VirtualBrainCloud project uses AI-based brain simulations to improve the classification of Alzheimer's disease

A new study from the Horizon 2020-funded VirtualBrainCloud project has shown that brain simulations can improve the classification of patients at different stages of Alzheimer's disease. We speak to Professor Petra Ritter, Coordinator of the VirtualBrainCloud project, to find out more.

Artificial intelligence (AI) is everywhere. From entertainment websites to navigation tools and e-commerce applications, AI algorithms power services that we encounter and use in our daily lives. AI also holds great potential for improving healthcare, with advocates saying it could reduce the strain on limited resources and free up time for clinicians.

AI is at the heart of the Horizon 2020-funded project, VirtualBrainCloud, which is using AI algorithms and clinical data to construct personalised, highly detailed brain simulations of individuals with Alzheimer's disease and other neurodegenerative disorders. VirtualBrainCloud researchers have just published a new AI study in the Alzheimer's and Dementia: Translational Research and Clinical Interventions journal. This study shows that AI-based brain simulations could also improve the diagnosis of Alzheimer's disease, accurately classifying people at different stages of disease.

To find out more, we spoke to Prof. Petra Ritter, coordinator of the VirtualBrainCloud project. Petra is the Johanna Quandt Professor for Brain Simulation at the Berlin Institute of Health at Charité Universitätsmedizin (Germany), and leads a research team that is focused on developing brain simulation technologies for personalised medicine.

What is the VirtualBrainCloud approach, and how was it used in your new research paper?

The VirtualBrainCloud approach is to use brain network modelling to construct realistic, highly detailed models of the patient brain, which we can use to run simulations of disease. By pooling and analysing data from tests such as electroencephalogram (EEG) and magnetic resonance imaging (MRI) scans, we can accurately simulate the interactions that occur between neurons in specific areas of the brain. These areas can be located deep within the brain, and may not be easily accessible using routine or non-invasive tests. However, using mathematics, we can dynamically model the behaviour of these neuronal populations – and then use these simulations to make accurate predictions of what is happening in the brain during the development of disease.


Petra Ritter

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In our new research paper, we applied this approach to data from the Alzheimer's disease Neuroimaging Initiative (ADNI) study, including brain scan data from 10 participants with AD, 8 participants with mild cognitive impairment (MCI) and 15 healthy peers. By integrating features from these brain scans into our brain simulation framework, we were able to improve the classification of participants into different stages of disease. This shows how the VirtualBrainCloud approach can increase the sensitivity and specificity of clinical analyses, and might one day enhance patient stratification and diagnosis.

What is patient stratification, and why is it important to improve our mechanistic understanding of AD and dementia?

Patient stratification involves the grouping of patients into subgroups of individuals that share similar health, disease, or other characteristics. It represents a move away from a "one size fits all" approach in medicine, towards personalised approaches that are tailored to the individual.

Understanding the mechanisms of disease in a specific patient means that we can find better target points for interventions. For AD and dementia this is a big unmet need, as there is a constellation of mechanisms that contribute to the development of these complex diseases. This constellation will differ between individuals – and therefore, the best target point for therapy, intervention or prevention will also differ.

The work we and others are doing in research projects such as VirtualBrainCloud is bringing us a step closer towards being able to stratify patients, individually, according to their specific disease mechanisms.

What are the next steps for your research, and what implications could it have for clinical trials and healthcare?

The recent study proved that our approach is feasible, but only used data from a small number of participants. We would now like to validate our approach on larger and more diverse datasets. We need high-quality, well annotated and complex datasets to construct our brain simulations – however they can be challenging to obtain.

If accessing these datasets would be possible in the future, at a larger scale, then our analysis algorithms could be applied much more widely. This would help us to identify early biomarkers that could signal a risk of AD or dementia, and using our models we could see what the contributing mechanisms are, in an individualised way. As well as being useful for healthcare systems, this could be important information for clinical trials on presymptomatic or very early AD, or for trials that are studying drugs which are currently used for other conditions. By improving the stratification of patients, researchers will be able to recruit the populations who are most likely to benefit from trials of novel and repurposed drugs.

Data sharing can increase the impact and value of research, and is a fundamental part of your work in VirtualBrainCloud. What challenges have you faced in sharing and reusing data?

Effective data sharing relies on trust, knowledge and competence. However there is a knowledge and competence gap when it comes to privacy regulations and the GDPR, and how these can be navigated to allow data to be shared. There are also motivational factors that can be challenging to deal with. A mindset of ownership over data can impede data sharing, and different stakeholders may have their own plans and use priorities for data that take precedence over sharing.

However, there is a solution for this problem: by involving stakeholders in constructive dialogue, and by building competence and knowledge, we can create win-win solutions that benefit all parties and, ultimately, benefit patients and citizens. Policymakers and funders also have an important role to play. Traditional research metrics, such as publications and grant funding, do not adequately incentivise collaboration. By developing and promoting metrics that incentivise collaboration and data sharing, policymakers and funders can help push the field in a direction where researchers will actively work together to find joint solutions, and where they are rewarded for their efforts to share and reuse data.

How does VirtualBrainCloud promote collaboration and data sharing, and how has this benefited your research?

Collaboration is at the heart of VirtualBrainCloud. We have bi-weekly meetings where our technologies are developed together with users, lawyers, data protection specialists and data providers; everyone is welcome and provides input. We have also actively reached out to sister projects and initiatives such as EBRAINS, the Human Brain Project and AI-Mind, developing external collaborations as well as building a solid internal network.

As a result, VirtualBrainCloud has achieved a GDPR compliant, auditable platform that facilitates collaboration between researchers. Researchers in different institutions can use the VirtualBrainCloud platform to access valuable datasets in a protected, secure environment, which also provides compute resources that they need to generate results.

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Another key achievement of VirtualBrainCloud has come through collaboration with the teams of Martin Hofmann-Apitius and Holger Fröhlich at Fraunhofer SCAI (Germany). These groups developed AI algorithms for automated literature searches, which have generated complex inventories of disease mechanisms based on decades of peer-reviewed scientific research. Building on these tools, we have linked AD pathways and cascades from the published literature to specific locations in the brain, using our simulations. This adds biological accuracy and disease specificity to our models, an enormous and innovative step forwards for the field. As a consortium, we have built the first complex, individualised models of the brain, which will take us closer to more personalised, stratified approaches to AD diagnosis, treatment and prevention.

You can read the published study, here: http://dx.doi.org/10.1002/trc2.12303

VirtualBrainCloud

For more information, visit:

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