Advance Cataract Onset Detection Using Deep Learning

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Abstract: ***Cataract is an illness which induces partial or reversible blindness globally, usually seen in aged people. AI or Artificial Intelligence is the next approach in the technology which specifically focuses on automation and quicker results. Using AI, we can create a system which can used to detect cataract as early as possible by the people. Using AI to determine the results will certainly make it more accurate than being determined through manual means. Human errors are bound to happen which can generally determine the fate of the patient but AI will certainly prompt out the best and accurate result.***

Keywords: Machine Learning, Convolution Neural Network, Deep Learning, Fundus Imaging, Kaggle Dataset

1. Introduction

Cataract is a leading eye disease across the world [25]. If cataract is not diagnosed in earlier stage, then it may lead to blindness. Cataract causes temporary or reversible blindness which can and only be treated via cataract surgery.

To date, cataracts are clinically diagnosed by ophthalmologists using slit-lampbiomicroscopy in [1] [2] [5] [14], and graded based on established clinical scales such as the Lens Opacities Classification System seen in [17] [21] [24]. The aim of this paper is to efficiently use a deep convolutional neural network to detect and classify cataracts. The key intention behind this work is to develop an inexpensive robust and convenient algorithm which in conjugation with suitable devices will be able to diagnose the presence of cataract from the true color images of eye. For that purpose we will be using a CNN architecture to diagnose a potential case of cataract in advance, thus minimizing or eliminating any damage to the lens.

Computer-aided cataract diagnosis (CACD) methods play a crucial role in early detection of cataract, as referenced in [11], [12], [13] and [15]. The existing CACD methods are suffering from performance diminution due to the presence of noise in digital fundus retinal images. The lack of robustness in CACD methods against noise is a serious concern since even the presence of small noise levels may degrade the performance of cataract detection. However, noise in fundus retinal images is unavoidable due to various processes involved in the acquisition or transmission. Hence, a robust CACD method against noisy conditions is required to diagnose the cataract accurately.

In this study, an efficient network selection based robust CACD method under additive white Gaussian noise (AWGN) is proposed [19]. The presented method consists a set of locally- and globally-trained independent support vector networks with features extracted at various noise levels. A suitable network is then selected based on the noise level present in the input image. The automatic feature extraction technique using pre-trained convolutional neural network (CNN) is adopted to extract features from input fundus retinal images.

Thus, our aim is to provide an effective solution to the cataract problem by giving optimized and cheaper alternatives to the existing methods of detection. As earlier detection of cataract will give a higher rate of surgical success, our model will allow for better and more accurate diagnosis of the cataract condition.

2. Literature Review

Following are the research papers that were studied and researched thoroughly. In [1] this paper, attempts were made to detect aberrations in a patient's fundus with the use of AI techniques. This was achieved by using machine learning to detect and report and aberrations that was not expected by the system. Both sets of reliability classification were satisfactorily tested. Images were preprocessed using Naturalness Image

In [2] this paper detection of corneal diseases was carried out using a deep learning algorithm. There was a unique training function developed to characterize the different losses occurring due to the disease. The accuracy rates were checked for multiple diseases. The dataset used was obtained by the consented pictures of 510 live patients along with ImageNet. Facebook's Pytorch was used to preprocess and conform the images used. Inception v3 CNN was used as mainframe architecture.

In [3] this paper, the objective was to derive an algorithm to diagnose corneal disease using slit lamp inputs. The Active Shape Model (ASM) was used in this case. The dataset used was fundus images (7030), from the clinical database of Beijing Tongren Eye Center. ResNet-50 and Resnet-18 were used in conjunction as the main image preprocessing techniques. Ladas Super Formula was the mainframe architecture with support from the Hill Radius Base function.

In [4] this paper the aim was to automatically diagnose cataract by image scanning using a DCNN. The slit-lamp-adapted anterior segmental photography was proposed methodology. The accuracy derived was satisfactory across several cases. Slit lamp images were obtained from Zhongshan Ophthalmic center. Image preprocessing techniques primarily involve wavelet transformation (WT), local binary pattern (LBP), scale-invariant feature transform (SIFT).

The aim [5] is to evaluate machine Learning as aviable option in cataract phase detection and classification. 5 unique methods were evaluated across different parameter. The unweighted accuracy was tested for all 5 methods.100 cataract surgery videos from John Hopkins University were used as the dataset. Primus-trained GoogleNet was main image preprocessing methods used. 5-fold cross validation architecture was used as mainframe.

The aim of [6] this survey was to get a summary of the current state-of-the-art, a critical discussion of open challenges and directions for future research. Multiple CNN operational functions were compared based on performance and efficiency. Accuracies were recorded based on methods used. The Kaggle dataset was used. Image preprocessing was done using GoogleNet and VGGNet and ResNet. Auto Encoders (AEs) and Stacked Auto Encoders (SAEs) were used as mainframe architecture. The advantages and disadvantages of the methods used were discussed.

The study proposed [7] the use of Artificial Intelligence and machine learning to automatically classify retinal eye disease. They have used data set (300 images of normal retina, 100images of cataract, another 100 images of glaucoma and 100 images of retinal disease) to pre-process using histogram and data augmentation respectively. For Convolution Neural Network (CNN), two types of architecture were used, smaller version ofResNet50 with filter and second one with custom built 7 layers. Accuracy was less than 60% and for ML was 59% (random forest method), 61% for (gradient boosting), 56% (SVM). As per the author, when machine learning model were used it was found that the binary classifier was far more useful when compared to multi class classifier.

Deep convolution neural network for [8] detection of cataract using transfer learning algorithm was studied. They used 4 sets of cataract eye images where set A consisted of 100 images, set B consisted of 200 images, set C consisted of 300 images and set D consisted of 400 images. The images were pre-processed using digital image processing paradigm and Deep convolution neural network was used with GoogleNet transfer learning algorithm. With the help of Machine learning model, the images were classified based on type, severity, color, grade and hardness. It was concluded by author that the proposed model was far more reliable with accuracy rate of 33.33% for set A, 66.67% forest B, 88.33% forest C and 100% for set D along with 100% reliability rate.

Recent study approaches proposed for [9] detection of cataract with the help of image processing technique. They have used 4 different data sets of which set 1 consists of 5620 fundus images, set 2 consists of 100 images, set 3 consists of 5378 images and set 4 consists of 4545 images. The images were pre-processed using digital image processing. accuracy of 86.69 %, for SVM (Support Vector Machine) classifier whereas for back propagation (BP) neural network the accuracy was 89.56%. It was concluded that SVM was very effective.

In [10] this paper the authors discussed detection of cataract in diabetic patient and classifying them using methods of deep learning. The data set consisting of 2000 images from Kaggle website were classified as class 0 (1290img of healthy people) & class 1 (460img of diabetic patients). The images were pre- processed using gaussian blur and resized to 512x512. ResNet34 architecture based on (CNN) containing 34 blocks was used to minimize error rate to 3.6%. It was observed that the proposed model had an accuracy of 86% with sensitivity of 85%.

The study [11] proposed detection of cataract instantly and classifying the type as nuclear sclerotic, cortical, posterior sub capsular along with their stages using SVM algorithm and machine learning. The author used data set of 40 images containing both cataract and non-cataract eye which are then pre-processed with the help of digital image preprocessing technique. Using sample images (positive and negative) the model is trained for testing. If the test turns out negative the process is terminated whereas if test turns out positive, the feature is extracted from the image and fed to the algorithm which further classifies and grades. The accuracy was 90%, precision 77%. The work concluded that model also helped in determining the cataract position.

The [12] objective of this paper is to detect cataract remotely using 261fundus images (of which 89, 78, 57 and 37 fundus images are of non-cataract, mild cataract, moderate cataract and severe cataract). The data set is pre-processed using Contrast-limited Adaptive Histogram Equalization technique and binary SVM classifier trains for classification. The Multi-class fisher discriminant analysis algorithm helps to grade the image into 3 different classes which are mild, moderate and severe. The image features are extracted using Discrete Wavelet Transform (DWT) algorithm. result of the proposed (Accuracy -93%, Specificity - 77.7%, F-measure - 84.66%). It was concluded that proposed system could perform remotely which would enable the less developed places to detect cataract.

The [13] aim of the paper is to efficiently use a deep convolutional neural network to detect and classify cataract. Pre-processing of images is done by using the maximum entropy method. The main aim of this model is to reduce the economic burden for patients. If the images are not properly differentiable the accuracy will come down. The dataset they have collected is divided into a training dataset and testing dataset. The image is the user input while the categories of eye and accuracy percentage are the output of the model. The categories can be a normal eye, immature cataract, and mature cataract. The image preprocessing is done by removing unwanted borders in image.

The [14] objective of this paper is to assist Ophthalmology using deep learning technologies to detect cataract and other retinal disease. The data sets consisting of 75137 fundus images in it. DL, for the most part, they employ convolutional based neural networks (CNNs). DL has also been applied to slit lamp images of pediatric cataracts. A CNN algorithm had high sensitivity and specificity for grading, density, and location of pediatrics cataracts. DL tools would empower patients, facilitate early diagnosis, as well as identify treatable eye disease. Use of DL networks for diagnosis with a single-label per image for training (image-classification methods) can cause the network to associate incorrect information with the presence of the disease.

The [15] objective of this paper Is to assist ophthalmology using AI. ML and deep learning algorithms to detect cataract and other retinal disease. The data sets (12875 retinal images) have AUC (0.958), sensitivity100%&specificity (91%). DL used for signal processing, pattern recognition & statistical analysis. Image processing and segmentation have been used. By applying ML algorithms such as RF and SVM, the diagnosis and grading of cataract has been made by utilizing fundus images, ultrasound images and visible wavelength eye images.

The [16] objective of this paper is to assist ophthalmology using ai to detect cataract and other retinal disease. The data set is 1475 fundus images are used applications focus on ROP or congenital cataracts. All CNN based systems used versions of the Inception architecture with transfer learning by pretraining on ImageNet. They used 3 types of CNN methods there are normal CNN, pre-CNN and plus-CNN with accuracy (76.42%-97.69%). Most of these systems detect disease based upon one snapshot in time, without consideration of longitudinal imaging of the case. Its high reliability and have good sensitivity and specialty. They used deep rop and rop di architecture.

The [17] objective of this paper is automatic cataract detection system from the digital eye image and retinal fundus images using hybrid techniques is proposed. The data set is 500 fundus images are used. The proposed system developed a new algorithm for improving the cataract detection and other eye disease detection from the retinal fundus images. The accuracy of the proposed system is improved using the genetic algorithm. Digital image processing techniques are used close to 98.3% accuracy. Pre-processing can improve the image quality and this make automatic eye disease and cataract detection accurately. Kernel Hyper Support Vector Machine (KHSVM) and modified genetic algorithm named as IIGA (Iterative Intensity Genetic Algorithm) architecture are used.

The [18] objective of this paper is eye disease classification machine learning is proposed. The data set is 3025 fundus images is used. Different classification algorithms were used, namely, decision tree, random forest, naïve Bayes and artificial neural network algorithms. Efficiency was more than 90% and accuracy was 98.5%. The proposed model is based on real-time patient data from electronic health records. However, as computer technology is advancing, this is expected to be resolved in the near future. The user interface developed for data recording is unique and hasbeen greatly admired for its ease of use. Nearest neighbor classification methods can also be used by converting codes into numerical data.

This [19] paper was introduced to apply artificial intelligence models to predict the occurrence of posterior capsule Opacification (PCO). The status of eyes operated on for age-related cataract were determined after the literature review. 10 input variables were selected. The QUEST algorithm was used to develop a decision tree. For this, three back- propagation artificial neural networks were constructed and trained with the same transfer functions and training protocol with randomly selected eyes. They were then tested on the remaining eyes and the results obtained were compared with previously analysed and pre- determined results.

This [20] paper explains the fundamental need to introduce new diagnostic and imaging techniques to ophthalmologists. These techniques are solemnly depended on Machine learning. They can help practitioners to diagnose certain medical condition and act according to it. Their usefulness is not limited as to act as diagnostic tool, but they can be used to detect diseases at early phases or predict the evolution of the condition. This work aims to be a concise over view of all the steps of the process.

This [21] paper solemnly introduces AI algorithms which are used build up an AI model which is used to detect any anomaly in an eye. One such algorithm commonly used for detection is CNN or Convolutional Neural Network, which works on the principle of Deep Learning. It consists of multiple convolutional layers that considers several extracts of the input images and combines them to produce a final image which is than compared to the pre-determined scale to detect any anomaly. Also, this paper lays down different steps which are used to build up a successful AI model.

This [22] paper proposes to build a platform using Artificial Intelligence recording multiple clinical scenarios which can be accessed globally to improve efficiency and to cover resource usage. Here various results or datasets are taken into consideration and integrated using three process so to determine a pattern which can used to refer for the upcoming cases. This method can help to determine the exact disease condition enhancing performance and saving a lot of work and time. For this a deep learning algorithm is used to validate and process the dataset.

Here, [23] an AI agent known as CC-Guardian is developed using Bayesian and Deep learning algorithms. This agent takes all the datasets of the patients and from medical sources, combines them and uses it to predict the anomaly in an eye. This agent validates the result obtained automatically multiple times before finalizing it.it is integrated to web-based smart phone app and prediction-tele health cloud system so that it can become a fully automated system and can provide result such as alerting patients or doctors about any change.

Variety [24] of techniques related to image diagnosis have helped to determine various eye diseases very easily, based on datasets with millions of data points. Machine learning, a field under Artificial Intelligence is used. Machine learning can help to automatically detect or identify any slight variation into an eye or detecting ocular diseases, which can help ophthalmologists reducing their workload orin other words it can greatly enhance detection, treatment or in any case prevention (like any suitable methods which can help to prevent future.

Table 2.1: Machine Learning Papers

Reference No.	Publisher	Methods	Accuracy	Reliability	Dataset	Image Processing	Architecture	Advantages	Limitations
[2]	Nature Magazine	Guided loss function	Area under curve 0.930	95%	510 slit-lamp photo ImageNet data set	Facebook's Pytorch deep learning framework	Inception-v3 convolutional neural network architecture	Superior Performance	Only images covering around cornea can be used.
[3]	Asia-Pacific Journal	Active Shape Model	95% success rate.	This system achieved a MAE of 0.304.	7030 fundus images	ResNet-50	Ladas Super Formula was used as main framework	Free up current workload & enable to serve 10x more	Patients with history of refractive surgery poses challenge.
[4]	PLoS ONE journal.	The slit-lamp-adapted anterior segmental photography	Classification (0.9686) density (0.97433) & location (0.95911).	70%	Slit-lamp image datasets	Wavelet transformation (WT), local binary pattern (LBP), scale-invariant feature transform (SIFT)	CNN	Performance better than a customized feature method	Multi kernel learning and ensemble learning is not yet enabled
[8]	International Journal of recent technology and engineering (IJRTE) in 2019.	Deep Convolution Neural Network.	Taken across 4 sets: A - 33% B - 66.67% C - 88.33% D - 100%	100% based on Likert Scale.	A–100 img B-200 img C-300 img D-400 img	Standard operations of Image Processing.	GoogleNet V4 DCNN model.	Developed systems were able to attain high rates of reliability under series tests.	ROI for area computation & color sampling for cataract can affect result.
[10]	Leonardo Electronic Journal of Practices and Technologies (LEJPT) in 2018	CNN (Convolution Neural Network).	86% (Average accuracy) Class 0 - 0.88 precision Class 1 - 0.78 precision.	Reliability is 75%	(I)Class 0 (2000 img of healthy) (II)Class 1 (2000 img of diabetic)	Standard operations of Image Processing along with wavelet and multi-resolution processing.	ResNet	automatically extracts features available in image and uses it to distinguish	Only Two dimensional images can be tested.
[13]	International Journal of Innovative Tech. & Exploring Engg. Aug 2019	CNN based transfer learning.	87.5% in transitional scale.	89 % immature cataract & 99 % mature cataract.	100 images	Resizing the images Cropping the image	Inception V3 architecture	The system is designed to recognize a more varied set of images.	Image requirements are very limited and strict.
[15]	Asia Pacific Journal of *Ophthalmology* 2019	ML and AI	77.3%	AUC, Sensitivee &specific for vision threat RDR (95%, 92% & 91.4%)	12875 retinal images	Retinal imaging, namely OCT layer segmentation	CRVO with Optos img.	Reduceneedless blindness across the world.	Many ethical challenges occur, including, bias, human values, data.

Reference No.	Publisher	Methods	Accuracy	Reliability	Dataset	Image Processing	Architecture	Advantages	Limitations
[17]	SSN:2454-4248 Vol:3 IJFRCSCE In 2017	SVM and NN	98.3%	96%	500 fundus images	Shading standardisation.	Kernel Hyper SVM&genetic algorithm.	New algorithm for improving the cataract detection	Not suitable for large and fundus image datasets.
[18]	Tech.& Eng. Univ. of Suffolk, Ipswich UK 2019	Neural Network, Naïve Bayes and Support Vector Machines	98.75%	More than 90%	3025 fundus images	Involves data cleaning and normalization, filtering and handling of missing values.	Decision Tree, Random Forest	Alg. made better predictions	Gives only a sufficient amount of data
[19]	Elsevier Inc. 2017	Machine learning	89%	80%	20-30 images	Axial length over 24.5 mm to develop visually significant PCO necessitating laser capsulotomy	Quest algorithms	It is fast and less prone to biases.	not useful for more than 70-year-old people with a non-mature cataract
[21]	Hindawi Journal of ophthalmology 2018	AI and includes DL and CML and CNN	92%	87%	Messidor 1748 fundus images	Grading cataractfrom fundus img, ultrasounds img & visible wavelength eye img	DCNN	Detect different retinal diseases with high accuracy	Need of huge amount of data
[22]	Chinese research company Volume103, Issue 11may 2019	Chinese Medical Alliance for AI (CMAAI) and DCNN	99.28% to 99.71%	99%	37 638 img	Resnet	Identifies Relationship between the lens plague with capsules.	Cost and time-consuming factors	Identifies Relationship between the lens plague with capsules.

Tables 2.2 Survey Papers

Reference No.	Publisher	Methods	Accuracy	Reliability	Dataset	Image Processing	Architecture	Advantages	Limitations
[9]	Journal of Network Communications and Emerging Technologies (JNCET).	DCNN (Deep Convolution Neural Network), BP (Back propagation) neural network,	84.8% to 98% depending on the techniques selected.	83% to 90% as it varies with each new test.	Data set 1 (5620 fundus image) Data set 2 (100) Data Set 3 (5378) Data Set 4 (4545).	Standard operations of Image Processing along with wavelet and multi-resolution processing.	BP, CNN LeNet, VGG (Very Deep Convolutional Networks are used.	Effective retinal analysis for other eye diseases and accurate distinct veins and artery for pathology detection.	Reliability rate is inconsistent with each test case.
[14]	Canadian Journal of Ophthalmology 2018	Deep learning CNN	88.4% to 91.6%	93.4%	75137 images	Retinal imaging, namely OCT layer segmentation	Neovascular AMD, DME	It has been shown to effectively screen for common blinding diseases	Lack computational Power

Table 2.3: Data Mining Papers

Reference No.	Publisher	Methods	Accuracy	Reliability	Dataset	Image Processing	Architecture	Advantages	Limitations
[1]	Hal Archives	Light focus method	93.52% cataract detection 86.69% Scale grading	100% normal, 88% Moderate, 90% Severe	HRF, STARE, DIARETDB, MESSIDOR, 200 fundus images	Naturalness Image Quality Evaluator (NIQE), Perception based Image Quality Evaluator (PIQE)	Alex Net model using ImageNet database	High accuracy guaranteed in all 4 stages of disease	Costly and Time consuming.
[5]	JAMA Network	SVM I/P, (RNN) I/P, CNN I/p, CNN-RNN	Unweighted accuracy for 5 algorithms ranged 0.915-0.959	Only CNN-RNN (0.752) was greater than CNN	Videos of 100 cataract surgery procedures captured	21 videos, Primus 16 trained a GoogleNet to assign frames to phases	Used 5-fold cross-validation setup.	Accuracy greater than 0.910 for all 5 algorithms on avg	Real-life applications require alg. to detect segment boundaries

[11]	International Journal of Research & Advanced Development (IRJAD) in 2017.	SVM algorithm ML (Machine Learning)	It is on average 93% Precision is around 77 %	Reliability, (is 72 %)	400 images (cataract and non-cataract)	Standard operations of Image Processing with wavelet and multi-resolution processing.	Linear SVM	Minimal complexity of operation	Proposed model is still in initial phase of testing condition
[12]	International Journal of Innovative Research in Science, Engineering and Technology	SVM algorithm. MDA algorithm (existing)	SVM Precision77% Sensitivity93% F-measure84% MDA Precision -73% Sensitivity92% F-measure81%	For SVM (Support vector machine)-56% For MDA algorithm -77.7%	261 images (89, 78, 57 and 37 fundus images of non-cataract, mild cataract, moderate cataract and severe cataract	Contrast-limited Adaptive Histogram Equalization	Dual derivative SVM.	Helps to reduce the workload of well-experienced ophthalmologists	Reliability rate is inconsistent

[20]	Univ. of Sci. & Tech., Wroclaw, Poland may 2018	AI, NN and DM	97%	99.4%	5378 slit-lamp images	Parameter selection and a regression model training	Naïve Bayes technique and k- mean	Identification of a certain ocular conditions	makes results difficult to interpret.
[23]	Research translational Institute may 2019	Bayesian and deep learning algorithms	96.8%	95.9% sensitivity and 94.5% specificity	4881 images	Resnet	Translate correct predictions	Only be applied in preoperative patients for primary screen and diagnosis	Translate correct predictions
[24]	Medical Research Inst.Wuhan Univ, Wuhan 2018	Conventional ML, (CNN), (RNN)	96%	Sensitive:94% Specific:98% AUC: 0.97	494,661 retinal images	Cleaning up data, Data Normalization, Noise reduction	Decision tree, naive Bayes algorithm, (RF), (SVM), (KNN)	Disease diagnosis by performing classification	The quality of input images is inherently variable

3. Proposed Methodology

a) Data Set

The dataset for this research-based project was used from an online community website named Kaggle (https://www.kaggle.com /jr2ngb / cataract dataset). The data set contains 1800 images of normal retina, 800 images of cataract. All the images in the dataset are of the high resolution (2464x1362 pixels). An image from each of the classes mentioned are shown in Figure 1below.

Normal Retina **Cataract**

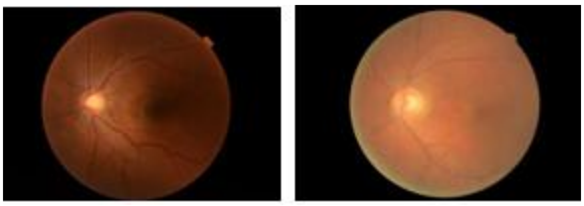

Figure 3.1: Data Sample

b) Pre-Processing

Before using the images from the data set as input, it is necessary to do pre-processing to ensure that the dataset is consistent and displays only relevant features. Images are then resized to 512x512 pixels and normalization is then applied to remove image defect. Normalization of their histogram by stretching red, green, blue channels of image to cover full range 0-255.

c) Data Augmentation

Data augmentation which is a data analysis technique is used to increase the amount of data by slightly modifying the copies of existing data (image). It helps to reduce over-fitting when training the machine learning model. In this process, the original images are flipped from left to right then up to down while taking each separate as a data point.

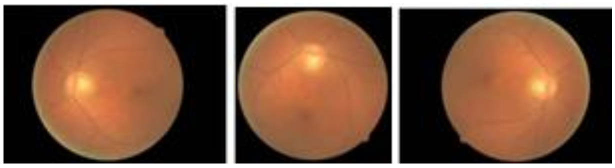

Figure 3.2 Augmentation Sample

4. Proposed Model

A) CNN Architecture

CNN (Convolution Neural Network) a class of deep neural networks is used. For our project we used ResNet architecture which is usually composed of 152 convulsion layers+1 fully connected layer. This model is trained to use human object recognition power and detects objects far better than humans. The convolution operation is completed after the filter is slided across the width and height of the input image.

B) Training Phase

Neural network training consists of determining the appropriate weights for the neural network. For this purpose, a powerful and fast optimization method must be used. Since neural network training for small datasets can result in over- fitting, the purpose of the convulsion layer is

Paper ID: MR21716094257 DOI: 10.21275/MR21716094257

extraction of patterns, e.g., finding the sequence of distinctive patterns in the input which usually occur all along the training data.

C) Test Phase

The test phase comes after the training phase, and the model accuracy in label prediction can be evaluated. In the test phase a new image is fed to the network and all the things that were done in the training phase are also repeated in this phase. The only difference of this step with the training step is the lack of error back propagation phase. Here, merely the input is multiplied by weight values that were set at the training stage and finally, after doing all the calculations, a number appears at the end of the network.

Figure 2

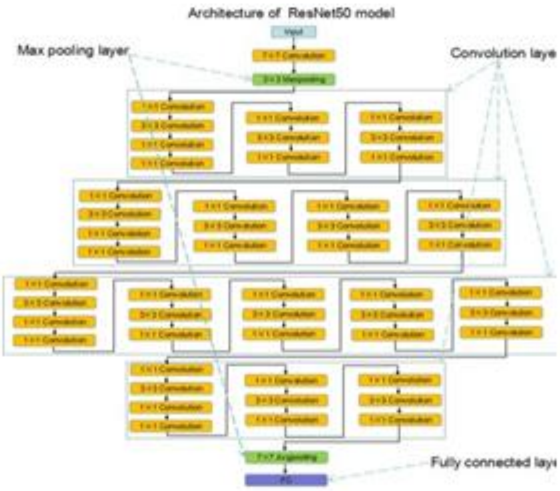

Figure 4.1: ResNet50 Architecture

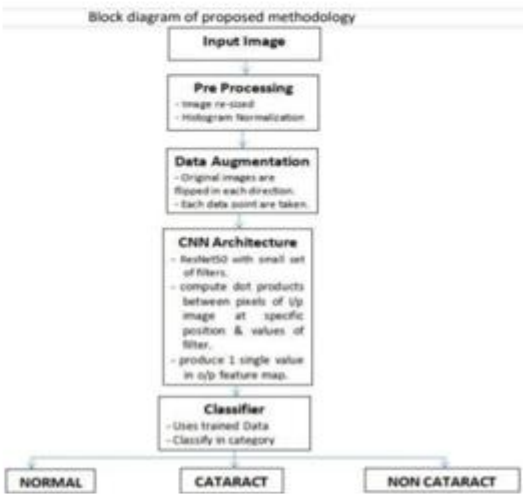

Figure 4.2: Flowchart of proposed Methodology

5. Conclusion

This research has brought to light the growing concerns about the impact of cataract on vision and daily life and has sought to make the detection of this anomaly easier. The present methods of detection such as slit lamp photography are not very effective and riddled with harmful side effects. This model aims to mitigate these issues by using Convoluted Neural Networks, which do not require the actual scanning of the patient's retina, but only an image of it. The trained CNN then checks for the formation of a cataract layer and gives a final diagnosis. This uses less time, less resources and provides a more accurate result.

As we have previously discussed, our system is quite primitive due to technological constraints, but there is ample room for further development and advancement. The CNN training can be done more intensively to be able to compensate for the unique differences in each individual's retina. The system can also, with slight adjustments, be used to detect diseases of similar effects as cataract. The quick and accurate diagnosis that the system provides can save a lot of valuable time for ophthalmologists to begin treatments and thus save the patient's vision. The accuracy of the system can be improved by training it with more varied images and improving the architectural algorithms.

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