Doctoral School EEA

RESEARCH SUJECT TITLE :

Contrast enhanced computerized tomography measurement of vascular blood flow

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Doctoral School/Ecole doctorale : EEA
Lab Language/Langue de travail: English

Abstract:

The objective of this PhD is to develop and validate a new imaging technology based on Spectral Photon Counting Computed Tomography (SPCCT) and dedicated contrast agents in order to evaluate accurately the blood velocity. Blood velocity in arteries is a very important clinical parameter to characterize cardiovascular diseases. Yet, in contrast enhanced computed tomography imaging this velocity measurement is not a well-established method. Few blood velocity estimation methods using CT are known. For example the time-of-flight TOF technique is based on the difference in arrival time of the contrast agent at two different locations. This measurement of the intravascular blood velocity is based on the temporal changes in the sinogram obtained in a sequential scanning mode. The method is limited to the estimation of the mean of the speed of the flow component along the flow field propagation axis [1]. Recently a new method to evaluate the more precisely the blood velocity has been proposed based on spiral CT scans with a contrast agent. The transport equation is used as a constraint to obtain stable solutions. An optimal control formulation of the 3D+t tomography inverse problem has been investigated to reconstruct at the same time the flow velocity and the density of the contrast agent [2]. The optimality system for the density of the contrast agent and the flow field are solved iteratively. Promising results have been obtained for very simple synthetic flow configurations and transport equations but the convergence is low.

Goal and tasks

The goal of this project is to improve the proposed method and to generalize it to more complex reconstruction problems. Several transport and diffusion equations and various velocity profiles can be investigated for more realistic arterial blood flow. The PhD student will study first and second order adjoint methods which have proven very useful for pde constrained inverse problems [3]. In each case, based on the proposed optimal control methodology, he will study the corresponding inverse problems, derive the optimality conditions and implement the iterative reconstruction to validate the approach. The optimality conditions involve a system of partial differential equations and several numerical schemes may be studied obtain stable solutions and to have a fast convergence.

References/mots-clés: Inverse problems, fluid flow, partial differential equation

References

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[2] “Vascular blood flow reconstruction with contrast enhanced computerized tomography” B.Sixou, L.Boussel, M.Sigovan Inverse Problems in Science and Engineering 26, 855-876, (2018).

[3] “M.Herzog, K.Kunisch Algorithms for Pde constrained optimization” M.Herzog, K.Kunisch GAMM-Mittelungen, 33:163-176, (2010).

Monica Sigovan received her PhD degree from the University of Lyon in 2009. Since 2016 she is a CNRS researcher in the Creatis laboratory. Her work focuses on improving the non-invasive diagnosis of vascular diseases by developments in imaging acquisition and reconstruction methods and imaging-based modeling of the vessels.

B.Sixou (HDR) received a M.Sc degree in Physics from ENS Lyon, France and a Ph.D degree from University of Grenoble, France in 1994 and 1996 respectively. Since 1999, he is assitant Professor in Physics in the National Institute for Applied Science (INSA) in Lyon, France. Since 2011, he focusses his research activity in the Creatis laboratory specialized on biomedical imaging. His is the author of more than 50 papers in material science and applied mathematics. His current research interests are applied mathematics, inverse problems, phase retrieval, tomography.