



40 years of Alzheimer's disease dynamics in 14 seconds

TakeAIM Runner-up 2020:

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Alzheimer's disease (AD) is a neurodegenerative disease characterised by the propagation and accumulation of misfolded proteins in the brain. Unhealthy proteins spread through the brain in a manner reminiscent of a game of hide and seek, where captured proteins join the team of seekers. In a healthy brain, dangerous proteins are cleared through a number of interconnected clearance pathways. However, an imbalance in the brain's ability to remove them is thought to incite an army of unstoppable seekers that leads to neuronal damage, dementia, and ultimately death.

Network mathematical models of neurodegenerative disease thus far focus exclusively on the dynamics of toxic proteins; irrespective of clearance. Conversely, the clinical research community has raised the alarm on the urgency of studying the role of clearance in AD. Understanding the link between toxic protein behaviour and clearance failure could provide critical insights for life-changing treatments.

At the University of Oxford, in partnership with Simula Research Laboratory, we heed this alarm by developing the first mathematical, data-driven, network models coupling the clearance and spread of toxic proteins through the brain. Our research captures the essence of the game of hide and seek that AD plays as our brain ages. Moreover, our mathematical model, and software, provides clinical researchers worldwide with a set of tools to harness information from 40 years of patient-data-informed, clearance-mediated AD progression in 14 seconds of computational time. Our model brings us closer to answering the fundamental questions which underpin Alzheimer's research, and to saving mankind from this terrible disease.

The Smith Institute, enabled by the generous sponsorship of our leading corporate partners, ran the TakeAIM competition in 2020 to make visible the crucial role that mathematics will increasingly play in all aspects of our lives. The competition, also celebrating its 10th anniversary in 2020, was open to undergraduate and postgraduate students working in the mathematical sciences. First prize was £1,000, with three second prize winners receiving £400.