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COMBINED CLUSTER-NEURAL NETWORK APPROACH TO DETERMINISTIC AND PROBABILISTIC PROPERTY VALUATION

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The purpose of the publication is to substantiate the usage of combined approach, which unites artificial neural networks and clusterization principles and to develop the overall structural model of the artificial networks for the assets valuation applications. We aim to compare this approach with existing algorithms of solving such tasks and to substantiate its efficiency in deterministic and probability ranged valuation of real estate and other types of assets.

Assets valuation usually accounts for many factors affecting their value. Their number is large enough reaching normally several dozens [1,2].

These determines reasonable uncertainty and probabilistic character of property valuation in general since finding out the real effect of each influencing factor especially in cases of their interrelations is a complicated problem [3]. In its turn as it is demonstrated through the conducted analysis this leads to low efficiency of classical methods of multi-factor regression analysis (MFRA) utilization for the purposes of assets cost valuation.

Apart of multi-factor regression analysis, one of the promising approach for the efficient solving of existing problems in probabilistic cost estimation of property cost is the neural network application [4]. This approach does not require any analytical model of the process because neural network does the modelling by itself including nonlinear processes. Important advantage of the neural networks is also their capability of self-training which gives them ability of adaptation to changes in the process and tolerance to the statistical noise.

We use the universal neural network model [5, c. 7] as specified below:

$$y(t) = \sum_{j=1}^{m} w_j x_j(t)$$

$$\frac{du}{dt} = -\alpha_1 u(t) + \beta_1 y(t)$$

$$\frac{d\theta}{dt} = -\alpha_2 \theta(t) + \alpha_2 \theta_0 + \beta_2 x(t) + \beta_3 u(t)$$

$$x(t) = F(u, \theta, y, t)$$

where $y(t)$ is the general output signal of a neuron , $u(t)$ – its membrane potential, $\theta(t)$ – the threshold for response, $x(t)$ – output signal. All the other coefficients are constant values between 0 and 1, which specify the behavior of a neuron:

- α_1 – inertia of the neuron membrane potential;
- β_1 – inertia of the spatial summation of the input signals;
- α_2 – dynamic coefficient of a neuron threshold adjustment;
- β_2 – coefficient of a threshold adjustment by input signal;
- β_3 – of a neuron threshold adjustment by membrane potential.

At the same time as demonstrated by the research performed, artificial neural networks performance can be improved by using multi-layer networks with various combination of networks type. After preliminary analysis combination of multi-layer perceptron and Hamming, Kohonen and Hopfield networks was proposed.

On the other side for the purpose of real-estate valuation preliminary geographical clusterization is also useful [5]. One of the basic algorithms for that is the so called k-means approach. It is also demonstrated that k-means approach can be used not only for determination of mean values but also for range assessment.

Based on these preliminary results and comparative analysis conducted, a combined cluster-neural network approach is proposed for different assets price valuation. Methodology of comparative calculations based on different approached indicated above is described. The open data from US and Ukraine real estate resources was used as the dataset for analysis. The learning dataset contained 35 000 real estate objects and testing dataset contained approximately 2500 objects.

Any processing of large amount of heterogeneous statistical information has a problem of identifying and extracting obviously false elements from the dataset. Mathematical statistics propose a wide range of criteria and approaches for processing statistical noise, including one of the most common Mahalanobis criteria, which were developed for regression models. Hence, they contain parameters that are related to the structure of these models, which makes it impossible to use them in the described model. Therefore, more general Chauvenet's criterion is used for detecting statistical outliers. Critical value of this criterion corresponds to a probability level close to 95%, or the 2 standard deviations of the dataset.

Two simple metrics are used to evaluate effectiveness of the algorithms mentioned above. The first one is average absolute error and the second one is average absolute error in percent.

The results of testing for single price case are presented in a Table below.

The conducted comparative calculations demonstrated that the proposed approach with two-layer neural network considerably exceeds corresponding results of k-means algorithm. Within the learning dataset the accuracy meets the given values and the price ranges are on average 48% smaller for different probability levels.

Table1. Price assessment comparison for specified algorithms.

Algorithm	Learning dataset		Test dataset	
	Error, $	Error, %	Error, $	Error, %
N100	164.375	30.920	167.680	29.975
K400	152.774	27.621	159.818	27.089
G40/10	151.188	27.181	154.489	26.627

Such combined cluster-neural networks approach, which gives more reliable results with probability related range of property cost as demonstrated in the research conducted, is recommended for calculation of assets market values both in deterministic and probabilistic applications.

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