Bridging the translational gap for artificial intelligence in clinical neuroimaging

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What is artificial intelligence?

What is AI?

Artificial Intelligence (AI) is the field of computer science devoted to creating systems that can perform tasks that typically require human intelligence. These tasks include perception (e.g., recognizing images or speech), reasoning (e.g., solving problems, making decisions), learning (e.g., adapting from data and experience), and interaction (e.g., understanding natural language, generating responses, collaborating with humans).

At a high level, AI can be divided into:

- **Symbolic AI (knowledge-based, rule-based, expert systems):** Uses explicit rules, logic, and symbolic representations to encode reasoning.
- **Machine Learning (data-driven):** Learns patterns from data, with subfields like deep learning, reinforcement learning, and probabilistic modeling.

AI is not a single method but a spectrum of approaches for replicating or augmenting cognitive functions in machines.

Would you like me to give you a **concise working definition** (one sentence) or a **taxonomy of types of AI** (narrow, general, superintelligence, etc.)?

Ask anything

ChatGPT

Spot

1X Neo

AlphaFold

AlphaZero

What is artificial intelligence?

Artificial intelligence:
Machines that solve tasks requiring some kind of (often human-like) intelligence.

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Deep learning:
Machine learning approaches relying on artificial neural networks (inspired by the human brain)

What is artificial intelligence?

Artificial neuron

What is artificial intelligence?

Artificial intelligence and clinical neuroimaging

The state of AI 2025, McKinsey & Company

Artificial intelligence and clinical neuroimaging

NANDA, MIT (2025). State of AI in Business 2025. *Preprint at https://www.artificialintelligence-news.com/wp-content/uploads/2025/08/ai_report_2025.pdf*

Artificial intelligence and clinical neuroimaging

Publications containing "(neuroimaging OR clinical neuroscience) AND (artificial intelligence OR deep learning)"
from https://pubmed.ncbi.nlm.nih.gov

Artificial intelligence and clinical neuroimaging

Artificial intelligence and clinical neuroimaging

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AI adoption

The black-box problem of artificial intelligence

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Understanding artificial neural networks

Understanding artificial neural networks

Artificial neuron

Understanding artificial neural networks

Artificial neuron

$$\text{output} = \max(0, b + w_1 * \text{input}_1 + w_2 * \text{input}_2 + w_3 * \text{input}_3)$$

Understanding artificial neural networks

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Banerjee, I., Bhattacharjee, K., Burns, J. L., Trivedi, H., Purkayastha, S., Seyyed-Kalantari, L., ... & Gichoya, J. (2023). "Shortcuts" causing bias in radiology artificial intelligence: causes, evaluation, and mitigation. *Journal of the American College of Radiology*, *20*(9), 842-851.

Understanding artificial neural networks

Artificial neuron

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Understanding artificial neural networks

Artificial neuron

$$\text{importance}_i = \frac{\text{input}_i * w_i}{\sum \text{input}_j * w_j} * output$$

Understanding artificial neural networks

Explainable artificial intelligence and dementia

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Explainable artificial intelligence and dementia

Explainable artificial intelligence and dementia

Explainable artificial intelligence and dementia

Explainable AI

Explainable artificial intelligence and dementia

Explainable AI

Human researchers

Explainable artificial intelligence and dementia

Explainable artificial intelligence and clinical neuroimaging

Although artificial neural networks very often result in accurate predictions, their opaque nature make it hard to understand how they work.

- Learning shortcuts to solve problems that appear valuable but are really not related to the problem at hand gives rise to ”Clever Hans”-predictors.
- Explainable artificial intelligence provides methodology for probing how these models work, building trust and potentially enabling clinical use.

The availability of neuroimaging data

The size of neuroimaging datasets

Dataset	Size	Description
MNIST	$\sim$70K	Handwritten digits
CIFAR	$\sim$60K	Natural images
COCO	$\sim$330K	Contextualized objects
ImageNet (21k)	$\sim$14M	Natural images
CLIP	$\sim$400M	Image-caption pairs from the internet
JFT-3B	$\sim$3B	Image-caption pairs from the internet
LAION-5B	$\sim$2.3B	Image-caption pairs from the internet

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UK Biobank	45,891	Population MRI data
ABCD	11,660	Population MRI data
ADNI	2,729	Clinical MRI data
TOP	2,222	Clinical MRI data
HBN	1,365	Population MRI data
QTIM	1,201	Population MRI data
PING	1,176	Population MRI data
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Transfer learning

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Transfer learning on neuroimaging data

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Transfer learning on neuroimaging data

Training modern artificial neural networks require *really* large datasets (millions or billions of training examples).

- Existing neuroimaging datasets are relatively small (tens of thousands of participants), a problem further exacerbated in clinical datasets (thousands of participants).
- Transfer learning represents a promising approach for training complex models with limited data.

The applicability of research models

Use-cases in neuroimaging research

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The applicability of research models

Most models trained for research are proof-of-concepts relying on simplified prediction problems and sanitized data.

- Training models for more appropriate use-cases requires clinical insights and access to clinical data.
- **More collaboration between technologists and clinical experts are crucial.**

Thank you for your attention!

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