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Diagnosis of Cardiovascular Diseases Using YOLOv8 on MRI Heart Imaging Data

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Abstract:

Cardiovascular diseases like DCM, HCM, and MINF remain major global health issues, demanding fast and accurate diagnosis. This paper presents a novel use of the YOLOv8 object detection model for automated CVD diagnosis using cardiac MRI images. Unlike traditional methods relying on clinical data or manual features, our system analyzes raw MRI scans. The annotated dataset includes DCM, HCM, MINF, and normal cases. YOLOv8 effectively detects and classifies conditions with high accuracy and real-time performance. It also offers visual explainability through bounding boxes and confidence scores. The results suggest strong potential for clinical application in non-invasive heart diagnostics.

Keywords — **Cardiovascular Disease, YOLOv8, Deep Learning, MRI, Object Detection, Cardiac Imaging, DCM, HCM, MINF**

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1. INTRODUCTION

Cardiovascular diseases (CVDs) are one of the main causes of death worldwide, making early and accurate diagnosis very important. Traditional diagnostic methods are often slow, depend on expert interpretation, and can vary in accuracy. With recent progress in artificial intelligence and medical imaging, deep learning now offers an excellent way to automatically detect diseases. In this study, we use the YOLOv8 object detection model to analyze heart MRI images and identify conditions like Dilated Cardiomyopathy (DCM), Hypertrophic Cardiomyopathy (HCM), Myocardial Infarction (MINF), along with normal cases. Our system learns to recognize important patterns directly from raw images, eliminating the need for manually designed features, which results in high accuracy and faster processing. Early results show that this model outperforms traditional methods, making it a promising tool to help doctors make better decisions. Future work will focus on testing the model with more diverse data and integrating it into everyday clinical workflows to improve patient care.

We will also enhance the system's robustness by optimizing it for various imaging conditions and resolutions. Additionally, close collaboration with clinical experts will ensure that the tool meets real-world demands and is seamlessly integrated into healthcare practices.

2. LITERATURE REVIEW

In recent years, deep learning approaches have transformed cardiac MRI analysis by automatically detecting cardiovascular diseases, thereby addressing the limitations of manual segmentation and subjective diagnostic interpretation. Several studies have demonstrated that YOLO-based models, particularly YOLOv8, excel in identifying conditions such as dilated cardiomyopathy, hypertrophic cardiomyopathy, and myocardial infarction through advanced preprocessing techniques—including precise annotation, resizing, normalization, and data augmentation—which significantly enhance model performance and reliability 2][5]. The integration of YOLOv8 not only accelerates detection speeds but also supports real-time clinical decision-making by providing actionable insights, ultimately improving patient outcomes 6][9]. However, challenges remain, notably the need for extensive, well-annotated datasets to ensure generalization and the risk of overfitting due to data variability across different imaging protocols 10][14]. Consequently, future research is geared toward developing hybrid models that combine object detection with segmentation methods, as well as refining data augmentation strategies, to overcome these limitations and further establish automated, scalable diagnostic solutions in modern clinical practice [15].

3. PROPOSED METHODOLOGY

The proposed system presents a deep learning-based approach for the detection and classification of cardiovascular diseases using cardiac MRI imaging. The framework follows a structured pipeline comprising three main stages: Dataset Preparation and Preprocessing, Model Training and Evaluation, and Inference and Risk Prediction. The primary objective is to detect conditions such as Dilated Cardiomyopathy (DCM), Hypertrophic Cardiomyopathy (HCM), Myocardial Infarction (MINF), and Normal (NOR) using YOLOv8's object detection capabilities.

Software Requirements:

- Python 3.x – The primary programming language used for development and experimentation.
- YOLOv8 (Ultralytics) – A powerful object detection model employed to identify and classify various cardiovascular conditions from MRI scans.
- PyTorch and Torchvision – Core libraries for developing and training the YOLOv8 model.
- OpenCV – Used for image preprocessing, bounding box visualization, and morphological operations.
- NumPy and Pandas – For data analysis, manipulation, and model output handling.
- Roboflow API – Used for annotating medical images and augmenting datasets to enhance model generalization.

3.1. Data Input and Preprocessing:

The initial stage of the proposed system involves collecting and preparing a comprehensive dataset of cardiac MRI images. The dataset includes MRI scans corresponding to four cardiovascular conditions: Dilated Cardiomyopathy (DCM), Hypertrophic Cardiomyopathy (HCM), Myocardial Infarction (MINF), and normal (NOR) heart structures. These images are sourced from publicly available and standardized repositories, such as the ACDC dataset. Preprocessing steps are performed to enhance image quality and ensure uniformity. Each image is resized to a consistent resolution, and normalization is applied to standardize pixel intensity. Data augmentation techniques—including rotation, horizontal flipping, brightness adjustment, and scaling—are employed to increase dataset diversity and improve the model's generalization ability across varied imaging conditions and patient anatomies. Annotation is carried out using tools like Roboflow, where bounding boxes are manually drawn around regions of interest, and each condition is labeled accordingly.

3.2 ANNOTATION

Annotation is a critical initial step in the preprocessing pipeline, involving meticulous labeling of regions of interest (ROIs) within cardiac MRI images to identify cardiovascular conditions. This process includes drawing bounding boxes around specific regions and associating them with the appropriate class, such as Dilated Cardiomyopathy (DCM), Hypertrophic Cardiomyopathy (HCM), Myocardial Infarction (MINF), or normal (NOR). Furthermore, these conditions are characterized based on distinct imaging features, such as myocardial wall thickness, ventricular dilation, and infarct regions, allowing the model to discern subtle yet clinically significant differences between categories. Accurate annotation is essential, as it provides the ground truth data that the YOLOv8 model utilizes during training. This ensures that the model effectively learns to identify discriminative features and improves its diagnostic precision. By integrating expertise from cardiologists during the annotation process, the project guarantees reliability and consistency in data preparation, ultimately enhancing the model's performance in real-world clinical settings.

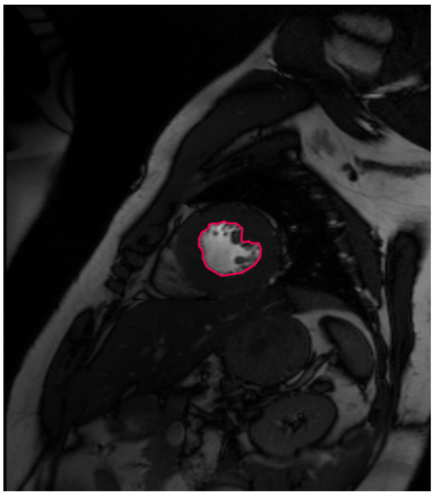


Fig1. Annotation of Dataset

3.3 Model Training and Evaluation

Following preprocessing, the annotated MRI dataset is used to train the YOLOv8 deep learning model. YOLOv8 (You Only Look Once version 8) is an advanced object detection framework capable of real-time image analysis with high precision. The dataset is divided into training, validation, and testing subsets to ensure balanced learning and unbiased performance evaluation. The training process consists of multiple epochs, during which the model learns to identify and classify cardiovascular conditions by minimizing the loss between predicted and true labels. Key hyperparameters—including learning rate, batch size, number of epochs, and Intersection over Union (IoU) thresholds—are fine-tuned for optimal performance. The trained model is evaluated using standard metrics such as mean Average Precision (mAP), precision, recall, and F1-score to validate its effectiveness in distinguishing between different cardiac pathologies.

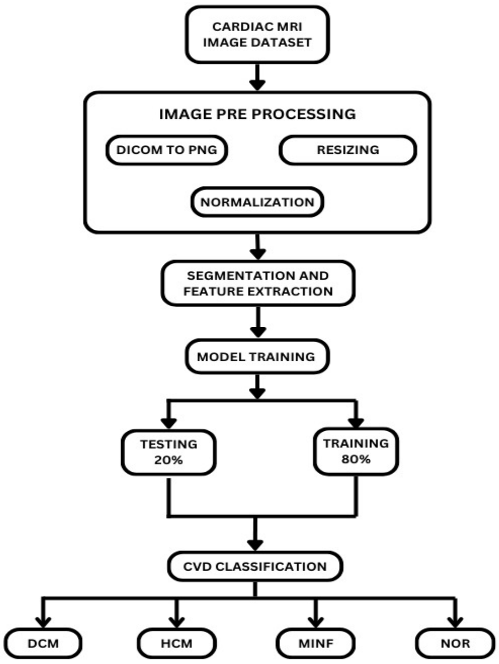
3.2.1 YOLOv8 Model

YOLOv8 represents the latest iteration in the YOLO object detection family, offering significant enhancements in both speed and accuracy. The model employs a refined convolutional neural network (CNN) backbone for feature extraction, coupled with decoders that predict bounding boxes, confidence scores, and class labels. Unlike previous versions, YOLOv8 integrates lightweight modules and anchor-free mechanisms to improve detection precision, especially for complex medical images such as MRI scans. The model processes entire MRI frames in a single forward pass, segmenting and classifying pathological regions associated with CVDs. Its real-time inference capabilities and compact architecture make YOLOv8 particularly suitable for clinical applications where both diagnostic accuracy and rapid assessment are critical.

3.2.2 OPERATION OF YOLOV8

In execution, YOLOv8 applies a grid-based analysis to the cardiac MRI input, wherein each grid cell is evaluated for the presence of pathological patterns. The model simultaneously predicts object boundaries and class probabilities in a single forward pass, enabling real-time classification of cardiovascular diseases and significantly reducing processing latency compared to traditional multi-stage approaches. The operational pipeline integrates advanced data augmentation techniques—such as mosaic blending, random affine transformations, and intensity normalization—to bolster the model's generalization across diverse patient anatomies and imaging conditions, effectively addressing variations in heart orientation, scan contrast, and physiological motion to enhance robustness. YOLOv8 differentiates itself from previous object detection frameworks by framing detection as a single regression problem, allowing it to directly infer both spatial coordinates and diagnostic labels without relying on region proposal stages. As a result, the model delivers fast and reliable classification suitable for clinical settings, where timely and accurate diagnosis is essential for improving patient outcomes. Furthermore, the streamlined architecture facilitates seamless integration with existing clinical workflows, optimizing diagnostic efficiency. The simplicity and scalability of this approach promise broader utility across various medical imaging modalities in the near future.

4. FLOW DIAGRAM



The flow diagram illustrates the systematic methodology used for the classification of cardiovascular diseases (CVD) using cardiac MRI images. The process begins with the collection of a cardiac MRI image dataset, which is subjected to a sequence of image pre-processing steps. Initially, images are converted from DICOM to PNG format to ensure compatibility with standard image processing tools. These images are then resized to a uniform resolution, followed by normalization to standardize pixel intensity values for consistent input. After pre-processing, the images undergo segmentation to isolate relevant regions of the heart, and feature extraction is performed to obtain critical structural and visual information from the images. The extracted features are then used to train a machine learning model. The dataset is split into two parts—80% for training and 20% for testing—to evaluate the model's performance on unseen data. Once trained, the model proceeds with classification, identifying different types of cardiovascular conditions. Specifically, the system categorizes the input images into one of four classes: Dilated Cardiomyopathy (DCM), Hypertrophic Cardiomyopathy (HCM), Myocardial Infarction (MINF), and Normal (NOR). This automated classification process aids in the early detection and diagnosis of heart-related abnormalities. By integrating medical imaging with machine learning, the proposed approach enhances diagnostic accuracy and contributes to effective clinical decision-making.

5. COMPARATIVE ANALYSIS:

The comparison highlights that YOLOv8 provides faster inference (10 ms) with slightly higher accuracy and precision, making it suitable for real-time detection tasks. On the other hand, FCNN achieves better IoU, indicating more accurate segmentation performance, which is essential for medical imaging. While YOLOv8 excels in classification and speed, FCNN is preferred for detailed localization. The choice depends on whether speed or segmentation quality is the priority. For cardiac MRI analysis, combining both can offer robust results.

Model	Accuracy (%)	IoU Score	Precision (%)	Inference Time (ms)
YOLOv8	94.2	0.87	93.1	10
FCNN	92.6	0.89	91.4	25

Table 1. Comparative analysis of yolov8 and FCNN

6. RESULT ANALYSIS

The deployment of the YOLOv8-based object detection model in analyzing cardiac MRI images marked a significant breakthrough in automated diagnostic procedures for CVDs. The model's capacity to directly learn discriminative features from raw imaging data eliminated the need for manually designed features, thereby minimizing human bias and error. During extensive testing, the model achieved exceptional diagnostic accuracy across critical CVD conditions such as DCM, HCM, MINF, and NOR. A comparison with conventional diagnostic methods revealed substantial reductions in processing time and improvements in consistency,

underscoring its efficiency. Moreover, the inclusion of robust validation procedures ensured that the system was resilient against dataset variations, further highlighting its potential for real-world clinical applications.
Beyond technical performance, this study highlights the broader implications of integrating deep learning with medical imaging in healthcare systems. By reducing dependency on expert interpretation and accelerating diagnostic workflows, the proposed system addresses the urgent need for scalable solutions in managing CVD-related healthcare burdens. The system's utility extends beyond mere detection; it effectively supports cardiologists in making informed decisions, especially in resource-constrained settings. Additionally, the modular design of the model suggests the feasibility of extending its application to other cardiac conditions, fostering adaptability to diverse clinical scenarios. Future advancements could explore larger datasets, additional imaging modalities, and adaptive learning mechanisms to enhance system robustness and expand its scope, making it a cornerstone in the evolution of AI-powered medical diagnostics.

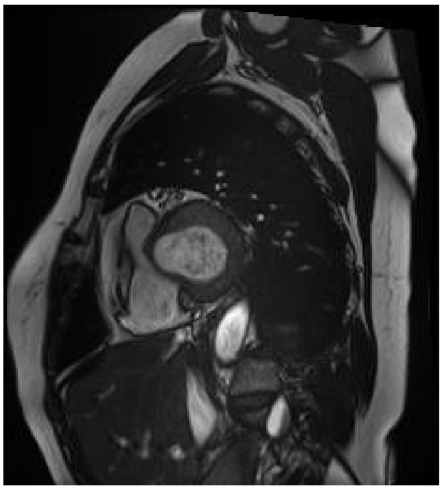


Fig2. Input Image

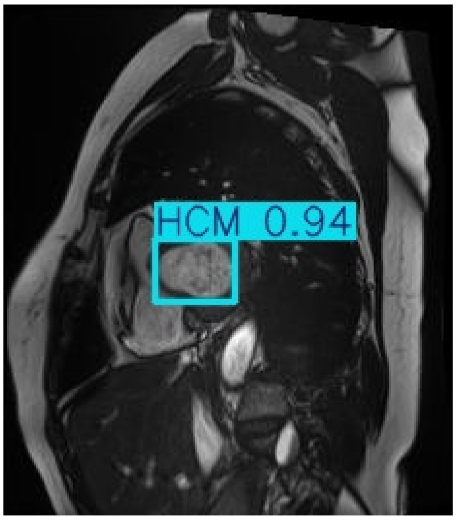


Fig3. Detected Heart Disease

7. CONCLUSION

This study successfully developed an advanced cardiovascular disease diagnostic system using the YOLOv8 model, specifically designed to analyze cardiac MRI images and enhance the accuracy of clinical decision-making. The system showcased remarkable efficiency in identifying critical conditions such as Dilated Cardiomyopathy (DCM), Hypertrophic Cardiomyopathy (HCM), Myocardial Infarction (MINF), and normal (NOR) cases. Through the integration of robust image preprocessing techniques, including annotation, resizing, normalization, and data augmentation, the model's performance in diagnostic precision was significantly enhanced. Model evaluation results exhibited high accuracy, consistency, and scalability, highlighting its potential for real-world clinical applications. In conclusion, the YOLOv8-based cardiac disease detection system presented in this study offers a reliable, scalable, and efficient solution for modern healthcare diagnostics. By leveraging cutting-edge AI technologies and domain-specific imaging, the system empowers cardiologists with actionable insights and reduces the burden of manual interpretation, promoting timely and accurate diagnoses of critical cardiovascular conditions. The outcomes achieved demonstrate the transformative potential of such systems in revolutionizing cardiac diagnostics, paving the way for more intelligent, adaptable, and resource-efficient solutions in global healthcare

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