FACULTY OF ENGINEERING AND ARCHITECTURE

MEDISIP

Modelling of the Vascular Accessibility of Human Brain Regions using 7T MRI

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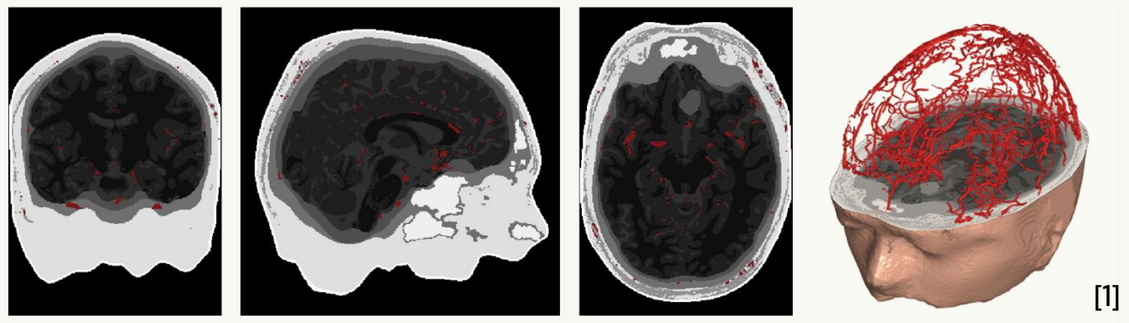
Background and goal

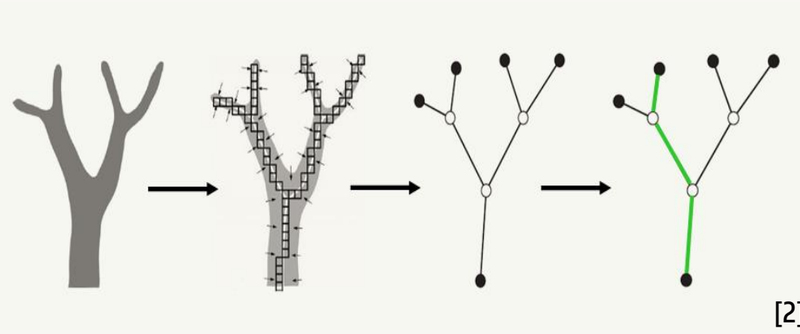
During the last couple of years there has been a trend towards minimally invasive procedures in clinical practice. Especially in the brain, one of the most fragile structures in the human body, more and more **catheter-based procedures** are being introduced or are under investigation However, navigation in the intricate cerebral vascular network is extremely complex.



[1]

This study aims to investigate **which brain regions are accessible** and hence could be possible candidates for transvascular therapies. Furthermore we wish to develop the **framework for a tool that can help the neuro-interventional surgeon during preoperative planning**.

Materials and methods



[2]

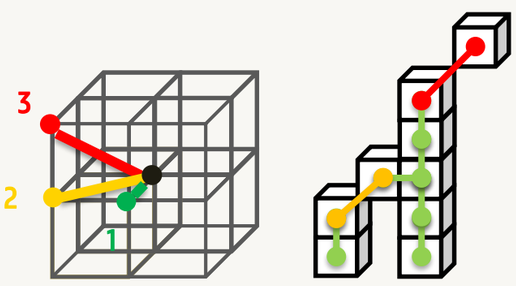
Skeletonization

1. Euler invariance and connectivity → Topology
2. Rechecking connectivity → Geometry
3. No end points removed → Length

Graph conversion

Connectivity ranking

Face > Edge > Vertex



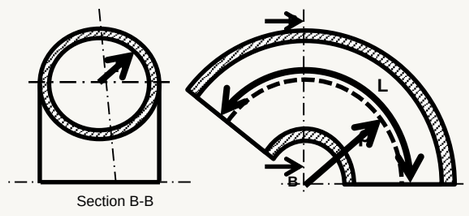
Geometric analysis

R - Intraluminal radius

L - Branch length

ρ - Radius of curvature

α - Intersection angle



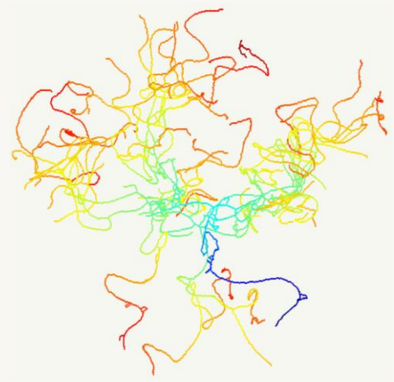
Graph analysis

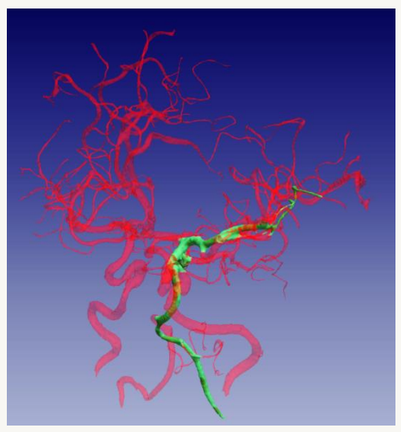
Dijkstra's shortest path algorithm → Optimal path

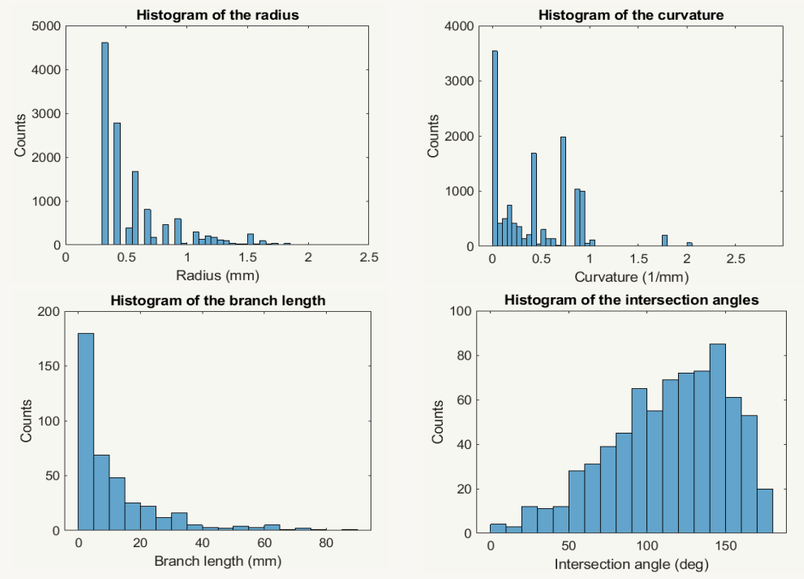
Radius mask + spherical dilation → Vascular accessibility map

Results

Path cost calculation



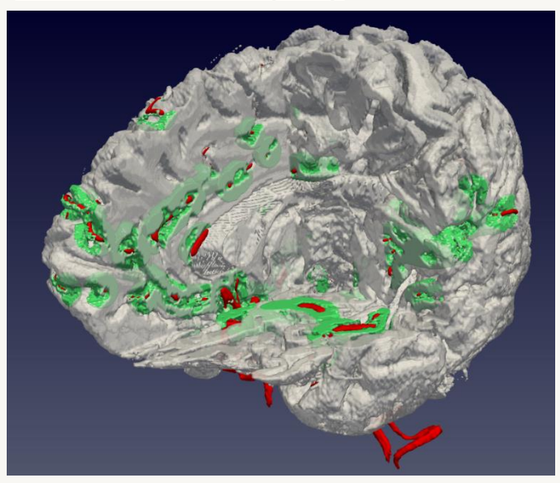




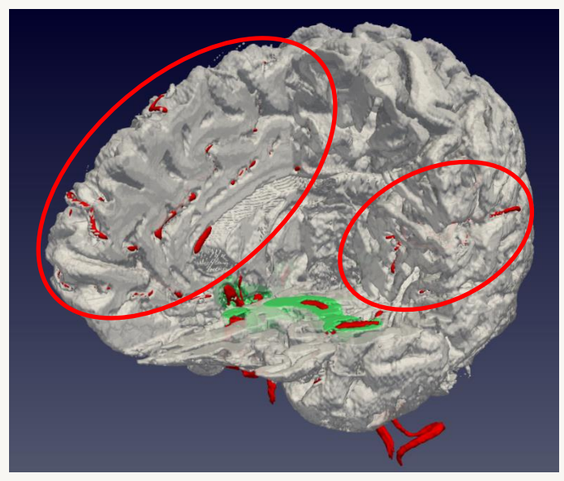
Optimal path

Source location	Left carotid	Left vertebral	Right carotid	Right vertebral
Optimal path cost	1409	1383	1748	1701
Min. diameter	0.6 mm	0.6 mm	0.6 mm	0.6 mm
Max. curvature	1.8 mm^{-1}	1.8 mm^{-1}	1.8 mm^{-1}	1.8 mm^{-1}
Min. angle	83°	83°	83°	83°
# intersections	25	25	32	23

Vascular accessibility map



R_{min} = 0,45 mm [minimal intraluminal radius]



R_{min} = 1 mm

Conclusion

In this study we developed a processing pipeline that's capable of generating vascular accessibility maps and determining the optimal path towards a user- specified region, starting from a segmented image of the vasculature. This way we obtained an **adequate framework for pre-operative planning of minimally invasive procedures**, inside the human brain.

Furthermore the accessibility maps for minimal intraluminal radii of 0,45 mm and 1 mm show the **significant impact of the catheter radius on the accessibility** of brain regions and highlight the **need for smaller vascular interventional tools**.

References

[1] Lüsebrink F. et al., 2012, Cortical thickness determination of the human brain using high resolution 3T and 7T MRI data

[2] Selle D. et al., 2000, Mathematical methods in medical imaging: analysis of vascular structures for liver surgery planning

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