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NON-FERROUS METAL PRICES FORECAST ON THE LONDON METAL EXCHANGE USING A NEURAL NETWORK

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Abstract. Any enterprises specializing in the mining industry deal directly with a variety of minerals that are located deep under the thickness of the earth's crust. Among these minerals, ores of non-ferrous metals such as copper, aluminum, zinc, iron, titanium, etc. are also often found. These ores undergo primary processing after the mining stage. Enrichment, processing, smelting of the non-ferrous metals themselves and their various alloys, as well as the manufacture of various products or raw materials necessary for use in other branches of industry, can follow. Certain non-ferrous metals play an important role in the further chain of the production process. As a result, finished products of metal processing or raw materials can become an object of import-export on the international market. The most interesting market is the non-ferrous metals themselves due to the complexity of their extraction and value for the industry as a whole. In order to make the most profitable purchase of non-ferrous metal raw materials on the international exchange, it is necessary to know the exact price of this metal at a certain point in the future, when the cost of the metal at the time of purchase will be as cheap as possible. But, since the future price is practically unknown in advance, there is a need to forecast the price of a certain non-ferrous metal, at least in the short term. In this article, a software device based on the work of a neural network is developed, which predicts the price of some non-ferrous metals for a short period of time in the future based on already existing data on the value of these metals. As an example of the work of the neural network, the article uses a temporary series of prices for iron, aluminum and zinc on the London Metal Exchange, which has accurate data at its disposal with an interval of 1-3 days. The proposed neural network device performs cost forecasting based on a nonlinear autoregression algorithm with pre-set neural network parameters. The developed forecasting method makes it possible to determine the price of non-ferrous metal with a certain degree of accuracy for its further purchase at a price favorable to the buyer.

Keywords: forecast, neural network, training, accuracy, time series.

Introduction. Today, at any enterprise which operates in the mining industry, the main priority is the extraction of various minerals, including non-ferrous metal ores, such as iron, titanium, aluminum, copper, zinc, tin, nickel, etc. These ores are then subjected to primary processing to obtain semi-finished products. Also, the processing includes enrichment, processing, smelting, etc. for the purpose of using these metals in other industries, as well as for buying and selling to international markets. The non-ferrous metals market is of interest due to the difficulty of extracting raw materials and their value in a particular industry.

In order to profitably buy one or another non-ferrous metal in the form of raw materials at the best price, it is necessary to know in advance the cost of this metal. Since international exchanges offer prices, mostly in real time (here and now, the chronology is also stored in the exchange database), the question arises about the need for such a mathematical or software apparatus that would forecast the value of non-ferrous metals at least in the short term (up to 10 days). To this end, the article proposes a software package based on an artificial neural network (hereinafter – ANN), the purpose of which will be to predict the cost of non-ferrous metal with acceptable accuracy and relatively small prediction error.

It should be noted that, numerous methods were developed before to use neural networks in modeling the price forecast, which make a prediction of the price rate for a particular economic indicator. The applied methods predict using a classical perceptron and astrological cyclic indices [4], recursive neural networks [5], and/or using elements of mathematical statistics (for example, the use of U-statistics and the coefficient of determination R^2) [6]. Also in works [7-8] the same method is used as in this article, but it is a question of forecasting of a course of the precious metals concerning other specificity of formation of a course of cost.

The purpose of this article is to try to use in the problem of forecasting a model of the neural network that allows you to predict the price of non-ferrous metals in the near future. This attempt is based on a learning algorithm that makes a prediction based on an array of input data and does not depend on the above elements of mathematical statistics. It is expected that such an algorithm will give a forecast as close as possible to the real value.

Methods. We will use a nonlinear autoregressive neural network model (NAR) as ANN. This model makes predictions based on the input time series $y(t)$:

$$y(t) = f(y(t-1), y(t-2), \ldots, y(t-d)), \quad (1)$$

where d is the delay parameter (how many of the first elements of the input series will not be included in the predicted series), f is the function of the neural network that predicts the series.

As an input time series for the neural network, take the prices for aluminum, copper and zinc from the website of the London Metal Exchange (hereinafter – LME) [1-3] at the rate for the period from 16.11.2020 to 9.04.2021 excluding weekends and holidays, as well as days on which LME did not provide new prices. The size of such a time series is 100 values.

Now we use the NAR neural network algorithm to predict the time series of prices for these metals for the next ten days and then compare the value obtained with the true value of the value of metals in the period from 12.04.2021 to 23.04.2021.

Before learning the neural network, we set the delay parameter and the size of the hidden layer of the neural network. The following network learning parameters are also set:

1) Training – what percentage of the input time series will be involved in training (Default – 75%).
2) Validation – what percentage of the time series will be used to generalize the network. If the generalization does not improve, the training is stopped (Default – 15%).
3) Testing – what percentage of the time series will be used to verify the generalization of the network (Default – 15%).

Having set all the necessary parameters, we start learning the neural network. Learning is based on the method of inverse propagation of Bayesian regularization. After training, there is a so-called "closure" (close-looping) of the neural network. Then, the network starts predicting the time series directly.

Results and discussion. The forecasting is carried out with a sufficiently large error. The discrepancy with the real data may be due to the fact that the time series of prices for color does not have a certain mathematical association, and this fact creates complications for ANN in the predicted prices.

The chaos and disorder of this series provides an element of unpredictability and as a result the forecasting process is complicated and deteriorated. Also, this model in contrast to real data does not take into account the human factor, namely the political geopolitical and media influences on the cost of products that come from outside and cannot be taken into account when learning the neural network.

Conclusion. Thus, a new method of forecasting the price of non-ferrous metals using ANN was presented, which uses a nonlinear autoregressive model of the neural network and performs short-term cost forecasting based on training and testing with input data.

This method can be improved in the future by revising the procedure for predicting and testing neural network learning, changing the sample size, learning duration, changing the delay and number of hidden layer neurons, and trying to take into account non-mathematical factors in network learning.

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ПРОГНОЗ ЦІН НА КОЛЬОРОВІ МЕТАЛИ НА ЛОНДОНСЬКІЙ БІРЖІ МЕТАЛІВ ЗА ДОПОМОГОЮ НЕЙРОННОЇ МЕРЕЖІ

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Анотація. Будь-які підприємства, що спеціалізуються на гірничодобувної промисловості, мають справу безпосередньо з різними корисними копалинами, що знаходяться глибоко під товщею земної кори. Серед цих корисних копалин також часто зустрічаються руди кольорових металів, таких як мідь, алюміній, цинк, залізо, титан, і т.п.

Ці руди після етапу видобутку піддаються первинній обробці, далі може йти збагачення, переробка, виплавка самих кольорових металів і їх всіляких сплавів, а також виготовлення різних виробів або сировини, необхідних для використання в інших галузях промисловості. Той чи інший кольоровий метал, або його вироби, грають важливу роль в подальшій ланцюжку процесу виробництва. Готові продукти переробки металу або саме сировину в результаті можуть стати об'єктом імпорту-експорту на міжнародному ринку. Найбільше цікавий ринок самих кольорових металів в силу складності їх видобутку та цінності для промисловості в цілому. Для того, щоб максимально вигідно скуповувати сировину кольорового металу на міжнародній біржі, необхідно знати точну ціну на цей метал в певний момент майбутнього часу, коли вартість металу при покупці буде якомога більш дешевою. Але, оскільки майбутня ціна заздалегідь практично невідома, то виникає необхідність в прогнозі ціни на певний кольоровий метал хоча б у короткостроковій перспективі. У даній статті розроблений програмний апарат, заснований на роботі нейронної мережі, який передбачає ціну на деякі кольорові метали на короткий період майбутнього часу на основі вже існуючих даних про вартість цих металів. Для прикладу роботи нейронної мережі в статті використовуються тимчасової ряд цін заліза, алюмінію і цинку на Лондонській біржі металів, яка має в своєму розпорядженні точних даних з проміжком в 1-3 дні. Запропонований нейромережевий апарат виконує прогнозування вартості на основі алгоритму нелінійної авторегресії із заздалегідь встановленими параметрами нейронної мережі. Розроблений метод прогнозування дозволяє визначати ціну на кольоровий метал з певним ступенем точності для подальшої його закупівлі за вигідною покупцеві ціною.

Ключові слова: прогноз, нейронна мережа, навчання, точність, часовий ряд.

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