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CARTESIAN GENETIC PROGRAMING APPLIED TO EQUIVALENT ELECTRIC CIRCUIT IDENTIFICATION

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Abstract: Equivalent electric circuits are widely used in electrochemical impedance spectroscopy (EIS) data modeling. EIS modeling involves the identification of an electrical circuit physically equivalent to the system under analysis. This equivalence is based on the assumption that each phenomenon of the electrode interface and the electrolyte is represented by electrical components such as resistors, capacitors and inductors. This analogy allows impedance data to be used in simulations and predictions related to corrosion and electrochemistry. However, when no prior knowledge of the inner workings of the process under analysis is available, the identification of the circuit model is not a trivial task. The main objective of this work is to improve both the equivalent circuit topology identification and the parameter estimation by using a different approach than the usual Genetic Programming. In order to accomplish this goal, a methodology was developed to unify the application of Cartesian Genetic Programming to tackle system topology identification and Differential Evolution for optimization of the circuit parameters. The performance and effectiveness of this methodology were tested by performing the circuit identification on four different known systems, using numerically simulated impedance data. Results showed that the applied methodology was able to identify with satisfactory precision both the circuits and the values of the components. Results also indicated the necessity of using a stochastic method in the optimization process, since more than one electric circuit can fit the same dataset. The use of evolutionary adaptive metaheuristics such as the Cartesian Genetic Programming allows not only the estimation of the model parameters, but also the identification of its optimal topology. However, due to the possibility of multiple solutions, its application must be done with caution. Whenever possible, restrictions on the search space should be added, bearing in mind the correspondence of the model to the studied physical phenomena.