УДК 004.853
МРНТИ 28.23.25, 28.23.29

MODELING FORECAST CRYPTOCURRENCY PRICE QUOTES USING NEURAL NETWORKS

AMZE D.

Kazakh British Technical University

Abstract: *In the current conditions of the formation of the cryptocurrency market, studies on modeling forecasts of price quotations are of particular importance. In advanced developed countries, fluctuations in this market are less and less dependent on political influence and the influence of other non-market factors, which confirms the need for objective research in this area. Scientific and methodological developments on this topic can be useful for both legal entities and individuals.*
As a result, the introduction of predictive modeling of cryptocurrency quotes can give a certain economic effect, a specific financial benefit to individuals and legal entities and deserves further study on a more extensive data set.

Key words: *Cryptocurrency, Neural network, Forecasting, Backpropagation neural network*

МОДЕЛИРОВАНИЕ ПРОГНОЗА ЦЕНЫ НА КРИПТОВАЛЮТУ С ИСПОЛЬЗОВАНИЕМ НЕЙРОННЫХ СЕТЕЙ

Аннотация: *В современных условиях формирования рынка криптовалют исследования по моделированию прогнозов ценовых котировок приобретают особое значение.*
Научно-методические разработки по данной теме могут быть полезны как юридическим, так и физическим лицам. В развитых странах колебания на этом рынке все меньше зависят от нерыночных факторов и политического влияния, что подтверждает необходимость объективных исследований в этой области. В результате введение прогнозного моделирования котировок криптовалюты может дать определенный экономический эффект, конкретную финансовую выгоду для физических и юридических лиц и заслуживает дальнейшего изучения более обширного набора данных.

Ключевые слова: *криптовалюта, нейронная сеть, прогнозирование, нейронная сеть обратного распространения*

НЕЙРОНДЫҚ ЖЕЛІЛЕРДІ ҚОЛДАНА ОТЫРЫП КРИПТОВАЛЮТА БАҒАСЫН МОДЕЛЬДЕУ

Аңдатпа: *Криптовалюта нарығының қалыптасуының қазіргі жағдайында, баға ұсыныстарын болжауды модельдеу бойынша зерттеулер ерекше маңызға ие.*
Дамыған елдерде нарықтағы ауытқулар саяси ықпалға және басқа да нарықтық емес факторлардың әсеріне тәуелді емес, бұл осы салада объективті зерттеулердің қажеттілігін растайды. Осы тақырыптағы ғылыми-әдістемелік әзірлемелер заңды және жеке тұлғалар үшін тиімді болуы сөзсіз. Нәтижесінде криптовалютаға баға белгілеулерінің болжамды моделін енгізу жеке және заңды тұлғаларға белгілі бір экономикалық тиімділік, нақты қаржылық пайда әкелуі мүмкін және бұдан да мол мәліметтер жиынтығын зерделеуге лайық.

Түйінді сөздер: *криптовалюта, нейрондық желі, болжау, артқы тарату нейрондық желісі*

Introduction

Despite the rapid growth in popularity today, there is no single, universally recognized definition of cryptocurrencies that would unambiguously reveal their essence and economic nature. To a certain extent, this is due to the novelty of this tool and the variety of technical solutions implemented in electronic settlement systems. So, in the world they treat cryptocurrencies differently, for example, in Canada and the Netherlands - as currency, and in Austria, Finland and Germany - as “commodity” - goods/raw materials. On the Internet, a fairly correct and complete definition of cryptocurrencies is given on Wikipedia, where cryptocurrency is considered as a type of digital currency, emission and accounting of which are based on asymmetric encryption and the use of various cryptographic protection methods, such as Proof-of-work and Proof-of-stake.

However, it is worth noting that the cryptocurrency market is very speculative, but the most stable cryptocurrencies managed to survive due to expectations regarding their growth. Of course, this factor also stands behind the high volatility of the cryptocurrency market. Because of this, new technologies of blockchain or smart contracts are overvalued, while market participants are trying to figure out what crypto assets mean for them - all this leads to an alternation of sharp ups and downs, so familiar to traders.

Forecasting is a complex process, as a result of which it is necessary to solve a large number of different issues. For its production, various forecasting methods should be used in combination.

According to the Russian scientist, Professor A.N. Hunchback with the help of artificial neural networks can solve almost all the problems that can be solved by other methods. Such a conceptual statement is actually the basis of the significant interest that is observed today in the world in the study of the theory and practice of neural network modeling. In favor of the use of neural networks indicate:

– inheritance of certain mechanisms of the brain;
– the possibility of universal approximation of continuous dependencies;
– ability to recover information during the destruction or removal of some part of the neural network;
– parallel processing of information.
– The disadvantages of neural networks include:
– lack of a clear theory and mechanisms for interpreting the functioning and results of work;
– low learning speed and the need to develop algorithms to avoid "paralysis", retraining and getting into local optima;
– the need to select neural network paradigms and develop appropriate formalizations to solve specific problems.

These circumstances are the reason that neural network technologies are quite attractive for the study, research and improvement, as well as the development of systems in which neural networks and other methods are integrated, but their practical application is still quite limited.

Traditional methods for assessing forecast accuracy based on measuring its deviation from real data (for example, calculating MAPE, MSE) do not always allow an adequate assessment of the forecast quality for stock price dynamics (which are characterized by high volatility), since for such data it is more important to determine when there will be growth and when the fall, and most importantly - it is difficult to predict the jumps that separate the stationary periods of change in value from each other.

Backpropagation neural networks are a modern modeling tool that allows you to effectively solve the problems of searching for patterns, forecasting, and qualitative analysis, taking into account these features.

Model description

To build a forecast model, a neural network consisting of three blocks is used (Fig. 1):

1) Input data;
2) computing and analyzing unit;
3) Ouput data.

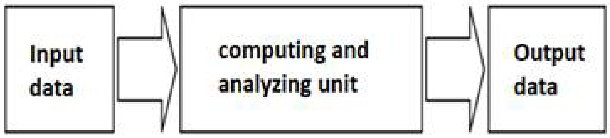


Fig. 1. Block Diagram of a neural network model

In the computational and analyzing unit, all computational, corrective, and analyzing processes for processing the input sample occur. The indicators calculated by the neural network are fed into the output data that the analyst needs to make any decisions..

The network is trained on a sample

$$(X^t, D^t), t = \overline{1, T},$$

where $X^t = x_1^t, x_2^t, \dots, x_n^t$ – examples of input images

$D^t = d_1^t, d_2^t, \dots, d_n^t$ – examples of input images

T – number of input images

When training a neural network, the task is to minimize the objective error function, which is found by the least squares method:

$$E(W, V) = \frac{1}{2}\sum_{k=1}^{p}(y_k - d_k)^2,$$

Где y_k – the obtained real value of the kth output of the neural network when one of the input images of the training sample is fed to it;

d_k – the required (target) value of the k-th output for this image.

Neural network training is performed by the well-known optimization method of gradient descent, i.e. at each iteration, the change in weight is made according to the formulas:

$$w_{ij}^{N+1} = w_{ij}^{N} - \alpha\frac{\partial E}{\partial w_{ij}},\ v_{jk}^{N+1} = v_{jk}^{N} - \alpha\frac{\partial E}{\partial v_{jk}},$$

Where α – learning rate parameter;

N – number of iterations when training a neural network.

The logistic function is usually used as an activation function in a backpropagation network.

$$f(s) = \frac{1}{1+e^{-s}},$$

S – weighted sum of neuron inputs.

This function is convenient for calculations in the gradient method, since it has a simple derivative:

$$f'(s) = \frac{e^{-s}}{(1+e^{-s})^2} = f(s)(1-f(s)).$$

The backpropagation network learning algorithm goes through several stages. First of all, the network is initialized – small random values are assigned to the weighting coefficients - for example, from the range (–0.3, 0.3) the following are set: ε – parameter of learning accuracy, α – parameter of learning speed (usually ≈ 0.1,, and it can still decrease during training) Nmax - the maximum allowable number of iterations.

Then, the current output signal is calculated. In the network input is one of the learning samples and the determined output values of all neurons of the neural network. As the samples used for training the neural network, consisting of values of securities prices, the various numerical characteristics affecting the securities quotes. Then the synaptic balance adjustment operation is performed.

Application of a model for forecasting cryptocurrency quotes using neural networks

To model the forecast, the neural network uses knowledge of the values of quotes for the previous period. For example, analyzing the prices of cryptocurrency for 15 months, the neural network predicts the price for May with a certain degree of probability. Thus, to build a forecast, it is necessary to know the values of quotes of past time periods. To test the neural network model, we used quotes for the XRP Cryptocurrency prices for the period August 31, 2019 to May 31, 2020 (table. 1).

In the table. Figure 1 presents a set of dates and price quotes for each date, which are a training sample of a neural network. The input values of cryptocurrency quotes are the values that are fed to the input of a neural network. Target values are the values that a neural network should aim for in training.

Based on the available data, the network should receive a set of weighting coefficients

Table 1 – Training sample

Input values					
Date	High	Low	Date	High	Low
30.06.2019	0,42918	0,396411	31.07.2019	0,322465	0,317244
31.07.2019	0,322465	0,317244	31.08.2019	0,260507	0,255454
31.08.2019	0,260507	0,255454	30.09.2019	0,260146	0,23832
30.09.2019	0,260146	0,23832	31.10.2019	0,302379	0,290938
31.10.2019	0,302379	0,290938	30.11.2019	0,233615	0,224546
30.11.2019	0,233615	0,224546	31.12.2019	0,194878	0,189969
31.12.2019	0,194878	0,189969	31.01.2020	0,244273	0,234905
31.01.2020	0,244273	0,234905	29.02.2020	0,241962	0,231193
29.02.2020	0,241962	0,231193	31.03.2020	0,177883	0,171549
31.03.2020	0,177883	0,171549	30.04.2020	0,235703	0,211577

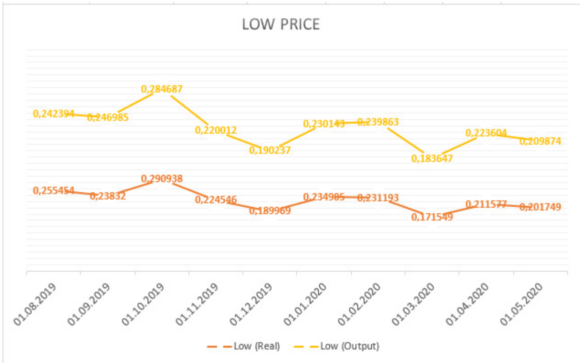
reflecting the dependence of changes in quotations for the specified period.

The error between the real and the obtained values of the neural network is 0.01. If the difference between the real value and the value at the output is less, then the training stops. However, if this accuracy is not achieved, the limit on the duration of training is the threshold of 15,000 iterations.

To check the accuracy of training, it is necessary to input the values of the training sample. After analyzing them, the neural network should produce output values that are close to real. The success of training can be judged by the degree of difference, predicted and real values of quotes. The values given in the table. 2, show that the degree of difference is small, this indicates a small error and successful training of the network.

Table 2 – Neural network output values for the predicted sample

Neural network training data						Real value			Neural network output	
Date	High	Low	Date	High	Low	Date	High	Low	High	Low
30.06.2019	0,42918	0,396411	31.07.2019	0,322465	0,31724	31.08.2019	0,26051	0,25545	0,256397	0,242394
31.07.2019	0,322465	0,317244	31.08.2019	0,260507	0,25545	30.09.2019	0,26015	0,23832	0,253697	0,246985
31.08.2019	0,260507	0,255454	30.09.2019	0,260146	0,23832	31.10.2019	0,30238	0,29094	0,325871	0,284687
30.09.2019	0,260146	0,23832	31.10.2019	0,302379	0,29094	30.11.2019	0,23362	0,22455	0,245369	0,220012
31.10.2019	0,302379	0,290938	30.11.2019	0,233615	0,22455	31.12.2019	0,19488	0,18997	0,203645	0,190237
30.11.2019	0,233615	0,224546	31.12.2019	0,194878	0,18997	31.01.2020	0,24427	0,23491	0,236901	0,230143
31.12.2019	0,194878	0,189969	31.01.2020	0,244273	0,23491	29.02.2020	0,24196	0,23119	0,245143	0,239863
31.01.2020	0,244273	0,234905	29.02.2020	0,241962	0,23119	31.03.2020	0,17788	0,17155	0,19364	0,183647
29.02.2020	0,241962	0,231193	31.03.2020	0,177883	0,17155	30.04.2020	0,2357	0,21158	0,248702	0,223604
31.03.2020	0,177883	0,171549	30.04.2020	0,235703	0,21158	31.05.2020	0,21152	0,20175	0,226893	0,209874



To visually reflect the dependencies of the real value and the value at the output of the neural network, we construct using the Excel package: the X axis is the time interval, the Y axis is the value of the crypto-quote price (Fig. 3, 4).

A histogram of real quotes and quotes at the output of a neural network for high and low prices

The histogram shows not only the proximity of the real value and the value at the output of the neural network, but also the direction of the change in values - with an increase or decrease in the real value of the output of the neural network, they change in the same direction by the same order.

Now we estimate the accuracy of the forecast. To do this, we will choose other dates for the periods of the training sample, the periods of the value of quotes, which we will send to the input of the neural network. Having received a certain value at the output, we can numerically evaluate the accuracy of forecasting

Denote the real value of the crytocurrency quote by P, and the value obtained at the output of the neural network, by P`. Then, for each date, the absolute and relative errors are representable as a set of values presented in the table. 3

The absolute forecast error is determined by the formula: $\Delta = | P - P' |$

The relative forecasting error e is determined by the formula : $\varepsilon = \frac{\Delta}{P}.$

The average value of the relative error for n quotation values is determined as follows:

$$\bar{\varepsilon} = \frac{\sum \varepsilon}{n}.$$

Table 3 – Absolute error in predicting cryptocurrency quotes

Date	ERROR	
	Absolute	
	high	low
15.08.2019	0,00411	0,01306
15.09.2019	0,006449	0,008665
15.10.2019	0,023492	0,006251
15.11.2019	0,011754	0,004534
15.12.2019	0,008767	0,000268
15.01.2020	0,007372	0,004762
15.02.2020	0,003181	0,00867
15.03.2020	0,015757	0,012098
15.04.2020	0,012999	0,012027
15.05.2020	0,015374	0,008125

Table 4 – Cryptocurrency Sales for the period from 30.06.2019 to 31.05.2020

Data	Объем продаж
30.06.2019	1570726856
31.07.2019	996700948
31.08.2019	845142390
30.09.2019	1662002376
31.10.2019	1666132252
30.11.2019	1160032623
31.12.2019	1116761074
31.01.2020	1892170751
29.02.2020	2061348763
31.03.2020	2101862049
30.04.2020	3145263526
31.05.2020	1683149544

The weighted average value of the relative error for n quotation values can be determined by the following formula:

$$\overline{\varepsilon_Q} = \frac{\sum Q \cdot \varepsilon}{\sum Q},$$

where Q is the sales volume (Table 4) for each cryptocurrency for the specified date.

Having thus calculated the average and weighted average values of quotations of securities, we have:

$$\bar{\varepsilon} = 0{,}04733$$

$$\overline{\varepsilon_Q} = 0{,}10546$$

The accuracy of the measurement result is a characteristic of the quality of the measurement, reflecting the proximity to zero of the error of its result. Since the most pronounced correlation indicators of quotation changes are the average and weighted average values of the relative error, we can conclude that the error of forecasting results is 0.076.

Conclusion

The success of training can be judged by the degree of difference between the predicted and real values of quotes. The whole system was tested on other cryptocurrencies, as a result, the error was high, since backpropagation was more suitable for predicting patterns, and it was necessary to retrain the model for each currency separately.

In conclusion, the results obtained show that the use of a neural network model increases the economic efficiency of forecasting for stable currencies, while ensuring the reliability of information with a certain degree of forecast probability necessary for making informed economic decisions. This will allow you to get no big profit in the short term on time-stable cryptocurrencies.

Nowadays, making a profit in the short term with minimal risks is more effective than in the long term with big risks

Thus, the use of a system of economic and mathematical models of neural networks and the corresponding tools is a very effective tool for the practical solution of the urgent task of modeling the forecasting of cryptocurrency price quotes.

REFERENCES

1. Wassermen F. Neurocomputer technology: theory and practice. M .: Mir, 1992.
2. Kashirina I.L. Artificial neural networks. Tutorial. Voronezh: Publishing House of Voronezh State University, 2005.
3. Short S. Neural networks: backpropagation algorithm (http://www.gotai.net/download/filenn003.zip)
4. Introduction to counter distribution networks (http://www.intuit.ru/department/ds/neuronnets/6/)