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Machine learning detecting early brain tumour presence

By tapping the power of supercomputers, combined with machine learning algorithms, a team led by University of Texas at Austin researchers have developed a method to automatically identify brain tumours. This novel method, the product of nearly a decade of research, can characterise gliomas, the most common and aggressive type of primary brain tumour.

The technique uses biophysical models of tumour growth and machine learning algorithms for the analysis of magnetic resonance (MR) imaging data of glioma patients. Results of the new fully automatic method were presented by the research team at the 20th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI 2017). All the components of the new method were enabled by supercomputers at the Texas Advanced Computing Center (TACC).

The team's scalable, biophysics-based image analysis system was the culmination of 10 years of research into a variety of computational problems, according to George Biros, professor of mechanical engineering and leader of the ICES Parallel Algorithms for Data Analysis and Simulation Group at The University of Texas at Austin. Biros worked with collaborators from the University of Pennsylvania (led by Professor Christos Davatzikos), University of Houston (led by Professor Andreas Mang) and University of Stuttgart (led by Professor Miriam Mehl) to develop the new system, also known as "image segmentation classifier".

Biros' team tested their new method in the Multimodal Brain Tumour Segmentation Challenge 2017 (BRaTS'17), an annual competition where research groups from around the world present methods and results for computer-aided identification and classification of brain tumours, as well as different types of cancerous regions, using preoperative MR scans.

Their system scored in the top 25 percent in the challenge and was near the top for whole tumour segmentation.

"The competition is related to the characterisation of abnormal tissue on patients who suffer from glioma tumours, the most prevalent form of primary brain tumour," Biros said. "Our goal is to take an image and delineate it automatically and identify different types of abnormal tissue – oedema, enhancing tumour (areas with very aggressive tumours), and necrotic tissue. It's similar to taking a picture of one's family and doing facial recognition to identify each member, but here you do tissue recognition, and all this has to be done automatically."

The image processing, analysis and prediction pipeline that Biros and his team used has two main steps: a

supervised machine learning step where the computer creates a probability map for the target classes ("whole tumour," "oedema," "tumour core"); and a second step where they combine these probabilities with a biophysical model that represents how tumours grow in mathematical terms, which imposes limits on the analyses and helps find correlations.

Biros and his team were able to run their analysis pipeline on 140 brains in less than 4 hours and correctly characterised the testing data with nearly 90 percent accuracy, which is comparable to human radiologists.

The BRaTS competition thus represents a turning point in his research, Biros said. "We have all the tools and basic ideas, now we polish it and see how we can improve it."

The image segmentation classifier is set to be deployed at the University of Pennsylvania by the end of the year in partnership with his collaborator, Christos Davatzikos, director of the Center for Biomedical Image Computing and Analytics and a professor of Radiology there. It won't be a substitute for radiologists and surgeons, but it will improve the reproducibility of assessments and potentially speed up diagnoses.

Source: The University of Texas at Austin, Texas Advanced Computing Center
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