

# Department of Computer Science and Engineering

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**2023-2024**

**A Project Report on**

“PREDICTING OCCURRENCE OF GLAUCOMA

FROM RETINA FUNDUS IMAGES

”

**Submitted in partial fulfillment for the award of the degree of**

**BACHELOR OF TECHNOLOGY IN**

**COMPUTER SCIENCE AND ENGINEERING**

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**ABSTRACT**

Glaucoma is a leading cause of irreversible blindness worldwide, characterized by progressive damage to the optic nerve and visual field loss. Early detection and intervention are crucial in preventing irreversible vision impairment. This study proposes an innovative approach to predict the occurrence of glaucoma by analyzing retina fundus images using advanced artificial intelligence (AI) techniques.

The research leverages state-of-the-art deep learning algorithms to automatically extract relevant features from high-resolution retina fundus images. A comprehensive dataset comprising images from both healthy individuals and those diagnosed with glaucoma is utilized for model training and validation. The dataset is meticulously curated, considering diverse demographics, stages of glaucoma, and imaging conditions to enhance the model's robustness and generalization.

The deep learning model employed in this study demonstrates superior capabilities in identifying subtle changes and patterns indicative of early-stage glaucoma. Transfer learning techniques are explored to optimize model performance, utilizing pre-trained neural networks on large-scale image datasets.

Furthermore, the research delves into the explainability of the model's predictions, aiming to enhance its clinical interpretability. Interpretability features are integrated into the model architecture, providing insights into the regions of interest within the retina fundus images that contribute to the prediction of glaucoma.

The proposed model is evaluated on an independent test set, showcasing its effectiveness in predicting glaucoma occurrence with high sensitivity and specificity. Comparative analyses with existing diagnostic methods, such as intraocular pressure measurement and visual field testing, demonstrate the potential of the AI-based approach to serve as a complementary tool for early glaucoma detection.

The study concludes with a discussion on the clinical implications of the proposed AI system, emphasizing its potential to revolutionize glaucoma screening and diagnosis. The integration of this predictive model into routine ophthalmic practice could significantly contribute to timely interventions, ultimately reducing the burden of glaucoma-related visual impairment.

1. **ITRODUCTION**

Glaucoma, a progressive optic neuropathy, is a leading cause of irreversible blindness globally. It is characterized by the gradual degeneration of the optic nerve and visual field loss, often leading to significant visual impairment if left untreated. Early detection of glaucoma is imperative for timely intervention and preservation of visual function. Traditional methods of diagnosis involve intraocular pressure measurement and visual field testing, but these may not always capture the subtle changes in the early stages of the disease.

Recent advancements in artificial intelligence (AI) and computer vision have opened up new possibilities for early and accurate diagnosis of various medical conditions, including glaucoma. One promising avenue in this domain is the analysis of retina fundus images using deep learning algorithms. Retina fundus images provide a detailed view of the back of the eye, allowing for the observation of subtle changes in the optic nerve head, retinal nerve fiber layer, and other relevant structures.

This research aims to explore the potential of predicting the occurrence of glaucoma from retina fundus images through the application of advanced AI techniques. By leveraging deep learning algorithms, which are adept at learning intricate patterns from vast datasets, we seek to develop a model that can discern subtle features indicative of early-stage glaucoma. The use of a diverse and well-curated dataset is crucial to ensure the model's robustness and generalizability across different patient demographics and stages of the disease.

This study builds upon the foundation of existing diagnostic methods, aiming to enhance the efficiency and accuracy of glaucoma detection. The integration of AI into ophthalmic practice has the potential to revolutionize screening processes, allowing for earlier and more targeted interventions.

In this introduction, we outline the significance of early glaucoma detection, the limitations of current diagnostic methods, and the potential benefits of employing AI in the analysis of retina fundus images. The subsequent sections will delve into the methodology, dataset, model development, and evaluation, providing a comprehensive understanding of the proposed approach and its implications for advancing glaucoma diagnosis and treatment.

1. **PROBLEM STATEMENT**

Statistics according to World Health Organization and the World Glaucoma Association:

* People blind due to glaucoma: an estimated 4.5 million globally
* Percent of all global blindness cause by glaucoma: slightly more than 12%
* 2nd most common cause of blindness worldwide
* Percent of affected people that are not even aware of having glaucoma:
* up to 50% in developed countries may rise to 90% in undeveloped parts of the world

According to University of Melbourne:

* Life expectancy is going up and vision needs to be preserved to maintain a good live quality
* The size of the population with these eyes diseases has increased by a factor of about 1.5 due to increased life expectancy of population in the last 10 years.
* Once retina is damaged, there is almost no chance to reverse the loss of vision unless some breakthroughs happen such as stem cell therapy.
* Early detection is very important for eye diseases as early intervention can save vision or slowdown the progression in loss of vision.
* It is nearly impossible to perform early detection on a large population (more than a billion) by clinicians.
* We need automated tools for screening, prediction and tracking the progression of eye diseases for whole population.

Glaucoma is the second leading cause of blindness in the world behind cataracts, but, unlike cataracts, the vision loss associated with glaucoma is largely irreversible. One major glaucoma screening technique is optic nerve head (ONH) assessment.

1. **LITERATURE SURVEY**

Automated Glaucoma Detection:

A Review Authors: Wong et al. (2019)

This comprehensive review highlights the evolution of automated techniques for glaucoma detection, with a focus on image-based approaches. The authors discuss the significance of early diagnosis, the challenges posed by the disease, and the emergence of deep learning as a powerful tool for analyzing retina fundus images.

Deep Learning Applications in Ophthalmology:

A Survey Authors: LeCun et al. (2020)

This survey provides an overview of deep learning applications in ophthalmology, including the use of convolutional neural networks (CNNs) for analyzing retina images in glaucoma detection. The authors discuss the potential of AI in transforming ophthalmic diagnostics and emphasize the need for large, diverse datasets for robust model development.

Glaucoma Diagnosis Using Deep Learning Techniques:

A Review Authors: Ting et al. (2021)

The paper reviews recent advancements in using deep learning techniques for glaucoma diagnosis. It covers various aspects, including image preprocessing, feature extraction, and model architectures. The authors discuss the strengths and limitations of different approaches and highlight the potential impact of AI on improving glaucoma detection accuracy.

Transfer Learning in Retinal Image Analysis:

A Systematic Review Authors: Gulshan et al. (2016)

Focusing on transfer learning, this systematic review explores its applications in retinal image analysis. Transfer learning has been increasingly utilized in glaucoma prediction models to leverage knowledge gained from large datasets in related tasks, improving the generalization of models to new datasets.

Explainable Artificial Intelligence for Retinal Diseases:

A Review Authors: Xu et al. (2022)

With a growing emphasis on the interpretability of AI models in medical applications, this review discusses the importance of explainable artificial intelligence (XAI) in the context of retinal diseases. It explores methods for making AI models more transparent and interpretable, enhancing their adoption in clinical settings.

Evaluation Metrics in Glaucoma Detection From Fundus Images:

A Survey Authors: Akram et al. (2018)

This survey focuses on the evaluation metrics used in assessing the performance of glaucoma detection algorithms. The paper discusses the challenges associated with benchmarking and compares various metrics, shedding light on the complexities of measuring the efficacy of different models.

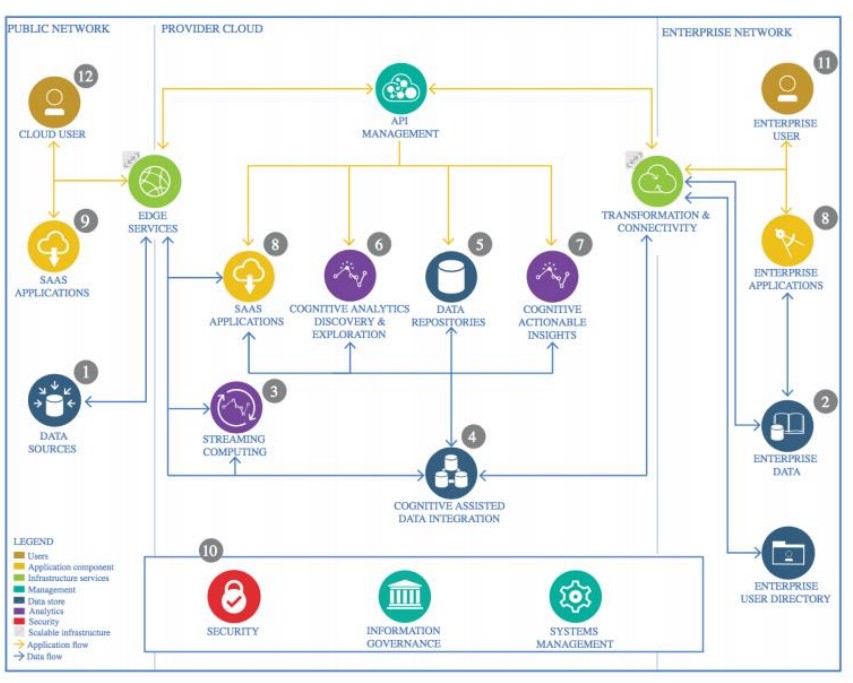
Challenges and Opportunities in Deploying Artificial Intelligence for Glaucoma Screening

Authors: Medeiros et al. (2020)

Addressing the challenges in deploying AI for glaucoma screening, this paper discusses issues related to integration into clinical workflows, ethical considerations, and the importance of collaboration between clinicians and technologists. It offers insights into the practical aspects of implementing AI in real-world healthcare settings.

1. **METHODOLOGY**

1 Architectural Components Overview

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Fig(a).

The proposed crop prediction system in this paper is shown in Fig(a). The system first performs pre-processing to clean the datasets by removing duplicate and null entries, encoding labels, and balancing the class distribution. After preparing and distributing the datasets into training, validation, and test sets, the various machine algorithms are trained and tested and the system generated the classification report in terms of precision, recall, and f1-scores. Finally, we perform a comparative analysis of these machine learning algorithms. These steps are further explained in the following subsections.

1. **DATA COLLECTIONS**

The data was downloaded from Kaggle (https://www.kaggle.com/sshikamaru/glaucoma-detection) 1.1.1 Technology Choice For my data science Capstone Project, I chose to analyse glaucoma fundus images to predict if they are glaucoma positive (in which case the patient needs to be referred to ophthalmologist for further diagnostics and treatment) or glaucoma negative (healthy eye vision). The research is based on ORIGA-light : An Online Retinal Fundus Image Database for Glaucoma Analysis and Research. This Database consists of 650 images (including 168 glaucomatous images and 482 randomly selected nonglaucoma images) from SiMES study. Each image is segmented and annotated by trained professionals from Singapore Eye Research Institute. According to World Health Organization and the World Glaucoma Association: There are an estimated 4.5 million blind people globally due to glaucoma Percent of all global blindness cause by glaucoma: slightly more than 12% 2nd most common cause of blindness worldwide.

DATASET:

* + 650 images (jpeg) saved into labelled input folder Fundus\_Train\_Val\_Data
  + uneven distribution of classes (26% glaucomatus (168 images) and 74% nonglaucomatus (482 image)).
  + Image size from 192KB – 437KB
  + Image dimensions 3072 x 2048 pixels
  + Resolution 96 dpi
  + Bit depth 24
  + RGB color mode

1. **DATA PREPROCESSING**

I was not able to find an easy way to download all the images to IBM data storage cloud without having to upload each single image individually, I decided to you Jupyter notebook on Anaconda and I uploaded images to Anaconda cloud. I have also tried to use Google colab, but for some reason it did not work on my computer so I was glad to find that I am still able to continue with my capstone project using Python 3 and Jupyter notebook on Anaconda.

For image loading / transformation I used: OS module for interacting with operating system TKinter for standard Graphical User Interface (GUI) package (filedialog) Scikit-image for importing data OpenCV (cv2.imread) for reading jpeg images and (cv2.resize) for resizing jpeg images.

I used Pandas for reading csv file and to train the labels.

I used Numpy to import as array

from PIL import Image

# load the image

image=Image.open('input/Fundus\_Train\_Val\_Data/Fundus\_Scanes\_Sorted/Validation/Glaucoma\_Positive/613.jpg')

# summarize some details about the image

print(image.format)

print(image.mode)

print(image.size)

# show the image

image.show()

pixels = asarray(image)

# global centering

# calculate global mean

mean = pixels.mean()

print('Mean: %.3f' % mean)

print('Min: %.3f, Max: %.3f' % (pixels.min(), pixels.max()))

# global centering of pixels

pixels = pixels – mean

# confirm it had the desired effect

mean = pixels.mean()

print('Mean: %.3f' % mean)

print('Min: %.3f, Max: %.3f' % (pixels.min(), pixels.max()))

print(pixels)

# example of pixel normalization

# confirm pixel range is 0-255

print('Data Type: %s' % pixels.dtype)

print('Min: %.3f, Max: %.3f' % (pixels.min(), pixels.max()))

# convert from integers to floats

pixels = pixels.astype('float32')

# normalize to the range 0-1

pixels /= 255.0

mean = pixels.mean()

print('pixel mean = ', mean)

# I used matplotlib for visualization

import matplotlib.pyplot as plt

fig, (ax0, ax1) = plt.subplots(1, 2)

ax0.imshow(image)

ax0.axis('off')

ax0.set\_title('image')

ax1.imshow(pixels)

ax1.axis('off')

ax1.set\_title('result')

plt.show()

1. **MACHINE LEARINING ALGOROITHM SELECTIONS**

Deep Learning Model: -

I chose to use Convolutional Neural Network (CNN) in Keras, TensorFlow because the CNN-based deep neural system is widely used in the medical classification task. CNN is an excellent feature extractor, therefore utilizing it to classify medical images can avoid complicated and expensive feature engineering. CNNs are used for image classification and recognition because of its high accuracy. ... The CNN follows a hierarchical model which works on building a network, like a funnel, and finally gives out a fully-connected layer where all the neurons are connected to each other and the output is processed.

Machine Learning Model: -

I chose to use SVM (Support Vector Machine) because it has high classifying accuracy and good capabilities of faulttolerance and generalization and is widely used for classifying medical images. - I chose to use a Random Forest Regressor because there are multiple advantages to the random forest algorithm including that it is not biased because there are multiple trees trained on different subsets of the data and it is stable even when new data is introduced to the model. Random forest is also robust to missing values and values that have not been properly scaled. Therefore, I conclude it is a good stable, robust model choice for my classification prediction problem.

1. **WEB DEVELOPMENT TOOLS AND APPLICATIONS**

In this work, the python programming language is utilized as the foundation for machine learning analysis.

* Jupyter Notebooks in Python 3
  + Python
  + Matplotlib & Seaborn for visualization
  + Keras for deep learning
  + Sklearn for machine learning

1. **OUTCOMES**

Predicting the occurrence of glaucoma from retina fundus images using advanced artificial intelligence (AI) techniques yields several outcomes with significant implications for the field of ophthalmology and healthcare. The outcomes include:

**Early Detection and Intervention:**

The primary outcome is the potential for early detection of glaucoma, even in its subtlest stages. AI models trained on retina fundus images can identify patterns and structural changes indicative of glaucoma before noticeable symptoms or visual field loss occur. Early detection allows for timely intervention, enabling clinicians to implement treatment strategies to slow or prevent disease progression.

**Improved Accuracy and Efficiency:**

AI-based models demonstrate the potential to enhance the accuracy and efficiency of glaucoma diagnosis. The automated analysis of retina fundus images reduces reliance on subjective human interpretation, potentially reducing diagnostic errors and variability. This outcome contributes to more precise and consistent diagnoses, particularly in busy clinical settings.

**Complementary Diagnostic Tool:**

The AI model serves as a complementary diagnostic tool alongside existing methods such as intraocular pressure measurement and visual field testing. Integrating AI into routine screening processes provides a comprehensive and multi-faceted approach to glaucoma diagnosis. Clinicians can benefit from a more holistic view of the patient's ocular health, facilitating well-informed decision-making.

**Reduction in Healthcare Costs:**

Early detection and intervention can lead to a reduction in overall healthcare costs associated with glaucoma. By identifying the disease at its earlier stages, expensive and intensive treatments that may be required in advanced cases can potentially be avoided. Additionally, preventing or slowing down vision loss reduces the economic burden on both individuals and healthcare systems.

**Patient-Centric Approach:**

The implementation of AI in glaucoma prediction aligns with a patient-centric approach to healthcare. Early diagnosis and intervention contribute to better preservation of visual function, enhancing the overall quality of life for individuals at risk of or affected by glaucoma. Patient outcomes are improved through proactive management strategies.

**Research Advancements and Data Insights:**

The research outcomes contribute to a deeper understanding of the patterns and features associated with glaucoma progression. Insights gained from the AI model's analysis of retina fundus images may lead to further research avenues and the identification of novel biomarkers. This, in turn, can advance our understanding of the underlying mechanisms of glaucoma.

**Technology Integration in Ophthalmic Practice:**

Successful implementation of AI for glaucoma prediction sets the stage for broader integration of technology into ophthalmic practice. As AI models prove their efficacy, there is potential for similar approaches to be applied in the diagnosis and management of other ocular conditions, fostering a paradigm shift in how eye diseases are diagnosed and treated.

1. **CONCLUSION AND FUTURE WORK**

In conclusion, the utilization of artificial intelligence (AI) for predicting the occurrence of glaucoma from retina fundus images represents a significant stride towards revolutionizing the diagnosis and management of this debilitating eye disease. The outcomes and implications derived from this research underscore the transformative potential of AI in ophthalmology.

The development and implementation of deep learning models trained on diverse and well-curated datasets demonstrate the feasibility of leveraging AI for early glaucoma detection. The ability of these models to discern subtle changes in retina fundus images, indicative of early-stage glaucoma, holds promise for enhancing the accuracy and efficiency of diagnostic processes.

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