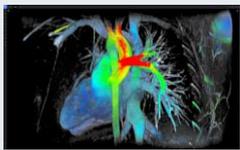
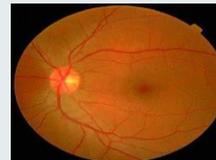
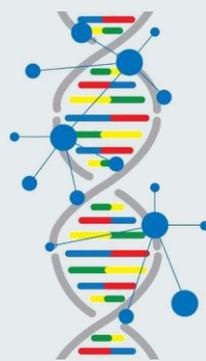
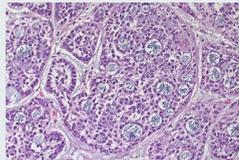
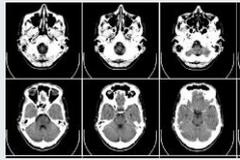
Marc Modat *et al.*

School of Biomedical Engineering & Imaging Sciences

Faculty of Life Sciences and Medicine, King's College London

Translation to clinical environments

Many potential applications, however ...



Radiology
CT, MR, US, X-RAY

Digital
pathology

Genetic

Dermatology
Ophthalmology

Electronic
Health
Record

27k Medical AI papers
~30 FDA Approved products
~7 Billion USD investment by 2021

Healthcare machine learning challenge

What about impact on patients?

ARTIFICIAL INTELLIGENCE

Hundreds of AI tools have been built to catch covid. None of them helped.

Some have been used in hospitals, despite not being properly tested. But the pandemic could help make medical AI better.

By Will Douglas Heaven

July 30, 2021

<https://www.technologyreview.com>

Analysis | [Open Access](#) | [Published: 15 March 2021](#)

Common pitfalls and recommendations for using machine learning to detect and prognosticate for COVID-19 using chest radiographs and CT scans

[Michael Roberts](#) , [Derek Driggs](#), [Matthew Thorpe](#), [Julian Gilbey](#), [Michael Yeung](#), [Stephan Ursprung](#), [Angelica I. Aviles-Rivero](#), [Christian Etmann](#), [Cathal McCague](#), [Lucian Beer](#), [Jonathan R. Weir-McCall](#), [Zhongzhao Teng](#), [Effrossyni Gkrania-Klotsas](#), [AIX-COVNET](#), [James H. F. Rudd](#), [Evis Sala](#) & [Carola-Bibiane Schönlieb](#)

[Nature Machine Intelligence](#) **3**, 199–217 (2021) | [Cite this article](#)

70k Accesses | **186** Citations | **1142** Altmetric | [Metrics](#)

Challenges associated with medical AI

Does the image have an artefact? In FOV?

Need for QC tools and robust algorithms

What are the acquisition differences?

Knowledge of acquisition physics

Is all necessary data available?

Deal with missing data

Is the image of the right kind?

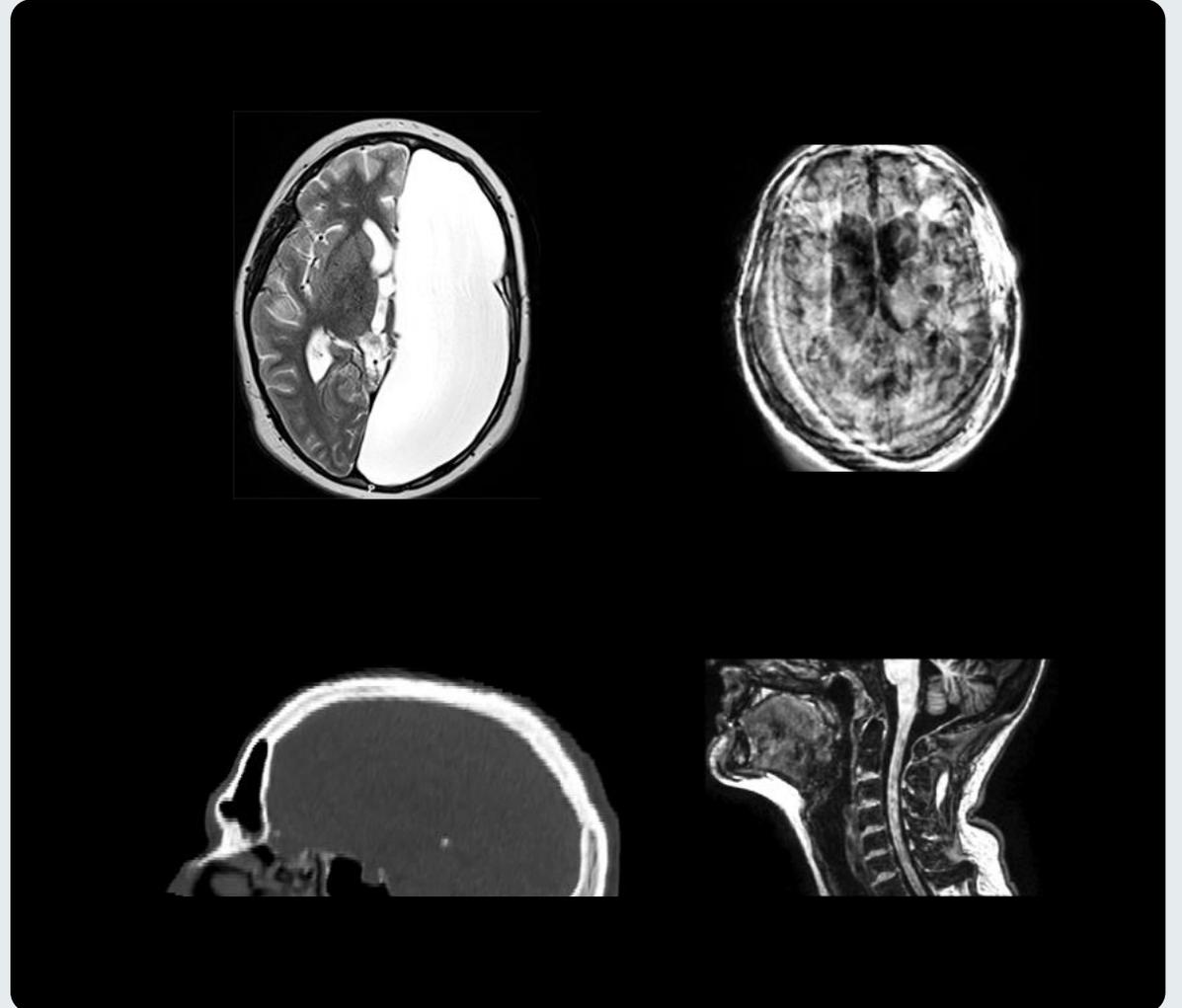
Modality and body part classifier

Does my model generalise?

Validation is key and often lacking

Can my code be used in the clinic?

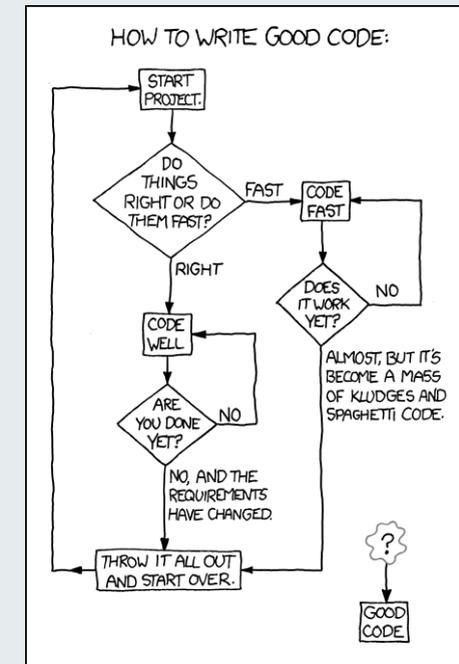
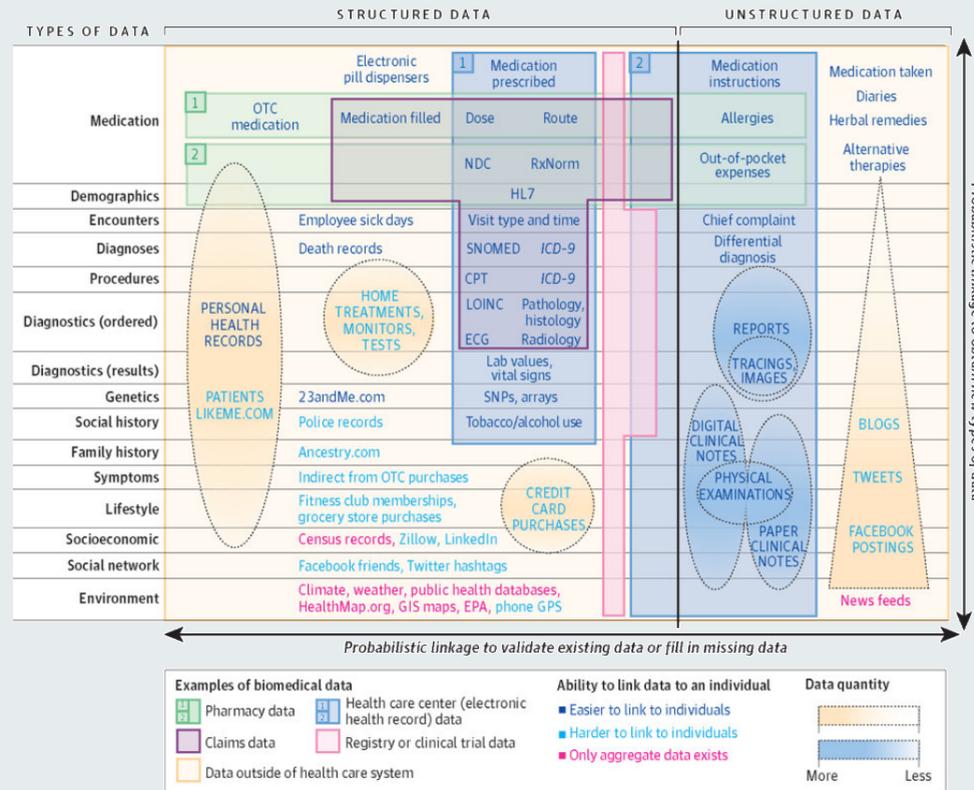
Research implementation are often crude



Blueprint requirements for “good” medical AI?

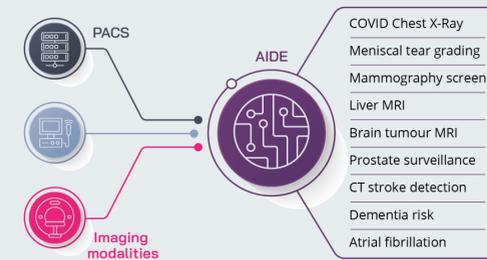
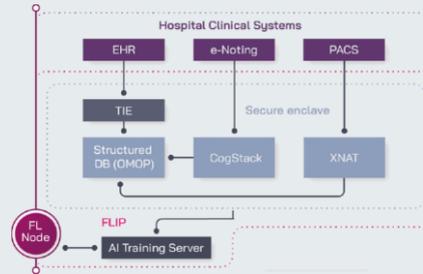
The development of medical AI tool should include (amongst other things):

- Implementation following industry coding standards & best practices.
- Model trained on large dataset(s) of “real” clinical data.
- Application deployed in clinical environments for prospective validation.



Outline

Interoperative platforms



<https://monai.io>, <https://github.com/Project-MONAI>
<https://www.aicentre.co.uk/our-platforms>



MONAI: Medical Open Network for Artificial Intelligence



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

Part of the PyTorch ecosystem and builds on other popular libraries, such as Pytorch Ignite, to leverage the technical expertise of the biomedical research community.

Community-based including academia and enterprise researchers.

Platform governance now includes an advisory board of members and many working groups.

Accelerating the pace of innovation, through code sharing and reproducible research.



Consortium Members.

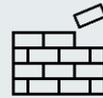


MONAI Design Goals



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

MONAI Workflow



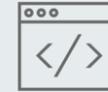
Data

*Easy access to standard datasets,
caching mechanisms, ...*



Labelling

*AI assisted segmentation with active
learning framework*
MONAI Label



App Deployment

Turn model into AI application

MONAI Deploy App SDK



Training

*Domain-optimized foundational
capabilities to train model*
MONAI Core



Deployment

MONAI Inference Service
MONAI Workflow Manager
MONAI Informatics Gateway

MONAI core components

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 seg.

MONAI TUTORIALS: to demonstrate the capabilities and integration with OSS packages

Segmentation

Classification

Registration

GAN & AutoEncoder

Interactive Seg.

Module demo

MONAI WORKFLOWS: for ease of robust training & evaluation of research experiments

Workflow engines
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

FOUNDATIONAL COMPONENTS: independent domain-specialised APIs compatible with PyTorch programs

Data
Cache-based datasets, patch-based datasets, enhanced data loader

Readers & writers
Support of various formats: NIfTI, PNG, NPY, CSV,...

Loss functions
Segmentation, regression, classification, registration

Networks,
differentiable modules
Network with 2D/3D, ND filtering, CRF, squeeze & excitation, warping

Transforms
Spatial, intensity, IO, utilities, compose with 3rd party libs

CSRC
C++/CUDA extensions, PyTorch JIT ext.

Inference modules
Sliding windows, saliency inferer, slice inferer

Visualisations
Tensorboard integration, Jupyter Notebook integration

Metrics
MeanDice, ROCAUC, FROC, Hausdorff, confusion matrix

Optimizers
LR finder, layerwise LR, Novograd

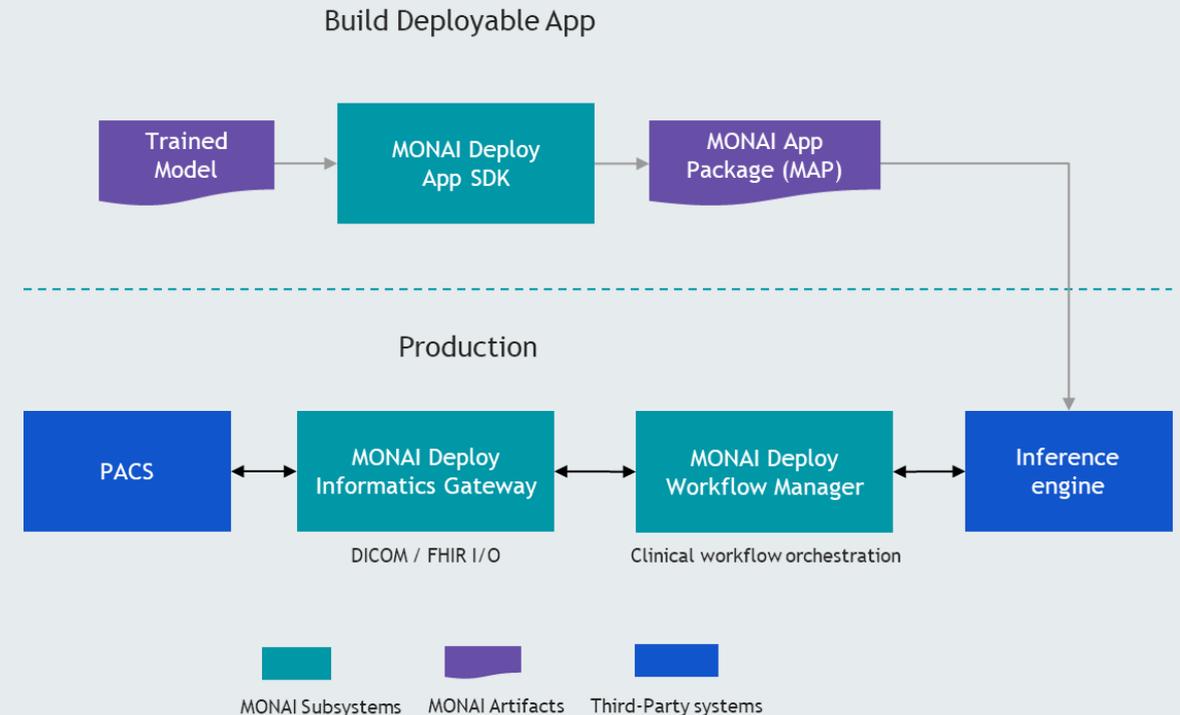
MONAI deploy

For Researchers and Developers

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

For Hospital Operations

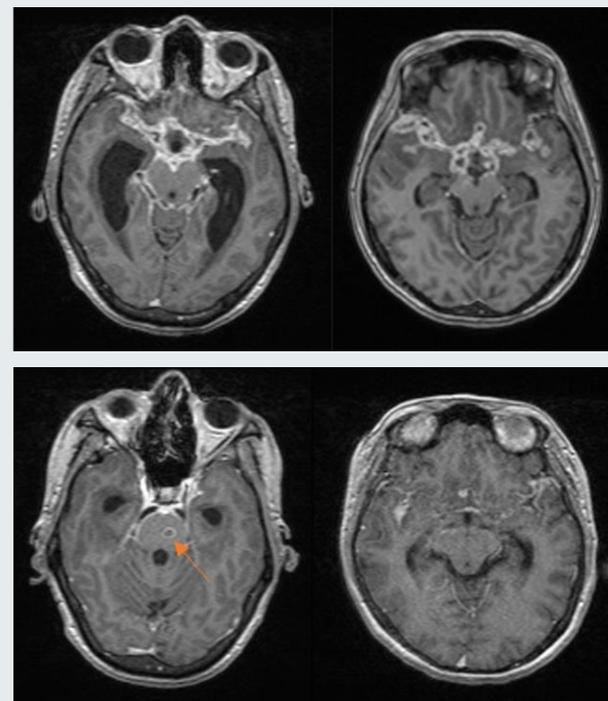
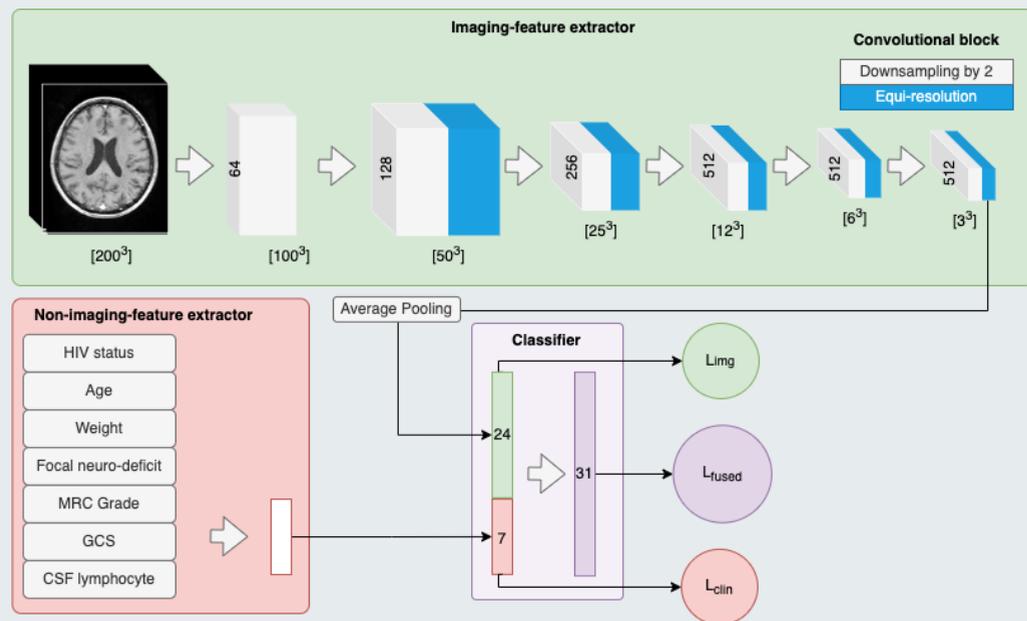
MONAI Deploy will define what a clinical infrastructure to run AI should look like, and how to interoperate with medical imaging systems over standards like DICOM and FHIR.



Example research project using MONAI

Convolutional neural network using magnetic resonance brain imaging to predict outcome from tuberculosis meningitis

- Exploration study to assess imaging complementary nature for prognosis
- Two-branch network with auxiliary losses

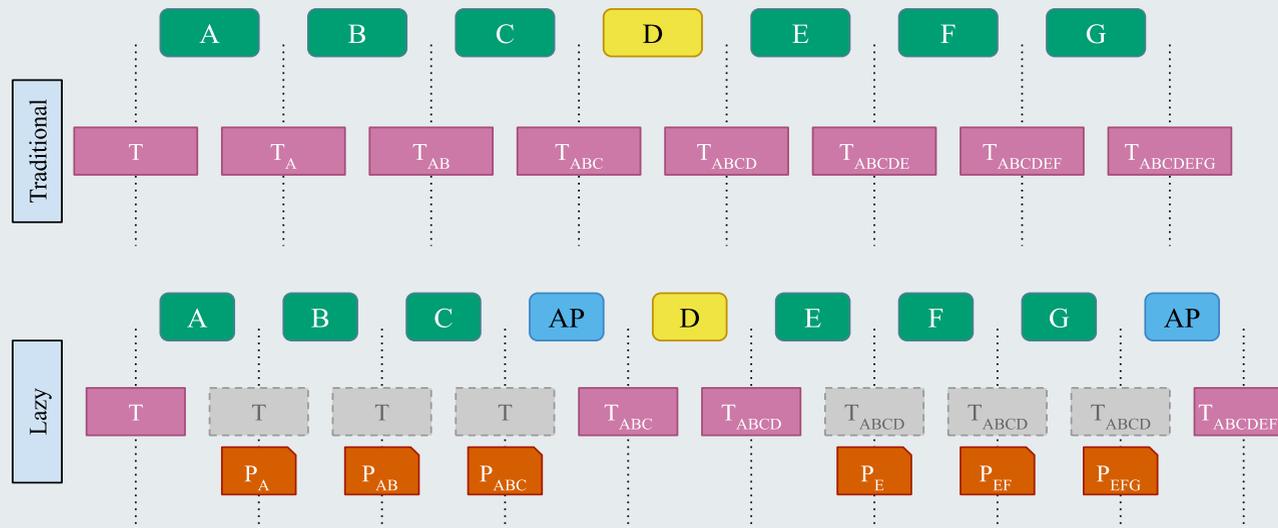


Trinh Dong *et al.*

Example core development to benefit the broader community

Lazy resampling, Fast and information preserving preprocessing for deep learning

- Suitable for all imaging preprocessing pipeline
- Abstract implementation
- Reduce image degradation



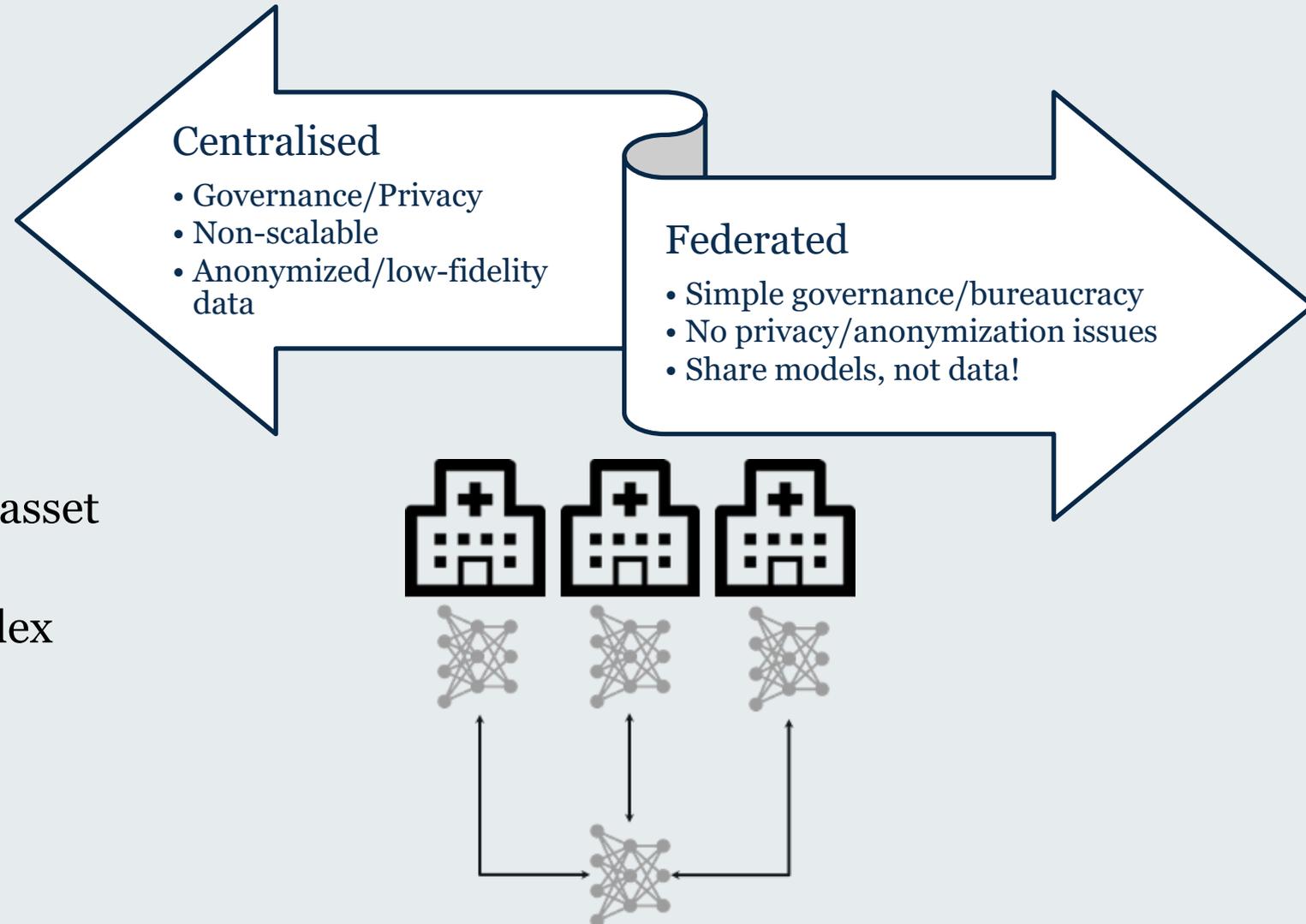
Benjamin Murray *et al.*

Model training at scale

Large training dataset tend to produce more robust network

Collaborative learning solves crucial issues in healthcare

- Private data can't be shared
- Anonymization is not truly effective
- Data annotation is costly. Data is an asset
- Bureaucracy of data sharing is complex
- Share models, not data!



FLIP: Federated Learning Interoperability Platform

Developed by the AI Centre for Value Based Healthcare

Safe

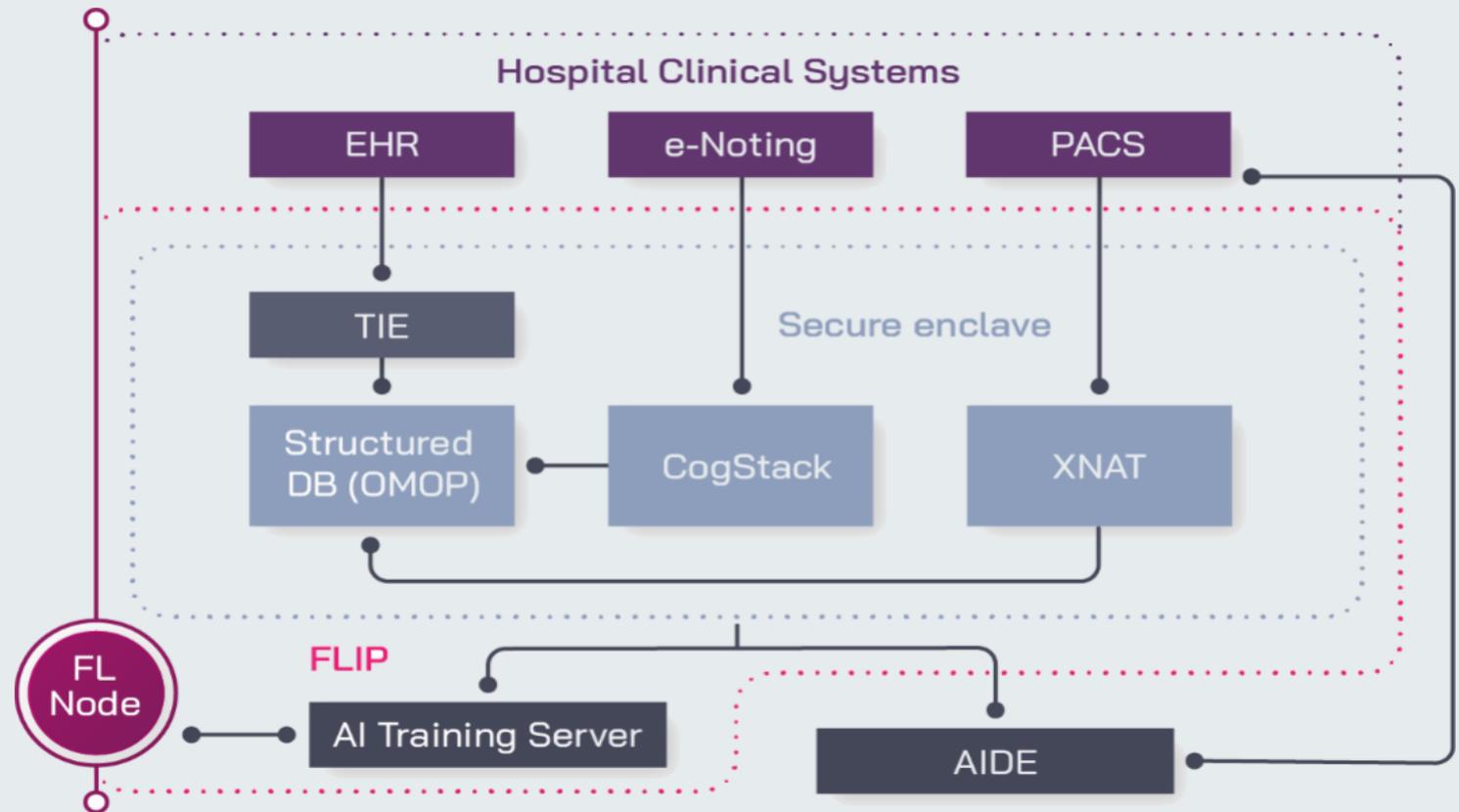
Open Source

Privacy-preserving

Traceability

Scalable

Governance compliance



AIDE: AI Deployment Engine

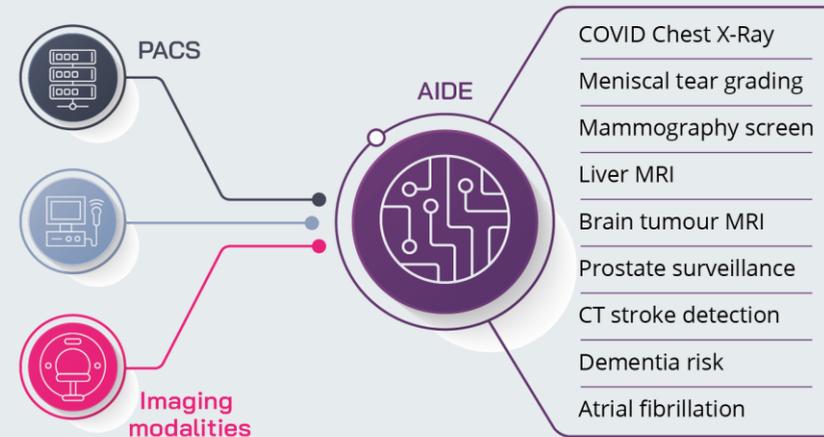
Needed to close the translational gap

It is critical to evaluate developed tools in the target environment

Integrating research software in clinical system is complicated and time consuming

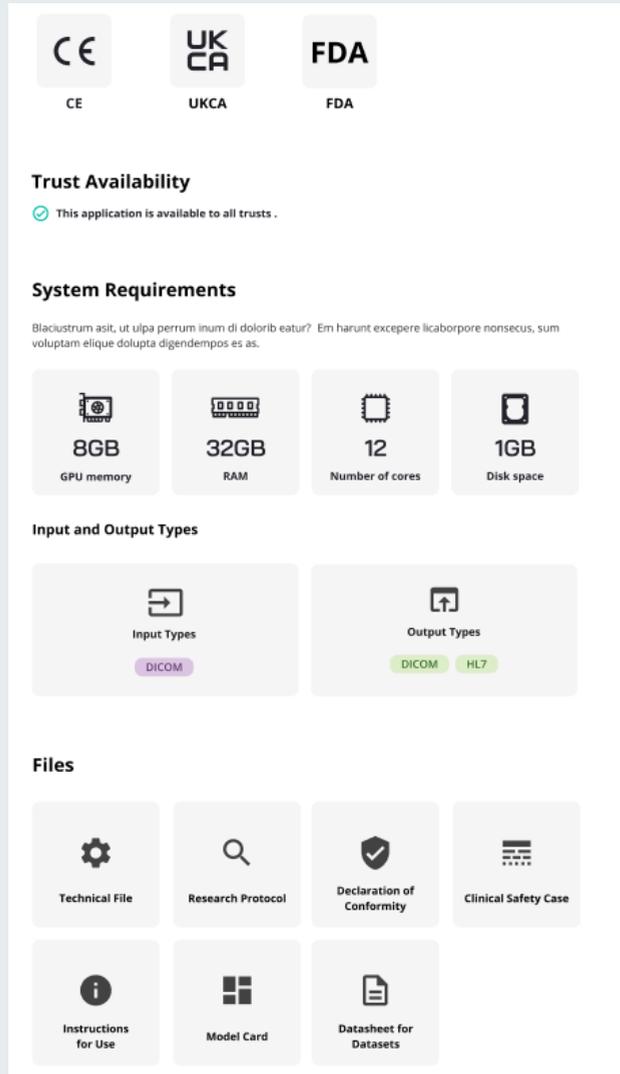
AIDE: AI Deployment Engine

AIDE was first deployed in 2021 in KCH
Deployment in 10 NHS Trust by Sept. 2023



AIDE: AI Deployment Engine

AIDE regulated market place



CE UKCA FDA

Trust Availability
This application is available to all trusts.

System Requirements
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8GB GPU memory
32GB RAM
12 Number of cores
1GB Disk space

Input and Output Types
Input Types: DICOM
Output Types: DICOM, HL7

Files
Technical File, Research Protocol, Declaration of Conformity, Clinical Safety Case
Instructions for Use, Model Card, Datasheet for Datasets

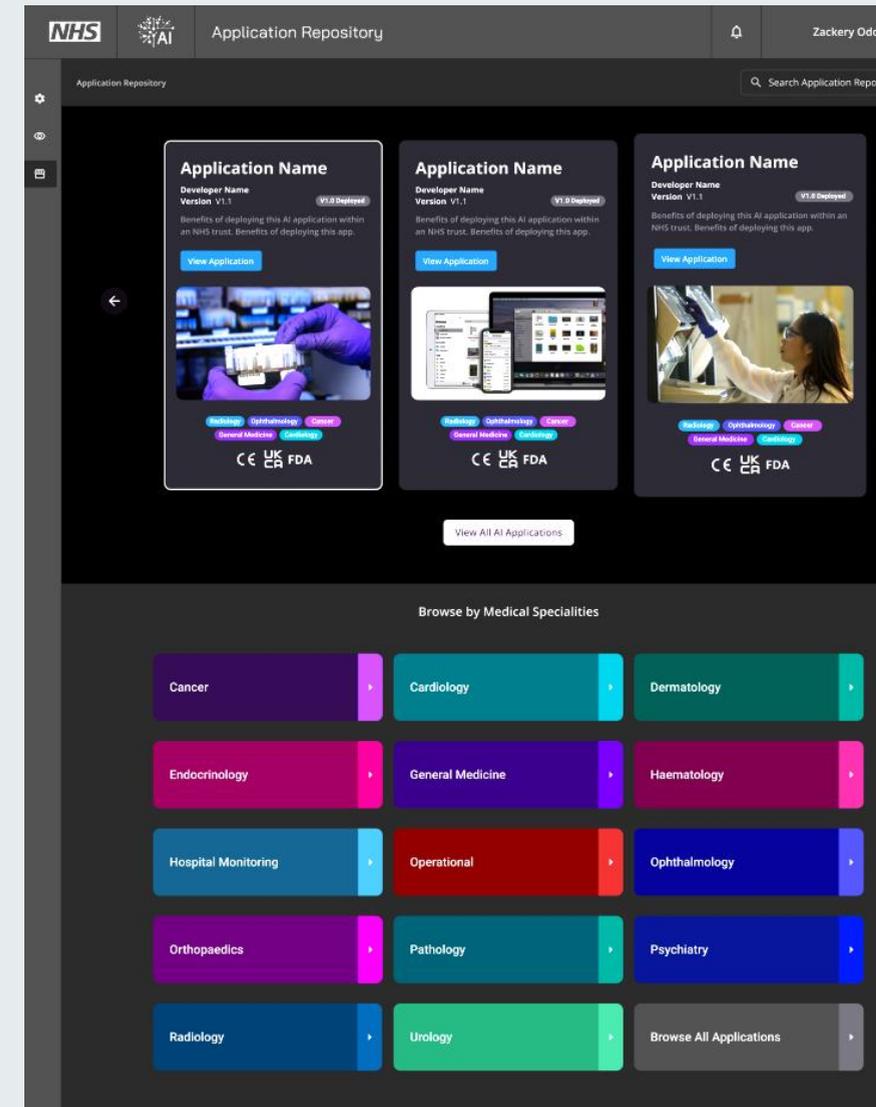
QA, shadow and research modes

Centralised reporting

Audit activity

App store with regulators

Distribution for commercial 3rd party AI



NHS AI Application Repository

Application Name
Developer Name
Version V1.1
Benefits of deploying this AI application within an NHS trust. Benefits of deploying this app.
View Application

Application Name
Developer Name
Version V1.1
Benefits of deploying this AI application within an NHS trust. Benefits of deploying this app.
View Application

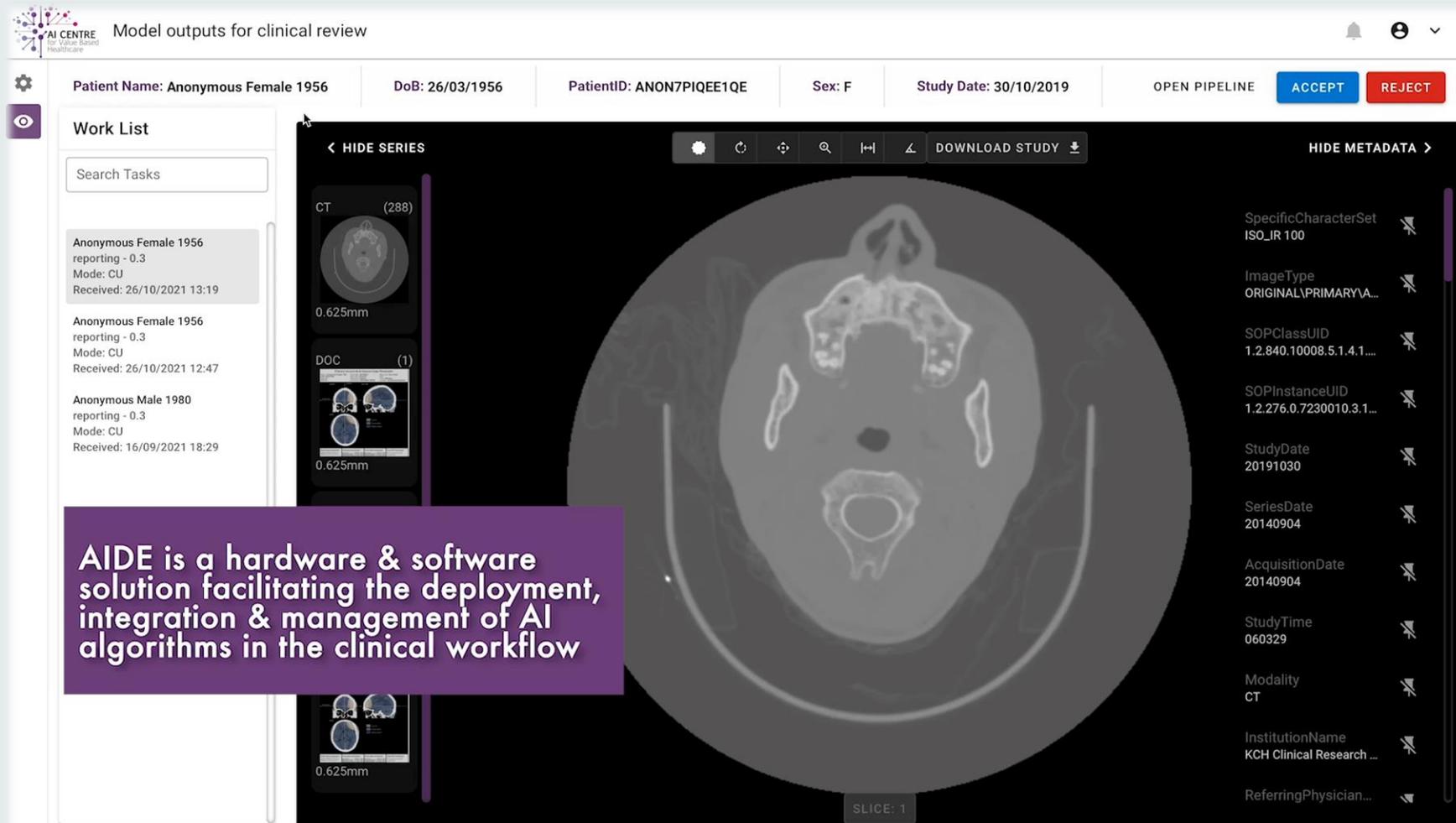
Application Name
Developer Name
Version V1.1
Benefits of deploying this AI application within an NHS trust. Benefits of deploying this app.
View Application

View All AI Applications

Browse by Medical Specialities

- Cancer
- Cardiology
- Dermatology
- Endocrinology
- General Medicine
- Haematology
- Hospital Monitoring
- Operational
- Ophthalmology
- Orthopaedics
- Pathology
- Psychiatry
- Radiology
- Urology
- Browse All Applications

Deployment ecosystem – A stroke exemplar



Model outputs for clinical review

Patient Name: Anonymous Female 1956 DoB: 26/03/1956 PatientID: ANON7PIQEE1QE Sex: F Study Date: 30/10/2019 OPEN PIPELINE ACCEPT REJECT

Work List

Search Tasks

- Anonymous Female 1956
reporting - 0.3
Mode: CU
Received: 26/10/2021 13:19
- Anonymous Female 1956
reporting - 0.3
Mode: CU
Received: 26/10/2021 12:47
- Anonymous Male 1980
reporting - 0.3
Mode: CU
Received: 16/09/2021 18:29

CT (288)
0.625mm

DOC (1)
0.625mm

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AIDE is a hardware & software solution facilitating the deployment, integration & management of AI algorithms in the clinical workflow

Academic leads for this project: Dr Jorge Cardoso (KCL), Prof Parashkev Nachev (UCL) and Prof Sebastien Ourselin (KCL)

Conclusion

Research related to medical AI is a very active field,
Medical AI impact could be transformative.

Very few tools are reaching patient care.

Project MONAI, FLIP and AIDE are open-source platforms aiming to accelerate development and deployment.

A lot more to do! Let's get coding!



Community-based



Consortium of universities,
hospitals and companies

Thank you for your attention

Acknowledgments:

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The Joint Academic Data Science Endeavour
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