Estimation of Local Lumen Intensity by Kernel Regression

Edward Hahn
HeartFlow, Inc.
Stanford Center for Professional Development
ekhahn3@stanford.edu

Motivation

Segmentation of tube-like structures is an important preparatory step in quantitative investigations of anatomical and physiological characteristics of the human body. Correspondingly, sustained interest in the medical imaging community is directed toward segmentation of blood vessel lumen from images generated by common medical imaging modalities, such as coronary computed tomography angiography (CCTA) [1]. Not only does lumen segmentation provide a basis for important anatomic measures that inform treatment decisions made by interventional cardiologists, it facilitates more sophisticated investigations via computational fluid dynamics (CFD).

Proposed Work

The subject of this proposal is the design, implementation, and exploration of a tool to perform the auxiliary task of estimating local lumen intensities in a coronary CT angiogram as a function of position along lumen centerlines. This intensity estimation will be given as input into an advanced vessel segmentation algorithm in development at HeartFlow. The estimation will be computed via iterative kernel regression [2, 3] in a 3D neighborhood around each point along the centerlines.

The tool will be prototyped in Matlab and subsequently implemented in C++ utilizing the Insight Toolkit (ITK) [4] or appropriate equivalent. Tool inputs will consist of a single CT image volume and corresponding hand-labeled vessel centerlines. Tool output will consist of estimated mappings from centerline points along each centerline segment to CT intensity values indicative of local lumen intensity.

Development of the tool will require varied CT image data and centerline qualities to prove robustness and eventual suitability for use in a production setting. Thus, important development steps will be:

1. Initial tool implementation and verification with excellent-quality synthetic patient CT data and excellent centerlines (the ideal patient data and centerlines)
2. Investigation of tool performance and optimization on excellent-quality real patient CT data with excellent centerlines (the ideal real-world patient data and centerlines)
3. Investigation of tool robustness in marginal quality real patient data with imaging artifacts such as noise, calcium blooming, significant lumen opacification inconsistencies, etc. (realistic real-world patient data and centerlines)

References

[1] David Lesage, Elsa D. Angelini, Isabelle Bloch, Gareth Funka-Lea, A review of 3D vessel lumen segmentation techniques: Models, features and extraction schemes, Medical Image Analysis, Volume 13, Issue 6, December 2009

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[3] M. Schaap, L. Neefjes, C.T. Metz, A.G. van der Giessen, A.C. Weustink, N.R.A. Mollet, J.J. Wentzel, T. van Walsum and W.J. Niessen, Coronary Lumen Segmentation using Graph Cuts and Robust Kernel Regression, Information Processing in Medical Imaging 2009 , 2009
[4] http://www.itk.org/