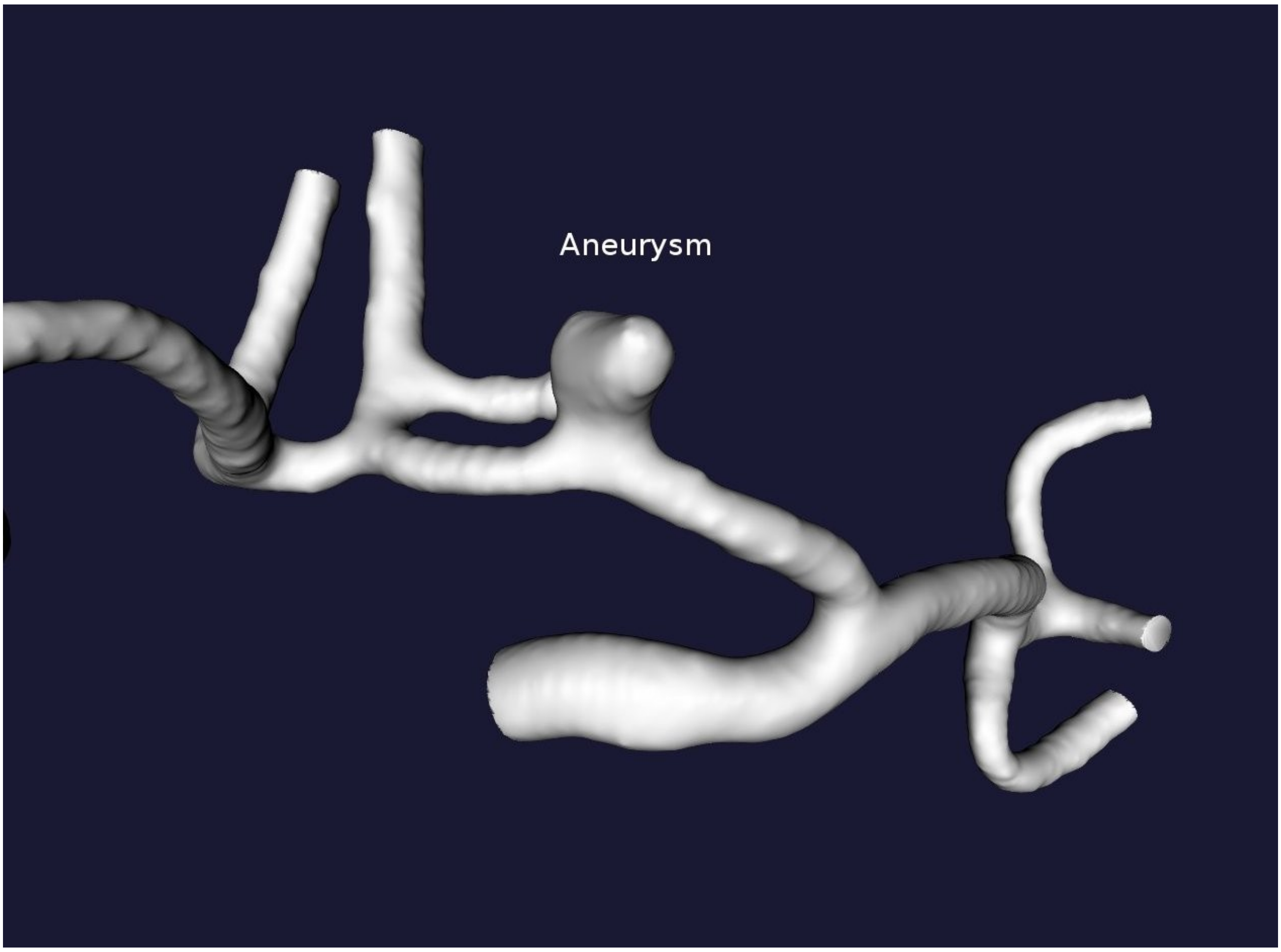
Laplacian surface editing of blood vessels

Background:

Aneurysms like the one shown in Picture 1, is quite common. Around 1% of the population have them.



Picture 1. Aneurysm in the circle of Willis.

The aneurysms are most often found in a network called the circle of Willis, Figure 2, which lies beneath the brain. This circle supplies most of the blood to the brain.

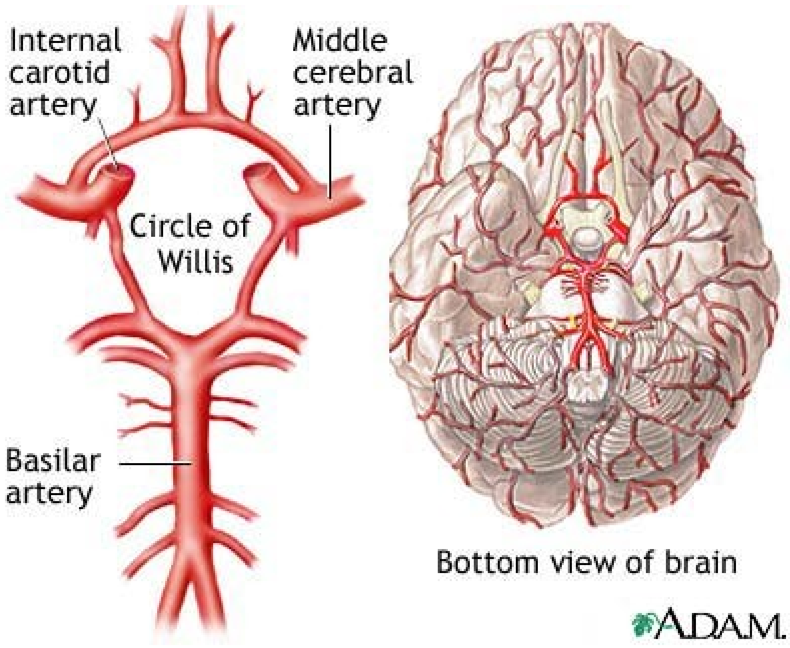


Figure 2. The circle of Willis.

The risk of having an aneurysm is that they may burst and cause a stroke. Developement and rupture of aneurysms have been related to high blood pressure, smooking etc. A recent theory suggests that also the shape of the network is important [1, 2]. As can be seen in Figure 3, the shape varies a lot.

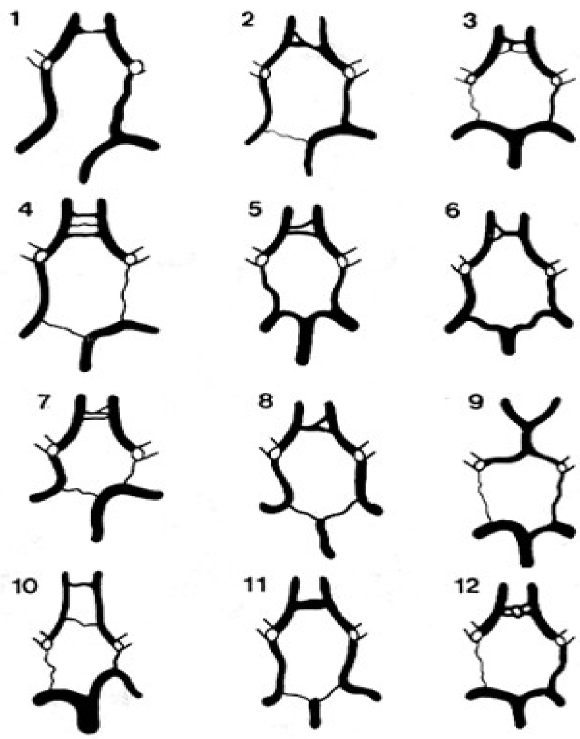


Figure 3. Variations in the circle of Willis.

Software library: vmtk - Vascular Modeling Toolkit

The Vascular Modeling Toolkit is a collection of libraries and tools for 3D reconstruction, geometric analysis, mesh generation and surface data analysis for image-based modeling of blood vessels. More information about this library can be found at

URL: http://villacamozzi.marionegri.it/~luca/vmtk/doku.php

VMTK has been implemenented by Luca Antiga (Mario Negri Institute, Bergamo, Italy) who will be one of the supervisors on this project. VMTK has been used to create the vessels shown in Figure 1 based on CT data.

Master Project.

In this master project we would like to extended VMTK with Laplacian surface editing [3] such that one can perform parametric variations of the circle of Willis. The geometry of blood vessels like that in Picture 1 will be represented by a triangular mesh where each triangle vertex is encoded relative to its neighborhood by means of Laplacian coordinates. This is an elegant and convenient geometric representation which make surface editing relatively simple. Our aim is to study the differences in the hemodynamic forces caused by the geometric variations. However, doing the blood flow simulations will not be a big part of this project.

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References:

[1] Ingebrigtsen T, Morgan MK, Faulder K, Ingebrigtsen L, Sparr T, Schirmer H. Bifurcation geometry and the presence of cerebral artery aneurysms. J Neurosurg. 2004;101:108 –113.

[2] M. S. Alnæs, J. G. Isaksen, Kent-A. Mardal, B. Romner, M. Morgan and T. Ingebrigtsen. **Computation of hemodynamics in the circle of Willis**, Stroke 38(9):2500--2505, 2007.

[3] Laplacian Surface Editing, O. Sorkine, D. Cohen-Or, Y. Lipman, M Alexa, http://cg.cs.tu-berlin.de/~sorkine/ProjectPages/Editing/LapMsEd_techreport.pdf