A procedure based on images for the optimal design in a cryosurgery operation

Master's Degree Thesis Abstract *University of Genoa, School of Mathematical, Physical and Natural Sciences, Department of Mathematics*

Author: Silvia Baglietto, Supervisors: Prof. Michele Piana, Prof. Giacomo Caviglia

The mail goal of this thesis is the edge detection of tumoral cells from CT images and, by the results, the individuation of an optimal configuration of cold needles, called *cryoprobes*, planning for a cryosurgery operation.

Cryosurgery is a minimally invasive technique aiming at the destruction of cancerous tissues by insertion of multiple cryoprobes in the shape of long hypodermic needles connected to an external generator of supercooled fluid: in this way, the cancerous tissue is frozen with temperature range of the solid phase below the lethal limit.

The thesis proposes a description and an analysis of some mathematical instruments those have a particular applications for tumor detection and treatment through cryosurgery. In particular, the studied cases suggest a design for a cryosurgery operation on a diseased liver.

Naturally, the intent is destroying the greatest possible number of diseased cells and, at the same time, saving the healthy ones. Therefore, it is necessary to plan an operation delimiting the involved region with utmost precision, applying appropriate techniques of image analysis to select the tumor contour on available CT data.

In addition, the available parameters must be adjusted in order to obtain the maximum efficiency. During an operation of this type, the free parameters to be fixed in advanced are many, such as the position and the number of needles to be inserted, the temperature necessary to freeze the tumor and the operation duration.

The used numerical development environments are Matlab and Freefem++ (a program that uses the programming language type C++ and solves problems by finite elements). Matlab is used for the edge-detection while a combination between Matlab and Freefem++ is used for the heat problem resolution by the finite element method and for the optimization of the solution.

Bibliography

[1] G. Allaire, *Numerical Analysis and Optimization*, Oxford University Press, 2007.

[2] M. Bertero, P. Boccacci, *Introduction to inverse problems in imaging*, Institute of Physics Pub., 1998.

[3] T.F. Chan, L.A. Vese, *Active Contours Without Edges*, IEEE Transictions on Image Processing, Feb. 2001.

[4] M. Dorigo, L. M. Gambardella , *Ant Colony System: A Coperative Learning Approach to the Travelling Salesman Problem*, IEEE. Trans. Evol. Comp. 1, 1997.

[5] G. Giorgi, L. Avalle, M. Brignone, M. Piana, G. Caviglia *An optimization approch to multiprobe cryosurgery planning*, Computer Methods in Biomechamnics and Biomedical Engineering, 2012.

[6] G. Giorgi, *Mathematical tools for microwave mammography and prostate cryosurgery*, PhD Thesis in Mathematics and Applications, XXIV cicle.

[7] S. Kichenassamy, A. Kumar, P. Olver, A. Tannenbaum, A. Y. Jr, *Conformal curvature flows:From phase transitions to active vision*, Arch. Ration. Mech. Anal. vol 134, Sett. 1996.

[8] S. Lankton, A. Tannenbaum, *Localizing Region-Based Active Contours*, IEEE Transictions on Image Processing, Nov. 2008.

[9] D. C. Lung, T. F. Stahovic, Y. Rabin, *Computerized Planning for Multiprobe Cryosurgery using a Force-field Analogy*, Comp. Meth. in Biomech. and Biomed. Eng. 7, 2004.

[10] J. M. Morel, S. Solomini, *Variational Methods for Image Segmentation*, Bostonm, MA: Brikhauser, 1994.

[11] S. Osher, R. Tsai, *Level set methods and their applications in image science*, Commun. Math. Sci., vol. 1, 2003.

[12] A. Yezzi, A. Tsai, A. Willsky , *A fully global approach to image segmentation via coupled curve evolution equations*, J. Vis. Comm. Image Rep. , 2002.