Fully Automatic Maximum Intensity Projections of Regions of Interest in Magnetic Resonance Angiograms

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Target audience – Researchers, clinicians and neuroradiologists working on MR Angiograms.

Purpose – A widely accepted rendering method for 3D MRA data is 2D maximum intensity projection (MIP). The current clinical post-processing of brain MRAs is done by a technologist and consists of removing tissue that has no diagnostic relevance, such as eyes, skull, fat etc. The volume is then cut into regions of interest (ROIs) and MIPs are generated from only the remaining volume (a.k.a. cutout-MIPs). The quality of those projections is highly dependent on how accurately MR technologists work, their experience and skill level, and how much time is invested. Generating cutout-MIPs of the major intracranial vessels takes up to 15 minutes. If it is done during the scan of a patient, technologists can get distracted from the current scan. If it is done after the scan, it delays the technologist from being able to proceed with the next patient. Here, we present the first fully automatic post-processing method to generate cutout-MIPs for 3D time-of-flight MRAs (TOF-MRAs), which allows transferring standardized cuts and views to any patient.

Methods – To facilitate automatic processing, a high-quality reference TOF-MRA of a healthy volunteer was acquired. The field of view was chosen to cover the whole brain, such that different coverage of the TOF-MRA slab in patient scans can be accounted for. The ROIs, as shown in **Fig. 1**, were then outlined on an in-house developed interactive 3D user interface. The 3D template are subsequently registered to a patient data set and the cutout ROIs are then warped to the patient using the deformation field that non-rigidly registers the template brain to the patient brain. Constraints in the cost function ensure that the registration also works in the presence of lesions or anatomical abnormalities. Our rendering software enables its operator to adapt parameters such as the number and angular increment of projections and rotation axes. In order to fully automate the data processing, our method is set up such that data can be sent to our processing server on a research PACS system (RAPID) directly from any DICOM device (e.g. MRI scanner, hospital PACS) [1]. Once the cutout-MIPs and the rendering parameters are defined, any new TOF-MRA data will be processed without any manual interaction.

Fig. 1: Anterior right (left), posterior (right) circulation.

Results – We have tested our approach on 30 consecutive patient data sets that were acquired on 3T MR scanners at our institution. At the same time as the automatic processing was done, an MR technologist performed the standard manual processing of the data. Both the output of the manual cutout MIPs and our automatic approach **(Fig. 2)** were validated by one board-certified radiologist and one board-certified neuroradiologist independently using a three-point Likert-type scale (automatic cutout MIPs to be better (1), same (2), or worse (3) than manually created MIPs). Eleven cases had regions that were rated better than the manual cutout MIPs, while only two were rated to be worse. The rest of the cases were rated to be of the same quality.

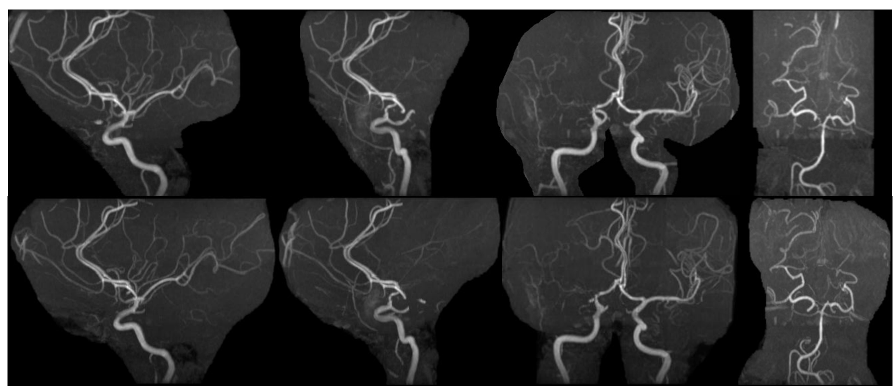

Fig. 2: Manual (top) and automatic cutout (bottom) of a Moya-Moya patient pre bypass surgery. Left to right: Anterior left, anterior right (both sagittal), whole anterior, and posterior (both coronal) circulation.

Discussion – The evaluation performed by both physicians showed that the MIPs resulting from our method are primarily of equal or even better quality than those performed by the technologists. In fact, automated processing turned out to be considerably superior in the presence of occluded vessels since human observers orient themselves on vascular structures when performing the cutouts. The diminished vascular signal makes it harder for them to identify vessels and perform reliable cutouts. Since the cutout MIPs were defined once with our method, there is also the added benefit of having standardized views without subjective variations from different technologists with different skill sets or personal preferences for rendering field of view, angular increment, or rotation axis. Most importantly, in none of the cases did our method remove vascular structures that would have affected diagnosis. Due to the close proximity of intracranial vessels supplying different vascular territories, particularly at the sella region, a sophisticated registration method was clearly of benefit and avoided inclusion of vessels not belonging to a particular vascular territory or unwanted removal of the vessels of interest. Current computation times (incl. data transfer) are on the order of 60min per patient for non-optimized code (i.e. no multithreading, etc.), but we expect this to be as fast as 10-15 min after optimization.

Conclusion – A novel segmentation tool has been developed that helps reduce the burden on MR operators by automatically computing cutout MIPs of pre-specified vascular territories. In this pilot study we demonstrated that our method performed as well as, or better than, manually outlined cutout MIPs.

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