MALARIA MICROSCOPIC CELL IMAGE CLASSIFICATION USING CUSTOM-BUILT CNN ARCHITECTURE

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ABSTRACT

In thisstudy, we propose a custom-built deep learningmodel for detecting malariaparasite by analyzing cell images. The custom-built CNN model is trained to classify distinguishable microscopic cell imagesinto two (2) different categories,Parasitized and Uninfected Cells.Experiment was conducted using the proposed custom-built CNN approach which is made of severalconvolution blocks with custom weights and multiple fully connected layersfor accurate classification. Thecustom-built deep learning model resulted in accuracy of 93%, which makes it optimum and accurate in determining malaria from microscopic cell images.

KEYWORDS

Classification, CNN, Custom-built, Deep learning, Diagnosis, Malaria Cell image.

1. INTRODUCTION

Malaria is among the most spread disease by an infected mosquito.This disease cancauselife-threatening conditions in people of all ages. A report by the World Health Organization (WHO) puts malaria infection to be behind 409,000 deaths in 2019 alone[1].The mortality rate for malaria disease is quite significant [2]. Several research shows how children of the age 5 below are the most susceptible to be affected by the mosquito transmitted disease. The World Health Organization (WHO) further estimates that 229 million cases of malaria disease worldwide were recorded in 2019[1][3].The main cause of malaria is from a parasite called plasmodium parasite, which are transmitted to humans via mosquito bites from an infected malaria vector formally known as female Anopheles mosquitoes. The disease is known to have high grounds in the African region[1]. The region houses about 94% of world malaria cases and deaths.

The most common symptoms of malaria include but are not limited to, fever, nausea, chills, headache, muscle aches, and tiredness[3]. Some more symptoms like vomiting, and diarrhoeaoften also appear in malaria patients. It has been seen in cases where malaria causes anemia and jaundice (skin and eyes turning yellow). If malaria is not promptly diagnosed and treated, the infection can be life-threatening which could lead to kidney failure, mental confusion, and seizures[3]. With all being said, malaria is highly preventable and curable but having little to no access to early-stage diagnostics tools often makes it fatal. Our research efforts are focusedon the ability to detect these malaria parasite traces in cell images using a deep convolutional neural network that would enable clinicians with vital information that makes malaria detection and treatment easier.

The ability to detect any kind of disease earlycannot be overemphasized. This further inspired the creation of this custom-built solution used to classify Parasitized and Uninfected cell images. The proposed solution could be deployed to those areas and regions with high share of malaria cases.

2. BACKGROUND

Advances in Machine Learning (ML) techniques stretches far back into antiquity which in recent years gave the rise to several custom-builtconvolutional neural network (CNN) based models[4]. This have been applied in several medical imaging and detection tasks such as, disease diagnosis, prediction, and classification et al. ML techniques like deep learning have been used in detecting anomalies. These technologieshave significantlychanged the face ofapplying deep learning techniques in medical applications[5]. The convolutional neural network (CNN) is just for of deep learning technique uses feature extraction to obtain higher-level results[6]. The complex nature of the convolutional neural network architectures gave it the potential of effectively extracting useful and relevant features from medical data whichaidsmedical practitioner's in carrying out clinical decisions. There are provenstudiesindicating how impactful deep convolutional neural network-based solutionsare in medical diagnostics[7][8]. In this paper, our model is one of those experimental studies indicating how effective these deep learning techniques can be in the medical field.

3. DATA

This experiment was conducted using malaria cell images dataset gotten from the National Library of Medicine (NIH) online repository[9]. This publicly available data is also accessible on Kaggle[10] data repository. These cell images were collected and analyzed from institutions which include Chittagong Medical College Hospital, Bangladesh and Mahidol-Oxford Tropical Medicine Research Unit in Bangkok, Thailand. The cell images and annotations collected are archived. These images were further screened for quality control by experts who deemed it valid for training artificial intelligence systems. The datasetconsists oftwo categories of malaria cell images namely, Parasitized and Uninfected. We further deduced the publicly available dataset to match our computing power. 5,000 cell images of JPEG format were used in this study. Thus,more details on the data are described and analysed in [11].

Table 1. Details of dataset.

Categories	Parasitized	Uninfected
Number of Cell Images	2500	2500

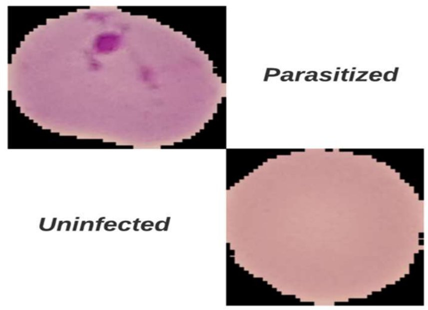

Figure 1. Sample cell images from malaria dataset

4. THE PROPOSED METHOD

In this study, we develop a custom optimum and efficient model to demonstrate how CNN based method can be used for detecting malaria in cell images. The experiment was conducted on a custom 13-layered Convolutional Neural Network model. This model can be employed in correct examination of malaria cells. Figure2. shows the Custom CNN model.

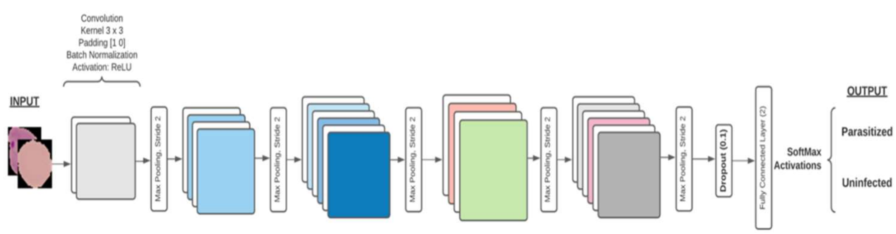

Figure 2. The Proposed Method.

The approach applied in this study for examining the custom CNN method proposed for classifying malaria cell images is explained below.

Step One: Access publicly available malaria cellimage dataset.
Step Two: Load malaria cell images onto MATLAB.
Step Three: Configure pre-processing options for image data augmentation.
Step Four: Augmented images are the inputs of the Custom-built CNN model.
Step Five: Dropout layer is applied to prevent the Custom model from overfitting.
Step Six: Output size is specified on FC layer and SoftMax function is applied to turn the vectors into probabilistic outcome for output classification.

Table 2. Data Augmentation Parameters

Augmentation Type	Random Rotation	Random reflection (x and y)	Range of scaling (x and y)	Image resizer
Parameters	5 degrees	1	0.05	227 x 227 x 3

Table 3. Optimal values of obtained for the custom CNN model.

Parameters	**Optimal Values**
Standardize Layer Inputs	Batch Normalization
Dropout	0.1
Optimizer	RMSProp
Activation	ReLU

4.1. Performance Evaluation

Performance of classifying the images using the custom method is evaluated based on the Accuracy, Misclassification,Precision, Recall, Specificity and F1 score parameters[12][13]. As indicated in the results,thecustom model could assist clinicians in diagnosing malaria from cell images.

Table 4. Performance evaluation metrics.

Metrics	**Measures**
Accuracy	$\frac{TP + TN}{TP + FP + FN + TN}$
Precision	$\frac{TP}{TP + FP}$
Sensitivity (Recall)	$\frac{TP}{TP + FN}$
Specificity	$\frac{TN}{TN + FP}$
F1 Score	$2 * \frac{(Sensitivity * Precision)}{(Sensitivity + Precision)}$

5. RESULTS

The performance of the custom-built model is evaluated using the metrices described in this study[12].

Table 5. Performance of the Custom-built model.

Metrics	***Score***
Accuracy	*93.0%*
Misclassification	*7.0%*
Precision	*96.0%*
Sensitivity (Recall)	*90.0%*
Specificity	*96.0%*
F1 Score	*92.8%*

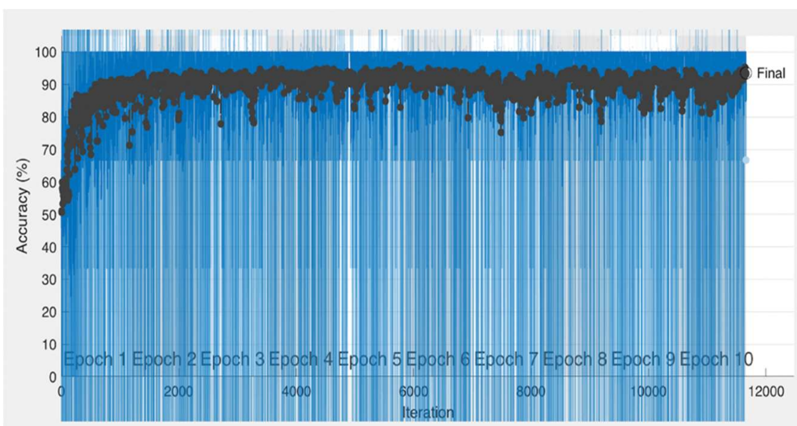

Figure 3. Accuracy of the custom CNN method.

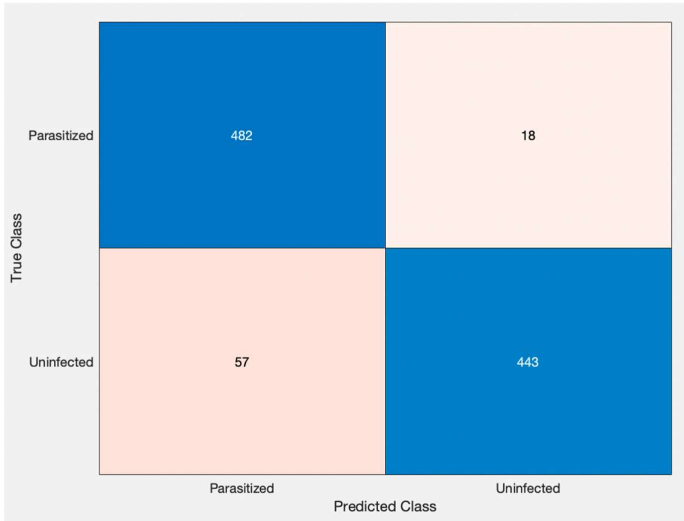

Figure 4. Confusion Matrix for the custom model.

6. CONCLUSION

This research is utilizing a custom-built CNN model for extracting features and classification tasks on microscopic malaria cell images. The malaria cell images used in the study were gotten from a public repository. The publicly available dataset was archived by several institutions. The malaria cell imagedataset used consists of two categories namely, Parasitized and Uninfected. The custom-built method overserved in this research achieved an accuracy level of 93%. Thisproved to be an optimum and precise way of diagnosing malaria disease from microscopic cell images.

As opposed to some previous experiments conducted using pre-trained networks on x-ray images for classification tasks, this custom method aims not just to classify the malaria cell images, but also to have some computational efficiency which in turn reduces the time taken to detect malaria parasites helping clinicians effectively and efficiently in taking decisions. The data sample size used in this study is 5000 cell images with 2500 in each category.

This work is a service to the biomedical research community, which aims to accelerate the efforts of clinical application of deep learning to health care[14].Malaria diagnosis in cell images is just a step towards achieving that goal. The plan for future works on this study is to use featureselection algorithm such as, Relief functions and some feature engineering techniques to improve the overall performance of our custom parasite classification method.

REFERENCES

[1] W. H. O. (WHO), "Malaria," April 2021. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/malaria. [Accessed 18 August 2021].

[2] W. &. D. Y. &. W. D. Pan, "Classification of Malaria-Infected Cells Using Deep Convolutional Neural Networks," *IntechOpen,* vol. 10, no. 5772, 2018.

[3] Centers for Disease Control and Prevention, "About Malaria," CDC, 26 January 2021. [Online]. Available: https://www.cdc.gov/malaria/about/faqs.html. [Accessed 18 August 2021].

[4] A. S. A. Z. U. e. a. Cite this article Khan, "A survey of the recent architectures of deep convolutional neural networks," *Artif Intell Rev,* vol. 53, p. 5455–5516, 2020.

[5] M. A. A. A. a. S. A. Mousa Al-Akhras, "USING MACHINE LEARNING TO BUILD A CLASSIFICATION MODEL FOR IOT NETWORKS TO DETECT ATTACK SIGNATURES," *International Journal of Computer Networks & Communications (IJCNC),* vol. 12, no. 6, 2020.

[6] A. S. K. S. R. R. Jaspreet Singh Chima, "Malaria Cell Image Classification using Deep Learning," *International Journal of Recent Technology and Engineering (IJRTE),* vol. 8, no. 6, pp. 2277-3878, 2020.

[7] S. J. S. Yadav, "Deep convolutional neural network based medical image classification for disease diagnosis.," *J Big Data,* vol. 6, no. 113, 2019.

[8] A. L. Alexander Selvikvåg Lundervold, "An overview of deep learning in medical imaging focusing on MRI," *Zeitschrift für Medizinische Physik,* vol. 29, no. 2, pp. 102-127, 2019.

[9] J. S, "LHNCBC - Full Download List," National Library of Medicine, [Online]. Available: https://lhncbc.nlm.nih.gov/LHC-downloads/downloads.html#malaria-datasets. [Accessed 9 August 2021].

[10] Arunava, "Malaria Cell Images Dataset," Kaggle, 2018. [Online]. Available: https://www.kaggle.com/iarunava/cell-images-for-detecting-malaria. [Accessed 9 August 2021].

[11] J. S. A. S. Rajaraman S, "Performance evaluation of deep neural ensembles toward malaria parasite detection in thin-blood smear images," *PeerJ,* vol. 7, no. 6977, 28 May 2019.

[12] R. Joshi, "Accuracy, Precision, Recall & F1 Score: Interpretation of Performance Measures," Exsilio , 9 September 2016. [Online]. Available: https://blog.exsilio.com/. [Accessed August 2021].

[13] S. P. S. S. S. B. PRIYA NERLIKAR, "Analysis of Intrusion Detection Using Machine Learning Techniques," *IJCNCS,* vol. 8, no. 10, pp. 2410-0595, 2020.

[14] F. W. S. W. X. J. J. T. D. Riccardo Miotto, "Deep learning for healthcare: review, opportunities and challenges," *Briefings in Bioinformatics,* vol. 19, no. 6, p. 1236–1246, 06 May 2017.

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