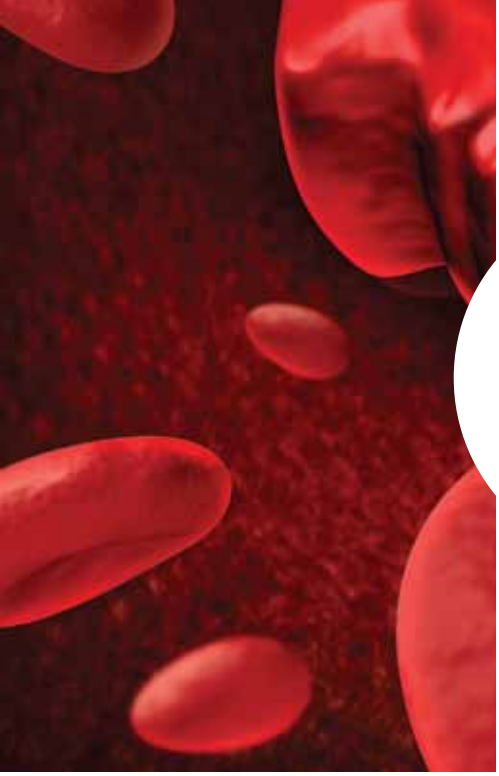
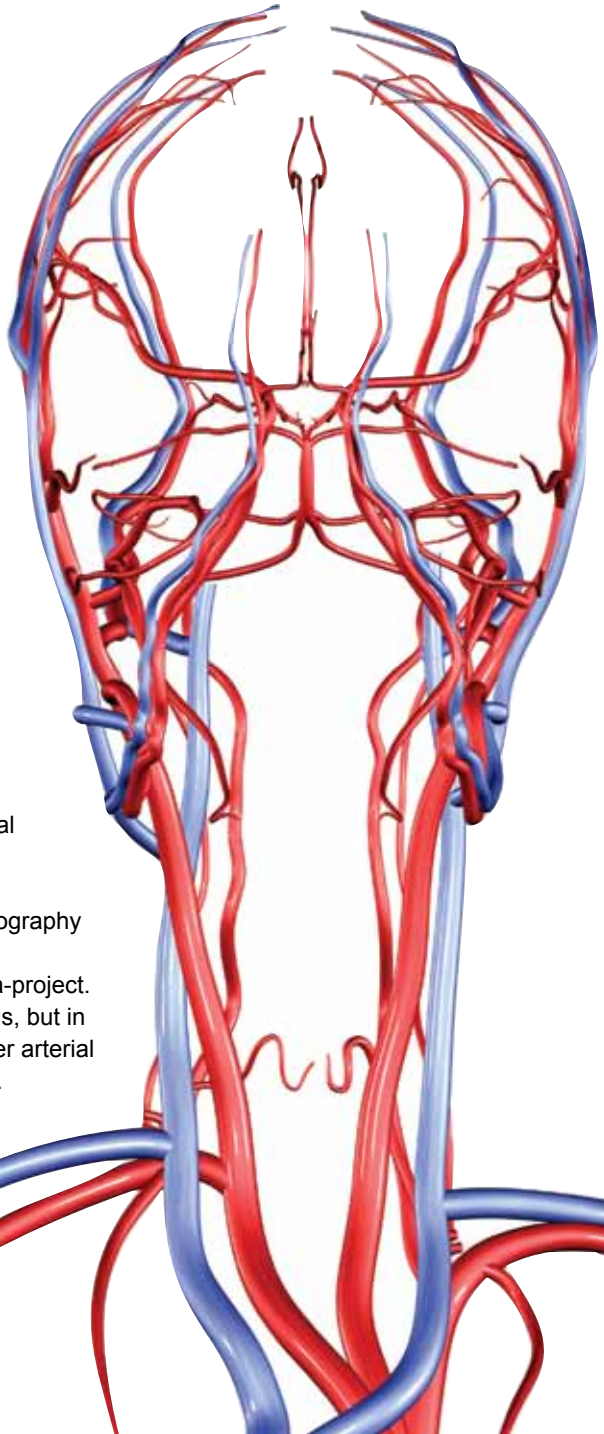


MODELLING BLOOD FLOW AROUND THE VESSELS OF THE BRAIN

The HemeLB research group at University College London (UCL) has an exciting vision that will exploit High Performance Computing (HPC) to change the way neurosurgeons operate in the future and improve outcomes for patients. The group develops software to model blood flow within the cranium, the part of the skull that encloses the brain.



Using ARCHER, the UK's national HPC service, and working in collaboration with a British software company, Allinea Software, the group has been able to study for the first time the blood flow within the Circle of Willis – a connecting system of arteries that sits at the base of the brain.

HemeLB is a piece of software used to understand how blood flows around vessels in the brain. Using a model of a patient's blood vessels generated by an MRI scan, simulations can calculate pressure near points of weakness, such as aneurysms. Since some aspects of such flows are difficult to obtain or reproduce in a clinical setting, these simulations may allow increased understanding and better treatment of conditions that can cause health issues, financial cost and ultimately even the death of a patient.

The HemeLB group currently relies on clinical MRI and angiography data, which they segment and convert to three-dimensional simulation domains. Within the CRESTA project (www.cresta-project.eu), they demonstrated simulations using a full Circle of Willis, but in their long production simulations they focus mainly on smaller arterial networks, as these are less expensive to analyse at present. However, it is expected that exascale computational resources will be required to simulate complete vascular networks in the brain, for patients at rest and at different levels of exercise.

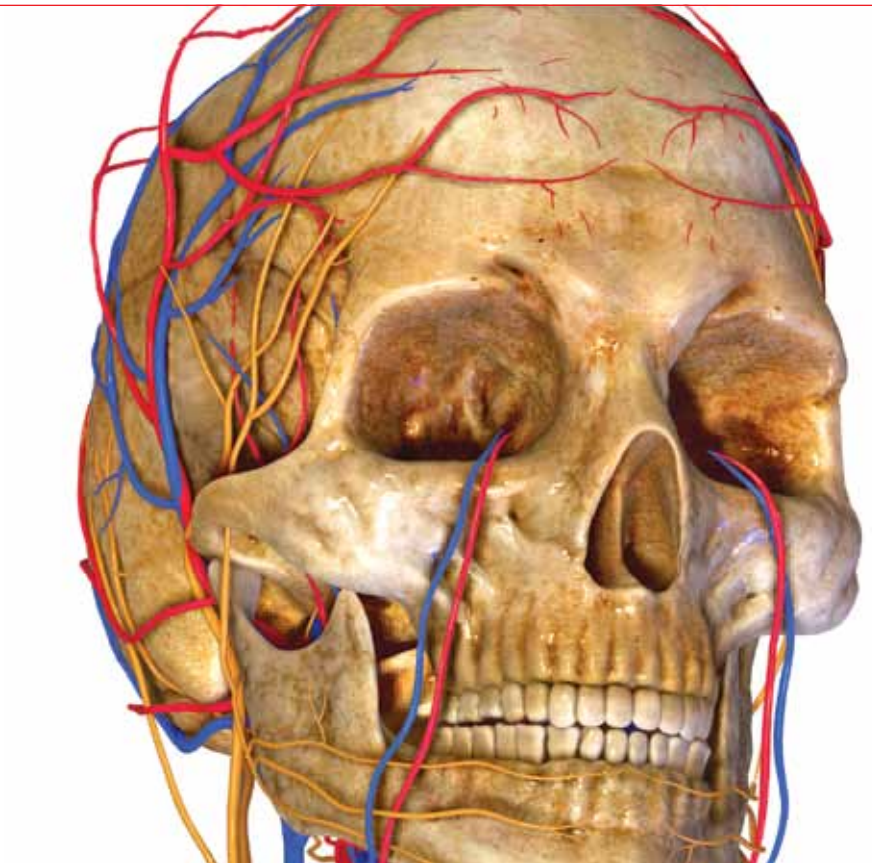
Each new generation of supercomputers brings more compute cores – and that brings greater challenges for software developers as they try to exploit the available computational power. Without development, software will run slower or may not run at all and crash. The CRESTA project has been at the forefront of preparing tools and software such as HemeLB for these supercomputers.

Although HemeLB is a modern code with well-designed test and verification processes, development still brings software challenges. HemeLB has undergone extensive development and performance improvement to be able to make the best use of ARCHER. In particular a close collaboration with the British software tools company, Allinea Software, solved a number of challenges. Allinea MAP highlighted various performance improvements while an unexpected code failure at 49,152 cores was solved using Allinea DDT, the only parallel debugger that can handle that scale of problem.

As a result of this work, a performance of 153 billion site updates per second was obtained using 49,152 cores on ARCHER. This constitutes a performance improvement of a factor of 16.8. As a consequence the developers were able to study blood flow within the Circle of Willis for the very first time. For more on the potential impact of this work, see this article from the Independent: **http://tinyurl.com/HemeLB-Archer**.

"Getting HemeLB to scale to 50,000 ARCHER cores is a real achievement: we are thankful for the productive collaborations we enjoy with Allinea in the CRESTA project that have allowed us to reach these intoxicating heights, which are enabling us to study hemodynamics within the Circle of Willis for the first time."

– Professor Peter Coveney, Director, Centre for Computational Science, UCL



About ARCHER

ARCHER is the UK National Supercomputing Service. The service is provided to the UK research community by EPSRC, UoE HPCx Ltd and its subcontractors: EPCC and STFC's Daresbury Laboratory, and by Cray Inc. Laboratory.

The Computational Science and Engineering (CSE) partners provide expertise to support the UK research community in the use of ARCHER, and researchers can also apply for longer-term software development support through the Embedded CSE (eCSE) programme. The ARCHER CSE partners are EPSRC and EPCC at the University of Edinburgh.

The Case Study Series

The ARCHER service facilitates high quality science from a broad range of disciplines across EPSRC's and NERC's remits. The outcome is science that generates significant societal impact, improving health and overall quality of life in the UK and beyond. This science influences policy and impacts on the UK's economy.

This case study is one of a series designed to showcase this science. It has been produced as part of the ARCHER CSE service, supported by EPSRC research grant No EP/N006321/1.

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www.archer.ac.uk

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