PhD thesis topic proposal

Breathing thorax modeling from 4D imaging for dynamic radiotherapeutic dose estimation

The thesis will be in co-tutelle between Creatis, CNRS UMR 5515, Inserm U630, Lyon, France and the Center for Machine Perception at the Department of Cybernetics of the Czech Technical University in Prague. The starting date is on September 1st, 2006. It takes place in the context of the European Marie Curie Early Stage Training WARTHE (Wide Area Research Training in Health Engineering) of the FP6 Human Resource programme.

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Medical Context
Currently, radiotherapy is one of the three main possible treatments for cancer, besides surgery and chemotherapy. In men, lung cancer is the second most frequently encountered type of cancer and it is the first one in terms of death. Prior to a radiotherapy session, the dose received by different organs is calculated while the organs are supposed to be static. However, especially in the case of lung, breathing induced movements might cause the dose received by the tumor to decrease, while increasing the dose received by the surrounding healthy tissues.

Goal
Starting from 4D images (a temporal sequence of 3D-CT volumes) of the patient and using spatio-temporal models of the thorax motion, design, implement and test methods to calculate the dose received by all the structures (thoracic anatomical structures and tumors) during the radiotherapy treatment session.

General approach
Computing a therapeutic dose distribution inside moving organs basically requires:
(1) to dispose of a 4D motion estimation model, then (2) to compute static dose distribution according to different breathing phases, and finally (3) to accumulate the dose distributions on a same reference using the estimated motion fields.

Motion estimation of the thorax structures can be achieved by deformable registration between a reference 3D CT image and each other images of the 4D sequence. Based on the work previously done in our group, the first task of this thesis will be to extend this registration to a full 4D approach taking into account lung density changes due to inspiration. In particular, mass preserving registration approaches will be studied.

In a second step, dose accumulation procedures using previously identified motion model will be performed. The energy deposit in anatomical structures (related to the dose) should be preserved during the warping/accumulation step. This could be performed by similar mass preserving approaches.

Benefits
For patients, we expect to be able to limit the uncertainty of the irradiation, reducing the impact on healthy tissues, increasing the dose received by the cancerous tissue within mobile organs, thus increasing the efficiency of the treatment and consequently reduce the number of irradiation sessions needed, reducing also the costs of the treatment.

Partners
The thesis work will be done in collaboration of the “Dynamic Imaging” group at CREATIS, with expertise in modeling and segmentation, the “Imaging, Radiation, Oncology” group of the Léon Bérard Cancer Treatment Center hospital, providing images and medical experience, and the “Center for Machine Perception” group at Czech Technical University in Prague, specialized in image processing, registration, and optimization. The thesis will be part of the Early Stage Training Marie-Curie project WARTHE (Wide Area Research Training in Health and Engineering), sponsored by the European Union.

Requirements
The applicants must be nationals from countries other than France, preferably from Europe or associated countries. At the start of their fellowship/activity, applicants may not have resided or carried out their main activity (work, studies, etc) in France for more than 12 months in the 3 years immediately prior to the reference deadline for eligibility.
The applicants should have a strong background in applied mathematics, modelling, signal and image processing and programming skills in C and C++.

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