**Title:**
3D Representation of Brain Vasculature using Transcranial  Power M-Mode Doppler

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**Background:**
Power M-mode modality of Transcranial Doppler (TCD) was originally developed to address difficulties in locating acoustic windows and cerebral vessels. M-Mode reflects intensity and direction of the blood flow signatures over 60 mm of depth, as a time-series signal. Using an investigational robotic, five degrees-of-freedom TCD system (rTCD), we have constructed a 3D projection of M-Mode data that represents brain vasculature.

**Methods:**
The investigational rTCD sytem was used to locate the transtemporal acoustic window and measure blood flow velocity. The robotic setup translates and rotates the TCD probe in x, y, Rx, and Ry directions while keeping contact (z-direction) with the subject's head at a constant force. Fine increments in translation (over ~100mm$^2$) and rotation (+/-15$^o$) of the probe provided a thorough spanning of the vasculature with the Doppler beam.

We have aligned positional information of the TCD probe from the robotic actuation system with Power M-Mode data in time. Using Euler rotation matrices, the corresponding projections of the power M-Mode in the 3D robotic (x-y-z) reference frame can be found. A visualization of the obtained coordinates reflects the topology of the vasculature and is shown in Fig. 1.

**Results:**
Fig. 1 depicts 4 views of the 3D M-Mode representation. Different parts of the vasculature are identifiable based on insonation depth, flow direction and vessel curvature.

**Conclusion:**
In this work, power M-mode was used to re-construct brain vasculature in 3D space. Initial results show promise that this non-invasive tool enables 3D vascular mapping, allowing for insights into cerebrovascular health unlocked by the rTCD system. Such mapping can help with vessel identification to assure TCD measurements are in the regions required for assessment or aid in the comparison of different vessels for a wide range of pathologies.
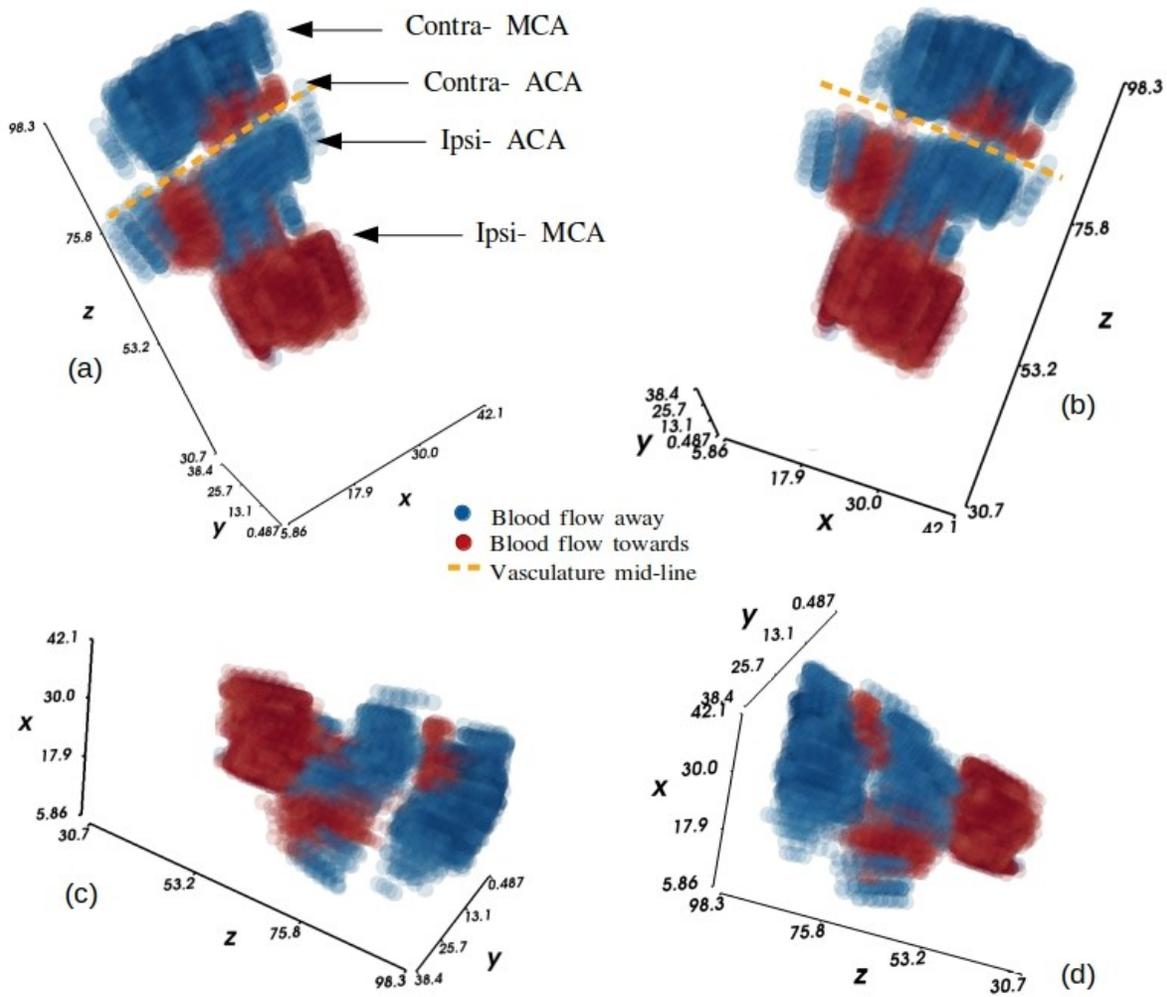
Figure 1. Four views of 3D Power M-Mode visualization (a,b,c and d). Ipsilateral and contralateral Middle-Cerebral-Artery (MCA) and Anterior-Cerebral-Artery (ACA) are marked in (a); Blue and red show mmode towards and away, respectively; x-y-z axes are in mm; z axis reflects "depth" of ultrasound insonation. Vascular mid-line is shown by dashed yellow line in a and b.