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Deep Learning for Cardiac Imaging: A CNN Based Web Application for Artery Detection

Vijay M. Rakhade, Akhilesh K. Sharma, Alok Tiwari, Prince Pandit, Gorakh Shinde,

Saniya Meshram

Associate Professor, Department of AIDS, SITRC, Nashik, India Associate Professor, Department of AIDS, SITRC, Nashik, India Student, Department of AIDS, SITRC, Nashik, India

ABSTRACT: Advancements in artificial intelligence (AI) and machine learning have opened new avenues for improving diagnostic processes in healthcare. This research paper delves into the development and implementation of a Convolutional Neural Network (CNN)-based image classification model tailored for detecting cardiac structures. The primary objective of this project is to enhance diagnostic efficiency and accuracy in cardiology by automating the classification of cardiac images. The system integrates several cutting-edge technologies to achieve this goal. Flask, a lightweight and versatile web framework, is employed to create an interactive and user-friendly interface that allows users to upload images and receive real-time classification results. TensorFlow/Keras serves as the foundation for building and training the CNN model, leveraging its robust capabilities in deep learning. The application also incorporates preprocessing steps, such as image resizing and normalization, to ensure compatibility with the model's input requirements. The CNN model is trained on a dataset comprising various cardiac structures, including the coronary sinus, descending aorta, inferior vena cava, left atrial appendage, and papillary muscle of the left ventricle. This research highlights the transformative role of AI in medical imaging and underscores its implications for healthcare applications. While the results are promising, challenges such as data quality, scalability, and integration into existing healthcare systems remain areas for future exploration.

KEYWORDS: Coronary artery Tracking, Convolutional Neural Networks, Medical Imaging, Deep learning, Cardiovascular Disease, MRI.

I. INTRODUCTION

Coronary course illness (CAD) is the conclusion result of the conglomeration of atheromas plaques interior the dividers of the courses that supply the myocardium (the muscle of the heart). While the signs and signs of coronary heart illness are celebrated in the advanced state of illness, most individuals with coronary heart ailment show up no demonstrate of ailment for decades as the disease progresses a few time as of late the to start with onset of signs, regularly a "sudden" heart ambush, at final develops. After decades of development, a few of these atheromas plaques may burst and (along with the sanctioning of the blood clotting system) start compelling blood stream to the heart muscle. The contamination is the most common cause of sudden passing.

Cardiovascular sicknesses remain one of the driving causes of horribleness and mortality around the world, making early location and correct conclusion essential for fruitful treat ment. Helpful imaging methods, such as echocardiography, CT checks, and MRIs, have finished up invaluable disobedient in the evaluation of cardiac structures. Be that as it may, the interpretation of these pictures habitually depends on the dominance of healthcare specialists, which can be time consuming and subject to human mistake. To address these challenges, our ask almost centers on leveraging Convolutional Neural Frameworks (CNNs) for the programmed area and classification of cardiac





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courses in helpful pictures. CNNs are a lesson of significant learning models especially well-suited for picture examination due to their capacity to thus learn dynamic highlights from unrefined pixel information.



Fig 1: Plague in heart.

The application we developed utilizes Flask as the web framework to provide an interactive platform for users to upload images and receive immediate classification results. This user-friendly interface not only enhances accessibility for healthcare professionals but also streamlines the diagnostic process. In this paper, we present a comprehensive analysis of our CNN-based approach for cardiac artery detection. We discuss the architecture of the model, the training process, and the evaluation metrics used to assess its performance. Our results indicate that this automated system has significant potential to improve diagnostic efficiency and accuracy in clinical settings, ultimately contributing to better patient care.

| Metric | Value | |
|---|-------------------------------|--|
| Age-standardized CVD death rate | 272 per 100,000 population | |
| Global average CVD death rate | 235 per 100,000 population | |
| Ischemic heart disease death rate | 321 per 100,000 population | |
| Years of life lost due to CVD (1990) | 23.2 million | |
| Years of life lost due to CVD (2010) | 37 million | |
| Increase in premature mortality (1990- 2010) | 59% | |
| Percentage of CVD deaths below age 50 | 50% | |

| Table 1: Cardiovascular Statistics | Table 1: | Cardiovascular | Statistics |
|------------------------------------|----------|----------------|------------|
|------------------------------------|----------|----------------|------------|

The Architecture of Convolutional Neural Networks



Fig 2: Architecture of CNN

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II. LITERATURE SURVEY

Recent advances in deep learning, particularly Convolutional Neural Networks (CNNs), have significantly impacted medical image analysis, especially in cardiac artery detection. CNNs have emerged as powerful tools for automating critical tasks such as coronary artery segmentation and stenosis identification, which are essential for diagnosing cardiovascular diseases (CVDs). Studies have employed CNNs for coronary artery segmentation in coronary computed tomography angiography (CCTA) and optical coherence tomography (OCT). For instance, Zreik et al. (2019) used a 3D CNN to segment coronary arteries in CCTA scans, achieving a Dice score of 0.82, which outperformed traditional thresholding methods. Similarly, Wolterink et al. (2017) demonstrated that CNNs could detect coronary artery classification with 94% precision, reducing manual annotation time. Furthermore, CNNs address challenges in cardiac imaging such as small vessel sizes, low contrast, and motion artifacts. Chen et al. (2020) proposed a U-Net-based model with attention mechanisms to focus on fine coronary artery structures in OCT images, improving segmentation precision by 12% compared to baseline models. Hybrid models, combining CNNs with recurrent neural networks (RNNs) or graph-based methods, have also been explored. For example, Li et al. (2021) integrated CNNs with graph convolutional networks (GCNs) to model the topological structure of coronary arteries, enhancing stenosis detection accuracy to 89%.

Despite these advancements, significant gaps remain in the application for cardiac artery detection. One key issue is generalization across datasets. Most models are trained on single-center datasets with limited diversity, which causes performance to drop by 15-20% when models are tested on external datasets, as highlighted by Zhang et al. (2021). This raises concerns about the robustness and generalizability of these models in real-world clinical settings. Another challenge is the lack of explainability in CNN models, which are often treated as "black boxes". This limitation restricts clinical adoption, as it is difficult to understand how CNNs localize arteries or stenosis. Few studies have integrated explainability tools such as Grad-CAM or attention maps to clarify the decision-making process, as noted by Petersen et al. (2023). Furthermore, while CNNs have achieved high accuracy, their computational demands hinder real-time processing in clinical workflows, and there is a lack of exploration into lightweight architectures optimized for edge devices.

The theoretical framework underlying CNN applications in cardiac artery detection aligns with established theories in medical imaging and deep learning. CNNs utilize hierarchical feature learning, as described by LeCun et al. (2015), to automatically extract low-level and high-level features from cardiac images. This approach mirrors the biological principle that coronary artery structures exhibit repetitive patterns, such as tubular shapes, which CNNs can leverage. Additionally, the U-Net architecture (Ronneberger et al., 2015), originally designed for biomedical segmentation, serves as a theoretical foundation for many cardiac artery detection models. Its encoder-decoder structure with skip connections is well-suited for preserving spatial details in small vessels. Finally, theories of domain adaptation, such as those proposed by Pan and Yang (2010), have supported efforts to pretrain CNNs on large natural image datasets like ImageNet and fine-tune them on smaller, specialized cardiac datasets. This approach addresses the challenge of limited labeled medical data and improves the generalizability and performance of the models.

III. METHODOLOGY

The study presents a systematic approach that spans data collection, preprocessing, model development, and application deployment. Each stage of the methodology has been designed to ensure robustness and reproducibility, while also addressing the challenges posed by medical image analysis and real-time system integration.

Data Collection and Processing- The dataset used in this project comprises labeled images of cardiac structures, which were sourced from several publicly available medical imaging repositories. The selection of these datasets was guided by a review of contemporary standards in medical image databases, ensuring both diversity and clinical relevance. To bolster the model's ability to generalize across varied imaging conditions, a suite of data augmentation techniques was employed. Specifically, random rotations were applied to expose the model to images from multiple perspectives, while horizontal and vertical flips accounted for anatomical variations inherent in cardiac imaging.

Preprocessing Techniques- Prior to model training, a series of key preprocessing steps were undertaken. Initially, all input images were converted to grayscale. This conversion was motivated by the need to standardize the input data and





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reduce computational complexity without compromising the diagnostic features of the images. Following grayscale conversion, images were resized to a uniform dimension of 512×512 pixels. Standardizing the image dimensions ensured compatibility with the subsequent convolutional layers, facilitating consistent feature extraction across the dataset. Finally, pixel values were normalized to a range of 0 to 1. This normalization was critical to stabilize the training process, as it ensured that the input data maintained a consistent scale, thereby enhancing convergence during optimization.

Model Architecture and Optimization- The core of the model architecture is built upon a Convolutional Neural Network (CNN), which leverages the strengths of transfer learning by incorporating pre-trained networks such as ResNet50. By employing transfer learning, the model is able to benefit from features previously learned from largescale datasets, thereby reducing the training time and improving overall accuracy. The architecture comprises several convolutional layers responsible for extracting spatial hierarchies of features from the input images.

Web Application and Deployment- To bridge the gap between model development and end-user application, a web application was developed using the Flask framework. This application serves as an intuitive interface, enabling users to upload cardiac images for analysis and to visualize preprocessing outcomes in real time. The Flask application is designed to handle both the prediction process and the presentation of results. When a user uploads an image, the system processes the image through the standardized pipeline, performs inference using the trained CNN model, and then returns the classification results in a clear and concise manner. This modular design not only facilitates ease of use but also allows for straightforward integration into clinical workflows.



Fig 3: Flow diagram of CNN

Overall, this methodology reflects a deliberate and structured approach that integrates rigorous data preprocessing, advanced model development techniques, and a robust deployment strategy. By addressing both the technical and operational challenges inherent to medical image analysis and real-time application deployment, the proposed framework offers a viable solution for enhancing diagnostic workflows in clinical settings.

IV. EXPERIMENTAL RESULTS

The system was evaluated using a validation dataset con taining diverse cardiac images sourced from multiple publicly available medical datasets, ensuring comprehensive coverage of common cardiac structures. The model achieved an overall accuracy of 92%, which is indicative of its reliability in practical applications. Precision and recall scores exceeded 90% for most classes, reflecting its robustness in distinguishing between closely related structures. Additionally, the system demonstrated consistent performance across augmented and non-augmented test sets, highlighting its ability to generalize effectively to varied imaging conditions.





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Fig 4: Result of CAD Classification

V. CONCLUSION

This project demonstrates the feasibility and effectiveness of integrating deep learning methodologies with web-based platforms for medical imaging tasks. By leveraging advanced convolutional neural network architectures and a userfriendly web interface, the system delivers a reliable tool for classifying cardiac structures, thereby assisting clinicians in their diagnostic processes. In particular, the seamless connection between the deep learning model and the web application bridges the gap between state-of-the-art research and clinical practice, providing an efficient means for realtime, accurate image analysis. This work thus contributes meaningfully to the rapidly expanding field of AI-powered healthcare solutions and sets a foundation for further innovations in similar diagnostic applications.

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