TOMASZ PELECH
University of Science and Technology, Krakow, Poland

ADAPTATIVE HOLT'S FORECASTING MODEL BASED ON IMMUNE PARADIGM

В современных условиях принятие управленческих решений вызывает необходимость прогнозирования (с применением соответствующих методов) для достижения прибыльности и стабильного функционирования малых и средних компаний или фирм. Модель Холта – это метод, который может быть применен для прогнозирования биржевых котировок. Он основывается на значениях двух переменных, которые отражают ожидаемое значение и его тенденцию. Для создания динамической модели прогнозирования необходимо применение адаптивных правил уточнения переменных. Рассматривается применимость иммунной парадигмы на примере адаптивной модели Холта. Представленные результаты расчетов с применением составленного алгоритма подтверждают, что иммунную парадигму можно рассматривать как перспективный способ повышения надежности (точности) результатов прогнозирования. Они незначительно превосходят результаты, полученные с применением классического метода Холта, с учетом некоторых факторов, таких как интервал исходных данных, характеристика метода и построение алгоритма, которые все еще находятся в стадии разработки.

In modern management, decision making causes necessity of forecasting (with appropriate methods) to reach profitable and smooth functioning of companies as well as of small and medium businesses. The Holt's model is a method that can be used to predict exchange quotations. It is based on values of two parameters that estimate expected value and its trend. To construct dynamic forecasting model it is necessary to apply adaptive rules of the parameters adjusting. The paper shows applicability of an immune-based paradigm on the example of adaptive Holt's model. Presented results of computations with the constructed algorithm show that immune paradigm can be thought as promising way to improve results (accuracy) of forecasting. They are not absolutely better than the results acquired with the classical Holt's method because of some factors like the length of input data, characteristic of the method and construction of algorithm that is still developed.

1. INTRODUCTION

Decision making problem is one of main management issues. Any economical choice generates appropriate results that could be positive or negative for each company or small and medium business. An information about past, present and future is necessary to profitable existing and functioning. Information about present is relatively ease to get, for example by exploring own information or buying data. To predict relevant factors in future one of forecasting methods may be used, which differ in some features like precision, complexity, etc.

The Holt's model is a forecasting method based on extrapolation of smoothes time series. Usually, two parameter exponential smoothing is applied. The model is flexible and it can be used as adaptative one; then its parameters are not constants, they adapt dynamically to new information and changeable environment.

The main objective of this paper is to show a possibility of applying an adaptative immune paradigm to improve classical forecasting methods. The Holt's model is exploited as the example, where two parameters, α and β are being adjusted (adapted). Prediction errors of classical model and immune-based adaptative one are analysed and compared. The study gives answers whether the immune paradigm can be successfully used to adapt Holt's parameters and which of these methods is better.

2. CLASSICAL AND IMMUNE-BASED ADAPTATIVE HOLT'S MODEL

In Holt's method polynomial of 1st degree is used to describe a development tendency (linear trend) in a time series. The variable

level and its rate of changes (represented by a linear trend coefficient) are smoothed exponentially. Two parameters: α and β, called smoothing constants, are real numbers between 0 and 1. α parameter smoothes variable level F_t and β represents the smoothed trend coefficient T_t. General equations of the model for time t and forecast period τ (τ equals 1 for one-day-forecasting) are [2]:

$$F_t = \alpha y_t + (1-\alpha)(F_{t-1} + T_{t-1});$$

$$T_t = \beta(F_t - F_{t-1}) + (1-\beta)T_{t-1};$$

$$y_{t+1} = F_t + \tau T_t, \ \tau > 0.$$

Forecasting with Holt's method is usually calculated for a few sets of α and β, compared with actual data (information) that gives an accuracy level of the forecasting expressed as appropriate error measure. In this paper the author uses RMSE (Root Mean-Square Error):

$$\mathrm{RMSE}_t = \sqrt{\frac{1}{n}\sum_{i=0}^{n-1}(y_{t-i} - \hat{y}_{t-i})^2}$$

where n denotes the number of recent data taken into calculations.

The parameter α, β can be found by optimization techniques minimizing an error measured (e.g. RMSE) for past data. The point is that both parameters are constant, so when we add new data (for example periodically, one a week) a set of α and β for longer (new) time series could not be optimal.

Thus there is a need to construct and apply adaptative method where α and β will change dynamically. Generally, it can be performed in three ways:

arbitrary changes of both parameters (if error exceeds fixed threshold, α and β will be modified by a constant value);

random changes (parameters will be modified by a random value);

genetic changes (α and β will be modified by genetic operators).

In this paper genetic changes of parameters and their structure are inspired by an idea of artificial immune systems.

Artificial immune system is viewed as a new form of engineering, when problem doesn't need detailed specification of a behaviour of each of the studied system components. The system is defined as a program or algorithm based on general rules of natural immune system [1]. Immune approach foremost treats clonal selection principle (theory), immune response, somatic hyper mutation, negative selection and immune memory.

This article shows results of forecasting performed by means of quasi-immune algorithm i.e. an algorithm that use only some features of artificial immune system.

3. RESULTS OF COMPUTATION

Quotations of WIG20 (price index of the 20 biggest polish companies) from Warsaw Stock Exchange (from 22.11.1999 to 28.01.2005) were used as input data. Forecasting was performed 30 times for 12 different pairs of parameters α and β with τ fixed to 5 days (week at stock exchange). Forecasting with classical Holt's model and immune-based adaptative are compared to real (historical) WIG20 data. To indicate differences between methods RMSE for five past days was used ($n = 5$). Errors computed for all recent data at the time t get similar results for both methods.

Table 1 shows results of computation for classical Holt's method (denoted as method *C*) and immune-based one (denoted as method *I*), where m denotes average RMSE and s – its standard deviation. Better results have lower averages and/or lower standard deviations.

Table 1: Results of computation

		method *C*		method *I*	
α	β	m	s	m	s
0.30	0.50	42.32	28.82	26.94	21.06
0.30	0.70	47.32	33.11	25.68	21.99
0.30	0.90	51.70	36.68	36.70	25.85
0.40	0.60	43.37	29.84	26.40	21.04
0.45	0.55	41.64	28.38	26.11	21.15
0.50	0.30	34.15	22.72	26.34	20.41
0.50	0.90	50.20	33.33	43.78	29.46
0.55	0.45	38.39	25.84	27.02	21.30
0.60	0.40	36.78	24.65	26.39	21.65
0.70	0.30	33.44	22.26	26.41	21.51
0.90	0.50	41.93	28.66	43.50	29.42
0.90	0.70	49.82	34.55	48.93	34.01

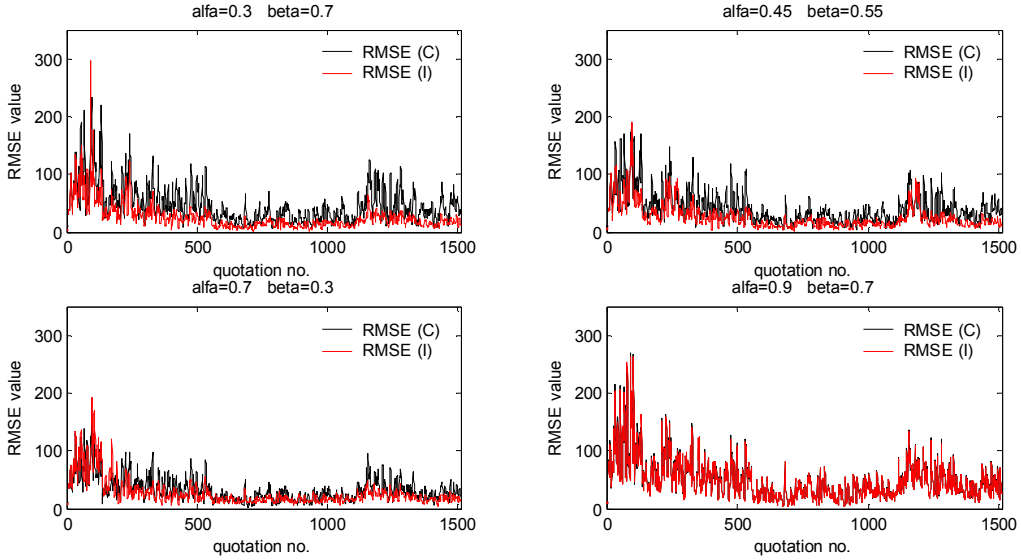

Figure 1: RMSE value

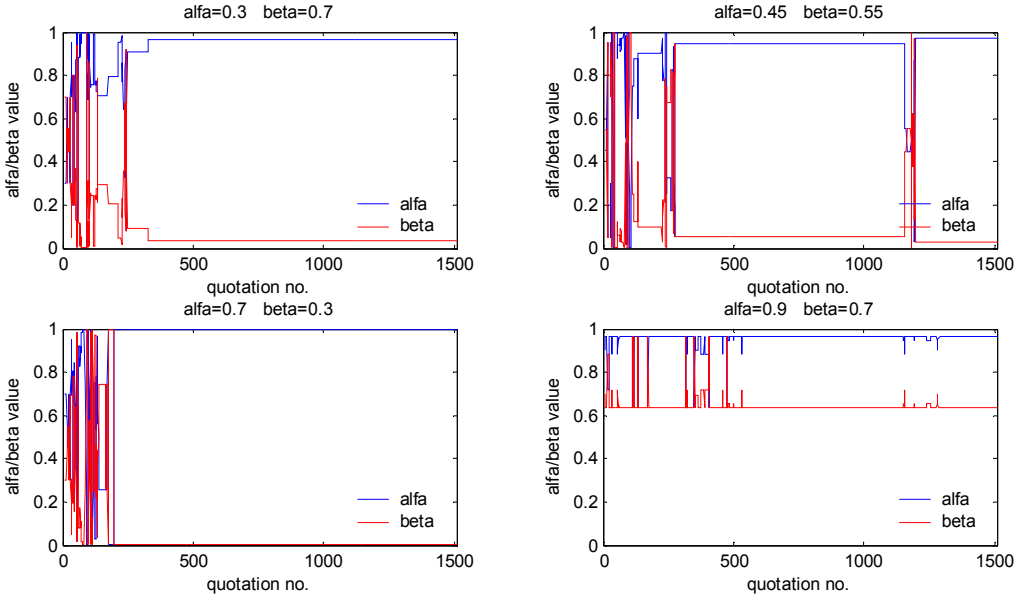

Figure 2: α and β changes

For most pairs of α and β results get with the immune-based method are better or much better than for classical one. For two pairs when α parameter is close to 1, average values and standard deviations are worse than the others. It can be caused by the fact that algorithm is sensitive to starting values of α and β. Computed RMSE at the beginning of computations has a large value being held during running (the length of input data may be too short).

The accuracy of performed forecasting is depicted in Figure 1, which shows changes of relative RMSE and compares standard deviations of classical and immune-based method.

There are four sub-figures for four different starting points (α and β) which get acceptable results.

In most cases RMSE standard deviation for adaptative method is better (what is also seen in Table 1) especially for first and last 500 quotations.

Figure 2 presents α and β changes during running algorithm. As depicted below, immune-based method changes dynamically the both parameters. Significant changes are for about first 250 quotations when algorithm begin from starting values and adapt them to such ones that give the smallest error. From about 500 to 1000 quotation α and β are constant like RMSE in the same range as shown in Figure 1.

4. CONCLUDING REMARKS

Immune-based paradigm applied to create adaptative Holt's model (dynamic changes of parameters) is promising way to increase forecasting accuracy.

At present state the proposed algorithm is not evidently better than classic one. For some starting pairs of α and β immune-based method results are worse. It can be caused by too small number of input data. Depicted changes of RMSE, α's and β's, suggest that immune-based adaptative method needs hundreds of inp adaptative method needs hundreds of input data to reach optimal values of parameters for which RMSE value will be small and relatively constant.

Another problem is the appropriate choice of α, β starting values and the prediction error threshold, which are vital for the Holt's method.

The used algorithm is quasi-immune-based and it is still under study so there is possibility of improving results when its structure will be completed.

REFERENCES

[1]. de *Castro L.L.*, von *Zuben F.J.*: «Artificial Immune Systems: Part I – Basic Theory and Applications», http://www.dca.fee.unicamp.br/~lnunes/immune.html.

[2]. *Holt C.C.*: «Forecasting seasonals and trends by exponentially weighted moving averages», Pittsburgh, Pennsylvania, Carnegie Institute of Technology, 1957.