Abstract

This thesis presents the contribution given to the development of a microwave imaging system for the diagnosis of brain stroke. The work focused on the software processing of the data. On one side, a deterministic algorithm for the quantitative imaging of the dielectric properties distribution in the head is implemented in an alternative way. On the other side, a method to gather a great quantity of data employed in the training of machine learning (ML) algorithms for the classification of stroke's patient is described.

For the first section, the implemented algorithm is the 3-D Contrast Source Inversion (CSI) method, which is an iterative non-linear algorithm, and here, it is based on a finite element method solver. In the classical discretization, the contrast source is written with the same basis functions as the dielectric contrast, for this reason, here this kind of discretization is called contrast-based. An alternative way to discretize the involved variables is presented: the field-based discretization. In this implementation, the contrast source variable and the field are written with the same basis functions. The first advantage of this choice is the simplification of the algorithm, since all the quantities are implemented as scalar even in a 3-D scenario. Besides, another benefit is the lower discretization error in the contrast source, leading to a higher accuracy in the discretized variables and to better final results of the CSI method. In the thesis, the standard and the proposed discretization are compared in a synthetic realistic scenario, which simulates the complexity of a human head. Moreover, some preliminary experimental tests are reported.

The second main topic of this work is the use of artificial intelligence in order to extract information regarding the patient conditions. An innovative method to generate a large amount of data for the training phase of the ML algorithms is presented. Indeed, in medical applications is usually difficult to have available data in a short time. The gather of real measurements or full-wave simulations could imply an unfeasible period of time. Here, the features of the data-set are obtained via linearized simulations that enable an important gain of time in the generation of huge sets of data. In this thesis, the capacity of the algorithms to classify the presence, the typology and the location of the stroke is tested. A realistic anthropomorphic numerical phantom is employed for the synthetic tests and the performances of three ML algorithms are presented: multilayer perceptron, support vector machine and k-nearest neighbours. Also for this section, some preliminary experimental tests are mentioned.

The promising results described in this thesis are the basis of the data software processing for a preliminary system prototype. However, they need further investigation especially for their application to experimental data.