Fathoming Linear Forecasting Models

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***Resumo*—This work presents and discusses a proposal to optimize parameters of general linear forecasting models using immune algorithms. After the technical discussion, the authors analyze a selection of relevant simulation results generated with a class of time series of high practical relevance: seasonal streamflow series.**

***Index Terms*—Immune Algorithms, Time Series Forecasting, Linear Models**

I. Background, Motivation and Objective

When dealing with linear forecasting models, there is an intrinsic need for obtaining their optimum parameters, typically in terms of minimum mean squared prediction error. In models without feedback of any nature - Autoregressive model (AR) it is possible to obtain the minimum in closed form, using the Yule-Walker Equations. The AR is given by 1

$$\tilde{x}_t = \phi_1 \tilde{x}_{t-1} + \ldots + \phi_p \tilde{x}_{t-p} + \ldots + \phi_P \tilde{x}_{t-P} + a_t, \quad (1)$$

However, a general linear predictor must include feedback loops, as in the Autoregressive and Moving-Average model (ARMA) described in Equation 2

$$\tilde{x}_t = \phi_1 x_{t-1} + \ldots + \phi_p x_{t-p} - \theta_1 \epsilon_{t-1} - \ldots - \theta_q \epsilon_{t-q} + \epsilon_t \quad (2)$$

However, this model necessarily demands an iterative method to find the best coefficients. A model of this sort is potentially more accurate, but, on the other hand, it is less tractable in mathematical terms. The contribution discussed in this work is related to this contrast.

II. Statement of Contribution/Methods

The presence of feedback loops in a linear forecasting model produces an increase of generality at the cost of optimization task. This is the motivation of this work: to consider the CLONALG algorithm as an alternative to establish a general linear prediction framework.

Immune-inspired algorithms are optimization techniques whose inspiration comes from the mechanism of biologic immune system. They have characteristics as robustness and flexibility relative to the steps that have to be followed in their computational implementation. There is no guarantee of global optimality, but, because of their implicit parallelism, they have some mechanisms with potential global search.

III. Results, Discussion and Conclusions

The results show that recursive models with CLONALG algorithm can be beneficial to forecasting. The chosen application is related to seasonal streamflow series prediction.

The selected series is relative to the plant FURNAS, with the test samples being the average of the monthly streamflows between the years 1952 and 1956 (dry) and 1972 and 1976 (medium). The models have 2 inputs and one feedback parameters (except for the AR model) and the prediction is for one step ahead. The best results found are summarized in Table I, in the real and deseasonalized domains.

Tabela I
Results

Series	Best R.	MSE $\times 10^4$ m^3/s	Best D.	MSE D.
56-Tr.	ARMA	7.21	ARMA	0.337
76-Tr.	ARMA	3.49	ARMA	0.326
56-Test	ARMA	4.21	ARMA	0.286
76-Test	ARMA	4.19	AR	0.387

We can observe that, almost invariably, the feedback models present an error smaller than the error obtained for AR models. Just in one scenario the AR was the best, since it can achieved its global optimum point regarding the coefficients adjustment.

In summary, this work dealt with forecasting with recurrent linear models from the perspective of use immune algorithms to calculate their parameters.