I. J. Mathematical Sciences and Computing, **2022, 2, 46-54**
Published Online June 2022 in MECS (http://www.mecs-press.org/)
DOI: 10.5815/ijmsc.2022.02.05

Deep Classifier for Conjunctivitis – A Three-Fold Binary Approach

Subhash Mondal
Meghnad Saha Institute of Technology, Kolkata, India
Email: subhash@msit.edu.in

Suharta Banerjee
Meghnad Saha Institute of Technology, Kolkata, India
Email: suharta_b.cse2018@msit.edu.in

Subinoy Mukherjee
Meghnad Saha Institute of Technology, Kolkata, India
Email: subinoy_m.cse2018@msit.edu.in

Ankur Ganguly
Meghnad Saha Institute of Technology, Kolkata, India
Email: anksjc2002@yahoo.com

Diganta Sengupta
Meghnad Saha Institute of Technology, Kolkata, India
Email: sg.diganta@{ieee.org, msit.edu.in}

Received: 04 October 2021; Revised: 02 December 2021; Accepted: 09 January 2022; Published: 08 June 2022

Abstract: Alterations in environmental and demographic equations have resulted in phenomenal rise of human centric diseases, ocular being one of them. Technological advancements have witnessed early diagnosis of much of the previously un-ciphered diseases. This paper addresses two research questions (RQs) with the study being focused on conjunctivitis (the most prevalent eye ailment in adults as well as minors). The motive of both the RQs rests in implementing three state-of-the art deep learning framework for classification of the ocular disease and validation of the frameworks. Validation of the frameworks is seconded by improvised proposals for enhancements. RQ1 establishes and validates whether the three off the shelf Deep Learning frameworks VGG19, ResNet50, and Inception V3 properly classify the disease or not. RQ2 analyses the effectiveness of each classifier with further enhancement proposals. The algorithms were implemented on 210 images and generated an accuracy of 87.3%, 93.6%, and 95.2% for VGG19, ResNet50, and Inception V3 using Adam optimizer, with slightly variant results when applying Adadelta optimizer. These results were typical of the classification frameworks with enhancements. With pervasive penetration of Artificial Intelligence in healthcare, this paper presents the efficacy of Deep Learning Frameworks in conjunctivitis classification.

Index Terms: Ocular Diseases, Deep Learning, Deep Classifiers, VGG19, Resnet50, Inception V3, Conjunctivitis Classification.

1. Introduction

In recent years, the inclusion of various Artificial Intelligence (AI) techniques in the medical health system has paved the way for speedy diagnosis. AI-based disease detection systems are generally built using both medical test results as well as domain knowledge [1, 2, 3]. The expert systems led the way for the application of machine learning to medicine. Healthcare largely depends on AI to diagnose disease in the field of radiology, dermatology, pathology, and ophthalmology [4]. The use of image processing has been applied in ophthalmology to diagnose glaucoma, diabetic retinopathy, and other retinal diseases [5]. With the increasing dependency on AI in healthcare, building a generalized system that can correlate actual symptoms and clinical observations have become necessary.

Conjunctivitis, also known as pink eye, is an eye infection that occurs due to inflammation of the conjunctiva [6]. It is generally caused by a bacterial or viral infection, leading to redness, itching, and a gritty feeling in the eyes [7]. Like other ophthalmic diseases, conjunctivitis is also not life-threatening but can impact a person's life if left untreated. Physical diagnosis of such disease becomes problematic, especially in remote areas, due to a shortage of trained medical practitioners. Dependency on AI-based systems is increasing, and it becomes necessary to build systems that can diagnoses diseases with fewer human interventions. Based on involvement of Artificial Intelligence in Ophthalmology, and catering to a huge population with one of the most prevalent disease, it was decided to automate the initial diagnosis of the disease using learning models.

In this communication, we first binary classify the disease using three deep learning frameworks. The objective is to check whether proper classification is obtainable using the three frameworks. The three frameworks are VGG-19, ResNet50, and Inception V3. Post classification, we also validate the models to check their performances, the results of which are provided in Section 4 in this paper. We have proposed a customized data pre-processing framework based on clustering prior to application to the state-of-the-art models. We have trained our model using two different optimizers, namely Adam and Adadelta. We observed an accuracy reduction of 4.69% in the case of one of the models but witnessed significant appreciation with other models. Similar was our observation with recall and f1 score. The detailed performance observation is presented in the paper later in section 4. The discussed approach helped us build a more generalized and robust model compared to other existing proposed approaches. Results of Research Question 1 have exhibited proper binary classification of conjunctivitis based on image data. Although our model has presented appreciable results in diagnosis of the disease, we believe with a bigger dataset, the performance will increase even further.

With the advancement in AI technologies, researchers have adopted various techniques for building healthcare systems that can correlate symptoms and diagnosis. Machine learning-based approaches were used for detecting conjunctivitis. The region of interest was extracted by using segmentation. The researchers have also used Convolutional Neural Network (CNN) for classifying the disease. In this paper, we have used the transfer learning technique to train our model using three standard state-of-the-art CNN architectures, namely VGG-19, ResNet50, and InceptionV3. This approach of using transfer learning was not used previously for conjunctivitis classification. We have also used clustering as an added data pre-processing step, and the patient dataset is divided into different clusters accordingly. These ensured different models were trained for separate clusters, which helped us reduce the problem of overfitting. It also enhanced the performance, and a more generalized model could be obtained. The performance of the approach was analyzed using several evaluation parameters such as accuracy, recall, F1 score, and ROC-AUC curve, which was absent in previously proposed approaches. In this paper, we have also compared the similarities between one or more models performing the same task by using entropy, as shown in research question 2 later in the paper. The paper provides the potency of CNN frameworks in classifying conjunctivitis with improved performance.

The rest of the paper is organized as follows, Section 2 deals with the literature survey, Section 3 elaborates the Research Question 1, followed by research question 2 in Section 4, and the paper discusses the models in Section 5 with Section 6 presenting the Conclusion.

2. Previous Studies

Healthcare system specifically the domain of ophthalmology has started to adopt the use of AI-based system to detect eye diseases [8, 9]. At late, researchers were more focused on using image processing techniques to see such conditions [10]. This section deals with some of the previous approaches that the researchers used for building disease detection systems.

Rahul Kapoor, Benjamin, and Lama [11] have highlighted various used cases of AI in optical coherence tomography (OCT) in ophthalmology. OCT is believed to be the future of ophthalmological disease management. The authors also discussed various limitations of AI in their review. The availability of digital information and color fundus photography in the 1990s was the breakthrough for using AI in ophthalmology [12]. However, the use of AI could not be generalized due to the low specificity rate. The authors in [13] have proposed an automated segmentation method for OCT images using a deep regression network. They considered features like intensity, gradient, and intensity score, which are normalized for learning the features from the segments. The experiment was carried out using 114 images and the processing time was 10.596 s per image.

Eye diseases like glaucoma, diabetic retinopathy, macular degeneration is not life-threatening but require prolonged treatment. The authors in [14] proposed a fuzzy-based image processing technique for segmenting OCT images into different segments. The model was evaluated using 225 OCT B-scan images, and the results ensured that early detection of eye-described above diseases was possible. The authors in [15] provide an overview of AI in the diagnosis of anterior segments. They addressed various segments like keratoconus, adult and paediatric cataract, and angle-closure glaucoma and discussed the potential integration ability with telemedicine.

Hitoshi Tabuchi and Hiroki Masumoto [16] have discussed various objective measurement methods for classifying conjunctivitis. They mainly focused on the technique of using slit-lamp microscopic images and claimed it was able to correlate the severity of the disease. In [17], different machine learning algorithms were used for classifying eye diseases. The authors suggested that the prediction rate of random forest and decision tree outperformed Naïve Bayes and neural network algorithms using structured data.

Xiaohang et. al. in [18] discussed the applications of state-of-the-art models in ophthalmic diseases and their challenges while implementing them clinically. The use of deep learning for diagnosing and identifying conjunctivitis is presented by Sundararajan and Saravana in [19]. They have used fuzzy techniques for pre-processing and segmenting the images.

The authors in [20] proposed a machine learning-based approach for detecting conjunctivitis disease using facial images. They have segmented the region of infection in corneal images and achieved an accuracy of 93% in detecting the disease. Joydeep et. al. in [21] proposed using multiclass SVM and KNN algorithms to identify the eyes affected with conjunctivitis. They have also used PCA for extracting the features from the images.

3. Research Question 1

In this section, we discuss our approach for validating the three state-of-the-art architectures, namely VGG-16, ResNet-50, and InceptionV3 [22, 23, 24] in classifying conjunctivitis. We have proposed a customized clustering-based methodology, as shown in Fig. 1, for classifying the disease. The three existing state-of-the-art models have been trained using transfer learning techniques.

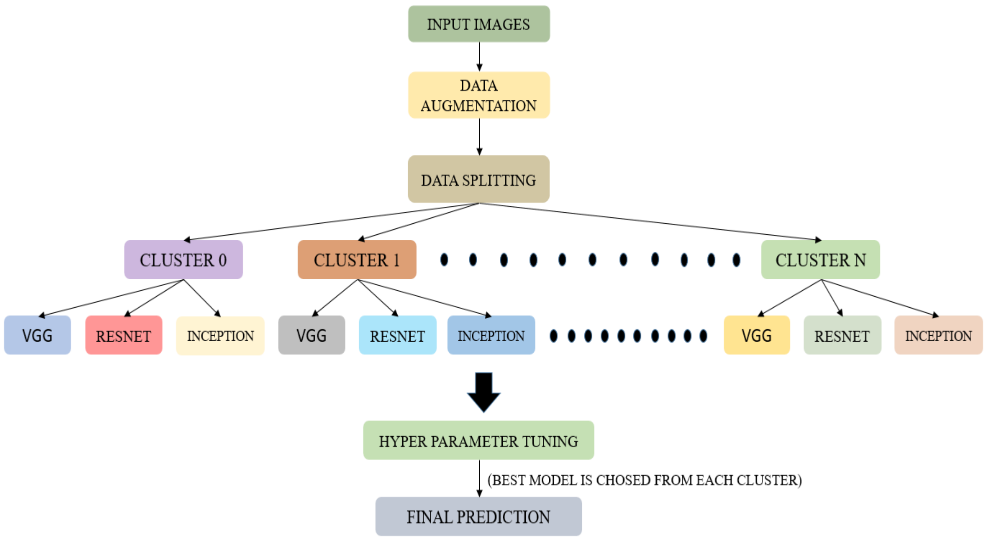

Fig.1. Proposed Framework.

The entire experimental study has been carried out using the Eye Disease Virus dataset [25]. The sample images are shown in Fig. 2. These images present four types of eye images with varying degrees of redness in the eye, and possible occurrence of conjunctivitis. Moreover it can be observed that the last figure (bottom right) is that of a good eye, thereby helping the models to diagnose the prevalence of the disease with acceptable accuracy. The input images have been pre-processed using different pre-processing techniques to improve each model's performance. Data augmentation technique is incorporated, which helped us increase the amount of training data. It also introduced a significant diversity among the training data that ensured our model was free from overfitting problems. Some pre-processing steps include resizing images, cropping of the images, performing various flipping, and rotating techniques, and rescaling images.

The pre-processed dataset is further cross-validated, and the entire dataset is divided into training and testing set using the K-fold cross-validation technique. The training set is used for performing clustering. Density-based clustering, i.e., DBSCAN [26], is done, and the dataset is divided into N number of different clusters based on the similarity of the features present in the data. For each cluster, we train three different state-of-the-art architectures using transfer learning techniques and obtain the results. With the help of Keras Tuner, hyperparameter tuning is performed, and the best-performing model for each cluster is finalized.

When unknown data is fed into this framework, it also undergoes the same process starting from the pre-processing steps, and further, it is being mapped into any one of the clusters based on the algorithm. After mapping, the model that is being finalized in the training phase for this cluster is now used for classifying the image. The approach introduced ensures that a generalized framework is created, and we can improve the performance of the system. The performance of the framework based on certain metrics is discussed in the subsequent section.

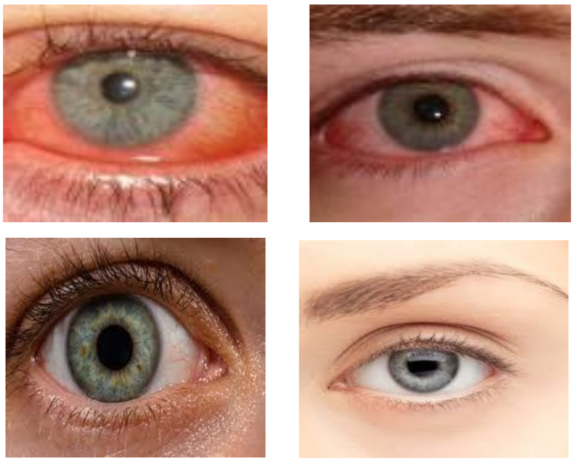

Fig.2. Sample images of Conjunctivitis and Normal eyes [25].

The pre-processed dataset is further cross-validated, and the entire dataset is divided into training and testing set using the K-fold cross-validation technique. The training set is used for performing clustering. Density-based clustering, i.e., DBSCAN [26], is done, and the dataset is divided into N number of different clusters based on the similarity of the features present in the data. For each cluster, we train three different state-of-the-art architectures using transfer learning techniques and obtain the results. With the help of Keras Tuner, hyperparameter tuning is performed, and the best-performing model for each cluster is finalized.

4. Research Question 2

This section addresses the second research question as to whether the models used in Research Question 1 reflect a proper diagnosis of conjunctivitis using AI, which can supplement the human diagnostic approaches. The results obtained in this section exhibit better performance due to the data pre-processing part, which has been augmented prior to data injection to the different models used in RQ 1. We have used the method of transfer learning to build our model using VGG-19, ResNet-50, and Inception-V3 architectures. The use of clustering in our proposed approach helped us in improving the accuracy of our model. Besides achieving good accuracy, the objective was to reduce the number of false negatives. The performance parameters are calculated using Equation 1 and Equation 2 respectively.

$$\mathrm{Re}call = \frac{True\ Positive}{True\ Positive + False\ Negative} \tag{1}$$

$$F1\ Score = \frac{2 \times \mathrm{Pr}ecision \times \mathrm{Re}call}{\mathrm{Pr}ecision + \mathrm{Re}call} \tag{2}$$

As a result, we have trained our model with both Adam and Adadelta optimizers using various combinations of learning rates. The proposed approach helped us in building a generalized model along with enhanced performance.

The performance analysis of the three standard state-of-the-art architectures is shown in Table 1.

Table 1. Performance Analysis

Params	Accuracy		Recall		F1 Score		ξ
Model/Opt	A	AD	A	AD	A	AD	
VGG-19	87.3	83.2	0.81	0.86	0.72	0.73	0.82
ResNet 50	93.6	94.8	0.87	0.82	0.75	0.78	0.95
Inception V3	95.2	97.5	0.92	0.95	0.81	0.85	0.97

The graphical representation for comparing accuracy, recall, and f1score using both Adam and Adadelta optimizers, along with entropy comparison, is shown in Fig. 3., Fig. 4., Fig. 5., and Fig. 6., respectively.

The Receiver Operator Characteristic (ROC) [27] curve provides an evaluation metric for any classification problem. The probabilistic curve depicts the relationship between true-positive rates and false-positive rates at different threshold values. The Area Under the Curve (AUC) determines the ability of a model to distinguish between various classes, and it is often used as a summary for the ROC. The value for AUC lies between 0.5 to 1. The higher the value of AUC, the better the performance of any model. The ROC curve for the three state-of-the-art models used in our discussed approach is shown in Fig. 7.

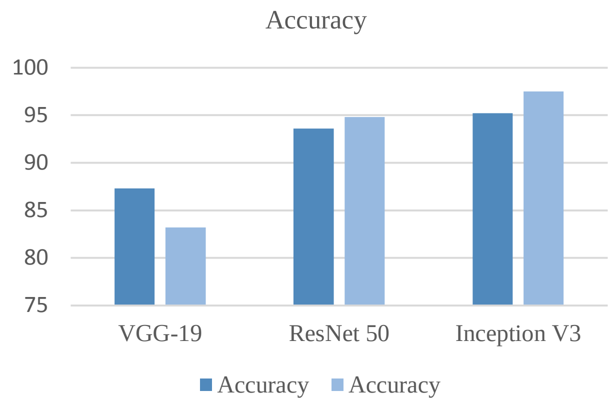

Fig.3. Accuracy comparison of Adam and Adadelta optimizers (A=Adam, AD=Adadelta).

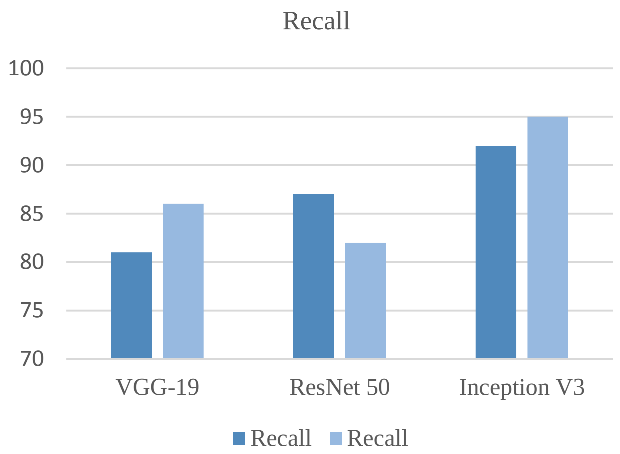

Fig.4. Recall comparison of Adam and Adadelta optimizers (A=Adam, AD=Adadelta).

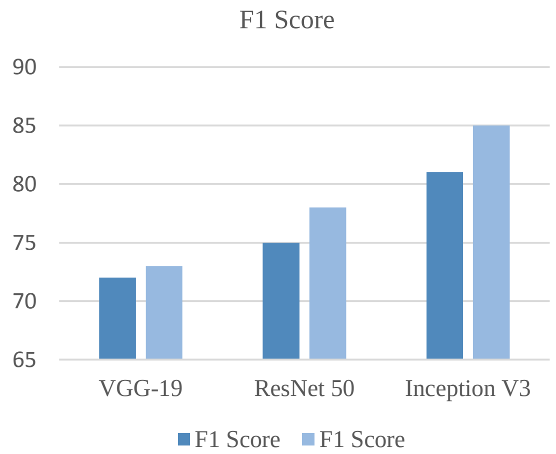

Fig.5. F1-Score comparison of Adam and Adadelta optimizers (A=Adam, AD=Adadelta).

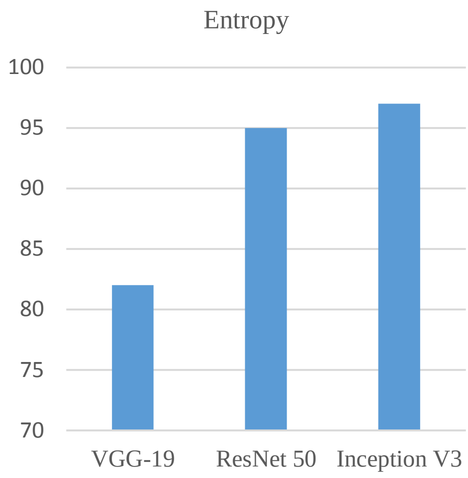

Fig.6. Entropy comparison of the state-of-the-art models.

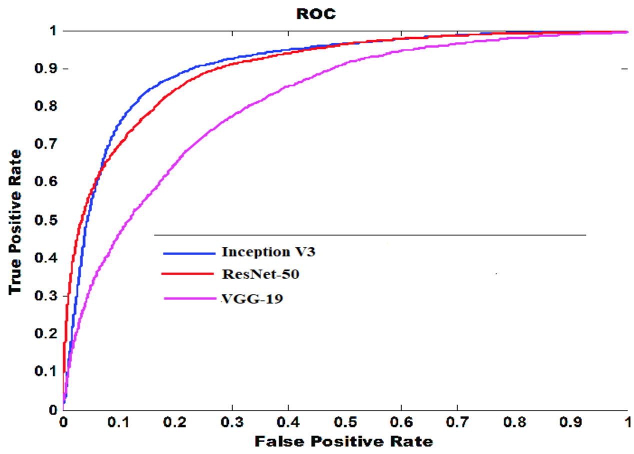

Fig.7. ROC curve of the state-of-the-art models.

The comparative study of our discussed approach with other existing approaches for detecting the disease is presented in Table 2. We have considered features such as pre-processing, clustering, data augmentation, and entropy calculation. These features have been considered based on the fact that these generate better qualifiers for a model based on learning algorithms for its suitability. Moreo`ver Table 2 presents the comparative analysis with existing proposals in with respect to different approaches taken for designing the models.

Table 2. Comparative Analysis with literary proposals

Ref No.	Pre-Processing	Clustering	Data Augmentation	Entropy
[16]	✓	X	✓	X
[17]	✓	X	X	X
[18]	✓	X	X	X
Proposed	✓	✓	✓	✓

5. Discussion

The work in this paper presents a first-hand impression of application of Deep Learning models to the field of Ophthalmology, specifically, diagnosis of conjunctivitis among the varied eye image datasets. We have implemented three state-of-the-art models, VGG-19, ResNet-50, and Inception V3 as it has been observed that these three models are frontrunners in feature extraction as well as classification of images. In this paper, we have proposed three models for binary classification of Conjunctivitis based on three deep learning frameworks. The classification results have provided acceptable accuracies which have been further enhanced with data preprocessing which have been augmented to the model prior to the training. We have also validated the results and observed the models to properly classify the diseases. We claim that the proposed models can be deployed for automatic detection of Conjunctivitis for initial screening and diagnosis. We also believe that the proposed models can present better accuracy with lower false negatives when trained with a larger dataset.

6. Conclusion

This paper presents a preliminary approach in the diverse domain which can be further extended to an ensemble environment, whose work is already in progress. Moreover, we also intend to develop Deep Generative Adversarial Network (GAN) frameworks for binary classification of conjunctivitis as well as prediction of the disease at a premature level. We have used ‘clustering’ as a data pre-processing layer in this work. We intend to use more pre-processing layers to generate uniform image for feature extraction. Moreover, experiments can be conducted using other CNN frameworks in place of the three models used in this work. On the other note, only two optimizers have been used for model training in the current communication. We also intend to implement other optimizers and explore the results to find the best fitting optimizer for the best CNN model. The work in this paper already suggests a generic framework for binary classification of conjunctivitis which can be further extended for multivariate classification.

References

[1] G An et al., "Comparison of machine-learning classification models for glaucoma management.," in 2018 J. Healthc. Eng. , 2018.

[2] K Saito and R Nakano, "Medical diagnostic expert system based on PDP model," in IEEE International Conference on Neural Networks, San Diego, CA, USA, 24–27 July, pp. 255–262.

[3] M.L Huang and H.Y Chen, "Development and comparison of automated classifiers for glaucoma diagnosis," in 2005 Investig. Ophthalmol. Vis. Sci. , 2005.

[4] Poplin R, Varadarajan AV, and Blumer K, "Prediction of cardiovascular risk factors from retinal fundus photographs via deep learning," in Nat Biomed Eng 2018, 2018, pp. 2:158-64.

[5] Ting DSW, Peng L, and Varadarajan AV, "Deep learning in ophthalmology : The technical and clinical considerations.," in Prog Retin Eye Res 2019, 2019.

[6] Doreen L Teoh, Sally Md, and Md Reynolds, "Diagnosis and management of paediatric conjunctivitis," in Paediatric Emergency Care, vol. 19, 2003, pp. 48-55.

[7] (2020, Jun) Pink eye (conjunctivitis). [Online]. https://www.mayoclinic.org/diseases-conditions/pink-eye/symptoms-causes/syc-20376355

[8] Md R Khan and A S M Shafi, "Statistical Texture Features Based Automatic Detection and Classification of Diabetic Retinopathy," I.J. Image, Graphics and Signal Processing, no. 2, pp. 53-61, April 2021.

[9] L Dharmanna, S Chandrappa, T C Manjunath, and G Pavithra, "A Novel Approach for Diagnosis of Glaucoma through Optic Nerve Head (ONH) Analysis using Fractal Dimension Technique," I.J. Modern Education and Computer Science, no. 1, pp. 55-61, Jan 2016.

[10] N N Rather, C O Patel, and S A Khan, "Using Deep Learning Towards Biomedical Knowledge Disovery," I. J. Mathematical Sciences and Computing, no. 2, pp. 1-10, April 2017.

[11] Rahul Kapoor, Benjamin T Whigham, and Lama A, "Artificial Intelligence and Optical Coherence," Asia-Pacific Academy of Ophthalmology, vol. 8, Feb 2019.

[12] Paisan Ruamviboonsuk, Carol Y Cheung, Xiulan Zhang, Rajiv Raman, and Sang Jun Park, "Artificial Intelligence in Ophthalmology: Evolutions in Asia," Asia-Pacific Journal of Ophthalmology, vol. 9, 2020.

[13] Lua Ngo, Jaepyeong Cha, and Jae-Ho Han, "Deep Neural Network Regression for Automated Retinal Layer Segmentation in Optical Coherence Tomography Images," IEEE Transactions on Image Processing, vol. 29, pp. 303 - 312, Aug 2019.

[14] Bashir Isa Dodo, Yongmin Li, Djibril Kaba, and Xiaohui Liu, "Retinal Layer Segmentation in Optical Coherence Tomography Images," Data-Enabled Intelligence for Digital Health, vol. 7, pp. 152388 - 152398, 2019.

[15] Darren Ting, Valencia HX Foo, Lily Yang, and Josh Sia, "Artificial intelligence for anterior segment diseases: Emerging applications in ophthalmology," British Journal of Ophthalmology, Jun 2020.

[16] H Masumoto and H Tabuchi, "Objective evaluation of allergic conjunctival disease (with a focus on the application of artificial intelligence technology),".

[17] N Kanwal and S Malik, "Data Driven Approach for Eye Disease Classification with Machine Learning," Computing and Artifical Intelligence, 2019.

[18] [18]W Xiaohang et al., "Application of artificial intelligence in anterior segment ophthalmic diseases: diversity and standardization," vol. 8, no. 11, 2020.

[19] S Sundararajan and P Saravana, "Detection of Conjunctivitis with Deep Learning Algorithm in Medical Image Processing," in 2019 Third International conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), Palladam, India , 2019.

[20] G Melih, G Evgin, and D Taner, "Automated Detection of Adenoviral Conjunctivitis Disease from Facial Images using Machine Learning," in 2015 IEEE 14th International Conference on Machine Learning and Applications (ICMLA), Miami, FL, USA, 2015.

[21] T Joydeep, J Aishwarya, V. D Aaishwarya, B Anupama, and K.M Dutta, "An image processing based method to identify and grade conjunctivitis infected eye according to its types and intensity," in 2015 Eighth International Conference on Contemporary Computing (IC3), Noida, India , 2015.

[22] K Simonyan and A Zisserman, "Very Deep Convolutional Networks for Large-Scale Image Recognition," in International Conference on Learning Representations 2015, 2015.

[23] k He, X Zhang, S Ren, and J Sun, "Deep Residual Learning for Image Recognition," , Las Vegas, NV, USA, 2016.
[24] C Szegedy, V Vanhoucke, S Ioffe, J Shlens, and Z Wojna, "Rethinking the Inception Architecture for Computer Vision," in 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2016.
[25] (2020, Oct) Kaggle. [Online]. https://www.kaggle.com/dangern00dle/eye-diseases-virus-dateset-vol-1
[26] (2021, Jan) DBSCAN Clustering Algorithm in Machine Learning. [Online]. https://www.kdnuggets.com/2020/04/dbscan-clustering-algorithm-machine-learning.html
[27] AUC-ROC Curve in Machine Learning. [Online]. https://www.analyticsvidhya.com/blog/2020/06/auc-roc-curve-machine-learning/

Authors' Profiles

Subhash Mondal, MIEEE, MACM, has obtained his M.Tech (CSE '07) and B.Tech ('05) form University of Calcutta, IN. Presently he is serving as an Assistant Professor in the Department of Computer Science and Engineering, Meghnad Saha Institute of Technology, Kolkata, IN. He is a member of ACM and is serving in the capacity of Faculty Sponsor for the ACM Student Chapter. He is conducting his doctoral studies in Artificial Intelligence and its Scope in Ophthalmology. His research interests concentrate primarily on Computer Vision, Bio-Informatics, Deep Learning Frameworks, and Internet of Things allied to Artificial Intelligence. Recently he has also scored publications in houses such as Springer Nature, and AGH University of Science and Technology, Krakow Poland. He has proven himself as a successful administrator in roles such as the Training and Placement depute from the department, PG Coordinator, convener for the Institutional Professional Membership Coordination Committee, and member of the Disciplinary committee, to name a few apart from successfully convening multiple institutional events under the banner of IEEE, and ACM.

Suharta Banerjee is presently pursuing his B.Tech (2022) in Computer Science and Engineering from Meghnad Saha Institute of Technology, Kolkata, India. He is a member of ACM. He has served as the Chair of the Student Chapter for MSIT ACM Student Chapter. His research interest includes Machine Learning, Computer Vision, Deep Learning, and Bio-Informatics. He has published one conference paper in EAIT 2021 (Springer) which is a part of Lecture Notes in Networks and Systems (LNNS) book series. Recently one more credible work has been accepted for publication in the ESCI, SCOPUS indexed journal Computer Science.

Subinoy Mukherjee is presently pursuing his B. Tech (2022) in Computer Science and Engineering from Meghnad Saha Institute of Technology, Kolkata, India. He is a member of ACM and has served as the Vice-Chair of the Student Chapter for MSIT ACM Student Chapter. He has published one conference paper in EAIT 2021 (Springer) which is a part of Lecture Notes in Networks and Systems (LNNS) book series. He also has a publication in Computer Science Journal which is ESCI Scopus indexed and a book chapter in Bentham Science Publications.

Dr. Ankur Ganguly is presently the Principal of Meghnad Saha Institute of Technology since 1st July 2020. He received his Bachelor's Degree in Electrical & Electronics Engineering from Mangalore University, Master's degree from MAHE Deemed University and PhD in Engineering from Jadavpur University. He worked in the industry for a couple of years and joined the Academic Fraternity as Lecturer in Electronics & Communication Engineering in 2002. He was the Head of the Department of Biomedical Engineering, Electronics & Instrumentation Engineering in different academic institutes before he took the responsibility of Principal in 2013. He has been appointed External Examiner of different Universities since 2004. He is also the Member & Convener of Board of Studies of Maulana Abul Kalam Azad University of Technology, West Bengal along with his regular assignments. He is also associated with various Governmental bodies in different capabilities. His main research interests are in the areas of Power Quality, Renewable Energy, Biomedical Signal Processing, Heart Rate Variability, etc. He has published widely in international journals and conferences. He has participated in many conferences in the capacity of PC member, invited speaker, etc. He was the Programme Committee Co-chair of various International Conferences. He is also on the editorial board of many international journals. Prof. Ganguly has multiple patents to his credit. He has guided 2 Ph.D. scholars and another two scholars are registered and in the process of completing their PhD degrees. Prof. Ganguly is the Fellow of Institute of Electronics & Telecommunication Engineers (India), Fellow of Institute of Engineers (India), Life Member of Indian Society for Technical Education, Senior Member of IEEE (USA), Life Member - Indian Society of Biomechanics (India) and Member of Computer Society of India.

Diganta Sengupta Ph.D. SMIEEE (M'16), SMACM (M'17), Life member of Computer Society of India (LM'18) and The Institution of Engineers (India) (M'16). He is also a member of IEEE Computational Intelligence Society. He has served as the State Student Coordinator for West Bengal, India for Computer Society of India. He received his B.Tech (2004) from University of Kalyani, WB, IN, his M.Tech (2010), and Ph.D. (Engg.) (2016) from Jadavpur University, WB, IN. Dr. Diganta Sengupta is presently working in the capacity of Associate Professor in the Dept. of CSE, and Faculty-In-Charge for the Dept. of Computer Science and Business Systems (additional responsibility), Meghnad Saha Institute of Technology, Kolkata, India. Formerly he was associated with Techno International Batanagar, Kolkata, India, the School of Computer Engineering (SCOPE), VIT University, Vellore, India and also with Future Institute of Engineering and Management, Kolkata, IN. His research interests include Computer Vision, Bio-Informatics, Deep Learning, Quantum Computing, Processor Architecture, and Taxonomy Generation Process. He has served as a reviewer for IEEE Access, JIKM (World Scientific), IJSAEM (Springer), IJBDCN (IGI-Global), ISSE (Springer), SIMPAT (Elsevier), Complexity (Hindawi), ISA Transactions, IET Journal of Engineering, IJEOE (IGI-Global) to name a few. He has also been associated with reputed international IEEE and Springer conferences in multiple committee member capacities, few of which are IEEE DCS VLSI 2022, IACC 2021 Springer, DICTA 2021 IEEE, ICRITO 2021IEEE, I2AS 2021 Springer, CICBA 2021 Springer, EAIT 2020 Springer, ICRITO 2020 IEEE, ICCSEA 2020 IEEE, ISCON 2019 IEEE, AICAI 2019 IEEE, ICRITO 2018 IEEE, ICRCICN 2017 IEEE, CSNT 2016 IEEE. He is currently serving as the Lead Guest Editor in a Special Issue titled "Reversible Quantum Communication & Systems" in IET Quantum Communication.

How to cite this paper: Subhash Mondal, Suharta Banerjee, Subinoy Mukherjee, Ankur Ganguly, Diganta Sengupta," Deep Classifier for Conjunctivitis – A Three-Fold Binary Approach ", International Journal of Mathematical Sciences and Computing(IJMSC), Vol.8, No.2, pp. 46-54, 2022. DOI: 10.5815/ijmsc.2022.02.05