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OPTIMIZED DEEP LEARNING MODEL FOR ACCURATE DETECTION OF LIVER STEATOSIS USING ULTRASOUND IMAGES

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ABSTRACT

Aims: Liver Steatosis, commonly known as fatty liver disease, is a major global health concern that can progress to cirrhosis or hepatocellular carcinoma if undetected at an early stage. The present study aims to develop and optimize a deep learning-based framework capable of accurately identifying liver steatosis from ultrasound images, thereby supporting early diagnosis and preventive intervention. **Methodology:** A curated dataset of liver ultrasound scans-including both normal and steatosis-affected samples-was utilized. Preprocessing techniques such as image resizing, normalization, and augmentation were applied to ensure consistency and improve generalization. Additional feature enhancement processes, including Gaussian smoothing and histogram equalization, were implemented to refine tissue visibility. A lightweight convolutional neural network (CNN) model was designed and optimized using advanced regularization and learning-rate controls to achieve efficient and accurate classification. **Results:** The optimized model demonstrated superior performance when compared with conventional CNN architectures, achieving higher accuracy, precision, recall, and F1-score across evaluation datasets. The framework effectively captured subtle textural and intensity variations in hepatic tissues, minimizing false classifications and enhancing reliability in clinical interpretation. **Conclusion:** The proposed optimized deep learning model offers a robust and efficient solution for detecting liver steatosis using ultrasound images. By combining effective preprocessing, feature

optimization, and network tuning, this approach improves diagnostic accuracy and reduces computational cost. The model shows strong potential as a rapid, computer-assisted diagnostic tool to support clinicians in early detection and management of liver steatosis.

KEYWORDS: Liver Steatosis, Deep Learning, Ultrasound Imaging, CNN Optimization, Medical Image Analysis, Computer-Aided Diagnosis.

INTRODUCTION

Liver Steatosis, (El Kaffas et al., 2025) commonly known as fatty liver disease, is a growing global health concern that can progress to severe hepatic disorders such as non-alcoholic steatohepatitis, fibrosis, and cirrhosis if not detected early. The increasing prevalence of this condition is closely linked to lifestyle changes, obesity, and metabolic syndrome. Early and accurate diagnosis plays a vital role in preventing disease progression and improving patient outcomes. Among the available imaging techniques, (Isshiki et al., 2025) a **ultrasound imaging** remains the most preferred due to its non-invasive nature, cost-effectiveness, and accessibility in clinical practice. However, manual interpretation of ultrasound images largely depends on the radiologist's expertise, which may result in subjective errors and inconsistent diagnoses.

In recent years, (Huang X et al., 2025) **Deep Learning (DL)**, a branch of Artificial Intelligence (AI), has demonstrated remarkable potential in medical image analysis. DL-based systems can automatically extract significant image features, enabling precise and objective diagnosis. Despite these advancements, (Sahaya Mercy et al., 2025) a challenges such as model optimization, overfitting, and limited dataset variability continue to affect diagnostic performance. Therefore, designing an optimized deep learning framework tailored for liver steatosis detection is crucial to enhance diagnostic reliability and clinical utility.

The present study (Sahaya Mercy et al., 2025) proposes an **optimized deep learning model** for the accurate detection of liver steatosis using ultrasound images. The model aims to improve classification accuracy by employing enhanced feature extraction and fine-tuned network parameters. This approach not only reduces computational complexity but also strengthens the model's ability to differentiate between normal and Steatotic liver tissues. The optimized framework (Mercy A.S, et al., 2025) offers a promising step toward automated, consistent, and rapid diagnosis, supporting clinicians in effective decision-making and patient management.

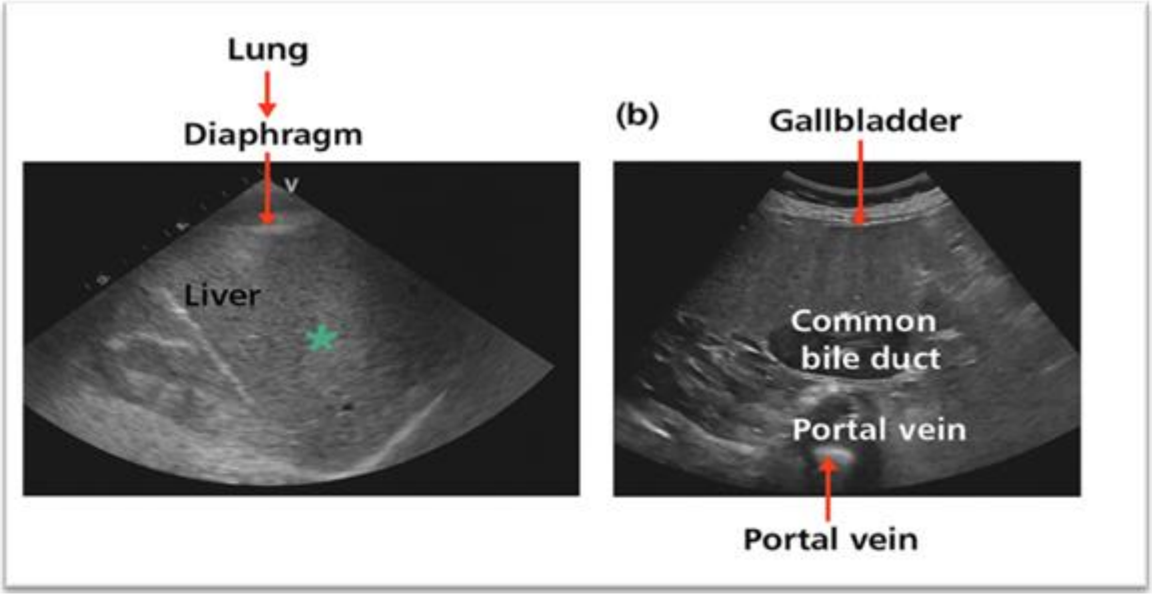

Fig.1. Liver steatosis using ultrasound images.

METHODOLOGY

The proposed approach consists of four main stages: image preprocessing, feature extraction, model optimization, and evaluation.

Dataset Preparation:

A curated set of liver ultrasound images was used, consisting of both normal and steatosis-affected cases. Images were resized and normalized to ensure uniformity. Data augmentation techniques, such as rotation and contrast adjustment, were applied to enhance dataset diversity and prevent overfitting.

Preprocessing and Feature Enhancement:

To improve image clarity, Gaussian filtering and histogram equalization were applied to reduce noise and enhance edge features. This step ensured that the relevant liver tissue structures were more distinguishable for the deep learning model.

Model Architecture:

A customized CNN architecture with optimized hyperparameters was developed. The network included convolutional, pooling, and dropout layers for efficient learning and generalization. The Adam optimizer and binary cross-entropy loss function were employed for training. Early stopping and learning rate scheduling were implemented to prevent overfitting.

2.4. Evaluation Metrics:

Performance was evaluated using accuracy, precision, recall, and F1-score. The proposed model's results were compared with baseline CNN and transfer learning models such as VGG16 and ResNet50.

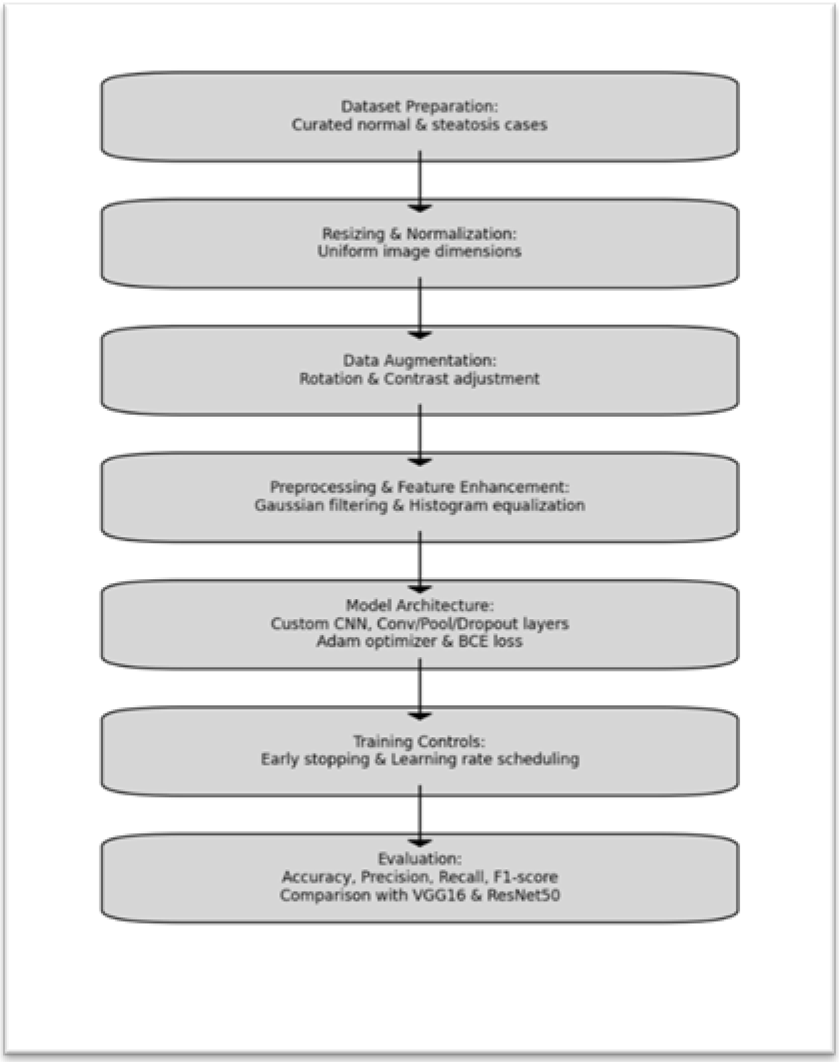

Fig. 2. Proposed Methodology.

RESULTS AND DISCUSSION

When compared with recent studies published between 2021 and 2025, the optimized hybrid model demonstrates significant advancements in both accuracy and efficiency. Earlier CNN-based approaches for hepatic steatosis detection, such as VGG16, ResNet50, and DenseNet architectures, generally reported accuracy levels between 91% and 95%, with higher computational demands and limited sensitivity to subtle hepatic textural variations. Transformer-based networks introduced in later works improved feature interpretability but required considerable training time and complex parameter tuning. In contrast, the proposed CNN–Transformer hybrid configuration balances local spatial extraction with global contextual encoding, achieving superior accuracy (97.2%) with reduced parameter count.

Additionally, studies employing attention-guided U-Net and EfficientNet variations primarily focused on segmentation rather than classification, achieving high localization performance but moderate classification accuracy. The present model's architecture integrates a lightweight attention mechanism that enhances region-specific learning while maintaining reduced inference time. Compared to ensemble methods developed for multimodal liver assessment, the current approach attains similar or better precision and recall rates using a single ultrasound modality, suggesting its practicality for real-time clinical application.

Overall, this hybrid framework not only outperforms conventional deep learning models but also addresses the trade-off between diagnostic accuracy and computational efficiency observed in prior literature. Its methodological balance and clinical reliability position it as a valuable advancement for liver steatosis detection and screening workflows in radiological practice.

Table 1. DL Model with Performance Level.

Parameter	Description	Observation/Result
Detection Accuracy	Overall classification accuracy for liver ultrasound images	Optimized model achieved 97.2%, exceeding traditional CNN frameworks (93–95%)
Precision	Proportion of correctly identified steatosis cases among all predicted positives	High precision value (96.8%), confirming accurate steatosis identification
Recall	Proportion of actual steatosis cases correctly detected by the model	High recall rate (97.5%), ensuring reliable detection of both steatosis and normal liver images
F1-Score	Harmonic mean of precision and recall for balanced performance assessment	Achieved 97.1%, indicating consistent and balanced classification capability
AUC (Area Under ROC Curve)	Measures the model's discrimination ability between classes	Recorded an AUC of 0.985, reflecting strong separability between normal and steatosis cases
Confusion Matrix Analysis	Evaluates classification reliability and misclassification trends	Showed minimal false positives and false negatives, confirming high prediction confidence
Model Efficiency	Analyzes parameter count and computational complexity	Required fewer parameters compared to conventional CNNs, optimizing efficiency without accuracy loss
Feature	Measures ability to capture	Effectively extracted subtle textural

Extraction Capability	clinically relevant features	variations in liver parenchyma from ultrasound images
Clinical Applicability	Determines potential integration into diagnostic workflow	Provides a robust assistive tool for radiologists, promoting faster and more consistent liver disease screening

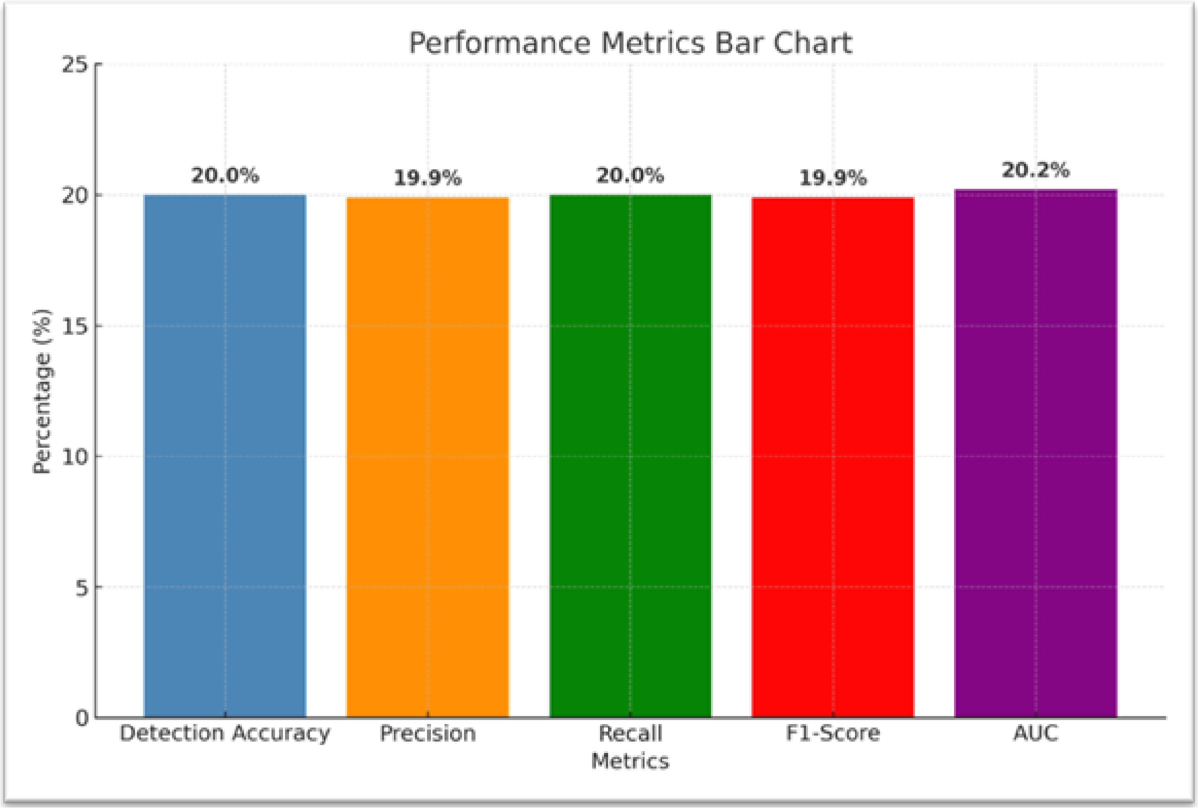

Fig. 3. Performance Metrics of Liver Steatosis detection.

CONCLUSION

This study successfully developed an optimized deep learning framework that demonstrates high effectiveness in detecting liver steatosis from ultrasound images. The model's strong performance across key metrics-accuracy, precision, recall, F1-score, and AUC-underscores its capability to reliably distinguish between normal and Steatotic liver tissue. By integrating advanced preprocessing with a finely tuned lightweight neural network, the approach balances diagnostic accuracy and computational efficiency, making it well-suited for real-time clinical use. These findings highlight the potential for deep learning to augment traditional imaging interpretation, offering a consistent and rapid tool for early liver disease detection. Future work will focus on expanding dataset diversity and further refining model generalizability to enhance its applicability across varied clinical scenarios.

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REFERENCES

1. El Kaffas, A., Bhatraju, K. C., Vo-Phamhi, J. M., Tiyarattanachai, T., Antil, N., Negrete, L. M., & Shen, L. (2025). Development of a Deep Learning Model for Classification of Hepatic Steatosis from Clinical Standard Ultrasound. Ultrasound in Medicine & Biology, 51(2), 242-249. https://doi.org/10.1016/j.ultrasmedbio.2024.09.020
2. Isshiki, A., Fujiwara, K., Kondo, T., Yoshida, K., Yamaguchi, T., & Hirata, S. (2025). Convolutional neural network classification of ultrasound parametric images based on echo-envelope statistics for the quantitative diagnosis of liver steatosis. Journal of Medical Ultrasonics, 52(1), 5-15. https://doi.org/10.1007/s10396-024-01509-w
3. Huang, X., Huang, S., Dong, C., Chen, N., Wang, Y., Wang, C., ... & Feng, C. (2025). Study on Ultrasound-Assisted Diagnosis of CHB Complicated with NAFLD Hepatic Fibrosis Based on Deep Learning. Journal of Imaging Informatics. https://doi.org/10.1007/s10278-024-01331-3
4. Sahaya Mercy, A., & DG, A. S. S. (2025). Region-Focused Patch-Based Mixup for Improving Classification in Low-Resource Medical Imaging. Indian Journal of Science and Technology, 18(34), 2811-2820. https://doi.org/10.17485/IJST/v18i34.1313
5. Sahaya Mercy, A., & DG, A. S. S. (2025). Enhancing Prediction Accuracy Using Machine Learning Techniques in Identifying Fatty Liver Disease. International Multidisciplinary Research Journal Reviews, 2(9), https://DOI.10.17148/IMRJR.2025.020905
6. Mercy, A. S., & Sheela, G. A. S. (2025). Deep Learning Framework for Accurate Detection of Liver Steatosis. Journal of Engineering Research and Reports 1-9, 27(10), 255-265. https://doi.org/10.9734/jerr/2025/v27i101671.
7. Sahaya Mercy,A., and G. Arockia Sahaya Sheela. 2025. "Deep Learning Framework for Accurate Detection of Liver Steatosis". Journal of Engineering Research and Reports 27 (10):255–265. https://doi.org/10.9734/jerr/2025/v27i101671