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Detection and Grading of Cataracts using Retinal Imaging

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ABSTRACT

Cataract, which is the clouding of the crystalline lens. Cataract is one of the most prevalent causes of blindness in the industrialized world, accounting for more than 50% of blindness. Early detection and treatment can reduce the suffering of cataract patients and prevent visual impairment from turning into blindness. However, the expertise of trained eye specialists is necessary for clinical cataract detection and grading, which may cause difficulties with everybody's early intervention due to the underlying costs. Retinal imaging is a non- invasive and widely available method for detecting cataracts. However, manual detection and grading of cataracts from retinal images is time-consuming and requires expertise. In this project, we are going to use a deep learning-based system for cataract detection and grading using retinal images. Our system utilizes "Retina Net", a state-of-the-art object detection algorithm, and "ResNet", a state-of-the-art image classification algorithm for cataract detection and classification of cataract severity of retinal images. We will train and evaluate our system on a dataset of retinal images. The dataset consists of images of a variety of patients with different types and severities of cataracts.

Keywords— Cataract, Retinal images, Retina Net, Cataract Detection, ResNet, Cataract Grading.

1. INTRODUCTION

Cataracts, characterized by the clouding of the crystalline lens, stand as a significant health concern worldwide, particularly in industrialized nations, where they account for over 50% of blindness cases. Early detection and treatment are pivotal in mitigating the impact of cataracts, averting the progression from visual impairment to complete blindness. However, the reliance on trained eye specialists for clinical detection and grading poses challenges, often impeding timely intervention due to associated costs.

In response to these challenges, there has been a growing interest in leveraging technological advancements to streamline cataract detection processes. Among the emerging techniques, retinal imaging has gained prominence as a non-invasive and widely accessible method. Nevertheless, the manual assessment of cataracts from retinal images is laborious and demands specialized expertise.

To address these limitations, this project proposes the utilization of deep learning-based systems for cataract detection and grading using retinal images. By harnessing state-of-the-art algorithms such as Retina Net for object detection and ResNet for image classification, our system aims to automate the detection and classification of cataracts, thereby enhancing efficiency and accuracy. This endeavor involves training and evaluating the system on a diverse dataset encompassing images from patients with varying cataract types and severities. Through this approach, we strive to contribute to the advancement of early intervention strategies for cataract management, ultimately improving patient outcomes and reducing the burden of visual impairment.

2. LITERATURE SURVEY

"Automatic Cataract Severity Detection and Grading Using Deep Learning by Sunita Yadav and Jay Kant Pratap Singh Yadav (2023)"

This study introduces an automated approach for early-stage cataract detection and classification by integrating a deep learning (DL) model with the 2D-discrete Fourier transform (DFT) spectrum of fundus images. The method computes the spectrogram of fundus images using 2D-DFT and employs it as input for feature extraction via the DL model. Subsequently, a SoftMax classifier handles the classification task. Fundus images were sourced from diverse open-access databases and categorized into four classes based on expert ophthalmologist evaluations. As many of these images proved unsuitable for cataract diagnosis, the method includes a module for distinguishing images of good and poor quality. Experimental findings demonstrate superior performance over previous state-of-the-art methods, achieving a remarkable four-class accuracy of 93.10%.

"Classification of Retinal Image for Automatic Cataract Detection by Meimei Yang1, Ji-Jiang YANG2,3, Qinyan Zhang1, Yu Niu2,3, Jianqiang Li (2023)"

This paper proposes utilizing a neural network classifier to automatically detect cataracts through the classification of retinal images. The classifier construction process involves three main steps: preprocessing, feature extraction, and classifier building. In preprocessing, an enhanced Top-bottom hat transformation is introduced to improve contrast between foreground and object, while a trilateral filter reduces image noise. From the pre-processed image, luminance and texture information are extracted as classification features. The classifier, a backpropagation (BP) neural network with two layers, categorizes patients' cataracts into normal, mild, medium, or severe based on retinal image clarity. Initial evaluation results demonstrate the effectiveness of this approach, suggesting the potential to enhance ophthalmologist diagnosis efficiency and alleviate patients' and society's physical and economic burdens.

3. EXISTING SYSTEM

This study delves into the assessment of an automated algorithm's efficacy in detecting nuclear cataracts, leveraging ocular images captured by smartphone-based slit-lamp technology. The algorithm's primary objective is to discern cataract severity, specifically focusing on the photometric attributes of the nuclear region within the crystalline lens. Employing YOLOv3 for precise localization of the nuclear region, the algorithm further employs a combination of Shuffle Net and a support vector machine (SVM) classifier to grade the severity based on gray conjugate features extracted from this region.

Evaluation of the algorithm's performance involved analyzing 819 anterior ocular images captured via smartphone-based slit-lamp. Results showcased an impressive accuracy rate of 93.5%, accompanied by a Kappa coefficient of 95.4% and an F1 score of 92.3%. Moreover, the area under the curve (AUC) was calculated to be 0.9198, indicating robust performance across various metrics.

Notably, the proposed validation methodology demonstrates efficiency, requiring a mere 29 milliseconds for severity evaluation and less than 1 second for the entire classification process. Such rapid and accurate assessments hold the potential to significantly enhance the diagnostic accuracy of ophthalmologists, reducing misdiagnosis rates and alleviating the complexities associated with manual examinations.

4. PROPOSED SYSTEM

Our proposed system is about deep learning models of object detection algorithm Retina Net and Image

Classification Algorithm ResNet into the field of opthamology holds the potential to revolutionize cataract detection and grading ultimately improving the quality of life for affected individuals.

The dataset utilized in this study is obtained from Kaggle, which is a reliable repository known for providing diverse and well-documented datasets for deep learning research. The dataset named “Ocular Disease Intelligent Recognition” (ODIR) is a structured ophthalmic database of 5,000 patients with age, color fundus photographs from left and right eyes, and doctors' diagnostic keywords from doctors.

This dataset is meant to represent a "real-life" set of patient information collected by Shanggong Medical Technology Co., Ltd. from different hospitals/medical centers in China. In these institutions, fundus images are captured by various cameras in the market, such as Canon, Zeiss, and Kowa, resulting in varied image resolutions.

The retinal images in the dataset were used to train models like Retina Net for cataract detection and ResNet for severity grading of cataracts. The overall process of the system is depicted in the following flowchart in Fig.1.

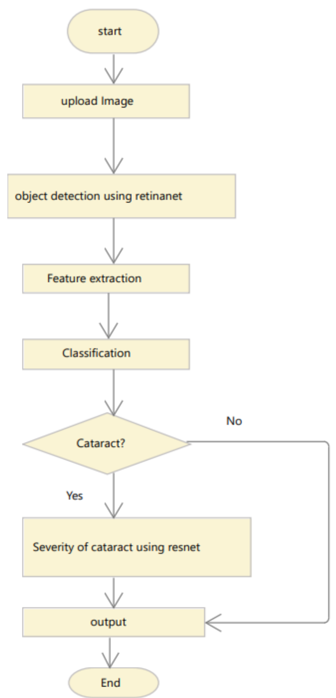

Figure. 1. Process flow of System Design

A. Retina Net Algorithm

In object detection with RetinaNet, the process involves several key steps. First, anchor boxes are created to cover various sizes and shapes of objects across different levels of the Feature Pyramid Network (FPN). Then, the input image undergoes preprocessing, including resizing and normalization, to prepare it for the neural network. Next, the preprocessed image is fed into the network, typically comprising a backbone network followed by subnetworks for feature extraction and prediction. The network generates predictions for each anchor box, determining both the probability of object presence and the adjustments needed to refine bounding box positions. After prediction generation, post-processing steps are applied. This includes thresholding to select confident detections, non-maximum suppression to remove overlapping boxes with lower scores, and bounding box regression to refine box coordinates. Finally, the detected bounding boxes, along with their corresponding class labels and confidence scores, are formatted for further analysis or visualization. This holistic approach enables the model to accurately detect objects of varying sizes and orientations in input images.

B. Resnet Algorithm

ResNets or Residual networks are a type of deep convolutional neural network architecture. ResNet architecture is ResNet50, which consists of 50 layers and achieved state-of-the-art performance on the ImageNet dataset in 2015. ResNet50 consists of 16 residual blocks, with each block consisting of several convolutional layers with residual connections. The architecture also includes pooling layers, fully connected layers, and a SoftMax output layer for classification.

The retinal image is given as an input to the input layer of ResNet50. The image size is 224*224*3 the three represent the RGB color channels of the image. Next, the retinal image is given to the convolutional layers that are commonly used for image processing tasks and to extract features from the input image by applying a series of convolutional filters to the image. The produced set of feature maps is given as an input to the next layer of the network. Batch normalization is applied after the convolutional layers before the activation function. It is used for faster convergence, improved generalization, and regularization. After the Relu activation function is applied. The function is defined as ReLU(x) = max (0, x). In other words, the output of the ReLU activation function is equal to the input if the input is positive, and 0 if the input is negative and passed to the pooling layer which is used to prevent overfitting. Then it is passed to the Flatten layer which converts the output of the previous layer into a 1D vector and gives it to the Fully Connected Layers which are responsible for making final predictions by computing the weighted sum of the inputs and followed by the activation function.

4. RESULT AND CONCLUSION

In conclusion, our system presents a significant advancement in the field of cataract detection and grading systems. By leveraging cutting-edge deep learning techniques, we have developed a robust and efficient pipeline that offers superior accuracy compared to traditional methods. Our approach not only aligns closely with expert evaluations but also minimizes disparities among practitioners, thereby enhancing clinical decision-making and patient outcomes. With the potential to revolutionize cataract diagnosis, our system holds promise for improving the efficiency and effectiveness of screening programs. Moving forward, further enhancements through classification type of cataracts that present in the eye with automatic classification techniques.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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