Iris Tumour Detection Using Convolutional Neural Networks (CNN)

(Infosys springboard internship 5.0)

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Abstract

Iris tumors, though rare, pose significant risks to ocular health, making early detection critical for effective treatment. This study presents a deep learning-based approach leveraging Convolutional Neural Networks (CNNs) for automated detection of iris tumors. Utilizing MobileNetV2 as the base model with customized layers and transfer learning, the system classifies iris images as normal or tumor-affected. The dataset underwent extensive preprocessing and augmentation to improve diversity and robustness. The model achieved an accuracy of 95%, precision of 100%, and an AUC of 1.0000, demonstrating its reliability for medical diagnostics. Integrated into a web-based interface, the system allows users to upload iris images for real-time analysis, delivering clear diagnostic results. This research highlights the potential of CNNs to enhance ophthalmology practices, offering a scalable and efficient solution for early diagnosis of iris tumors, ultimately aiming to improve clinical outcomes and patient care.

Introduction

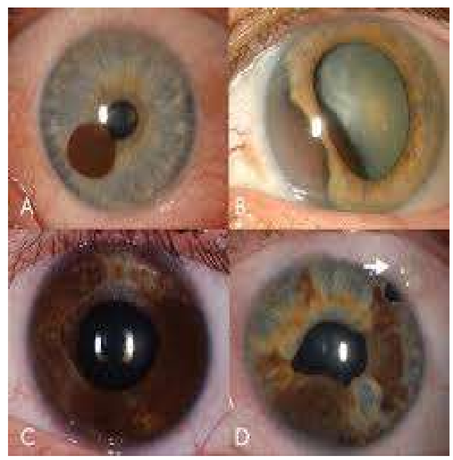
Iris tumors, though relatively rare, pose significant risks to ocular health. These tumors can be classified as either benign (non-cancerous) or malignant (cancerous), with malignant cases potentially leading to severe complications, including vision loss and metastasis, if left undetected. Early detection is critical to prevent these adverse outcomes and ensure timely medical intervention. However, conventional diagnostic methods often rely heavily on manual examination of medical images by ophthalmologists. These methods, while effective, are time-intensive and prone to errors due to variability in human judgment and fatigue. This necessitates the development of automated diagnostic systems to support healthcare professionals in making more accurate and efficient diagnoses.

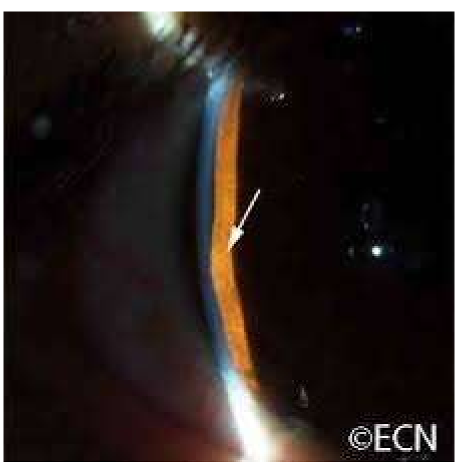
Medical imaging has become a cornerstone in modern diagnostics, providing detailed visual insights into internal structures of the body. However, interpreting these images often requires extensive expertise and is sometimes influenced by subjective bias. Recent advancements in artificial intelligence (AI) and deep learning have revolutionized the field of medical imaging. Among these, Convolutional Neural Networks (CNNs) have proven particularly adept at image analysis tasks. CNNs excel in recognizing patterns, detecting anomalies, and classifying complex visual data, making them an ideal candidate for tumor detection tasks.

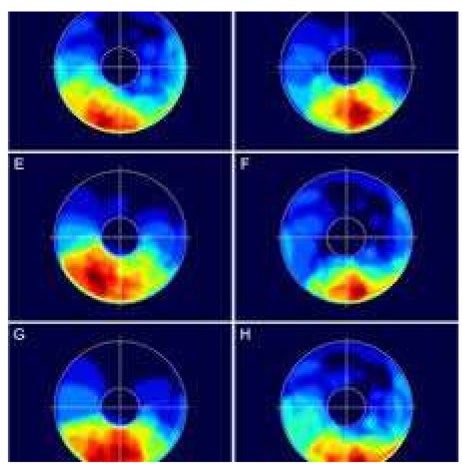
This project aims to develop a CNN-based system for the automated detection of iris tumors from medical images. The system is designed to classify images as either tumor-affected or normal with high accuracy. Python serves as the primary programming language, with Jupyter Notebook providing an interactive platform for implementation and visualization. Preprocessing and augmentation of the dataset are performed using libraries such as NumPy, OpenCV, and Pandas to enhance data quality and diversity.

The methodology involves several stages:

1. **Data Collection and Preparation**: Gathering and preprocessing a dataset of iris images, ensuring it is diverse and suitable for training the CNN model.







2. **Model Architecture and Training**: Designing a CNN architecture tailored for tumor detection and optimizing it through techniques like transfer learning and fine-tuning.
3. **Model Evaluation**: Using metrics such as accuracy, precision, recall, and F1-score to assess the performance of the trained model.
4. **Visualization and Interpretation**: Analyzing model predictions through visualizations, such as heatmaps, to understand its decision-making process.

This project addresses the limitations of traditional diagnostic methods by demonstrating how CNNs can be employed to enhance healthcare delivery. By automating tumor detection, the system not only reduces the time required for diagnosis but also improves accuracy and consistency, thereby supporting ophthalmologists in clinical decision-making.

Furthermore, the integration of this system into a user-friendly web application makes it accessible for practical use. The ability to upload an iris image and receive real-time diagnostic feedback underscores its potential for real-world deployment. By leveraging AI and deep learning, this project contributes to the ongoing transformation of healthcare, paving the way for faster, more reliable, and scalable diagnostic solutions.

Understanding CNN: Model for Iris Tumor Detection

Convolutional Neural Networks (CNNs) are specialized deep learning architectures designed for image processing tasks. The CNN model for iris tumor detection follows a systematic architecture to classify images effectively:

1. **Input Layer:**
   - Accepts preprocessed iris images, typically resized to a uniform dimension and normalized for consistency.
2. **Convolutional Layers:**
   - Extracts key features from images, such as edges, textures, and patterns, using filters .
   - Multiple convolutional layers help capture low- level and high-level features relevant for identifying tumors.
3. **Pooling Layers:**
   - Applies max pooling to reduce spatial dimensions, retaining essential features while minimizing computational complexity.
   - Prevents overfitting and ensures efficient processing.
4. **Activation Functions:**
   - Utilizes **ReLU (Rectified Linear Unit)** to introduce non-linearity, enhancing the model's capacity to learn complex patterns.
5. **Fully Connected Layers:**

   - Flattens the feature maps into a vector and feeds it into dense layers for classification.
   - Outputs probabilities indicating whether the iris is healthy or contains a tumor.
6. **Output Layer:**
   - A softmax or sigmoid activation function provides the final classification (e.g., binary output: normal vs. tumor-affected).
7. **Optimization Techniques:**
   - **Loss Function:** Binary cross-entropy for evaluating model predictions.
   - **Optimizer:** Adam optimizer is used to update weights and reduce loss during backpropagation.
8. **Regularization Methods:**
   - Techniques like dropout and L2 regularization are applied to prevent overfitting and improve generalization.

Problem Statement

The goal of this project is to create a robust CNN-based system that can classify iris images into two categories: normal and tumor-affected. The solution is integrated into a web application, enabling real-time tumor detection to aid ophthalmologists. This project addresses the challenges of small datasets, variability in image quality, and subtle tumor features by employing data augmentation, transfer learning, and model optimization.

Project Workflow

A. Dataset

The dataset consists of images categorized into:

1. Affected Eyes: Images showing tumors.
2. Normal Eyes: Images without any abnormalities.
   Data preprocessing includes resizing images to 224×224 pixels and augmenting them with rotation, shifts, zoom, and flips to increase diversity.

B. Model Architecture

The CNN architecture is built on MobileNetV2, a lightweight model pre-trained on ImageNet. Custom layers include:

1. Global Average Pooling 2D
2. Dense Layers with ReLU activation and dropout regularization

3. Batch Normalization
4. Sigmoid activation for binary classification

C. Training and Optimization

1. Initial Training: 30 epochs with frozen base layers.
2. Fine-Tuning: 40 epochs with selective unfreezing and a learning rate of 1E-5.
3. Features:
   - Batch size: 16
   - Class weight balancing
   - Early stopping (patience = 15)
   - Learning rate reduction and best model checkpointing

D. Web Application Features

1. Upload Image: Users can upload images for analysis.
2. Detect Image: Processes the image using the trained CNN model.
3. Show Results: Outputs whether the image contains a tumor or is normal.

Results and Evaluation

A. Performance Metrics

The model demonstrated the following performance:

- Loss: 0.2226
- Accuracy: 95%
- Precision: 100%
- Recall: 90.91%
- AUC: 1.0000
- F1 Score: 95.24%

B. Visualizations

- Confusion Matrix: Shows classification performance.
- ROC Curve: Highlights model effectiveness with AUC = 1.0000.

C. Dataset Expansion

Proposed actions for improving dataset diversity:

1. Collecting tumor images across demographics.

2. Generating synthetic data with GANs.
3. Collaborating with medical institutions for high-quality datasets.

Conclusion

This project successfully combines deep learning techniques with an accessible interface to detect iris tumors. The approach showcases the power of AI in medical diagnostics, aiming to support early detection and improve patient outcomes. Further research will enhance generalizability and extend the system to broader ocular conditions.

Acknowledgments

We thank Infosys Springboard for mentorship and the resources provided for this project.

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