KLASIFIKASI SUARA PARU-PARU BERBASIS DEEP LEARNING MENGGUNAKAN FITUR MEL-SPEKTROGRAM UNTUK DETEKSI DINI PENYAKIT PERNAPASAN

Skripsi

Untuk Memenuhi Persyaratan
Dalam Menyelesaikan Strata-1 Ilmu Komputer

Oleh

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PROGRAM STUDI S-1 ILMU KOMPUTER
FAKULTAS MATEMATIKA DAN ILMU PENGETAHUAN ALAM
UNIVERSITAS LAMBUNG MANGKURAT
BANJARBARU

NOVEMBER 2025

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SKRIPSI

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Telah dipertahankan di depan Dosen Penguji pada tanggal 18 November 2025.

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KATA PENGANTAR

Puji syukur penulis panjatkan ke Tuhan kita Yang Maha Esa karena atas berkat rahmat dan karunia-Nya penulis dapat menyelesaikan jurnal yang berjudul "*Deep Learning-Based Lung Sound Classification Using Mel-Spectrogram Features for Early Detection of Respiratory Diseases*" untuk memenuhi syarat dalam menyelesaikan pendidikan program S1 Ilmu Komputer, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Lambung Mangkurat.

Pada lembar ini penulis ingin menyampaikan ucapan terimakasih kepada semua pihak yang sangat mendukung penulis dalam pembuatan dan penyusunan jurnal ini, adapun yang dimaksud adalah sebagai berikut:

1. Diri saya sendiri yang tidak pernah patah semangat walaupun banyak menemui kesulitan baik disebabkan oleh diri sendiri maupun hal lain.
2. Keluarga besar yang selalu memberikan bantuan, semangat, doa dan dukungan dalam proses penyelesaian jurnal ini.
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Akhir kata penulis menyadari sepenuhnya bahwa penulisan ini jauh dari sempurna. Semoga tulisan ini dapat bermanfaat bagi ilmu pengetahuan dan pembaca khususnya serta mendapat keridhaan Allah SWT.

Banjarbaru, 25 November 2025

Midfai Yabani

SURAT PERNYATAAN

Dengan ini saya menyatakan bahwa dalam jurnal ini tidak terdapat karya yang pernah diajukan untuk memperoleh gelar kesarjanaan di suatu Perguruan Tinggi, dan sepanjang pengetahuan saya juga tidak terdapat karya atau pendapat yang pernah ditulis atau diterbitkan oleh orang lain, kecuali yang secara tertulis diacu dalam naskah ini dan disebutkan dalam Daftar Pustaka.

Banjarbaru, 25 November 2025

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Pada hari ini, Senin Tanggal 24 November 2025, telah dilakukan evaluasi kelengkapan dokumen pengganti kegiatan skripsi mahasiswa S1 Ilmu Komputer Fakultas MIPA ULM

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1.	Dodon Turianto Nugrahadi, S.Kom, M.Eng	1.	
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05th November 2025

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Dear,
Midfai Yabani, et al.

LETTER of ACCEPTANCE (LOA)

It's a great pleasure to inform you that, after the peer review process, the scientific committee agree that the **manuscript is accepted** for publication in **Journal of Electronics, Electromedical Engineering, and Medical Informatics** and manuscript will be published in **Vol. 8 No. 1, 2026.**

Title	Deep Learning-Based Lung Sound Classification Using Mel-Spectrogram Features for Early Detection of Respiratory Diseases
Affiliation	Department of Computer Science, Lambung Mangkurat University, Banjarbaru, Indonesia
Authors	Midfai Yabani, et al.

Thank you for your contribution to the **Journal of Electronics, Electromedical Engineering, and Medical Informatics** and we look forward to receiving further submission from you.

Sincerely,

Associate Professor Dr. Triwiyanto

Editor-in-chief
Journal of Electronics,lectromedical Engineering, and Medical Informatics
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Form Review

From: admin <editorial.jeeemi@gmail.com>

Date: Sun, Oct 26, 2025 at 21:51

Subject: [jeeemi] Editor Decision

To: Midfai Yabani <midfaiybni@gmail.com>, Mohammad Reza Faisal <reza.faisal@ulm.ac.id>, Fatma Indriani <f.indriani@ulm.ac.id>, Dodon Turianto Nugrahadi <dodonturianto@ulm.ac.id>, Dwi Kartini <dwikartini@ulm.ac.id>, Kenji Satou <ken@t.kanazawa-u.ac.jp>

Midfai Yabani, Mohammad Reza Faisal, Fatma Indriani, Dodon Turianto Nugrahadi, Dwi Kartini, Kenji Satou:

We have reached a decision regarding your submission to Journal of Electronics, Electromedical Engineering, and Medical Informatics, "Deep Learning-Based Lung Sound Classification Using Mel-Spectrogram Features for Early Detection of Respiratory Diseases".

Our decision is: Revisions Required

admin

editorial.jeeemi@gmail.com

Reviewer A:

Recommendation: Revisions Required

Comments

The manuscript presents a comprehensive approach to lung sound classification using deep learning

techniques, particularly CNN architectures with Mel Spectrogram features. While the methodology is generally well-executed, incorporating more detailed mathematical modeling can enhance clarity and reproducibility.

1.Provide explicit formulas or equations describing the steps involved in audio resampling, duration standardization, and data balancing. For example, mathematically define how audio normalization is performed, including any transformations or scaling applied to raw audio signals before feature extraction, to improve reproducibility.

2.Introduce mathematical representations of Mel Spectrogram computation. For instance, specify the formula for converting a windowed segment of audio into the frequency domain, using FFT, and then describe how mel filter banks are applied mathematically to generate the spectrograms, including equations for filter bank integration.

3.For each CNN architecture used, include a mathematical description of their structure such as convolution operations, activation functions, and pooling layers. For example, define the convolution operation as $y_{i,j}=\sum_{m,n} x_{i+m,j+n} \cdot w_{m,n}$ to clarify how feature maps are generated.

4.Explicitly describe how hyperparameters such as learning rate, batch size, and epochs influence the training process mathematically. For example, include the gradient descent update rule $\theta_{t+1}=\theta_t-\eta\nabla J(\theta_t)$, and specify how hyperparameter variations modify this process.

5.Add the specific loss functions used during training, such as cross-entropy loss, with their mathematical formulations. This should include the equations, such as:
$L=-\sum_{i=1}^{N} y_i \log(\hat{y}_i)$, to clarify the optimization objective.

6. If any data augmentation techniques are used, provide their mathematical basis or transformation equations. For example, if noise addition or time-shifting is applied, include the formulas governing these operations to better understand their impact on model robustness.

7.Include the formulas for evaluation metrics like accuracy, precision, recall, F1-score, and confusion matrices. For instance, accuracy can be mathematically described as:
$\text{Accuracy}=\frac{TP+TN}{TP+TN+FP+FN}$, providing transparency in performance evaluation.

8.Present the optimization process equations, such as the update rules for weights in CNN models, with clarification on how parameters like weight decay or regularization are incorporated mathematically to prevent overfitting.

9.Describe the criteria used to compare models numerically, possibly using statistical tests or confidence intervals. Including formulas or methods for significance testing will enhance the scientific rigor, such as applying paired t-tests on model accuracy results.

10.Encourage the inclusion of theoretical or empirical validation methods, such as statistical significance or confidence bounds, through equations. For example, estimating the confidence interval of accuracy rates helps in better understanding the reliability of comparisons made between different CNN models.

Reviewer B:

Recommendation: Revisions Required

Comments

The manuscript investigates the application of deep learning models, particularly CNNs, for lung sound classification, emphasizing feature extraction with Mel Spectrograms and data preprocessing techniques. While the methodology and results are promising, enhancing clarity, expanding discussions, and addressing certain ambiguities will strengthen the overall quality. Here are detailed comments and suggestions:

1.Although the introduction discusses previous work, it lacks a clear statement on how this research

uniquely advances the field. Explicitly articulate the gap your study aims to fill, such as the comparative analysis of multiple CNN architectures with standardized preprocessing, to better justify its novelty.

2.The introduction references the dataset but does not specify its size, class distribution, or any particular challenges like imbalance. Providing detailed statistical information about the dataset and any inherent biases helps contextualize the results and underscores the importance of the preprocessing steps.

3.While multiple CNN models are used, the rationale behind selecting LeNet-5, AlexNet, VGG-16, VGG-19, ResNet-50, and ResNet-152 should be clarified. Discuss their relative advantages, typical applications in audio analysis, and why these models are suitable for lung sound classification, adding depth to the methodology.

4.The results show moderate accuracy but lack discussion on specific limitations such as overfitting, computational constraints, or dataset limitations that might influence performance. Including these considerations enhances transparency and guides future research directions.

5.While accuracy is reported, metrics such as precision, recall, F1-score, and confusion matrices provide a more comprehensive evaluation, especially in class-imbalanced datasets. Presenting these metrics, along with their implications, would strengthen the validity of the results.

6.The comparison of different CNN architectures relies on accuracy percentages; however, statistical tests like t-tests or confidence intervals should be applied to determine if observed differences are significant. Incorporating such analysis will provide robust validation of the results.

7.The methods section mentions exploring various hyperparameters but does not detail the systematic procedures or criteria used for selecting optimal values. Including information about grid search, random search, or other optimization strategies enhances methodological transparency.

8.Table 5 compares model performances but would benefit from additional discussion on how differences in architecture, training duration, or parameter settings contribute to performance variations. Graphical representations like bar charts could also facilitate clearer comparisons.

9.The results are promising but are based on a specific dataset and controlled experimental settings. Discussing potential challenges in deploying these models in clinical environments or on unseen data would make the findings more relevant to practical applications.

10.Identify any biases introduced during data collection or preprocessing, such as class imbalance or audio quality variability. Suggest future validation with larger, more diverse datasets and external validation to confirm the robustness and applicability of the models developed.

Editor-in-chief: Associate Professor Dr. Triwiyanto (triwi@poltekkes-surabaya.ac.id; dr.triwiyanto@gmail.com)
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RESEARCH ARTICLE OPEN ACCESS

Deep Learning-Based Lung Sound Classification Using Mel-Spectrogram Features for Early Detection of Respiratory Diseases

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Abstract **Respiratory diseases such as asthma, chronic obstructive pulmonary disease, and pneumonia remain among the leading causes of death globally. Traditional diagnostic approaches, including auscultation, rely heavily on the subjective expertise of medical practitioners and the quality of the instruments used. Recent advancements in artificial intelligence offer promising alternatives for automated lung sound analysis. However, audio is an unstructured form of data that must be transformed into a suitable format for AI algorithms. Another significant challenge lies in the imbalanced class distribution within available datasets, which can adversely affect classification performance and model reliability. This study applied several comprehensive preprocessing techniques, including random undersampling to address data imbalance, resampling audio at 4000 Hz for standardization, and standardizing audio duration to 2.7 seconds for consistency. Feature extraction was then performed using the Mel Spectrogram method, converting audio signals into image representations to serve as input for classification algorithms based on deep learning architectures. To determine optimal performance characteristics, various Convolutional Neural Network (CNN) architectures were systematically evaluated, including LeNet-5, AlexNet, VGG-16, VGG-19, ResNet-50, and ResNet-152. VGG-16 achieved the highest classification accuracy of the tested models at 75.5%, demonstrating superior performance in respiratory sound classification tasks. This study demonstrates the potential of AI-based lung sound classification systems as a complementary diagnostic tool for healthcare professionals and the general public in supporting early identification of respiratory abnormalities and diseases. The findings suggest that automated lung sound analysis could enhance diagnostic accessibility and provide more valuable support for clinical decision-making in respiratory healthcare applications.**

Keywords **Lung Sound; Feature Extraction; Au; Audio Classification; Convolutional Neural Network**.

I. Introduction

Lung sound classification is crucial in medical diagnostics, particularly in identifying respiratory conditions such as asthma, chronic obstructive pulmonary disease (COPD), and pneumonia [1][2]. These conditions are often characterized by abnormal lung sounds, such as crackles and wheezes, which can be detected through auscultation [3][4]. However, manual interpretation of lung sounds requires specialized expertise and is often prone to inter-observer variability, which may lead to inconsistent diagnostic outcomes [5][6]. These challenges have motivated the development of automated lung sound classification systems that can support healthcare professionals as well as the general public in the early detection of respiratory diseases.

Recent advancements in artificial intelligence (AI) have provided promising alternative solutions for audio analysis, including lung sound classification [7][8]. Classifying lung sounds using AI generally follows the same pipeline as in other audio-based tasks, beginning with extracting raw audio into a structured format that machine learning algorithms can process. Commonly used feature extraction methods include spectral

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