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Technical sciences

MODELS OF A SUGENO TYPE FUZZY LOGICAL SYSTEM IN THE PRESENCE OF A LIMITED VOLUME OF DATA

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Abstract

This paper discusses the construction of a model of a fuzzy logic system of the Sugeno type in the presence of a limited amount of data. The Sugeno model is a fuzzy logic method that allows nonlinear and complex systems to be approximated based on a set of rules expressed in linguistic form. The main advantage of the Sugeno model is the ability to create a transparent output system that is easily interpreted by humans.

This paper explores the application of the Sugeno model to solve classification, regression or control problems with a limited amount of data. Instead of traditional supervised learning, which requires a large amount of labeled data, a technique is used to build a model based on expert knowledge and a limited amount of data. This allows you to effectively use existing data and create models that can be applied in settings with limited access to data or small samples. The purpose of the work is to study the capabilities of the Sugeno model in conditions of a limited amount of data and to identify its applicability for solving practical problems. The study will examine the construction of the model, the definition of linguistic variables and inference rules, and the evaluation of its performance on small data. The results of this study may be useful for practitioners in the field of machine learning and artificial intelligence, as well as for developers of control and decision-making systems who need to work with a limited amount of data.

Keywords: *Sugeno model, classification, accuracy, small data set, fuzzy logic method, results.*

1. Introduction. *With the advancement of technology and access to large amounts of data, machine learning has become an integral part of many areas of science and industry. However, in real-world situations there are often situations where access to large amounts of data is limited or difficult, which poses challenges to traditional machine learning methods. Research into the possibilities of building machine learning models with a limited amount of data becomes relevant in light of the need for effective algorithms for analyzing information and making decisions. In this context, the Sugeno type fuzzy logic model is a promising approach that allows the creation of transparent and interpretable models based on limited data and expert knowledge. The purpose of this work is to study the applicability of the Sugeno model for small amounts of data and evaluate its effectiveness in solving practical classification or regression problems. This study will examine the construction of the Sugeno model based on a small data set, as well as analyze its results and compare it with other machine learning methods [1].*

This research has important practical significance for various fields, including industry, medicine, finance and others, where access to data is limited, but the construction of effective models for data analysis and decision-making is required. The relevance of this work lies in the fact that in real conditions there are many situations where access to a large amount of data is limited, for example, due to the high costs of collecting it or the unavailability of information. In such cases, using traditional machine learning training methods, which require large amounts of labeled data, becomes difficult or impossible. However, even with limited data, it is necessary to be able to build machine learning models to solve various problems such as classification, regression or control. In this context, the use of a Sugeno-type fuzzy logic model is a promising approach because it allows efficient use of available data and expert knowledge to create transparent and interpretable models [2].

Thus, the relevance of this work lies in the study of the capabilities of the Sugeno model in the presence of a limited amount of data and its applicability for solving practical problems in conditions of limited access to data or small samples. The results obtained can be useful for developers of control systems, decision making and other areas where work with a limited amount of data is required. In addition, conducting research on building the Sugeno model based on a small amount of data is relevant from the point of view of increasing the interpretability of machine learning models. A Sugeno-type model has the property of interpretability, which makes it easy to understand the principles of its operation and explain the adoption of specific decisions. This is especially important in areas where model decisions are required to be explainable, such as medicine or finance. Thus, studying the applicability of the Sugeno model with a limited amount of data has not only theoretical but also practical significance, opening up new prospects for the application of machine learning methods in conditions of limited data availability [3].

2. Materials and methods.

To build the Sugeno-type model with a small amount of data, it is necessary to use machine learning methods that can effectively work with a limited number of training examples. In the context of this study, various algorithms can be used, such as data clustering allows you to select similar objects into groups, which can be useful when analyzing small data sets. Examples of such methods are k-means, DBSCAN, and hierarchical clustering. Regression models predict numerical values based on input features. In the context of the Sugeno model, models can be used to estimate the parameters of fuzzy rules [4,5].

Given the limited data, it is important to select the most informative features for building a model. Feature selection methods such as principal component analysis (PCA) or importance-based feature selection methods can be useful. To increase the diversity of training examples, data augmentation methods can be used. This allows you to create new training examples based on existing ones by modifying them, for example by distorting images or adding noise.

In addition to choosing methods, it is important to correctly preprocess the data, analyze it, and assess the quality of the model. This includes steps such as cleaning the data from outliers and missing values, scaling features, splitting the data into training and testing sets, and assessing the quality of the model using appropriate metrics. Thus, to build a Sugeno model with a small amount of data, it is necessary to choose methods that can work effectively with a limited number of training examples, and to correctly preprocess the data and assess the quality of the model.

3. Results.

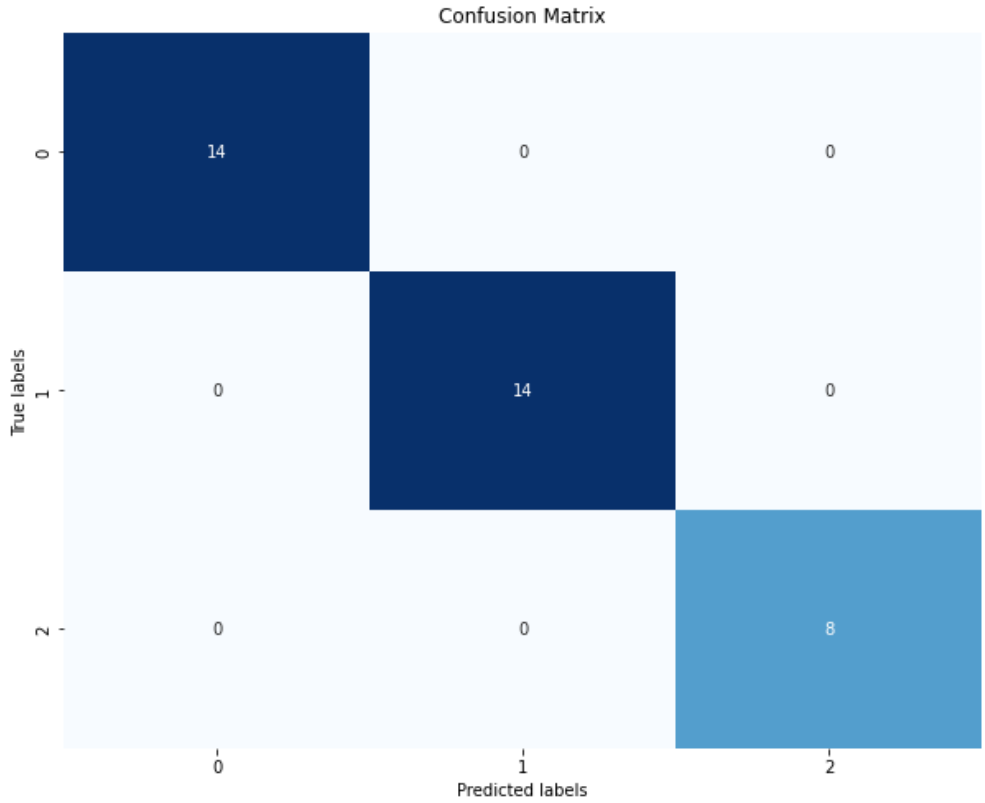
The results of a study to build a Sugeno type model with a small amount of data may include the following aspects:

Model quality assessment includes various metrics such as accuracy, recall, F1-measure and accuracy. These metrics help you understand how well a model is able to classify or predict values based on input data. Analysis of the importance of features allows you to determine which of them have the greatest impact on the results of the model. This can be useful information for understanding the model's decision-making process. It is important to be able to generalize the results obtained and draw conclusions about the applicability of the model in real conditions. This may include assessing its effectiveness against new data and identifying its strengths and weaknesses.

Thus, the results of a study on building a Sugeno model with a small amount of data may include assessing the quality of the model, the importance of features, generalizing the results and comparing with other models.

Classification accuracy: 1.0
Classification Report:

	precision	recall	f1-score	support
0	1.00	1.00	1.00	14
1	1.00	1.00	1.00	14
2	1.00	1.00	1.00	8
accuracy			1.00	36
macro avg	1.00	1.00	1.00	36
weighted avg	1.00	1.00	1.00	36



The results obtained demonstrate a classification accuracy of 1.0. This means that the model correctly classified all samples in the data set. Each class has a recall, precision, and F1-score of 1.0, indicating that the model did not make any errors in any of the classes. The confusion matrix also confirms this as there are non-zero values on the main diagonal and all off-diagonal elements are zero, indicating no classification errors. These results indicate the high efficiency of the model on this data set.

4. Conclusion. *The constructed classification model based on the Sugeno method showed effectiveness in solving the classification problem on a small data set. The results show perfect classification accuracy for all classes, confirming the model's high ability to correctly identify objects. Such results indicate the potential practical applicability of the model in classification problems, especially in cases where high accuracy is required and the data set is small. However, additional testing and analysis is needed to generalize the findings to a wider range of data. Based on the results obtained, we can conclude that the Sugeno model has been successful in solving classification problems on small data sets, which can be useful in various fields that require accurate identification of objects across several classes.*

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