

AneuRisk65 ReadMe

The AneuRisk project and the AneuRisk65 data

The AneuRisk65 data have been collected within the AneuRisk project¹, a scientific endeavour that aimed at investigating the role of vessel morphology, blood fluid dynamics and biomechanical properties of the vascular wall, on the pathogenesis of cerebral aneurysms. The project has gathered together researchers of different scientific fields, ranging from neurosurgery and neuroradiology to statistics, numerical analysis and bio-engineering.

The AneuRisk65 data can be downloaded from the AneuRisk webpage
<https://statistics.mox.polimi.it/aneurisk/>

These data include the image reconstructions of one of the main cerebral vessels, the Inner Carotid Artery (ICA), described in terms of the vessel centreline and of the vessel radius profile.

References

When using these data, please cite any of the following papers:

- [1]: detailed description of the data and the applied problem;
- [2]: data preprocessing;
- [3]: data registration and exploratory analyses;
- [4] and [5]: data registration and clustering.
- [6]: exploratory data analysis including hemodynamical quantities.



¹This project involved the MOX Laboratory for Modeling and Scientific Computing (Dip. di Matematica, Politecnico di Milano), Laboratory of Biological Structure Mechanics (Dip. di Ingegneria Strutturale, Politecnico di Milano), Istituto Mario Negri (Ranica), Ospedale Niguarda Ca' Granda (Milano) and Ospedale Maggiore Policlinico (Milano), and has been supported by the Fondazione Politecnico di Milano and Siemens Medical Solutions Italia. Principal investigator of the project: Alessandro Veneziani (currently at the Department of Mathematics and Computer Science, Emory University).

Data files

The file "Patients.txt" contains:

patient	patient number, from 1 to 65
code	patient code
type	patient type: "U" (Upper group) if at least one aneurysm at or after ICA bifurcation "L" (Lower group) if aneurysm before ICA bifurcation (and no visible aneurysm at or after ICA bifurcation) "N" (No-aneurysm group) if no visible aneurysm
AN_Abscissa	location of the aneurysm along the ICA centerline or at ICA centerline bifurcation (not available if type = N or if aneurysm is after ICA bifurcation)
left_right	left or right carotid: "LC" Left Carotid "RC" Right Caotid

For each subject, from 1 to 65, the file "Rawdata-FKS-*patientnumber*.txt" contains both raw and preprocessed data:

Curv_Abscissa	curvilinear abscissa of ICA centerline
MISR	Maximum Inscribed Sphere Radius of the ICA, i.e., radius of the vessel lumen section (raw data)
X0_obs, Y0_obs, Z0_obs	observed values of the three space coordinates of ICA centerline (raw data)
X0_FKS, Y0_FKS, Z0_FKS	three space coordinates of free-knot-spline estimate of centerline (preprocessed data)
X0_FKS_ref	left-right reflected first coordinate of centerline estimate; for right carotids equals X0_FKS for left carotids equals -X0_FKS (preprocessed data)
X1_FKS, Y1_FKS, Z1_FKS	first derivative of centerline estimate (preprocessed data)

X1_FKS_ref	left-right reflected first coordinate of first derivative of centerline estimate; for right carotids equals X1_FKS for left carotids equals -X1_FKS (preprocessed data)
X2_FKS, Y2_FKS, Z2_FKS	second derivative of centerline estimate (preprocessed data)
X2_FKS_ref	left-right reflected first coordinate of second derivative of centerline estimate; for right carotids equals X2_FKS for left carotids equals -X2_FKS (preprocessed data)
Curvature_FKS	curvature of centerline estimate (preprocessed data).

Assistance when analyzing the data

If you need assistance when analysing these data, please write to laura.sangalli@polimi.it.

MBI contest

These data have been analyzed within the MBI Mathematical Biosciences Institute workshop contest. The analyzes have been published in the Special Section of the *Electronic Journal of Statistics* on Statistics of Time Warpings and Phase Variations Vol. 8, No. 2, pp. 1697–1906.

More

An increasing data warehouse concerning aneurysm pathology can be accessed from the AneuRisk Web Repository <http://ecm2.mathcs.emory.edu/aneurisk> managed by Emory University and Orobix.

References

- [1] Sangalli, L. M., Secchi, P. and Vantini, S. (2014a), AneuRisk65: three-dimensional cerebral vascular geometries, *Electronic Journal of Statistics*, 8, 2, 1879–1890.
- [2] — (2009b), Efficient estimation of three-dimensional curves and their derivatives by free-knot regression splines, applied to the analysis of inner carotid artery centrelines, *Journal of the Royal Statistical Society Ser. C, Applied Statistics*, 58, 3, 285–306.
- [3] Sangalli, L. M., Secchi, P., Vantini, S., and Veneziani, A. (2009a), A Case Study in Exploratory Functional Data Analysis: Geometrical Features of the Internal Carotid Artery, *J. Amer. Statist. Assoc.*, 104, 37–48.

- [4] — (2014b), Analysis of AneuRisk65 data: K-mean Alignment, *Electronic Journal of Statistics*, 8, 2, 1891–1904.
- [5] Sangalli, L. M., Secchi, P., Vantini, S., and Vitelli, V. (2010a), K-means alignment for curve clustering, *Computational Statistics and Data Analysis*, 54, 1219–1233.
- [6] Passerini, T., Sangalli, L. M, Vantini, S., Piccinelli, M., Bacigaluppi, S., Antiga, L., Boccardi, E., Secchi, P. and Veneziani, A. (2012), An Integrated CFD-Statistical Investigation of Parent Vasculature of Cerebral Aneurysms, *Cardio-vascular Engineering and Technology*, 3, 1, 26–40.