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Computer tomography provides a clearer view of blood vessel interiors

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Narrowed and blocked arteries can now be diagnosed faster and more accurately with the help of special computer-aided image analysis techniques. This advance was made possible by the development of innovative techniques for the detailed visualisation of blood vessels with the support of the Austrian Science Fund FWF.

Peripheral arterial occlusive disease poses a major health risk to patients. Various treatment options (widening, stenting, bypassing) offer good chances of recovery. The treatment planning requires the comprehensive analysis of blood flow through all of the peripheral blood vessels. CT angiography is one modality for this task, however, it produces thousands of images. The analysis of this huge amount of images is quite a challenge for the medical staff. Experts from the fields of medicine and IT have now collaborated on a project funded by the Austrian Science Fund FWF that aims at simplifying this evaluation process considerably.

Seeing around corners

Project leader Milos Šrámek, who is based at the Austrian Academy of Sciences, explains the main objectives: "The imaging of blood-vessel lumen is entirely feasible using CT. However, complications arise when the orientation of the vessels changes or they ramify. Obtaining a complete 3-D visualisation has not been easy in such cases until now. The techniques we developed enable the accurate imaging of these

aspects." The development is based on the collaborative work of teams from the Technische Universität Wien and the Medical University of Vienna, which led to several pioneering innovations, i.e., "centerline reformation" and "curved surface reformation".

A continuous picture

Centerline reformation is based on new algorithms of image processing, which enable the continuous representation of the blood-vessel lumen in case they change their spatial orientation. Rüdiger Schernthaner from the Department of Biomedical Imaging and Image-Guided Therapy at the Medical University of Vienna explains: "Using this technique, we are actually able to visualise the lumen or inside of lung and brain blood vessels without overlaps – an approach that was considered extremely difficult up to now due to the sharp twists and turns." However, as Schernthaner points out, the technology is not yet perfect. In addition to known artefacts, which are inevitable with all imaging procedures, the simultaneous visualisation of several blood vessels requires further optimisation.

A new dimension

"Curved surface reformation" builds on "centerline reformation" and enables the complete 3-D visualisation of the blood-vessel lumen. The spatial orientation and position of the blood vessel are completely irrelevant here. The method is based on a process known as raycasting, which enables the rapid visualisation of three-dimensional objects.

Beyond the vessel walls

The project participants are particularly proud of succeeding in facilitating another clinically important task. Eduard Gröller from the

Institute of Computer Graphics and Algorithms at the Technischen Universität Wien remarks: "We further developed curved surface reformation so that, in addition to the blood-vessel interior, the adjacent anatomical structures are also visualized with low distortion. This allows the doctor to identify extravascular pathologies while examining the blood vessels." The adoption of appropriate "levels of detail", which process information near the centerline of a blood vessel with high accuracy, was crucial to this development.

Smart super views

The team's other developments include intelligent visualisation methods, which make it possible, for example, to show the full volume of a blood vessel in a single image. This enables the rapid assessment of the blood flow in the entire blood vessel. The project participants have also been aware of the difficulty in identifying the most suitable choice from the large number of available imaging techniques and developed the "smart super views" approach in response. The technique automatically selects images from the available pool that are best suited for the assessment of a given area of the body. They are then presented in such a way that their diagnostic significance is immediately identifiable.

The methods developed in the course of this FWF project have already been applied to over 600 medical cases per year. This underlines their relevance and importance in improving the health situation of patients.

More information: Ruediger Egbert Schernthaner et al. New hybrid reformations of peripheral CT angiography: do we still need axial images?, *Clinical Imaging* (2015). DOI: 10.1016/j.clinimag.2015.03.005

Accuracy and time-efficiency of multi-path curved planar reformations in the evaluation of low-dose CT angiography of the peripheral arteries. M.M. Schreiner, C. Loewe, S. Unterhumer, M. Weber, G. Mistelbauer,

M. Šrámek, E. Gröller, and R.E. Schernthaner. In ECR 2015 Book of Abstracts – B – Science Sessions and Late-Breaking Clinical Trials, pages B – 0632, March 2015.

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