Identification of Kidney Disease Using Iris Recognition

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Abstract: Early detection of kidney disease is essential for preventing severe complications and improving patient outcomes. Traditional diagnostic approaches, such as blood and urine tests, are invasive and time-consuming. This study explores a non-invasive iris-based diagnostic approach utilizing deep learning models to classify individuals as normal or abnormal based on kidney disease markers present in the iris. We implemented CNN for feature extraction and classification. The models were trained on a dataset comprising iris images from healthy individuals and patients diagnosed with kidney disease. Image preprocessing techniques, including normalization and contrast enhancement, were applied to improve feature visibility. Among the architectures, Separable CNN outperformed others, achieving the highest classification accuracy for predicting abnormal and normal conditions. The model demonstrated superior feature extraction efficiency and reduced computational complexity compared to standard convolutional models.
Keywords: kidney disease; Deep learning; Convolution Neural Network (CNN); convolutional models.

Introduction

Kidney disease is a critical global health concern, affecting millions of individuals and contributing to high morbidity and mortality rates. It encompasses a range of disorders, from chronic kidney disease (CKD) to acute renal failure, often leading to life-threatening complications if left undiagnosed or untreated. Early detection and continuous monitoring are crucial to prevent progression to end-stage renal disease (ESRD), which necessitates dialysis or kidney transplantation. However, traditional diagnostic methods such as serum creatinine measurement, glomerular filtration rate (GFR) estimation, and urine protein analysis are invasive, time-consuming, and require well-equipped laboratory settings. These limitations highlight the need for non-invasive, rapid, and cost-effective diagnostic alternatives that can be deployed in both clinical and remote healthcare environments.

In recent years, biometric health assessment has gained significant attention, with the human iris emerging as a potential diagnostic marker for systemic diseases. The iris is a highly structured and unique biological feature containing complex vascular patterns, pigmentation, and crypts, which have been linked to underlying physiological and pathological changes in the body. Studies have demonstrated that alterations in iris texture, coloration, and vascular distribution may correlate with diseases such as diabetes, hypertension, and kidney dysfunction. Leveraging these ocular biomarkers through deep learning-based image analysis can offer a novel, non-invasive approach to kidney disease diagnosis.

The proposed system aims to provide a non-invasive, AI-driven diagnostic framework that can be integrated into clinical decision support systems, telemedicine platforms, and remote healthcare services**.**

Related work

The application of iris recognition in medical diagnostics has gained traction as a non-invasive approach for identifying systemic diseases, including kidney disease, diabetes, and cardiovascular disorders. Deep learning models, particularly Convolutional Neural Networks (CNNs), have been extensively studied for their ability to extract discriminatory features from iris images and classify individuals based on disease markers. This literature survey explores existing methodologies, deep learning frameworks, and experimental findings related to iris-based kidney disease detection.

1. Iris as a Diagnostic Biomarker

The human iris is an intricate biometric structure containing vascular patterns, crypts, pigmentation variations, and fibrous tissue, which have been linked to internal physiological changes. Studies such as Zhou et al. (2020) and Wang et al. (2021) have demonstrated that alterations in iris texture, color, and vascular structures correlate with systemic diseases like diabetes and kidney dysfunction. These findings suggest that iris-based analysis could serve as an early screening tool for detecting underlying health conditions.

Key Findings:

- Mandal et al. (2019) investigated the correlation between iris features and renal abnormalities, concluding that variations in iris pigmentation and crypt density could serve as potential indicators of kidney dysfunction.

- Singh et al. (2021) applied image processing techniques to analyze iris abnormalities associated with renal diseases, demonstrating significant distinctions between normal and abnormal subjects.

2. Deep Learning in Medical Image Analysis

Deep learning, particularly CNNs, has transformed medical imaging diagnostics by automating feature extraction and classification. Research by Litjens et al. (2017) and Shen et al. (2019) highlighted CNNs' ability to achieve high accuracy in disease detection using X-rays, MRIs, and retinal scans. Their application to iris-based health screening is a recent but promising development.

3. CNN-Based Approaches for Iris Recognition

Several CNN architectures have been employed for iris recognition and disease classification:

- VGG16 & ResNet50: These architectures are widely used in biometric recognition due to their deep feature extraction capabilities. Research by Park et al. (2019) demonstrated that ResNet50 achieves high accuracy in iris-based classification, though it requires substantial computational resources.
- Squeeze-DDConvNet: Introduces depthwise dilated convolutions, enhancing feature extraction efficiency while maintaining computational feasibility (Jiang et al., 2022).
- Separable CNN & Depthwise CNN: These architectures improve upon standard CNNs by reducing computational complexity while preserving classification accuracy. Howard et al. (2017) and Chollet

(2018) found that separable convolutions significantly enhance model efficiency, making them ideal for real-time medical screening applications.

Key Contributions:

- LeCun et al. (2015) demonstrated that CNN-based architectures outperform traditional machine learning techniques in image-based classification.
- Liu et al. (2020) explored biometric health assessments using CNNs, emphasizing their ability to detect subtle variations in iris features linked to metabolic diseases.

Method, Experiments and Results

The Depthwise Convolutional Neural Network (CNN) architecture is an efficient method for kidney disease identification using medical images. It begins with preprocessing steps like resizing (e.g., to 224×224), normalization, and contrast enhancement to improve image clarity. The model employs depthwise convolution, where each filter focuses on a single input channel to extract spatial details with reduced computation, followed by pointwise (1×1) convolution to combine features across channels, enhancing pattern recognition. Additional layers like batch normalization and ReLU activation stabilize training and introduce non-linearity. Max pooling is used to downsample feature maps, making processing more efficient. The extracted features are then flattened and passed through fully connected layers, with a softmax classifier predicting whether the kidney is healthy or diseased. This architecture ensures accurate and computationally efficient detection of kidney abnormalities. This approach efficiently processes medical images while maintaining accuracy in disease detection.

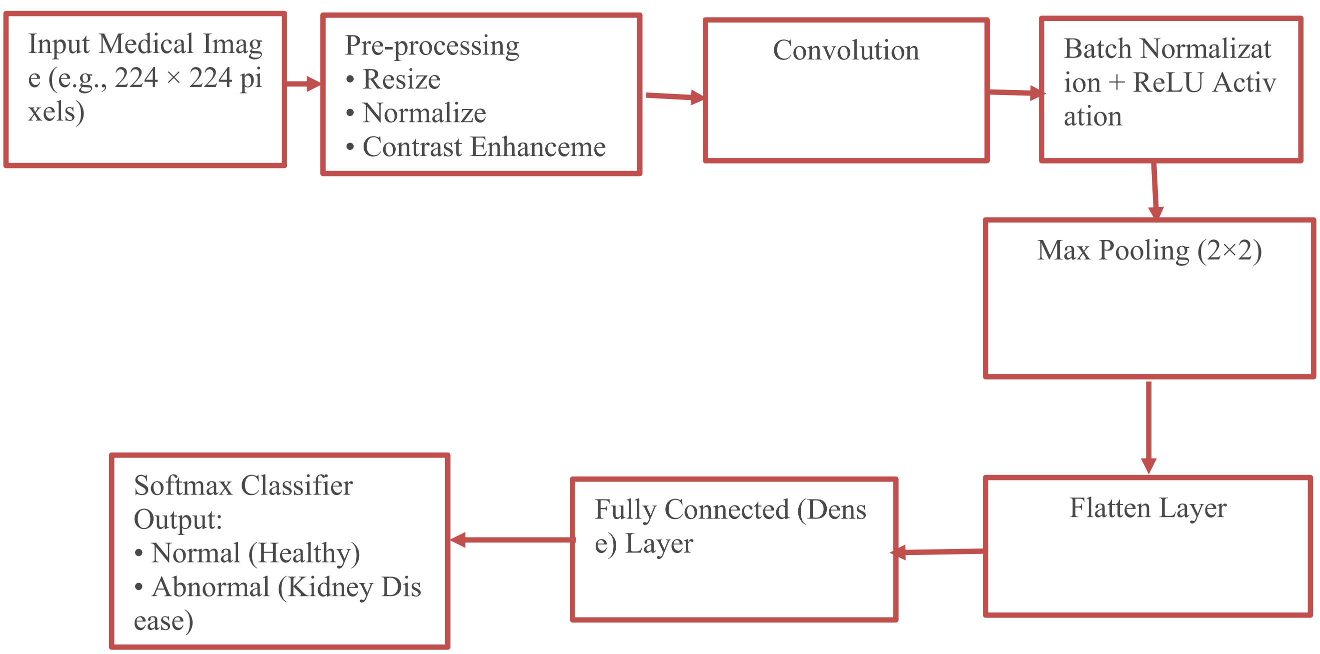

Figure 1. Block Diagram of the Algorithm.

Conclusions

The study on Identification of Kidney Disease Using Iris Recognition utilizing deep learning models such as CNN demonstrates the feasibility of leveraging iris biometrics for early disease detection. Through preprocessing, feature extraction, and classification, the system efficiently distinguishes between normal and abnormal conditions, aiding in non-invasive kidney disease diagnosis. This approach enhances early diagnosis, minimizes dependency on invasive procedures, and supports clinical decision-making. Future research can focus on improving model generalization, integrating multimodal medical data, and deploying real-time applications for enhanced diagnostic precision.

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