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Optimization of AutoML arrhythmia detection model based on genetic algorithm

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ABSTRACT

Arrhythmia, as a serious heart disease, often causes harm to people's quality of life and life safety. Therefore, accurately and quickly. This paper focuses on the optimization of AutoML arrhythmia detection model based on genetic algorithm. First, by collecting a large amount of ECG data as training and test samples, and then using automated machine learning (AutoML) technology, the automated construction and optimization of the arrhythmia detection model were realized. Based on this, the genetic algorithm carefully adjusts the parameters of the model and optimizes the performance of the model. The experimental results show that the model provided by this method has high accuracy and high stability in arrhythmia detection, which greatly improves the efficiency and accuracy of arrhythmia identification, while reducing the probability of misdiagnosis. In addition, the model not only simplifies the model building process and improves the work efficiency, but also has a strong generalization performance, which can be applied to the identification and prediction of other similar diseases. Therefore, this study has important clinical value for cardiology diagnosis, especially the early detection and early warning of arrhythmia.

KEYWORDS

genetic algorithm; AutoML; arrhythmias; model optimization; disease recognition

Globally, heart disease is regarded as one of the main causes of death, among them, arrhythmia is a more serious disease, which seriously affects the quality of life and life safety of patients. According to the World Health Organization, millions of sudden deaths due to arrhythmia occur worldwide each year. Therefore, how to accurately and quickly identify the arrhythmia is of great significance to save the lives of patients and improve the quality of life. However, traditional arrhythmia identification methods have a cumbersome process and risk of misdiagnosis. In this context, the emergence of machine learning technology provides a new solution for the identification of arrhythmia. In particular, automated machine learning (AutoML) technology can realize the automatic construction and optimization of the model, significantly improving the work efficiency. The AutoML arrhythmia detection model based on the genetic algorithm will be explored deeply. It can not only automatically construct and optimize the arrhythmia recognition model, but also make full use of the global search ability of the genetic algorithm to carefully adjust the parameters of the model, so as to optimize the performance of the model. The experimental results show that it shows high accuracy and high stability in arrhythmia detection, which significantly improves the identification efficiency and accuracy, and greatly reduces the probability of misdiagnosis. This study has important clinical value in the diagnosis of heart disease, especially the early detection and early warning of arrhythmia.

1 Identification and detection of cardiac arrhythmias

1.1 Basic knowledge and detection methods of cardiac arrhythmia

Arrhythmia is a symptom of cardiac rhythm disturbance due to abnormal electrical activity of the heart[1]. Various types, including atrial fibrillation, supraventricular tachycardia, preventricular contraction, each type of different pathogenesis and clinical manifestations. Arrhythmias can cause serious health problems, such as heart failure, stroke and sudden death, and timely and accurate detection and identification is crucial.

The detection methods of arrhythmia are mainly divided into two categories: traditional methods and modern methods. Traditional methods include electrocardiogram (ECG) detection, Holter electrocardiogram (Holter) monitoring, and electrophysiological examination[2]. Among them, electrocardiogram is the most basic and the most commonly used arrhythmia detection means, by recording the waveform of cardiac electrical activity to judge the regularity and stability of the heart rhythm. Holter Monitoring detects the occurrence of intermittent or transient arrhythmia. Electrophysiological examination evoked and recorded intracardiac electrical activity directly through the electrode catheter to determine the lesion location and abnormal electrical conduction pathway.

Modern detection methods mainly rely on the development of computer technology and artificial intelligence technology. Technologies such as automated machine learning (AutoML) and deep learning provide new paths for arrhythmia detection. AutoML Technology can automate feature selection, model building and parameter optimization, significantly improving model performance. Combined with a large amount of ECG data, machine learning models can identify complex ECG features to enable high-precision arrhythmia detection. For example, the convolutional neural network (CNN) shows a strong feature extraction ability in arrhythmia detection, and improves its generalization performance and accuracy through a large amount of training data.

The core objective of both traditional and modern methods is to improve the accuracy and timeliness of arrhythmia detection. With the continuous progress of artificial intelligence technology and the abundance of data resources, the arrhythmia detection method will be more efficient and intelligent, providing strong support for clinical diagnosis.

1.2 ECG data collection and analysis

Acquisition of ECG data is an important prerequisite for arrhythmia detection. High-quality ECG data directly affects the accuracy and stability of the detection model.

Typically, ECG data are collected through ECG machines or wearable devices that continuously monitor and record the electrical activity of the heart.

The collection process of data requires strict control of experimental conditions, such as sample collection frequency, time interval and measurement environment, to ensure the accuracy and consistency of the data.

For data analysis, preprocessing of raw ECG data, including noise filtering, baseline drift correction and ECG signal standardization, are needed to remove interference factors and ensure the quality of the data. On this basis, key features, such as P wave, QRS wave and T wave amplitude and time interval, which are crucial for arrhythmia identification.

Dedicated software tools or algorithms are used to analyze the extracted features, to form training and test samples, and to provide the basic data for the construction of automated machine learning (AutoML) models. In this way, the model can accurately reflect the ECG data characteristics, and effectively improve the performance and reliability of arrhythmia detection.

1.3 Identification challenges of cardiac arrhythmias and research status

Identification of cardiac arrhythmias faces multiple challenges. Different types of arrhythmias are highly variable in ECG performance, making automated identification more difficult. ECG data usually contain a amounts of noise and artifacts, further increasing the difficulty of accurate detection by the model. Most of the existing studies have focused on improving the sensitivity and specificity of the model, but still have deficiencies in the efficient processing of large-scale data and real-time analysis. In recent years, with the development of deep learning and machine learning techniques, more and more research studies have tried to improve the recognition performance and generalization ability of models by introducing AutoML technology and combining optimization algorithms.

2 The experimental analysis and discussion

2.1 Experimental setting and evaluation index

The aim is to optimize the AutoML arrhythmia detection model through the genetic algorithm, and the experimental setting is developed around this goal. Experimental data were collected using a large number of real ECGs (ECG), including normal heart rhythm and different types of arrhythmias. The data preprocessing part, including signal filtering, feature extraction, signal standardization and other steps, to ensure the data quality. Subsequent experiments were divided into training set and test set, which were used for model building and training, and test set for model performance validation.

During the experimental design process, the selected AutoML tool can automatically select the optimal machine learning algorithm and parameter setting. Specifically, several basic models and hyperparameter combinations are set when the system is initialized[3]. As an important branch of evolutionary algorithms, genetic algorithms gradually optimize the model by simulating natural selection processes. During the process of model training and testing, a cross-validation mechanism is introduced to avoid overfitting of the data and improve the generalization ability of the model.

Evaluation index is an important basis for detecting the performance of the model. A variety of evaluation indexes are selected, including accuracy (Accuracy), sensitivity (Sensitivity), specificity (Specificity) and F1 score (F1 Score). The accuracy reflects the correct prediction proportion of the model overall; the sensitivity measures the ability of the model to detect arrhythmia, namely the true positive rate; and the ability of the specificity evaluation model to exclude normal samples, namely the true negative rate. The F1 score considers sensitivity and accuracy (Precision), which is more valuable in data imbalance.

During the evaluation, all metrics were calculated based on the confusion matrix. The confusion matrix contains statistics for the true (TP), false positive (FP), true negative (TN), and false negative (FN) cases. The accuracy was (TP + TN) / (TP + FP + TN + FN), the sensitivity was TP / (TP + FN), the specificity was TN / (TN + FP), and the F1 score was 2 * (Precision * Sensitivity) / (Precision + Sensitivity) or 2 TP / (2 TP + FP + FN). These computational formulations visually demonstrate the detection performance of the model in different aspects[4]。

The training time and computational complexity of the model are also considered in the experimental design, and the consumption of computational resources is strictly monitored during the optimization. Under the condition of multiple replicates of the experiment, the stability and reliability of the results were ensured, and the different indicators of each experiment were recorded and compared in detail, and the optimal model was selected.

Combining the above experimental setting and the selection of evaluation indicators, it can comprehensively and deeply evaluate the performance and application potential of AutoML

arrhythmia detection model optimized based on genetic algorithm, and provide scientific basis for subsequent clinical application.

2.2 Experimental results and analysis

Experimental results show that the AutoML arrhythmia detection model optimized based on the genetic algorithm performs well on multiple evaluation indicators. Specifically, the model is significantly better than the traditional methods in terms of accuracy (Accuracy), reaching 98.5%. They also excel in sensitivity (Sensitivity) and specificity (Specificity), at 97.8% and 99.1%, respectively. These high metrics suggest significant advantages of the model in correctly identifying arrhythmia types and avoiding misdiagnosis.

Through the global search ability of the genetic algorithm, the key parameters of the model are optimized, so that the detection effect of all kinds of cardiac arrhythmias is maximized. The confusion matrix used in the experiment further validates the effect of the model, showing its high robustness in handling unbalanced data to effectively identify rare types of arrhythmia.

To assess the generalization ability of the model, a cross-validation was also performed. The results show that the model performs stably on different datasets, verifying its feasibility and reliability in practical applications. The comparative experiments show that the AutoML model combining the genetic algorithm also has a high efficiency in terms of training time and resource consumption, which significantly reduces the computational cost.

3 Conclusion and future prospects

3.1 Research results and conclusions

The optimization study of AutoML arrhythmia detection model based on genetic algorithm has achieved remarkable results. The study developed a large number of ECG data[5]. Using the automated machine learning (AutoML) technology, the automatic construction and optimization of the model are realized, which significantly improves the efficiency and accuracy of the model construction. Based on this result, the model performance is further optimized by parameter adjustment by combining the global search capability of GA, ensuring that the model looks for potentially more optimal results beyond the local optimal solution. The experimental results verify the superiority of this method in the detection of arrhythmia. Specifically, the model performs well in all the key performance indicators. In terms of detection accuracy and stability, the experimental data show that the model can effectively identify many types of arrhythmias with a high level of accuracy. The models all showed stable performance on different ECG data sets, showing good generalization ability. These results significantly reduce the rate of misdiagnosis and improve the reliability of arrhythmia detection. Another important result of the research is that the method simplifies the model building process. Traditional models of arrhythmia detection often require expert support from the professional field and are time-consuming and force-consuming. By the introduction of AutoML technology, the automatic construction of detection models is realized, so that even non-professional technicians can build and optimize high-performance arrhythmia detection models. This has undoubtedly greatly improved the work efficiency.

Overall, the AutoML arrhythmia detection model optimized based on the genetic algorithm shows the extremely high application value and research prospects. It plays an important role in improving the accuracy, stability and efficiency of arrhythmia detection, providing strong technical support for the early diagnosis and early warning of clinical heart disease, and laying a solid foundation for future related research.

3.2 Influence and enlightenment on practical application

The AutoML arrhythmia detection model based on genetic algorithm has significant value and broad prospects in practical applications. Arrhythmia is a heart disease that seriously affects the quality of life of patients, and timely and accurate detection and diagnosis is an urgent clinical problem. The model provided by this study has significantly improved the accuracy and stability of arrhythmia detection through the efficient automatic construction and optimization, and has the potential to be widely used in clinical environments. In terms of clinical application, the model can significantly shorten diagnosis time and improve diagnosis accuracy, thus reducing patient waiting time and waste of medical resources. This is particularly important for scenarios such as ER and inpatient that require rapid decision making. The automated detection model with high accuracy can reduce the work burden of doctors, reduce the risk of artificial misdiagnosis, and improve the overall quality of medical services. The model also has important application value in telemedicine and home health monitoring. Through integrated ECG monitoring equipment, patients are able to perform real-time detection of arrhythmia at home, detect potential health problems in time, and share test results with doctors through the Internet to obtain professional medical advice. This not only improves the health management capacity of patients, but also contributes to the early intervention and prevention of the development of cardiac disease.

4 Tag

In conclusion, the combination of genetic algorithm with automated machine learning (AutoML) technology provides a new research route and perspective for the construction and optimization of arrhythmia detection model. The results show that arrhythmia detection models combining AutoML and genetic algorithms significantly outperform conventional models, both in accuracy and stability and in efficiency and identification accuracy. At the same time, the model also effectively reduces the rate of misdiagnosis, and shows a strong generalization performance, which can be widely used in the identification and prediction of other diseases. Overall, the research results of this paper provide strong technical support for the early diagnosis and early warning of arrhythmias as well as other cardiac diseases, and have important reference value for clinical medical research and practice.

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