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Opinion

Use of Artificial Intelligence to Increase the Credibility of Biodiversity Assessment

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Abstract

The paper discussed the basic principles for assessing the biodiversity of ecological systems using artificial intelligence technologies based on neural networks. The use of neural networks for assessing biodiversity makes it possible to increase the credibility of the assessment, and, unlike existing mathematical models for assessing biodiversity, allows using a larger number of parameters, including human anthropogenic activity. In the forthcoming future, neural networks will facilitate decision support systems for adjusting human economic activities to preserve biodiversity.

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Opinion

The value of biodiversity both within a species and within a biosystem is one of the main indicators of the viability of a species and an ecosystem. In recent decades, the problem of biodiversity conservation has become one of the central issues in considering environmental and economic changes at the global, national, and local levels, as there is a decrease in the potential for sustaining life and economic activity. The conservation of certain types of bioresources at the local level has an impact on the situation in other regions. Despite a significant shift in the study of the relationship between economic activity and the preservation of the natural environment, the deterioration of the ecological situation continues in the last two decades, which leads to the degradation of biological diversity. In such conditions, it is relevant to increase the credibility of existing and introduce new quantitative assessments of the biodiversity of ecosystems, allowing to draw objective conclusions about the state of the biosystem at the current moment, as well as to predict the development of biosystems, considering external influences. This will allow to adjust the economic activity, considering the need to preserve species richness. So far, quantitative indices that allow for a quantitative assessment of the biodiversity of an ecosystem are the Shannon diversity, Pielou and Simpson indices [1]. These indices are calculated based on the dispersion and entropy formulas, which take as parameters the number of all relationships between pairs of individuals, regardless of their belonging to a particular taxon. Among the quantitative assessments of biodiversity, we can furthermore name the Theil, Berger-Parker, Gini, and McIntosh indices. These indices, as well as the forecast of the changes, can be obtained using currently widely used artificial intelligence methods based on neural networks. Neural networks will improve the objectivity of these assessments, since their use allows taking into account the influence of external factors on the quantitative assessment of biodiversity, and the result gained at the output of the neural network does not depend on the type of distribution of data supplied to its input, unlike most machine learning algorithms, in which work is based on the hypothesis of the normal distribution of the data under study, which is not always the case in practice. A quantitative assessment of biodiversity using a neural network is based on the methodology described below:

a) Forming the training database.

b) Identifying significant features.

c) Rationing.

d) Training a sequential neural network using the method of error back propagation algorithm and choosing quasi-optimal neural network parameters.

e) Using a trained neural network to quantify biodiversity, as well as to predict the sustainability of an ecosystem, considering changes of external factors.

Forming the training database

At this stage, it is supposed to draw up a pool that includes the most possible number of parameters characterizing the ecosystem. The created data bank may include quantitative indicators of human activity, climatic conditions, astronomical phenomena. Data must be presented for a specific time period. The longer this time interval is, the better it will be possible to train the neural network for the quantitative assessment of biodiversity in the future.

Identifying significant features

As a rule, the initial sample always contains a lot of 'garbage data': noise, outliers, and only a few predictors affect the real result [2]. For the selection of significant features, methods based on probability theory and statistical approaches can be used. The most popular in this group of methods are IG-indexing (calculation of information gain), chi-square (chi-square) and mRmR, which allow ranking features by significance, assessing the degree of correlation of each of them with the target variable [3]. Further, the machine learning model uses only those predictors that meet certain criteria.

Rationing

Significant features identified at the pre-processing stage have a wide range of values. However, to train the neural network, the input data must lie in the range from -1 to 1. Otherwise, the neural network will not be trained. Therefore, the next step of the proposed methodology is to change the dynamic range of the input data to the interval from -1 to 1. Min-max normalization is used, which is expressed by the formula:

$$X' = \frac{2(X - X_{\min})}{X_{\max} - X_{\min}} + 1$$

where X- current value, X_{min} - minimum value, X_{max}- maximum value.

Training a serial neural network using the error backpropagation algorithm and choosing quasi-optimal neural network parameters

Serial neural network is a device for parallel processing of information, consisting of artificial neurons. Artificial neurons are combined into layers, each neuron from the current layer is connected to all neurons from the previous layer. Each connection between neurons has its own weight value. The training of the neural network encompasses selecting such values of the weight values of the neuron connection coefficients, in which the neural network optimally performs its task. The training of a sequential neural network is done using the error backpropagation algorithm, which corrects the values of the weight coefficients of neurons, minimizing the error at the output of the neural network [4]. Sequential neural networks are characterized by significant scatter in their parameters, such as the number of layers and the number of neurons in these layers. At the same time, there is no methodology for selecting the optimal parameters of the neural network, so these parameters are set empirically. It is necessary to investigate the performance of sequential neural networks with a different number of layers and a different number of neurons in layers in order to identify quasi-optimal parameters of the neural network.

Using a trained neural network to quantify biodiversity, as well as to predict the sustainability of an ecosystem, considering changes of external factors

Further, the trained neural network is used to assess the biodiversity of various ecosystems. For this purpose, significant features that affect biodiversity are submitted to its input. In addition, a trained neural network is used to predict the biodiversity of an ecosystem depending on changes in traits that affect its biodiversity. All this will make it possible to adjust human economic activity in order to preserve biodiversity.

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