Heart Sound Segmentation Based on Personalized Gaussian Mixture Model and Convolutional Neural Network

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Chun Dong Xu
Jiangxi University of Science and Technology

Jing Zhou
Jiangxi University of Technology

✉ 1458311853@qq.com *Corresponding Author*
ORCID: <https://orcid.org/0000-0002-7945-3680>

Dong Wen Ying
University of the Chinese Academy of Sciences

Lei Jing Hou
key Laboratory of Speech Acoustics and Content Understanding, Institute of Acoustics

Qing Hua Long
Jiangxi University of Sciences and Technology

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SUBJECT AREAS

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Mel frequency cepstral coefficient, heart sound segmentation, heart sound classification, Gaussian mixture model, Convolutional neural network

Abstract

Background: Heart sound segmentation is a long-standing problem in heart analysis, and it is mainly caused by noise interference and diversification of heart sounds. Faced with the challenging of heart sound segmentation, a more applicable segmentation model was studied. **Methods:** In this process, the optimal modified Log-spectral amplitude and wavelet were used to suppress the noise in the heart sound, and used the duration-dependent hidden Markov model based on personalized Gaussian mixture model (PGMM-DHMM) to segment the fundamental heart sound (FHS) and the non-fundamental heart sound (non-FHS). Then used the optimized Mel frequency cepstral coefficient (MFCC) to realize the classification of S1 and S2 heart sound frames through the Convolutional neural network (CNN) classifier, which can avoid the errors caused by the ambiguity of the time domain features. **Results:** PGMM-DHMM can segment FHS more effectively, and the accuracy is 94.3%. The CNN classifier obtained the best results in the S1 and S2 classifications, the accuracy is 90.92%, the precision of S1 is 90.76%, the recall is 91.05%, the F-measure is 90.9%, and the precision of S2 is 91.07%, the recall is 90.79%, the F-measure is 90.93%. The final segmentation accuracy is 92.92%. In addition, the experimental results further indicate that CNN has more robust performance when classifying abnormal S1 and abnormal S2. **Conclusions:** The PGMM-DHMM model can better segment FHS and Non-FHS. The optimization of MFCC improves the classification effect of S1 and S2, and the improvement effect by the CNN classifier is significant, especially for abnormal heart sounds. The proposed algorithm is better than other algorithms at this stage.

Full Text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the manuscript can be downloaded and accessed as a PDF.

Figures

Figure 1

Detailed flow chart of the proposed algorithm

Figure 2

est results of noise reduction by OMLSA-W. (a1) The original a0001, (a2) The denoised a0001, (b1) The original b0087, (b2) The denoised b0087, (c1) The original c0018, (c2) The denoised c0018, (d1) The original d0052, (d2) The denoised d0052.

Figure 3

State transition between FHS and non-FHS

Figure 4

Detection of cardiac cycle

Figure 5

Gaussian modeling of eigenmode cardiac cycle

Figure 6

The cardiac cycle segmentation results of a0042

Figure 7

Visualization of MFCC: (a) Each dimension of MFCC, (b) 3D map of MFCC.

Figure 8

The test results of frequency scale conversion parameter correction

Figure 9

The structure of DNN classifier

Figure 10

CNN classifier

Figure 11

The training results, (a) Optimizing MFCC testing, (b) Fusion feature testing, (c) Classifier testing.

Figure 12

(a) The evaluation indexes of abnormality S1, (b) The evaluation indexes of the normal S1,
(c) The evaluation indexes of the abnormality S2, (d) the evaluation indexes of the normal

S2