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Trachoma Disease Detection using Deep Learning

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ABSTRACT

Trachoma is a bacterial infection of the eye caused by the bacterium Chlamydia trachomatis. It is a leading infectious cause of blindness worldwide. The infection causes inflammation and scarring of the conjunctiva, the lining of the eyelid, which can lead to eyelashes turning inward and rubbing against the cornea, causing pain, light sensitivity, and eventually blindness.. Trachoma is treated with antibiotics, and in cases of severe scarring with inward-turned eyelashes, surgery may be necessary to correct the eyelid position and prevent further corneal damage. The proposed model detects trachoma using deep learning model. In this model, advancement of Convolution ?Neural Network is utilized for feature extraction and classification.

Keywords: trachoma, deep learning, CNN

INTRODUCTION

Trachoma is an ocular disease caused by the bacterium Chlamydia trachomatis. It poses a significant public health challenge in 42 nations and is responsible for the blindness or visual impairment of approximately 1.9 million individuals. The blindness resulting from trachoma is irreversible. Trachoma typically affects both eyes. Initial symptoms include mild itching, irritation of the eyes and eyelids, discharge from the eyes, and redness. These symptoms can advance to blurred vision and ocular pain. Early-stage trachoma can be treated with antibiotics, while surgical intervention is necessary in more advanced stages. Access to clean water and enhanced sanitation practices are crucial for prevention. Initially, trachoma may present with mild itching and irritation of the eyes and eyelids. Subsequently, one may observe swollen eyelids and pus discharging from the eyes.

If left untreated, trachoma can result in blindness. It is recognized as the leading preventable cause of blindness globally. The majority of trachoma cases are found in impoverished regions of Africa, where 85% of individuals with active disease reside. In areas where trachoma is endemic, infection rates among children under the age of five can exceed 60%. The signs and symptoms of trachoma typically affect both eyes and may include: mild itching and irritation of the eyes and eyelids, discharge containing mucus or pus, eyelid swelling, sensitivity to light (photophobia), eye pain, redness, and vision loss. Young children are especially vulnerable to infection. However, the disease progresses gradually, and the more severe symptoms may not manifest until adulthood.

The World Health Organization (WHO) has delineated five distinct stages in the progression of trachoma: Inflammation — follicular. In the initial phase of infection, five or more follicles—small elevations containing lymphocytes, a specific type of white blood cell—can be observed with magnification on the inner surface of the upper eyelid (conjunctiva). Inflammation —intense. At this stage, the eye becomes highly infectious and experiences irritation, characterized by thickening or swelling of the upper eyelid. Eyelid scarring. Recurrent infections result in scarring of the inner eyelid, with scars often appearing as white lines when viewed under magnification.

This scarring may lead to distortion of the eyelid, potentially causing it to turn inward (entropion). In-turned eyelashes (trichiasis). The scarred inner lining of the eyelid continues to deform, resulting in the eyelashes turning inward, which causes them to rub against and scratch the transparent outer surface of the eye (cornea). Corneal clouding (opacity). The cornea is affected by inflammation, which is most commonly observed beneath the upper lid. Ongoing inflammation, exacerbated by the scratching from the in-turned lashes, leads to clouding of the cornea. All manifestations of trachoma are more pronounced in the upper lid compared to the lower lid. If left untreated, a disease process that commences in childhood may persist and progress into adulthood.

Fig: 1 Trachoma

Trachoma is an uncommon disease[2] resulting from a bacterial infection that impacts the eyes. This condition is caused by a bacterium known as Chlamydia trachomatis. The infection is frequently transmissible and is considered contagious. It typically spreads when an uninfected individual comes into contact with the secretions from an infected person's eye, eyelids, nose, or throat. In addition to transmission through direct contact with an infected person's secretions, an uninfected person may also become infected by using a handkerchief or face towel that has been utilized by someone infected. Chlamydia trachomatis is transmitted through direct contact. Infected young children act as reservoirs for the infection. The bacteria are then passed on through close physical interactions with family members and caregivers. Furthermore, the bacteria can be disseminated via shared blankets, pillows, and towels. The bazaar fly Musca sorbens lays its eggs in human feces that may be contaminated with trachoma bacteria. These flies can carry the bacteria on their bodies and potentially transmit them to humans. Certain environmental conditions facilitate the spread of trachoma bacteria, including: inadequate personal hygiene, poor disposal of bodily waste and trash, insufficient water supply for washing, shared sleeping arrangements, and close proximity to domestic animals.

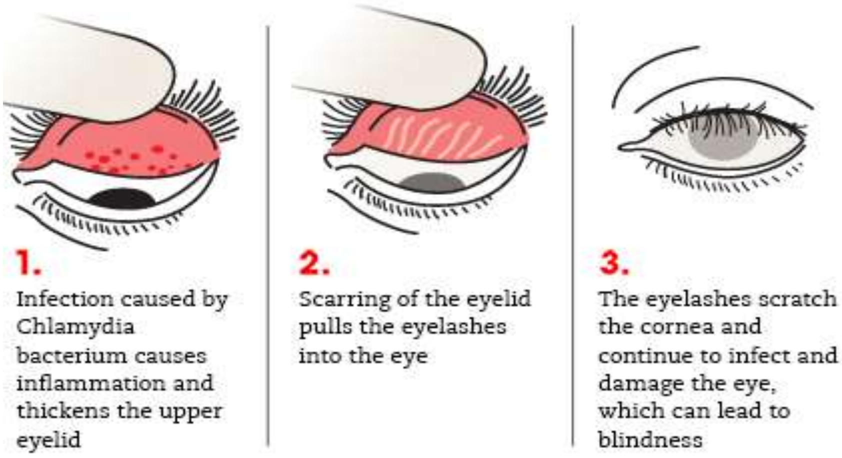

Fig: 2 Stages of Trachoma

According to the World Health Organization, trachoma progresses through five distinct stages in nearly all cases[3,4]. These stages are as follows: 1. Follicular Inflammation: This initial stage is characterized by the swelling of the follicles, which are small sacs containing lymphocytes, a type of white blood cell found in humans. When five or more follicles beneath the conjunctiva (the inner lining of the eyelids) begin to swell, it indicates the onset of trachoma. Typically, this inflammation is not visible to the naked eye and is primarily observed under a microscope. 2. Intense Inflammation: During this stage, additional follicles swell, leading to the spread of the infection. The eyelid begins to thicken and swell at this point. 3. Scarring of the Eyelid: Recurrent infections can lead to scarring of the inner eyelid. These scars often manifest as white lines on the conjunctiva when examined microscopically. As a result, the eyelid may start to distort and turn inward, a condition known as entropion. 4. Trichiasis: This condition occurs when the eyelashes grow inward rather than outward. It is typically a consequence of the deformation of the previously scarred inner eyelid, causing the lashes to rub against the cornea, the eye's transparent outer layer. This marks the transition to the next stage. 5. Clouding of the Cornea: As the eyelashes continue to irritate the cornea, inflammation develops, adversely affecting the cornea. This inflammation is often visible beneath the upper eyelid.

LITERATURE SURVEY:

In [1], a model was created for classifiers by employing two advanced Convolutional Neural Network architectures, ResNet101 and VGG16, alongside a range of data augmentation and oversampling techniques applied to the positive images. A dataset comprising 2300 images with a positivity rate of 5% for TFis is utilized.

Various pre-trained deep neural network models[5], such as ResNet and Xception, are utilized for image classification in the "active classification" task. Additional experiments were conducted under three scenarios: training from scratch, training from pre-trained models on raw images, and training on images focused on the region of interest (ROI).

A deep-learning algorithm[6] identifies three distinct diseases based on features extracted from Optical Coherence Tomography (OCT) images. This algorithm employs CNN to categorize OCT images into four classifications. These classifications include Normal retina, Diabetic Macular Edema (DME), Choroidal Neovascular Membranes (CNM), and Age-related Macular Degeneration (AMD).

An effective model[7] has been developed to predict eye diseases using machine learning (ML) and ranker-based feature selection (r-FS) methods, which is proposed to assist in achieving an accurate diagnosis. The objective of this model is to automatically predict one or more of five prevalent eye diseases, namely, Cataracts (CT), Acute Angle-Closure Glaucoma (AACG), Primary Congenital Glaucoma (PCG), Exophthalmos or Bulging Eyes (BE), and Ocular Hypertension (OH).

1. Proposed Work

I. Image preprocessing:

Adaptive Histogram Equalization (AHE) is a technique in digital image processing aimed at enhancing the contrast of images by redistributing their intensity values. Unlike traditional histogram equalization, which processes the entire image simultaneously, AHE operates locally on smaller sections or 'tiles' of the image. This localized approach enables AHE to effectively enhance contrast in areas with differing brightness levels, making it particularly beneficial for images that exhibit localized contrast problems. The input image is segmented into smaller, non-overlapping rectangular regions. For each tile, a histogram is generated that illustrates the distribution of intensity values within that specific tile. Subsequently, histogram equalization is performed on each tile individually, redistributing the intensity values to enhance contrast within that particular area.

II. Feature extraction using Convnext:

Convolutional neural networks represent a category of deep learning models that yield effective outcomes in areas like image recognition and classification. These networks process three or more dimensional data, including images and sounds, and are composed of various types of layers, such as convolutional layers, pooling layers, and fully connected layers. ConvNeXt is a contemporary convolutional neural network (CNN) architecture that reinterprets traditional CNNs by incorporating successful design features from Vision Transformers (ViTs). Created by Facebook AI Research, ConvNeXt attains state-of-the-art results in image recognition tasks while preserving the efficiency and scalability characteristic of CNNs. It is extensively utilized for transfer learning, computer vision research, and practical applications. The term "ConvNeXt" is frequently employed to denote a specific type of deep learning model utilized for feature extraction from datasets during the learning process.

This model falls under the deep learning subfield known as convolutional neural networks (CNN). ConvNeXt models are structured with convolutional layers succeeded by fully connected layers. These models are recognized for their exceptional performance on visual datasets, as convolutional layers are crucial in capturing features within datasets. Like other deep learning models, ConvNeXt models are trained on extensive datasets and subsequently applied to classify new data, execute regressions, or undertake other tasks. The training procedure typically employs an optimization technique known as backpropagation.

The ConvNeXt model adopts this convolutional neural network framework and introduces an additional layer, distinct from the fully connected layers that are typically positioned after the convolutional layers. This layer, referred to as "global average pooling" (GAP), condenses the outputs of the convolutional layers into a singular vector. This vector can then be utilized for tasks such as classification or regression by ultimately passing it through one or more fully connected layers.

The ConvNeXt architecture represents a distinctive combination of depth-wise convolution and self-supervised learning methodologies. It integrates the most advantageous elements of Vision Transformers, including the implementation of self-attention mechanisms, while preserving the straightforwardness and effectiveness of ConvNets. A prominent characteristic of the ConvNeXt architecture is its application of depth-wise convolution. This method entails utilizing a single filter for each input channel, as opposed to the conventional technique of employing multiple filters. Consequently, this leads to a considerable decrease in computational complexity, enhancing the efficiency and scalability of ConvNeXt models.

Self-supervised learning constitutes a fundamental aspect of the ConvNeXt architecture. This methodology involves training models with unlabeled data, enabling them to derive meaningful representations from the data itself. This contrasts with supervised learning, where models are trained on labeled datasets. In the context of ConvNeXt, self-supervised learning is employed to train the model on a substantial volume of unlabeled image data. This enables the model to extract valuable features from the data, which can subsequently be applied to a variety of vision-related tasks. The incorporation of self-supervised learning within ConvNeXt exemplifies the innovative nature of the model's design. By harnessing the capabilities of self-supervised learning, ConvNeXt achieves exceptional performance in vision tasks, surpassing numerous other models within the same category.

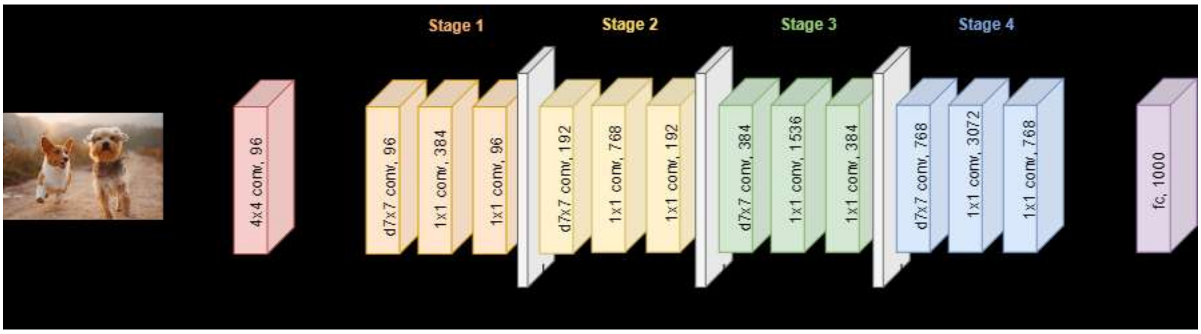

Fig: 3 Architecture of ConvNeXt

The GAP layer is designed to create a more lightweight model architecture by minimizing the number of fully connected layers. This characteristic renders ConvNeXt models particularly suitable for deployment on faster devices that require less computational power. In addition to the convolutional and pooling layers found in traditional convolutional neural network models, ConvNeXt models incorporate layers such as 'batch normalization' and 'non-linear activation.' These additional layers enhance the model's performance and improve its resistance to overfitting. Consequently, the ConvNeXt model integrates a GAP layer for feature extraction within the convolutional neural network framework, striving to achieve a more streamlined model structure through the inclusion of various other layers. The ConvNeXt model features a sophisticated architecture and encompasses numerous attributes.

CONCLUSION

Trachoma is the leading infectious cause of blindness worldwide. It is caused by an obligate intracellular bacterium called Chlamydia trachomatis. The infection is transmitted by direct or indirect transfer of eye and nose discharges of infected people, particularly young children who harbour the principal reservoir of infection. These discharges can be spread by particular species of flies. In this paper, a deep learning technique is developed for trachoma detection.

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