

Guest editorial preface: Computational intelligence for neuro-oncological diagnosis

HORACIO GONZÁLEZ-VÉLEZ

*School of Computing and IDEAS Research Institute, Robert Gordon University, St Andrew Street, Aberdeen AB25 1HG, UK;
e-mail: h.gonzalez-velez@rgu.ac.uk*

1 Introduction

The diagnosis of brain tumours is typically based on clinical symptoms, radiological appearance and, often, a histopathological diagnosis of a biopsy. Since treatment of histologically or radiologically similar tumours can vary widely according to their specific nature and patient's characteristics, accurate non-invasive diagnosing techniques are highly sought after in the neuro-oncological practice.

Computational intelligence can arguably contribute to enhancing current imaging and spectroscopy-based diagnosis of brain tumours by applying heuristic methods that can learn, adapt, and evolve over time. In particular, this special issue reports the state of the art in intelligent agents, security, knowledge representation, machine learning, clinical data management, and interactive user interfaces in the context of the HealthAgents project.

Funded by the European Commission from January 2006 to December 2008, HealthAgents was a successful trans-European interdisciplinary research project which employed over 50 researchers for the improvement of brain tumour diagnosis (Arús *et al.*, 2006). The HealthAgents consortium evolved from a cross-disciplinary collaboration among European partners, to a unique amalgam of areas of expertise. It comprised two commercial companies, one research institute, and six universities, and concentrated a unique group of well-accomplished, highly computer-literate researchers, most with doctoral degrees in biomedicine, radiology, biology, mathematics, or computer science.

The HealthAgents project created a distributed multi-agent decision support system (DSS) to provide advanced functionalities of machine learning for the analysis and interpretation of brain tumour imaging and spectral data (González-Vélez *et al.*, 2009). The endeavour included a large network of interconnected databases containing the clinical, histological, and molecular phenotype data of brain tumour patients. The DSS facilitated evidence-based clinical decision-making, using magnetic resonance spectroscopy and genetic-based tumour classifications, and included new criteria from the automated analysis of each local database. The HealthAgents project had ensured that all information about patients was kept confidential and stored securely, and provided a clinically validated graphical user interface.

2 Contents of this issue

This special issue contains six original articles and intends to reflect the project's progress from the standpoints of the different research groups involved. The main aim of this issue is to illustrate how the HealthAgents project has contributed to advance the field of computational intelligence applied to neuro-oncological diagnosis. Nevertheless, it is important to emphasize that all the distinct research contributions have been organized as coordinated building blocks of the HealthAgents DSS, the *raison d'être* of the entire project.

Entitled 'A knowledge-rich distributed decision support framework: a case study for brain tumour diagnosis' by Dupplaw *et al.*, the first contribution adumbrates the HealthAgents framework with special emphasis on the intelligent agent and semantic web technologies employed to interconnect the

contributing clinical centres. The framework underpins all the software development of the DSS, since it deploys the foundations for the data exchange among brain tumour classifiers and repositories on a local and global basis.

The second contribution is ‘The design and implementation of a novel security model for HealthAgents’ by Xiao *et al.* and describes the HealthAgents multi-layer security model. It identifies the link-anonymized data transportation, sharing and collection services as well as the access control mechanism. The model had to comply not only with the DSS technical requirements, but also with the legal regulations of the different countries involved.

In the third article of this special issue, ‘A generic and extensible automatic classification framework applied to brain tumour diagnosis in HealthAgents’, Sáez *et al.* enumerate the pattern recognition methods employed in the classification of brain tumours within the DSS. Two classification nodes located in Belgium and Spain furnished 25 new classifiers for multiple binary and multi-class clinical questions regarding brain tumour diagnosis, and ranked those classifiers based on their performance and suitability for the clinical case in hand.

Used to represent knowledge across the project, the HealthAgents ontology is explained by Hu *et al.* in the fourth manuscript ‘The HealthAgents ontology: knowledge representation in a distributed DSS for brain tumours’. The ontology played three crucial roles in the DSS: the common vocabulary for different databases, the shared conceptual repository for clinical terminology, and the translation template for legacy/existing data descriptors.

Described in the fifth article, ‘A web accessible distributed data warehouse for brain tumour diagnosis’, authored by Estanyol *et al.*, the database allows the DSS to be integrated with the graphical user interface to trigger the different classifiers. This database can be understood as a clinical tool providing clinical history, medical control, and medical experiment management.

Finally, ‘The development of a graphical user interface, functional elements and classifiers for the non-invasive characterization of childhood brain tumours using magnetic resonance spectroscopy’ by Gibb *et al.* outlines the design of the interactive clinical user interface of the project, which acted as the DSS front-end. As opposed to previous interfaces employed in medical imaging, the HealthAgents approach entailed an active participation of clinicians and was validated using a sample of children with cerebellar malignancies.

In summary, by providing a distributed agent-based evidence-based DSS, the HealthAgents project has broadened the ambit of machine learning classification, allowing classifiers to be built using geographically dispersed data sources, while keeping patient anonymity and data integrity. The HealthAgents project has deployed an evidence-based heuristic approach for the diagnosis of heterogeneous brain tumour types, displayed through an interactive graphical user interface that fitted the neuro-oncological practice.

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