Chapter 2
Using Extreme Learning Machines and the Backprojection Algorithm as an Alternative to Reconstruct Electrical Impedance Tomography Images

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ABSTRACT

Electrical Impedance Tomography (EIT) is an imaging technique based on the excitation of electrode pairs applied to the surface of the imaged region. The electrical potentials generated from alternating current excitation are measured and then applied to boundary-based reconstruction methods. When compared to other imaging techniques, EIT is considered a low-cost technique without ionizing radiation

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emission, safer for patients. However, the resolution is still low, depending on efficient reconstruction methods and low computational cost. EIT has the potential to be used as an alternative test for early detection of breast lesions in general. The most accurate reconstruction methods tend to be very costly as they use optimization methods as a support. Backprojection tends to be rapid but more inaccurate. In this work, the authors propose a hybrid method, based on extreme learning machines and backprojection for EIT reconstruction. The results were applied to numerical phantoms and were considered adequate, with potential to be improved using post processing techniques.

INTRODUCTION

Electrical Impedance Tomography (EIT) is a technique for imaging the interior of a body section based on the application of a low amplitude, high frequency alternating electric current. For this, electrodes are positioned on the surface of this body. They are responsible for sending this stimulus as well as for measuring the resulting electrical potentials. Thus, one can obtain images with estimates of the electrical conductivity or permittivity of the interior of a domain. Conductivity can be understood as the possibility of the medium to allow the displacement of electric charges, while permittivity is the measure of the ease of polarization of the material (Tehrani et al., 2010; Bera et al., 2011; Kumar et al., 2010).

EIT has applications in several areas: in geophysics, in industrial processes, in botany and medicine, for example. On the last, applications can be cited for detection of breast cancer (Pak et al., 2012), diagnosis of prostate cancer (Wan et al., 2013), monitoring of ventilator-imposed pulmonary ventilation (Alves et al., 2014; Adler et al., 2009) and in the measurement of intracranial bleeding.

EIT does not use ionizing radiation, which is harmful to human health. However, the technique still has low spatial resolution and a high computational cost in reconstructing its images compared to other medical imaging techniques, such as x-ray computed tomography (X-CT) and Nuclear Magnetic Resonance (NMR) and, therefore, is not yet strongly established. Hence, several methods have been studied and applied to solve these problems (Kumar et al., 2010).

For decades, breast cancer has been the most common type of cancer among women. In Brazil, the breast cancer mortality rates remain high, as the disease is still diagnosed in advanced stages. Even though Mammography, Ultrasonography, Magnetic Resonance and clinical breast examination (ECM) are the most widely used and indicated methods in mastology, there are still many problems associated to them. Sometimes they are not enough to identify breast lesions in women with dense and surgically altered breasts or in women under the age of 40 years old. In addition to it, some of these exams are extremely uncomfortable to the patient and there is concern about the risk associated to the use of ionizing radiation (Torre et al., 2015; Ministério da Saúde, 2017, Santana et al., 2018; de Lima et al., 2016; Cordeiro et al., 2017; Cordeiro et al., 2016a; Cordeiro et al., 2016b; Azevedo et al., 2015; Cordeiro et al., 2013; Cordeiro et al., 2012; Rodrigues et al., 2018; Oliveira et al., 2019; de Souza et al., 2019). Several works point out that electrical impedance tomography can be used successfully to aid at the diagnosis of breast cancer (Holder, 2004; Cherepenin et al., 2001; Halter et al., 2008; Choi et al., 2007; Zou & Guo, 2003; Hong et al., 2014; Soni et al., 2004).

In this work, the authors propose a new method for reconstruction of EIT images. They propose the use of the classic Backprojection Algorithm to obtain TIE images from sinograms. The sinograms, in turn, will be constructed from the data of electrical potential differences measured on the surface of the studied domain, using for this purpose Regression Extreme Learning Machine (R-ELM) Artificial