Educational Administration: Theory and Practice
2024, 30(5), 7792-7796
ISSN: 2148-2403
https://kuey.net/

Research Article

Deep Learning-Based Detection Of Cataract Diseases Using Convolutional Neural Network

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Citation: Shivam Kumar Upadhyay, Manish Kumar Srivastava *(2024),* Deep Learning-Based Detection Of Cataract Diseases Using Convolutional Neural Network *Educational Administration: Theory and Practice*, *30*(5), 7792-7796
Doi: 10.53555/kuey.v30i5.4238

ARTICLE INFO

ABSTRACT

The eye is the most essential sense organ that allows us to look at the world, and cataract is the most prevalent eye diseases that cause visual distortion. Cataract is a medical disorder defined by the impairing of the eye's lenses. We employ deep learning techniques such as CNN to predict cataracts beforehand. In this research, we developed two functioning models: one using the Random Forest technique and the other using the Convolutional Neural Network. We determined the accuracy of both models and even discussed the models employed by others and their accuracy.

Keywords: Cataract, Convolutional Neural Network (CNN), Random Forest

1 Introduction

Cataract is a blurring of the normally translucent lens in the human eye [1]. Typically, the lens converges light on the retina. The cataract blocks this light from reaching the lens, resulting in decreased visual acuity [2]. A person with cataract eyes has difficulty reading, driving, and even recognising other people's faces. While the specific processes driving cataract formation are unknown, ageing, genetics, diabetes, extended UV radiation exposure, smoking, and some drugs have all been linked to the condition.

Cataracts are a primary cause of visual impairment and blindness globally, particularly in older populations, yet they do not damage vision in the early stages [3]. However, over time, it can impair eyesight and possibly cause vision loss in persons over the age of 40. According to the World Health Organisation (WHO), approximately 285 million people worldwide are visually impaired. 39 million individuals are blind, while the rest have damaged eyesight. Cataracts accounted for 33% of visual impairment and 51% of blindness [5]. Manual cataract diagnosis by ophthalmologists is time-consuming and error-prone, especially in resource-limited areas with a paucity of skilled eye care specialists [3].

Artificial intelligence (AI) has showed potential in automating cataract identification and grading to help ophthalmologists [4]. Deep learning, a subclass of machine learning, excels in analysing large volumes of data and identifying complicated patterns. Deep learning algorithms, including as CNNs, can automatically learn visual cues from retinal pictures to identify cataract severity [6]. Random Forest models, which mix several decision trees, have also been used to predict cataract occurrence with excellent accuracy [4].

Random Forest is a flexible methodology for machine learning that uses many decision trees to make predictions that are accurate without requiring considerable hyper parameters modification. This technique is commonly used since it is simple and successful in solving problems related to regression and classification. Random Forest creates an ensemble of decision trees, using the bagging approach to enhance projected reliability and accuracy. Unlike typical decision trees, which evaluate all potential data splits, Random Forest randomly picks subsets of data for every single tree, reducing correlation between trees and reducing the potential risk of overfitting.

Additionally, using the Random Forest approach for analysing patient data, which includes demographics, medical history, and lifestyle factors, improves the accuracy of predicting the development of cataracts by effectively managing different data types and revealing complicated connections that would be difficult to detect using conventional methods [4].

Convolutional Neural Networks (CNNs) have transformed the processing of images and recognition of patterns, providing an effective tool for completing complicated visual computations. CNNs, which are inspired by the organisation of the brain of humans, automatically extract crucial components from input without any human involvement, making them extremely effective for applications such as computer vision and speech recognition. Unlike typical completely linked networks, CNNs use weight sharing and nearby connections to effectively interpret 2D input data, similar to how neurons function in the visual brain. CNNs' design generally consists of convolution layers followed by sub-sampling levels and fully linked layers, making them ideal for applications such as categorization of images. CNNs' capacity to automatically learn and identify characteristics from data has made them an essential component in deep learning research, with applications extending across multiple domains [7].

Convolutional Neural Networks (CNNs) in ocular imaging provide a transformational way to constructing prediction models that excel at analysing detailed features inside retinal and lens images, outperforming humans in early cataract identification. These improved models can detect minor traits suggestive of cataracts at various stages, allowing for early diagnosis and appropriate management to reduce the severity of cataract illness [8][9]. Integrating these tools into ordinary clinical practice has the potential to reduce the burden of cataracts by allowing proactive and personalised patient management [4].

Despite the enormous promise of deep learning, CNNs, and Random Forests in cataract prediction, ethical concerns about data privacy, bias, and patient permission are critical. It is critical that the development and deployment of these tools prioritise inclusion, justice, and ethical norms in order for them to be successfully integrated and accepted into healthcare. Addressing these ethical considerations is critical to achieving equal healthcare outcomes and building confidence in AI-powered medical devices [4].

2 Literature Review

Sunita et al. [8] proposes a deep learning-based method for automatically identifying cataracts from retina pictures. The technique distinguishes between retinal pictures as cataract or non-cataract using a network of convolutional neural networks (CNN) architecture. The CNN algorithm was trained on a dataset of retinal images and accomplished an accuracy of 92.85% in cataract identification. To improve performance even more, the authors used a stacked ensemble learning method, which integrated plenty of CNN algorithms.

Shetty et al [10] use machine learning to solve the essential issue of cataract diagnosis. Cataracts are the major cause of blindness, and early identification is essential for successful treatment. Traditional cataract detection procedures are time-consuming and need the skill of ophthalmologists. The authors propose using machine learning to automate and accelerate the detection procedure. Several machine learning models are used, such as Support Vector Machines (SVM), Random Forest, and Convolutional Neural Networks (CNN). The CNN model has an accuracy of around 95%, making it the most successful model examined in the study for diagnosing cataracts in eye pictures.

H. B. Koncha et al [11] employ deep learning, primarily CNNs, to detect and forecast cataracts in retinal pictures. To categorise photos into different phases of cataract severity, the researchers employed the VGG-19 model in conjunction with wavelet characteristics and retinal vasculature analysis. The approach has an accuracy of 92%.

Devanaboina et al. [12] investigate the detection of cataracts using machine learning approaches, namely Convolutional Neural Networks (CNNs) and picture preprocessing. The objective is to create an automated method for forecasting ocular eye disorders, particularly cataracts, to help ophthalmologists. The suggested method employs CNNs for feature extraction from retinal fundus pictures. The proposed model here has an accuracy of 94%.

3 Methodology

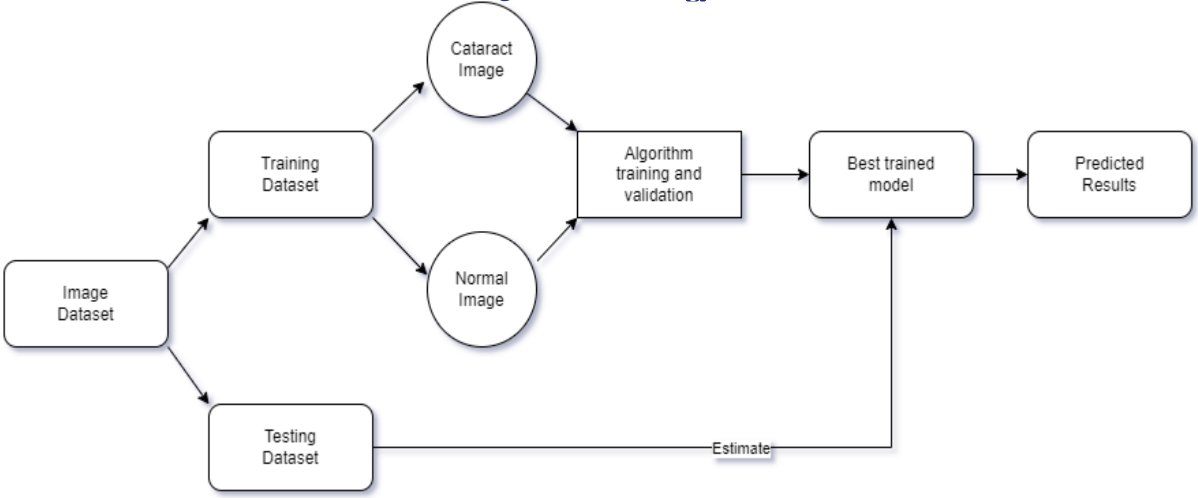

Fig 1: Flowchart of working of algorithm

This methodology defines the working model of our cataract disease prediction. We created two working models, one using Convolutional Neural Network (CNN) from deep learning and another model by using Random Forest.

3.1 Dataset

Link: https://www.kaggle.com/datasets/nandanp6/cataract-image-dataset

The dataset used for the training, validation and testing part of our algorithms is sourced from Kaggle website. The dataset has two folders each having names train and test. Each of the two folders has two folders, one contains cataract image and another contain normal eye image. The train folder has 245 cataract images and 246 normal eye images. The test folder has 61 cataract images and 60 normal eye images. The dataset used for training and validation of algorithm is from train folder which has total 491 images combined.

3.2 Preprocessing of images

The preprocessing part of the images of the project is done with the help of OpenCV and PIL library. The images in the dataset have different shapes and sizes, so we fixed the image size to (128,128) in CNN and for random forest it is (224,224) and the format of all the images was .png. All the images in the dataset are converted to array format using NumPy library for the training purposes.

3.3 Proposed Model/Algorithm

3.3.1 Using Random Forest

The first model was prepared using Random Forest method. In this method we first load the dataset in our algorithm with the help of PIL library. A separate function is created to open each image with the help of the Image.open() function and then convert the image which is opened to array along with its label.

All the data of both cataract and normal images which is converted into array is combined and distributed to X and y. Transformations are applied on the data using LabelEncoder() function and fit_transform() function on y. The size of each image is resized to 224 with the help of resize function. All the image resized is then flatten using img.flatten() function and all the data is stored in variable X_flat.

For the splitting the dataset into training and validation purposes, data is divided into 65% for training purposes and 35% for testing purposes. Random state is fixed to 42. For initialising part of Random Forest Classifier we set n_estimators to1000, we train the random forest algorithm. After training we test the accuracy of the trained model. Then we passed the image to the algorithm to test weather the image has a cataract or not, then our model predicted the results correctly for all the images passed.

3.3.2 Using Convolutional Neural Network (CNN)

The second model was proposed using Convolutional Neural Network (CNN). In this method we load the dataset in our algorithm with the help of OpenCV library. A separate function is created to open each image with the help of cv2.imread() function and then convert the image which is opened to array along with its label. All the data of both cataract images and normal images along with their labels are combined and stored in the variables images and labels respectively. Then we split the training and validation data into same partition as above as 65% for training purposes and 35% for testing purposes. Random state is fixed to 42. Then we the pixels between 0 and 1. Then we defined CNN model using Keras Sequential API. In which we initialised sequential model in which 2D convolutional layer with 32 filters, each of size 3x3 and the Rectified Linear Unit (ReLU) activation function is applied, which helps introduce non-linearity to the model. A layer of max pooling with a 2x2 filter is added. Then we used Flatten() function to convert 3D output to 1D vector and a Droput(0.5) is added to prevent overfitting. Then we use model.compile() function in which optimizer is set to 'adam' and loss is set to 'categorical_crossentropy'. After this data augmentation is done with the help of ImageDataGenerator() function.

After this we trained our model using model.fit() function in which batch size was set to 32 and epoch was set to 120. After training we test the accuracy of the trained model. Then we passed the image to the algorithm to test weather the image has a cataract or not, then our model predicted the results correctly for all the images passed.

4 Result

4.1 For Random Forest Algorithm

The Random Forest Algorithm used is producing 92.44% accuracy on the dataset used.

```
In [16]: # Calculate accuracy
         accuracy = accuracy_score(y_test, predictions)
         print("Accuracy:", accuracy)

         Accuracy: 0.9244186046511628
```

Fig 2: Random Forest Accuracy

The various performance matrices of Random Forest algorithm is:

	precision	recall	f1-score	support
cataract	0.93	0.92	0.93	88
normal	0.92	0.93	0.92	84
accuracy			0.92	172
macro avg	0.92	0.92	0.92	172
weighted avg	0.92	0.92	0.92	172

Fig 3: Performance Matrices of Random Forest Algorithm

4.2 For Convolutional Neural Network Algorithm

The Convolutional Neural Network Algorithm used is producing 97.67% accuracy. The losses of data during 120 epoch cycle is 14.95%.

```
In [24]: # Evaluate the model
         loss, accuracy = model.evaluate(X_test, y_test)
         print("Test Accuracy:", accuracy)

6/6 [==============================] - 0s 61ms/step - loss: 0.1495 - accuracy: 0.9767
Test Accuracy: 0.9767441749572754
```

Fig 4: Accuracy of CNN Algorithm

The various performance matrices of Convolutional Neural Network algorithm is:

Classification Report:

	precision	recall	f1-score	support
Normal	0.95	1.00	0.98	84
Cataract	1.00	0.95	0.98	88
accuracy			0.98	172
macro avg	0.98	0.98	0.98	172
weighted avg	0.98	0.98	0.98	172

Fig 5: Performance matrices of CNN Algorithm

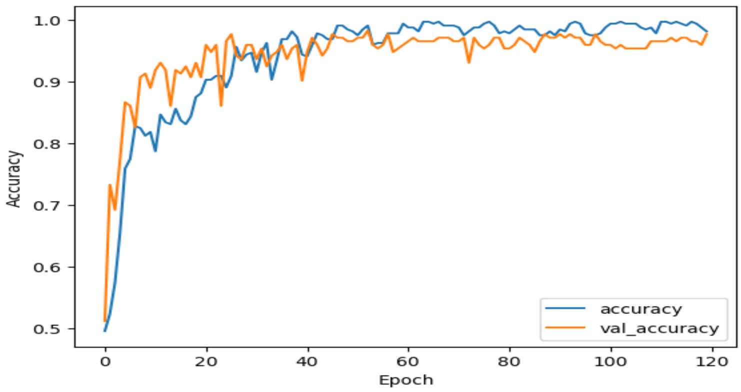

Fig 6: Graph of Accuracy vs Epoch

The above graph shows that accuracy of the CNN model increases with every epoch cycle.

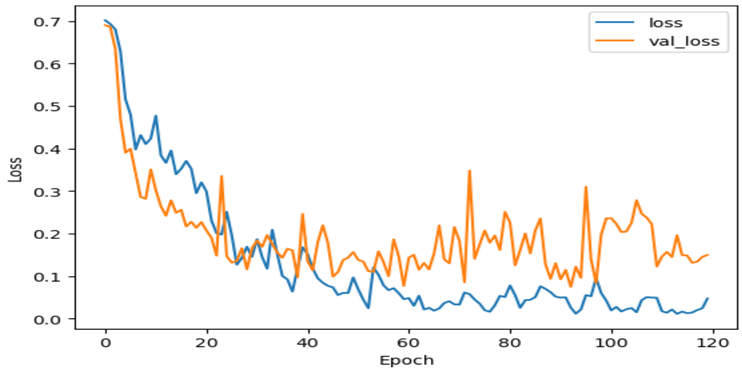

Fig 7: Graph of Loss vs Epoch

The above graph shows the losses with the epoch which shows that with each increasing epoch the losses were reduced.

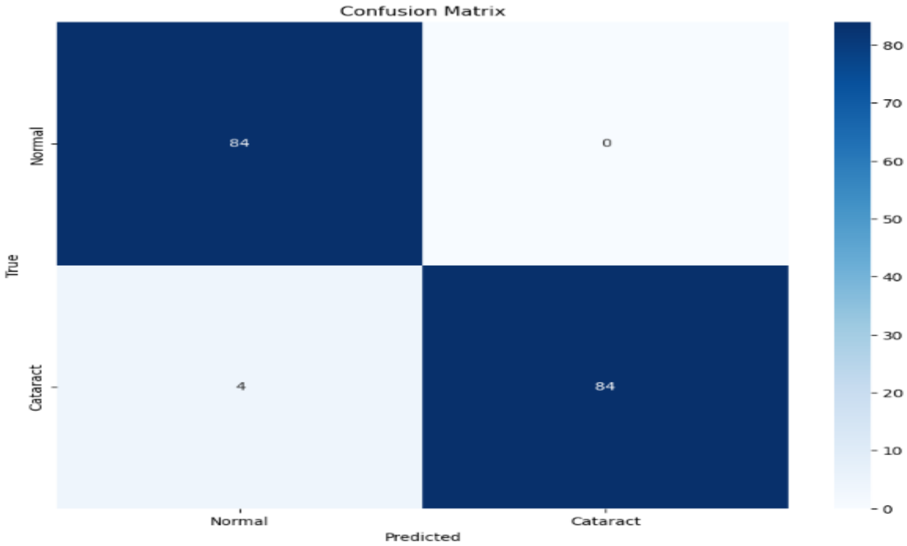

Fig 8: CNN Confusion Matrix

5 Conclusion

Cataracts are a fairly common disease in older adults. It affects people's vision and causes colorblindness. Early detection of symptoms is important. This study offers a simple approach to forecast the disease. We built two models using the Kaggle dataset. One used the Random Forest technique, while the other used Convolutional Neural Network (CNN). The model with Random Forest had an efficiency of 92.44%, which is quiet good, however the model with Convolutional Neural Network had 97.67% accuracy, which is the best in our scenario. Overall, we attempted to limit losses and build the best model feasible from our dataset.

References

[1] Panda, S. K., & Panjwani, N. (2023). Cataract Detection Using Deep Learning.

[2] Rana, J., & Galib, S. M. (2017, December). Cataract detection using smartphone. In *2017 3rd international conference on electrical information and communication technology (EICT)* (pp. 1-4). IEEE.

[3] Gutierrez, L., Lim, J. S., Foo, L. L., Ng, W. Y., Yip, M., Lim, G. Y. S., ... & Ting, D. S. W. (2022). Application of artificial intelligence in cataract management: current and future directions. Eye and Vision, 9(1), 3.

[4] Goh, J. H. L., Lim, Z. W., Fang, X., Anees, A., Nusinovici, S., Rim, T. H., ... & Tham, Y. C. (2020). Artificial intelligence for cataract detection and management. Asia-Pacific journal of ophthalmology, 9(2), 88-95.

[5] Yang, J. J., Li, J., Shen, R., Zeng, Y., He, J., Bi, J., ... & Wang, Q. (2016). Exploiting ensemble learning for automatic cataract detection and grading. Computer methods and programs in biomedicine, 124, 45-57.

[6] Aslam, A., Farhan, S., Khaliq, M. A., Anjum, F., Afzaal, A., & Kanwal, F. (2023). Convolutional Neural Network-Based Classification of Multiple Retinal Diseases Using Fundus Images. Intelligent Automation & Soft Computing, 36(3), 2607-2622.

[7] O'shea, K., & Nash, R. (2015). An introduction to convolutional neural networks. arXiv preprint arXiv:1511.08458.

[8] Yadav, S., & Singh Yadav, J. K. P. (2023). Enhancing Cataract Detection Precision: A Deep Learning Approach. Traitement du Signal, 40(4).

[9] Khan, M.S., Ahmed, M., Rasel, R.Z., & Khan, M.M. (2021). Cataract Detection Using Convolutional Neural Network with VGG-19 Model. 2021 IEEE World AI IoT Congress (AIIoT), 0209-0212.

[10] Shetty, A., Bathija, K., & Priya, R. L. (2021). Cataract eye detection using machine learning models. In Emerging Technologies in Data Mining and Information Security: Proceedings of IEMIS 2020, Volume 3 (pp. 919-929). Springer Singapore.

[11] Koncha, H. B., Mohd, P., Ravikanti, S., & Yadlapalli, P. (2023, April). Early Detection and Prediction of Cataract Using Deep Learning. In 2023 IEEE 8th International Conference for Convergence in Technology (I2CT) (pp. 1-6). IEEE.

[12] Devanaboina, R., Badri, S., Depa, M.R., & Bhutada, D. (2021). OCULAR EYE DISEASE PREDICTION USING MACHINE LEARNING.