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An improved random forest model for music genre classification algorithm based on sparrow search algorithm

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Abstract. In this study, a random forest model optimised based on the sparrow search algorithm is explored for the music genre classification problem. By introducing the sparrow search algorithm, the model is able to search the feature space more comprehensively during the training process, which improves the learning ability of complex data relationships. After 15 iterations of optimisation, the fitness value of the model is improved from 0.2002 to 0.197, showing better convergence. The performance on the training set shows that the model predicts 2,543 music genres with an accuracy of 99.59% and only 10 incorrect predictions, which verifies its excellent performance on the training data. While on the test set, the model's prediction accuracy for 623 music genres is 79.78%, which is slightly lower than the result of the training set, but still reflects good generalisation ability. The results of this paper imply that the improved random forest model based on the sparrow search algorithm has potential application prospects in the music genre classification task. By optimising the parameter settings and feature selection, we not only improve the prediction accuracy and generalisation ability of the model, but also provide new ideas for solving other complex data classification problems. In the future, we can further expand the sample size, try different feature combinations, and conduct in-depth research by combining more domain knowledge in order to further improve the model performance and promote the development of related fields.

Keywords: Random Forest, Sparrow Search Algorithm, Music Genre Classification.

1. Introduction

Music genre classification is an important research area in music information retrieval and music recommendation systems, aiming to classify musical works according to their styles, characteristics and traditions. Genre classification of music helps people to better understand and organise the rich and diverse music resources, and improves the accuracy and personalisation of music retrieval and recommendation. In the past decades, researchers have explored methods for music genre classification by analysing a variety of data such as audio signals, lyrics content, artist information, etc., in which the application of machine learning techniques has become an important direction [1,2].

Machine learning plays a crucial role in music genre classification. Firstly, machine learning algorithms can learn the features and laws between different genres from a large amount of data to help automate the classification of music [3]. Traditional rule-based or manually defined features face problems such as difficulty in feature extraction and subjectivity, while machine learning algorithms can automatically learn more effective representations by training models, improving classification accuracy and generalisation.

Secondly, machine learning can also make personalised recommendations based on users' preferences for different genres of music. By analysing the user's historical behavioural data, preference information, etc., the machine learning model can build a personalised genre preference model for each user, and based on this, it can recommend new songs or artists for the user that meet his or her tastes, which improves the user experience and the effectiveness of the recommendation system.

In practical applications, machine learning techniques are also widely used in audio feature extraction, similarity calculation and other aspects. For example, high-level abstract features can be effectively extracted from raw audio signals using deep learning models such as convolutional neural networks (CNN) [4]; algorithms based on support vector machines (SVM) [5] can model these features and perform genre classification; and clustering algorithms can help to discover the similarities and differences between different genres [6].

In conclusion, machine learning plays an important role in music genre classification, which not only promotes the development of related research fields, but also brings more possibilities for practical applications. In this paper, we classify music genres based on the random forest model optimised by the sparrow search algorithm, and with the increasing amount of data, the continuous optimisation of the algorithm, and the increasingly close interdisciplinary cooperation, the application of machine learning in the field of music will become more common and deeper in the future.

2. Data sources and statistics

The dataset chosen for this paper is selected from the Kaggle open source dataset at https://www.kaggle.com/datasets/purumalgi/music-genre-classification. The dataset contains several characteristics of music including popularity, danceability, loudness, mode, speech, acousticity, instrumentality, activity, tempo, and duration, etc., and ultimately the music genres are classified into four categories: rock, pop, metal, and hip-hop. Some of the data is shown in Table 1.

Table 1. Selected data sets.

Danceability	Energy	Loudness	Mode	Acousticness	Liveness	Time signature	Class
0.674	0.658	-9.647	0	0.404	0.0981	4	2
0.491	0.563	-8.588	0	0.957	0.263	4	3
0.431	0.852	-6.522	1	0.564	0.254	4	2
0.796	0.441	-9.83	1	0.16	0.118	4	1
0.341	0.47	-10.144	1	0.226	0.518	4	1
0.516	0.948	-3.994	1	0.0279	0.15	4	1

The music was statistically analysed for a number of characteristics popularity, danceability, loudness, mode, speech, acoustic, instrumental, activity, tempo and duration, and the maximum, minimum, mean and variance were calculated and the results are shown in Table 2.

Table 2. Statistical results.

variable name	Max	Min	Average value	Standard deviation
Popularity	89	1	37.995	16.31
Danceability	0.982	0.086	0.539	0.145
Energy	0.998	0.003	0.593	0.232
Loudness	1.342	-33.838	-8.868	3.859
Speechiness	0.597	0.022	0.064	0.061

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Table 2. (continued).

Acousticness	0.996	0	0.382	0.348
Liveness	0.987	0.014	0.194	0.158
Valence	0.978	0.028	0.535	0.234
Time signature	5	1	3.883	0.418
Class	3	0	1.417	0.888

3. Method

3.1. Sparrow Search Algorithm

Sparrow Search Algorithm (SSA) is a heuristic optimization algorithm based on the foraging behaviour of birds, which was proposed by Chinese scientists Zheng Huawei et al. in 2015 [7]. The algorithm simulates the strategy of sparrows when searching for food, and achieves the search of the global optimal solution through information sharing and collaboration among individuals.SSA has better convergence performance and global search capability, and has certain advantages in solving complex optimisation problems. The schematic diagram of sparrow search algorithm is shown in Fig. 1.

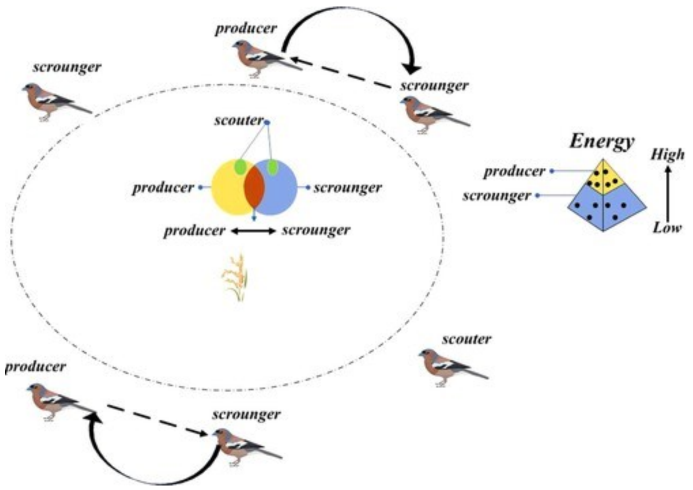

Figure 1. The schematic diagram of sparrow search algorithm.
(Photo credit: Original)

The principle of the sparrow search algorithm consists of three key steps: foraging, information transfer, and updating position. First, the algorithm initialises a group of individual sparrows and distributes them randomly in the search space. Each sparrow chooses an appropriate search direction based on the environmental information near its current location and travels to the potential food source area. During this process, individuals perceive and exchange information with each other to accelerate the convergence of the global optimal solution [8]. When a bird is able to find a better food source, it will transmit this information to its surrounding companions, thus guiding the whole group to move towards the more optimal solution.

Secondly, the sparrow search algorithm achieves intelligent group collaboration through information transfer. When a bird is able to find a better solution, it will release information and influence the surrounding group members to adjust their positions. This information sharing and collaboration mechanism enables the whole group to quickly converge to the global optimal solution and effectively avoid falling into the local optimal solution. Through continuous information exchange and position updating, the algorithm can effectively balance the relationship between exploration and exploitation, and improve the search efficiency and accuracy.

Finally, in the updating position stage, each sparrow adjusts its position according to the received information and its own experience and continues to search for a better solution. By iteratively updating the position many times and combining the foraging and information transfer process, the whole algorithm can gradually converge to the best solution. At the same time, it is also important to consider maintaining population diversity when updating positions to prevent premature convergence or falling into local optimal solutions.

3.2. random forest algorithm

Random Forest (RF) is an integrated learning method that performs classification or regression tasks by constructing multiple decision trees. A decision tree is a tree structure where each internal node represents a judgement on an attribute/feature, each branch represents the output of a judgement result, and each leaf node represents the final classification or regression result. The random forest algorithm reduces the risk of overfitting by constructing multiple decision trees and has a good generalisation ability [9]. Specifically, random forest contains random sampling, feature selection and voting mechanism. The structure of the random forest algorithm is shown in Figure 2.

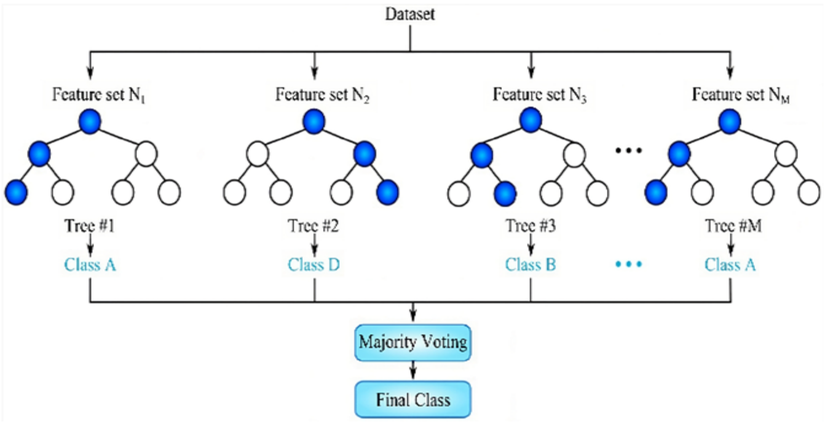

Figure 2. The structure of the random forest algorithm.
(Photo credit: Original)

When constructing each decision tree, Random Forest performs putative back sampling of the training data, i.e., a certain number of samples from the original training set are randomly selected for training. This ensures that each decision tree is trained on a different subset of data, increasing the diversity of the model.

When selecting features for each node, the best features are not selected from all the features, but a part of the features are randomly selected from all the features to be considered. This practice is called "random feature selection", which can further increase the diversity of the model.

In the prediction phase, Random Forest uses a voting mechanism to determine the final output. That is, for classification problems, each decision tree casts a vote to give the predicted category; for regression problems, the predicted values of each decision tree are averaged as the final prediction. Determining the final output result by majority voting or averaging effectively reduces the risk of overfitting.

3.3. Improved Random Forest Model Based on Sparrow Search Algorithm

Improved Random Forest Model based on Sparrow Search Algorithm combines two techniques, Sparrow Search Algorithm and Random Forest, aiming to improve the performance and efficiency of Random Forest Model. Random forest is an integrated learning method that consists of multiple decision trees and makes predictions by voting or averaging, which has better generalisation and overfitting resistance [10]. The improved random forest model based on the sparrow search algorithm can better explore the feature space during the training process, which improves the model's ability to learn

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complex data relationships, and by optimising the parameter settings and feature selection, it can effectively improve the model's prediction accuracy and generalisation ability. This approach not only accelerates the model training process, but also improves the performance of the model in practical applications.

4. Results

In terms of proportional division of the data, 70% of the data was randomly divided as the training set and the remaining 30% of the data was used as the test set. The training went through a total of 15 iterations process, the learning rate was set to 0.0002, Matlab R2022a was used for the experiments, and the CPU of the computer was 32G.

The model went through 15 iterations and the result of fitness during the iteration process is shown in Fig. 3, which shows that the fitness changed from the initial 0.2002 to 0.197.

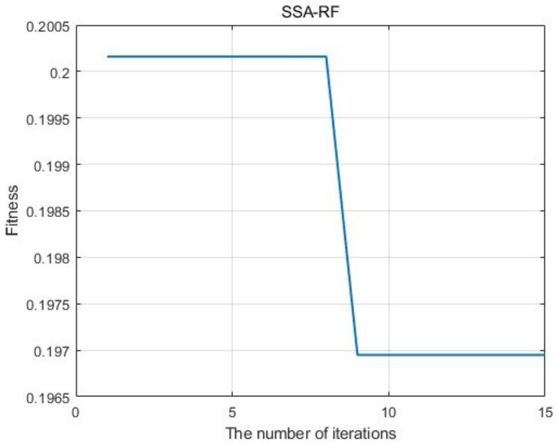

Figure 3. The result of fitness.
(Photo credit: Original)

The predicted confusion matrices for the training and test sets are output and the results are shown in Fig. 4.

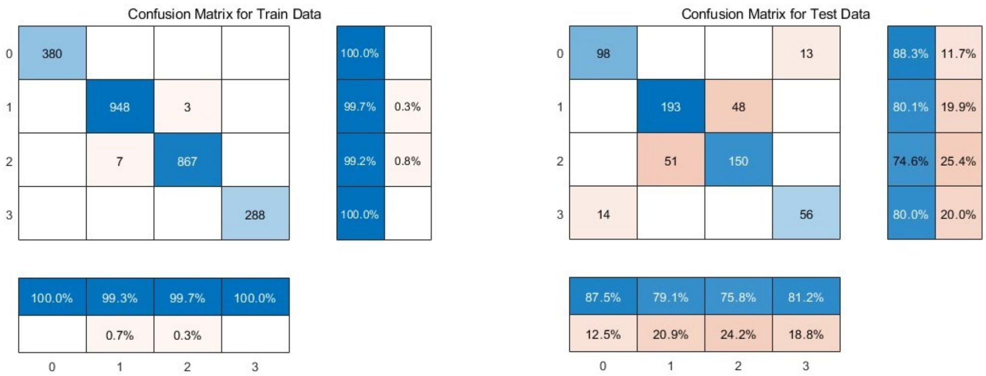

Figure 4. Confusion matrix for training and test sets.
(Photo credit: Original)

From the confusion matrix of the training set, a total of 2443 music genres were predicted correctly and 10 music genres were predicted incorrectly out of 2543 music genre predictions in the training set, with an accuracy of 99.59%.

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From the confusion matrix of the test set, a total of 497 music genres were predicted correctly and 126 music genres were predicted incorrectly out of 623 music genre predictions in the training set, with an accuracy of 79.78%.

5. Conclusion

This paper presents a random forest model optimised based on the sparrow search algorithm for classifying music genres. By introducing the sparrow search algorithm, the model is able to better explore the feature space during the training process, which improves the learning ability of complex data relationships. By optimising the parameter setting and feature selection, the model effectively improves the prediction accuracy and generalisation ability.

After 15 iterations, the fitness of the model decreased from the initial value of 0.2002 to 0.197, indicating that the model was gradually optimised and improved its performance during the iteration process. The confusion matrix on the training set shows that out of 2543 music genre predictions, 2443 were correctly classified and only 10 were misclassified with an accuracy of 99.59%. The performance on the test set is also quite impressive, with 623 music genres predicted, of which 497 were correctly classified and 126 misclassified, with an accuracy of 79.78%.

This study demonstrates that the improved random forest model based on the sparrow search algorithm has achieved significant results on the music genre classification task. By continuously optimising the model parameters and feature selection, the model's ability to learn data relationships and generalisation is improved, and a high accuracy rate is achieved on both the training and test sets.

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Yaohua Wang and Haoqi Chen made the same contribution. Yaohua Wang: Introduction, Data sources and statistics. Haoqi Chen: Method, Results, Conclusion.

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