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Machine learning detecting early brain tumour presence

Machine learning algorithms in brain tumour identification.

How machine learning is being utilised to characterise aggressive gliomas in a scalable analysis system.

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) held in Canada. All the components of the new method were enabled by supercomputers at the Texas Advanced Computing Center (TACC).

Collaboration and recognition
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."

Two-step analysis process
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 four hours and correctly characterised the testing data with nearly 90 percent accuracy, which is comparable to human radiologists.

The image segmentation classifier won't be a substitute for radiologists and surgeons, but it will improve the reproducibility of assessments and potentially speed up diagnoses.

Key Points

- Supercomputers and machine learning algorithms have developed a method for automatic identification of brain tumours
- The technique uses biophysical models of tumours with machine learning algorithms for MR imaging data analysis
- The two-step pipeline includes supervised machine learning with a computer probability map and combination of these probabilities with a biophysical model for analysis

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