Mathematical models may help predict the evolution of neurodegenerative diseases

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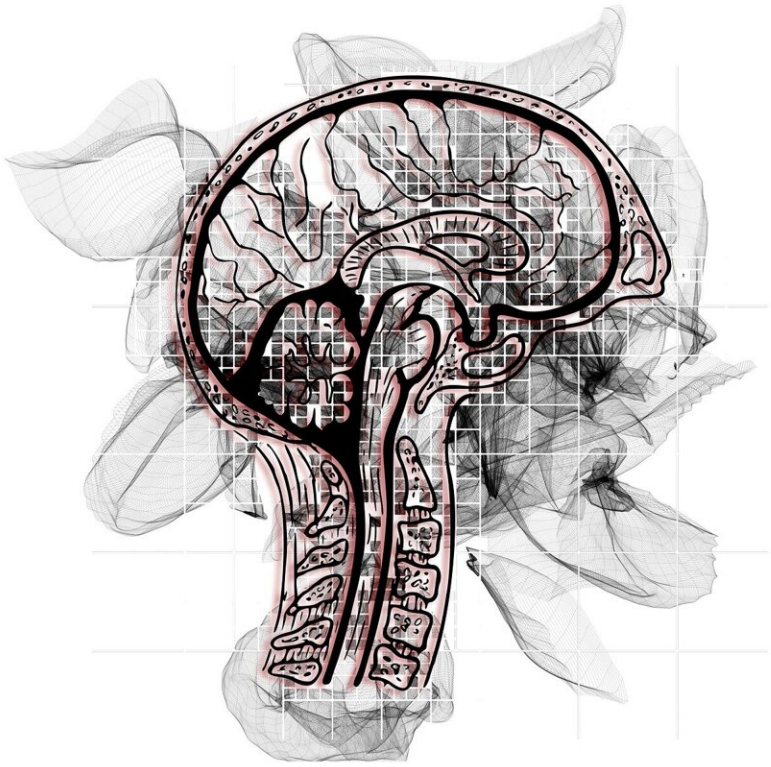

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Information and communication technologies (ICTs) are revolutionizing the world, and the health sector is no exception. ICTs are considered a strategic factor in improving individuals' health and guaranteeing a high-

quality, modern and sustainable health care system.

One of the most promising technologies is artificial intelligence (AI), which is capable of creating and training computer systems to make automatic data-based decisions. Two recent studies in which researchers from the Universitat Oberta de Catalunya (UOC) and the August Pi i Sunyer Biomedical Research Institute (IDIBAPS) have been involved highlight the potential of applying AI to the fields of image processing, and bioinformatics and genetics, respectively.

"There are a wide range of applications for big data and artificial intelligence in CT scans, X-rays, ultrasound and magnetic resonance imaging," says Jordi Casas Roma, a researcher in the ADaS Lab research group at the eHealth Center, and a member of the Faculty of Computer Science, Multimedia and Telecommunications and director of the Master's Degree in Data Science at the UOC.

In their latest study, the researchers involved have demonstrated that "integrating and processing all the data together, using multilayer networks, provides a more comprehensive analysis of the data than if they are analyzed individually and independently."

Mathematics to understand changes in the brain

Casas's study focuses on defining a mathematical model that provides a better understanding of cognitive changes and impairment in the brain. The model was initially tested with multiple sclerosis, but the pattern is applicable to other neurodegenerative diseases.

"Understanding what is happening in the brain when someone suffers from this type of disease is the first step towards being able to improve and personalize treatments. It is important to be able to determine and predict how the disease evolves, which will undoubtedly enable us to

distinguish between different groups of patients, with similar types of evolution and different treatments from the other groups," he says.

The study was led by Ferran Prados Carrasco, another member of the ADaS Lab, and also involved UOC researchers Marcos Díaz Hurtado, from the eHealth Center, and Albert Solé and Javier Borge, from the Complex Systems (CoSIN3) group at the Internet Interdisciplinary Institute (IN3).

Prados is now putting the theory of multilayer networks into practice: "We are in the initial phase, in which we have developed a biomarker—we have confirmed its sensitivity, we have published how to use it, and we have made the technology open so that other researchers and doctors everywhere can apply it to their data, […] At the same time, we have already begun the first clinical application using magnetic resonance data from people with neurodegenerative diseases such as multiple sclerosis and Alzheimer's or dementia."

Bioinformatics and genetics

Another important area of application for artificial intelligence in the field of health is bioinformatics and genetics, with metaheuristic algorithms. "These algorithms are very popular in combinatorial optimization, in other words, when there is a finite set of solutions for a problem, and you want to find the one that optimizes a specific objective function. They provide high-quality solutions to complex problems in real time," explained Laura Calvet Liñán, a researcher and member of the Faculty of Computer Science, Multimedia and Telecommunications, and the lead author of the study "On the role of metaheuristic optimization in bioinformatics."

Calvet highlighted that "metaheuristics play a key role in medical imaging and disease modeling by means of variable selection and

parameter fine-tuning, among other things."

The research was published in *Network Neuroscience* and *International Transactions in Operational Research*.

More information: Jordi Casas-Roma et al, Applying multilayer analysis to morphological, structural and functional brain networks to identify relevant dysfunction patterns, *Network Neuroscience* (2022). DOI: 10.1162/netn_a_00258

Laura Calvet et al, On the role of metaheuristic optimization in bioinformatics, *International Transactions in Operational Research* (2022). DOI: 10.1111/itor.13164