Abstract

Quantitative microwave imaging is a nonlinear inverse scattering problem, where the complex permittivity of a biological object is reconstructed from the measured scattered field produced by the object. This thesis presents a contribution to the Quantitative Microwave Imaging. The study focuses on the development of imaging algorithms in which nonlinear inverse scattering is used to create images of the biological object of interest.

A state of the art review report has been created in the Chapter One covering the major contributions in both imaging systems and algorithms in the field of microwave imaging. Chapter Two is related to 2D scalar scattering problem, considered in the frame of the interaction between an incident microwave and the biological object of interest. The 2D scalar Electrical Field Integral Equation (EFIE) has been discussed in this chapter followed by its numerical solution known as Forward Problem.

After providing an overview of some of the different possible formulations in terms of a nonlinear optimization problem, details on the use of the Gauss-Newton inversion algorithm which solves the Inverse Problem has also been discussed in Chapter Two. Usually, the non-linear inverse scattering problem is solved by the iterative optimization process. The Gauss-Newton method has been chosen here for the minimization of the output least square error. The difference between the measured field and the computed field is minimized in this case. For a sufficiently small error, the reconstructed image of the object is the complex permittivity map used in the Forward Problem.

Chapter Three represents the several algorithms proposed by the author for the optimization of the objective function. To obtain quantitative images of high-contrast objects, a nonlinear inverse scattering problem has to be solved. Seven different algorithms have been proposed in this thesis meant for calculating the updates. The proposed algorithms use a Newton-based imaging algorithm to reconstruct the 2-D complex permittivity distribution of the object of
interest. These algorithms must deal with the nonlinearity and ill-posedness of the Inverse Problem. To combat the ill-posedness of the problem several regularizing procedures have been adopted in those algorithms. Also the so-called Inverse Crime has been avoided by considering different mesh sizes for the Forward Problem and the Inverse Problem respectively. Each of the proposed algorithms has shown the significant improvement in terms of the reconstruction of the biological object with respect to the previously proposed algorithm.