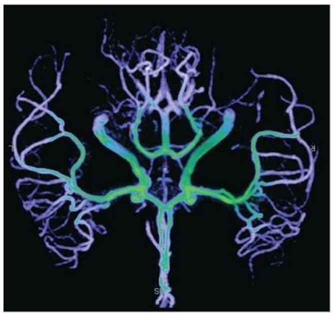

Mobile In-Vitro Neurovascular Cast System

NORTHERN ARIZONA UNIVERSITY

College of Engineering, Forestry, and Natural Sciences

Analytical Assignment: 3D Modeling of the Circle of Willis

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ATI Neurovascular Cast System - C3

Section 8

An essential step in building a realistic model of the Circle of Willis is creating a realistic CAD model. Many such models already exist, however, they are always simplified to some degree. This is necessary due to the variations found in different people. For a model to be useful across the maximum number of cases, it should represent the average of these variations.

For specifying the various lengths, diameters, and wall thicknesses, two studies were used. Lengths of specific sections are estimated relatively loosely, approximately +/- 2 mm, due to factors such as curvature and elasticity. Average diameters of each section were used to create a variable profile based on various MRI scans and other models. Wall thickness varies by only 0.2 mm [1] so an average was taken and uniform wall thickness is assumed. This value may change later to achieve desired properties based on the material. The client has stated that only the inner diameter is critical. Average dimensions of specific regions can be seen in table 1.

Table 1: Average dimensions [2]

Name of artery	Length (cm)		Diameter (cm)	
	Right	Left	Right	Left
1. Posterior cerebral artery	0·68 ± 0·27	0·69 ± 0·31	0·21 ± 0·07	0·22 ± 0·06
2. Posterior communicating artery	1·35 ± 0·34	1·33 ± 0·33	0·15 ± 0·07	0·14 ± 0·07
3. Internal carotid artery	0·48 ± 0·15	0·47 ± 0·15	0·42 ± 0·09	0·42 ± 0·09
4. Anterior cerebral artery	1·47 ± 0·30	1·38 ± 0·27	0·22 ± 0·06	0·24 ± 0·05
5. Anterior communicating artery	(0·25 ± 0·18)		(0·19 ± 0·09)	

To model the arteries, the loft tool was used instead of the swept boss/base tool. This allows the use of varying diameters to achieve a more realistic model. The path was created using the spline tool. The points of the splines were set using constriction lines on all 3 axes so that they are fixed while being easily adjustable. Organization was a priority so all features were named and planes were organized into files. The lofted feature creates the inner profile of the model, due to that being the critical dimension. The shell tool (outward) is used to create the actual model with wall thickness easily adjustable. Images of the models can be seen in the figures below. A technical drawing is not included due to the complexity and non-linear dimensions of the model.

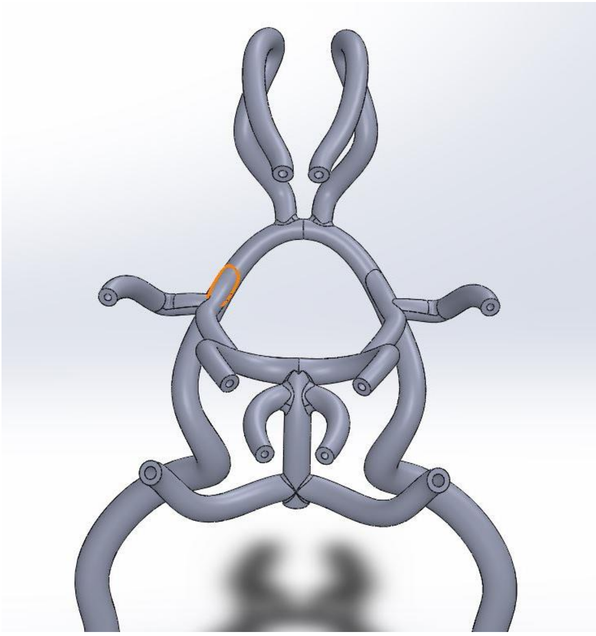

Figure 1: A rear view of the model with a 1 mm outer shell

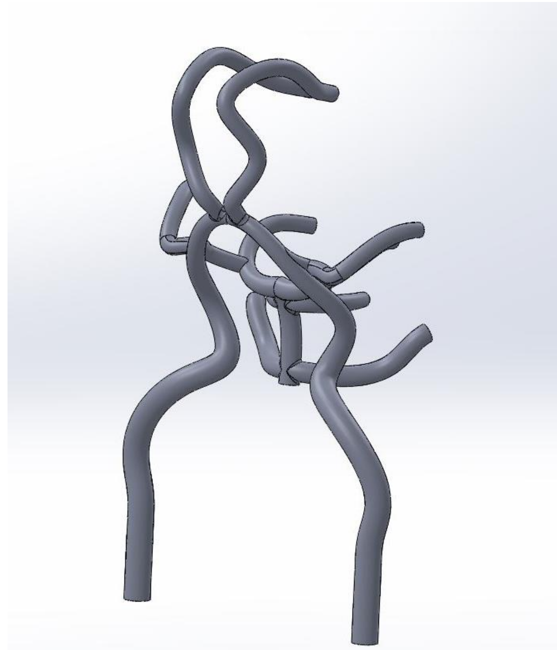

Figure 2: Front view of the model with a 1mm shell

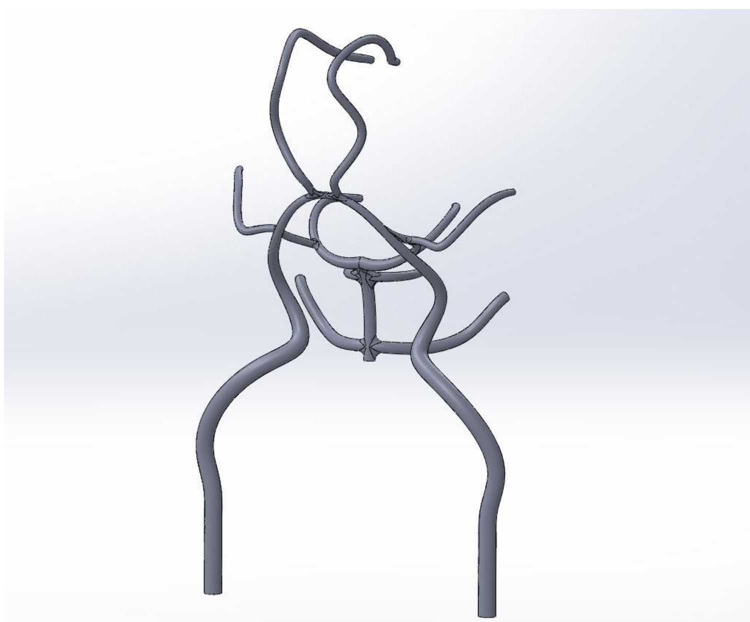

Figure 3: Front view of the "negative" model displaying the internal dimensions

The resulting 3D model is both accurate and easily adjustable. It may not be the final version, but it is likely not far off. In addition, Solidworks gives the volume of the inner profile as 3.057 cm^3. This value gives us a good estimation of how much blood-like fluid we will need for the model. There will also be tubing to create a flow system. Modifications will eventually need to be made to accommodate for such a system.

References

[1] D. Ivanov, A. Dol and O. Pavlova, "Modeling of human circle of Willis with and without aneurisms", *Acta of Bioengineering and Biomechanics*, vol. 16, no. 2, 2014.

[2] S. Kamath, "Observations on the length and diameter of vessels forming the circle of Willis", *Department of Anatomy, St John's Medical College*, vol. 133, no. 3, pp. 419-423, 1880.