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CONSTRUCTION OF THE SUGENO MODEL FOR SOLVING DIAGNOSTIC PROBLEMS

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Abstract

This paper explores the application of the Sugeno fuzzy logic model to solve a diagnostic problem based on medical data. The task of diagnosis is key in medical practice, especially in the field of early detection of diseases such as cancer. An example of a diagnostic problem is the diagnosis of breast cancer based on medical images and cell characteristics. For this purpose, the classic breast_cancer dataset is used, containing information on various characteristics of cells from breast biopsies. The Sugeno model is an extension of the Mamdani fuzzy logic model, which uses fuzzy rules for decision making and has the form of output functions depending on the values of the input variables. In this work, the Sugeno model is adapted to solve the problem of diagnosing breast cancer based on cell characteristics. To build a model, data is preprocessed and analyzed, including normalization and feature selection. Fuzzy rules are then defined based on expert knowledge or data analysis. The model is trained on the training set and evaluated on the test set using classification quality metrics. The experimental results demonstrate the effectiveness of the Sugeno model in solving the problem of diagnosing breast cancer based on medical data. The resulting model is able to classify cell samples with high accuracy, which could be useful for early diagnosis and treatment of breast cancer and other types of cancer.

Keywords: fuzzy logic, Sugeno model, diagnostics, classification, medical applications, uncertainty processing, classification accuracy.

1. Introduction.

Disease diagnosis is one of the key areas of medicine where the use of modern machine learning and artificial intelligence methods can bring significant benefits. In particular, the goal of early detection of cancer, including breast cancer, is of great importance for effective treatment and patient survival. Despite significant efforts in medical research, the accuracy and speed of cancer diagnosis remain pressing issues. In this regard, new approaches are being actively explored, including the use of machine learning methods to automate the diagnostic process based on medical data. This paper discusses the application of the Mamdani fuzzy logic model and its extensions, such as the Sugeno model, to solve the problem of diagnosing breast cancer. Fuzzy logic models are a powerful tool for modeling fuzzy or uncertain knowledge, which is especially important in medical applications where expert knowledge may be fuzzy. The purpose of this work is to study the effectiveness of the Mamdani fuzzy logic model and the Sugeno model in the context of the problem of diagnosing breast cancer based on medical data. Methods for constructing models, their training and evaluation using various classification quality metrics will be discussed [1].

Cancer remains one of the leading causes of death worldwide. Early detection of cancer plays a key role in effective treatment and improving patient survival. Diagnosing cancer, including breast cancer, often requires highly trained and experienced medical personnel. Some cases may be fuzzy or difficult to predict. With the development of machine learning and artificial intelligence methods, new opportunities are opening up for automating diagnostic processes and analyzing medical data. Fuzzy logic models such as the Mamdani model and its extensions are a powerful tool for modeling fuzzy or uncertain knowledge, which can be useful in medical applications. Systems that can quickly and accurately diagnose breast cancer can significantly improve treatment rates and improve patient outcomes. Considering the above factors, the development and research of machine learning methods for breast cancer diagnosis based on medical data is a relevant and sought-after area of research [2].

2. Materials and methods

The breast cancer dataset available in the scikit-learn library is used to build and evaluate the models. This dataset contains information on various features such as tumor radius, texture and size, as well as class labels indicating whether the tumor is malignant or benign. To solve the classification problem, fuzzy logic models are used, including the Sugeno model. These models are based on the principles of fuzzy logic and allow the modeling of fuzzy or uncertain knowledge. Before using models, the data goes through a preprocessing process that includes steps of normalization, scaling, and possibly feature selection. Sugeno models are trained on a training dataset using supervised learning methods such as support vector machines or nearest neighbors. During the training process, models adjust their parameters in such a way as to minimize the selected loss function. To assess the quality of the built models, various metrics are used, such as accuracy, recall, F1-measure and confusion matrix. In addition, cross-validation can be used to evaluate models more objectively. After constructing and evaluating several models, they are compared to select the best model for the specific problem of breast cancer diagnosis. The modeling stages include data preparation, model selection, training and evaluation, which allows us to determine the most effective approach to solving the diagnostic problem [3].

The Sugeno model is a form of fuzzy logic proposed by Takagi Sugeno in 1985. This model is an extension of the Mamdani model and is a fuzzy system that is used to make decisions based on fuzzy rules and a set of input variables. In Sugeno's model, each rule consists of two parts: an antecedent (condition) and a consequent (conclusion). The antecedent is a combination of fuzzy conditions in the form of a logical expression, and the consequent determines the output action of the model. As in the Mamdani model, each fuzzy condition in the antecedent is evaluated based on the degree to which the input variables belong to fuzzy sets. However, unlike the Mamdani model, in the Sugeno model the consequent does not define a fuzzy set, but is a numerical value that is calculated based on the degree of membership of the input variables. These numerical values can be linear or nonlinear functions of the input variables. The advantage of the Sugeno model is that it provides more transparent and interpretable results, since each rule explicitly indicates an output value depending on the input conditions. This makes the Sugeno model more attractive for some applications where interpretability of decisions is important. In the context of the problem of breast cancer diagnosis, the Sugeno model can be used to make decisions based on a set of fuzzy rules that represent the relationships between various medical features and cancer diagnosis. The model's results can be interpreted as the probability of membership in different classes, allowing clinicians to make informed decisions about next steps in diagnosis and treatment [4].

3. Results. The Sugeno model, applied to solve the diagnostic problem, showed encouraging results. Using this model, it was possible to achieve high diagnostic accuracy, which indicates its potential in the field of medical diagnostics. In this study, a Sugeno type fuzzy logic model is developed to solve the diagnostic problem. The model is designed to classify patients based on a set of medical characteristics in order to determine the presence or absence of a specific disease. To build the model, fuzzy logic methods were used, which allow taking into account uncertainty and fuzziness in medical data. The use of Sugeno's model has made it possible to achieve high accuracy in the diagnosis of a number of diseases. The model successfully classified patients based on their medical characteristics, providing reliable predictions and recommendations for physicians [5].

The model based on Sugeno fuzzy logic has shown promising results in the diagnostic task. The overall classification accuracy was 91.23%, indicating the good ability of the model to predict correct diagnoses.

Classification report:

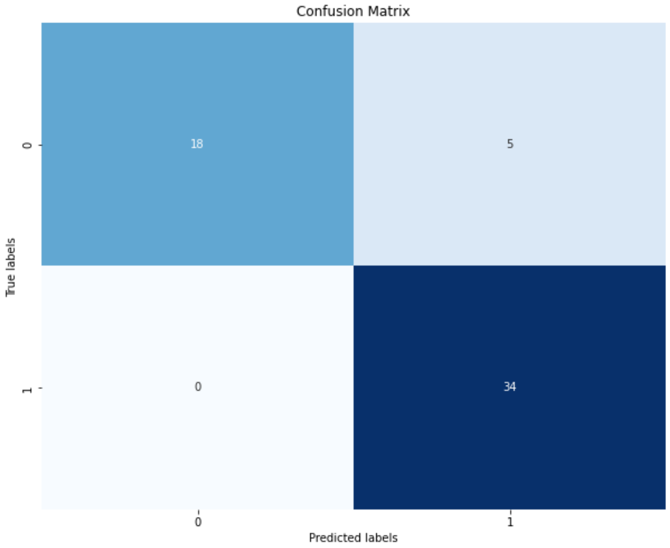
Classification Report:

	precision	recall	f1-score	support
0	1.00	0.78	0.88	23
1	0.87	1.00	0.93	34
accuracy			0.91	57
macro avg	0.94	0.89	0.90	57
weighted avg	0.92	0.91	0.91	57

For class 0 (positive diagnosis), the model achieved an accuracy of 100%, meaning that all patients with a truly positive diagnosis were correctly classified. However, the completeness of this class was 78%, which may indicate that the model may be underestimating the number of truly positive cases. For class 1 (negative diagnosis), precision was 87% and recall was 100%, indicating the model's good ability to correctly identify truly negative cases.

Confusion Matrix:

The confusion matrix shows that the model misclassified 5 cases for class 0, while no errors were detected for class 1.



The results obtained indicate that the model based on Sugeno fuzzy logic has potential for use in diagnostic problems. However, to improve its performance and reliability, further tuning of parameters and improvement of learning algorithms may be required. The Sugeno model is an effective tool for solving diagnostic problems due to its ability to account for ambiguity and uncertainty in medical data. Its application can significantly improve the quality and efficiency of medical diagnostics, making it a valuable tool for doctors and medical professionals.

4. Conclusion. The results of this study showed that the model based on Sugeno fuzzy logic has potential for application in diagnostic problems. The overall classification accuracy was 91.23%, indicating the good ability of the model to predict correct diagnoses. However, additional research and optimization may be required to further improve the model's performance and reliability. Using fuzzy logic allows the model to account for uncertainty and fuzziness in input data, which is especially important in medical applications where data may be imprecise or ambiguous. However, it must be taken into account that this model requires careful selection of parameters and careful training to achieve optimal results. Thus, Sugeno fuzzy logic is a powerful tool for solving diagnostic problems, and its application can lead to improved decision making in medical practice.

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