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Malaria Detection System Using Microscopic Blood Smear Image

Priya Singh, Priyanshu Singh, Rahul Sharma, Ragini, Saumya Gupta

Research Scholar, U.G. Student, U.G. Student, U.G. Student, U.G. Student
Department of Computer Science and Engineering
Greater Noida Institute of Technology (AKTU, Lucknow, U.P.) Greater Noida, U.P., India

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Abstract - *The impact of malaria is very high all over the world, according to the World Malaria Report 2021 published by WHO, around 627000 malaria-related deaths were reported in the previous year. Most of the malaria cases occur in less economically developed countries where medical testing facilities are not good enough. The malaria screening process requires microscope specialists to calculate malaria parasites in red blood samples. The result of Malaria testing completely depends on the microscopist and the Probability of human error always exists. Therefore, to eliminate human error and increase test speed, Machine Learning (ML) can be used to automatically create a testing process. We used the Convolutional Neural Network (CNN) to isolate blood cells as parasitized or healthy. We use a wide range of ML strategies such as data enhancement, familiarity, and map detection features. Our model gained 95.70% accuracy at the end. To use the model easily, we designed a simple web app visual using Flask. The application must be widely used, as it is mainly used in low-economy developed countries. Therefore, this application can be used on almost any device like a smartphone, laptop, tablet, and other similar electronic devices.*

***KEYWORDS*: Convolutional Neural Network, Machine Learning, Deep Learning, Rectified Linear Unit, User Interface, World Health Organisation**

1. INTRODUCTION

Malaria is, a mosquito-borne life-threatening disease, that causes fever, vomiting, headaches, and fatigue; in severe cases, it can cause coma or even death. There were around 627000 malaria-related deaths in the preceding year, as mentioned in World Malaria Report 2021. Malaria can affect humans as well as other animals. Malaria is generally transmitted by female Anopheles mosquitoes. Due to a mosquito bite, the parasite is injected into the blood and after some time it becomes more mature and the population of parasites in the blood gets increases. Malaria is caused by a single-celled virus called Plasmodium, five of which can infect humans. Plasmodium falciparum is the most dangerous and deadly among these species. Symptoms of malaria are much similar to flu and generally appear in 6 to 30 days after the mosquito bite, but sometimes it can take up to a year for symptoms to start. The preliminary signs of malaria consist of a headache, sweats, fever, chills, muscle aches or pains, vomiting, etc. At the start, those symptoms can start moderate and can be hard to pick out as malaria. A generally used procedure for testing Malaria is to examine thin blood smears and search for infected cells. In Malaria testing, we have to count the number of parasitized red blood cells manually - sometimes up to 5,000 cells according to the WHO protocol [2]. To overcome the error probability due to the manual process we decide to use Machine learning to automate the testing process of Malaria. According to WHO, a Quick and accurate diagnosis of malaria is necessary for effective disease management and monitoring. Therefore, using AI to automate the testing process plays a big role in accurately diagnosing malaria, as it has many advantages over its manual counterparts [3]. There are several deep neural network architectures are designed for malaria detection. In this project, we apply Convolutional Neural Network (CNN) algorithms using different pre-processing techniques such as standardization, normalization, and stain normalization to contribute to the model having overall performance. In this red blood cell smears images have been used directly as an input, after that deep learning is used for predicting malaria parasites. Again several pre-processing and post-processing methods & techniques are applied to maximize performance in an unbiased test set.

2. LITERATURE REVIEW

Being a deadly and global disease, Malaria has been an important focus of research and study in the last few years. Some of the literature related to Malaria and its detection and diagnosis that we studied are defined here –

- In literature [4], Dr. Peter Manescu from UCL Computer Science explains that testing of malaria blood samples using a microscope completely depends on skilled technicians of microscope and it also takes a lot of time and is open to human error caused by workload pressure. But malaria classification using machine learning allows more patients to be tested in a shorter amount of time, as the workload will be reduced for the microscopists. Furthermore, reducing the workload will reduce the costs of testing, thus making it more accessible to remote areas.

- This study [5] reveals that many systems are describing computerized image analysis methods that typically include three main steps, In the first pre-processing is done, in which the luminance of

the image is corrected and transformed into a constant color space, In the next step, a histogram-based image segmentation process was performed which helps in avoiding maximum artifacts and over-stained objects, and in the last one, a neural network algorithm was used for classifying objects.

- Another related, more accurate method of counting blood cells using Python OpenCV is explored [6]. It uses microscopic samples of blood to calculate the number of cells. In this study, the images were processed and a blood detection algorithm was used to detect and differentiate RBCs from WBCs. Image processing involves signal processing and mathematical procedure. For counting the red blood cells and white blood cells, Cell counting methods have also been used.

- Another piece of Literature [7] proposes a method for detecting parasites based on digital image processing. Thin blood smear images are used and the parasites in the cells are identified using an image processing approach.

- Ghana is one of the countries broadly affected by malaria. In Ghana, around 5.9 Million [10] cases of malaria were reported In the year 2020. This study [8] looked at determining the extent to which Hematological parameters and Demographic characteristics cases could be used to predict Malaria using logistic retrogression. The sensitivity and specificity of the model were 77.4% and 75.7 %, respectively, with a PPV and NPV of 52.72% and 90.51%, respectively.

3. METHODOLOGY

3.1 Deep Learning for Malaria Detection

At present time Deep learning is widely used in many machine learning projects and image classification & video recognition are very trendy nowadays. In this project, we used a Convolutional Neural Network (CNN), a type of deep neural network. it is one of the most considered algorithms for research in the computer vision field because. The convolutional layers present in the CNN model are able to extract hidden and important features automatically. In the next step, the extracted elements are transferred to a fully connected neural network that enables the classification of images by optimizing probability scores. A CNN Architecture is shown in the following figure (Fig 1).

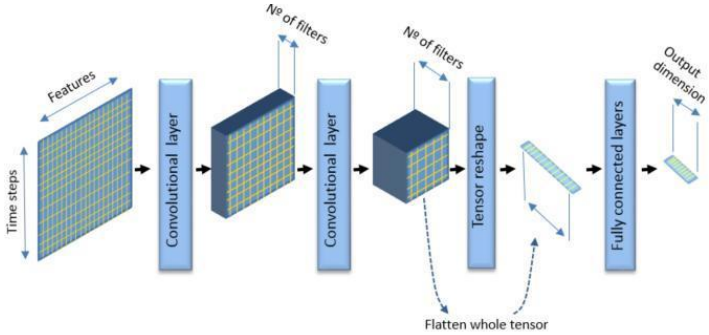

Fig 1 CNN Architecture

3.2 Dataset and its pre-processing

3.2.1 Dataset Collection

We have used a publicly available malaria dataset from the Kaggle website[9]. There are 27,558 images in the dataset with an equal number of normal and parasitized instances.

Parasitized Cell sample

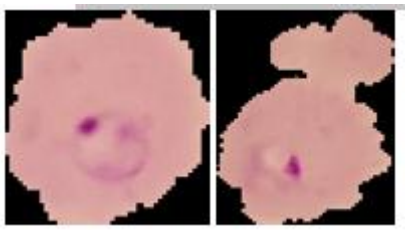

Fig 2

Normal Cell sample

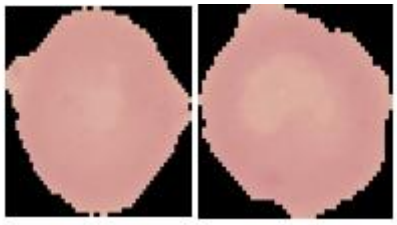

Fig 3

3.2.2 Data splitting

The dataset is split into two sets, namely, training and test sets having a ratio of 80:20. We did this using the Scikit-learn library popularly known as Sklearn. Scikit-learn is an open-source library containing a lot of tools for machine learning and statistical modeling.

3.2.3 Data processing

3.2.3.1 Stain Normalization

For the examination of malaria parasites from blood film using a microscope, the thin blood films are prepared by

adding various chemical stains, such as Giemsa stain, and Wright stains. Color variation occurs in the images because the microscope specialist uses different chemical stains, scanners, staining, and staining processes. Due to this network can learn much more complex features, which results in an increased error margin. This problem can be solved using standardization and normalization of input images.

3.2.3.2 Rescaling (Min-Max Normalization)

To achieve faster convergence, the patches of images were rescaled to map the range of features from 0 to 1. In, the original 8-bit RGB color images the value of the data point can range from 0 to 255. Therefore, using the following equation, we rescale our input data.

$$z = \frac{x - \min(x)}{\max(x) - \min(x)} = \frac{x}{255}$$

3.2.3.3 Standardization

Here the values of each feature in the data are rescaled to have a mean of 0 and a standard deviation of 1

3.3 Model Configuration

Our CNN model has two fully connected dense layers and three convolutional blocks. Fig. 4 shows the proposed CNN model. Each convolutional block consists of convolution, max pooling, and batch normalization layers.

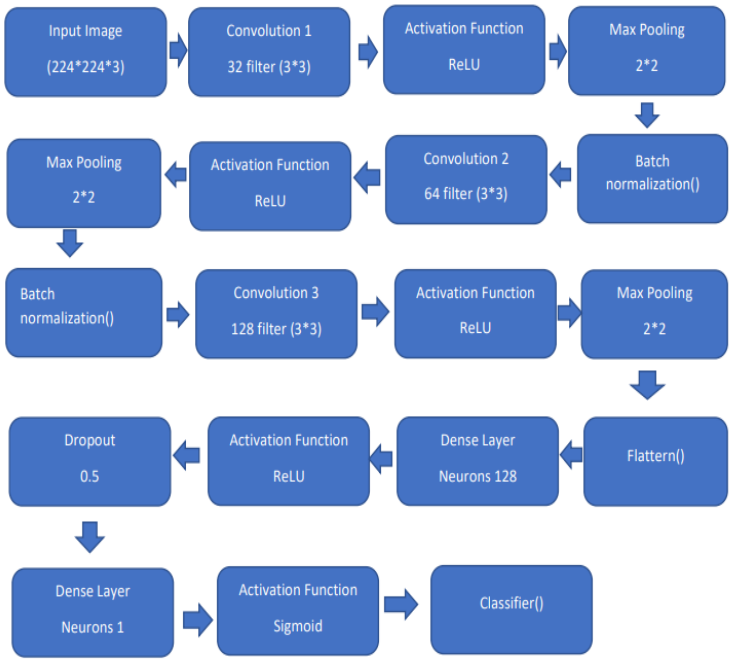

Fig 4

3.4 Model Training

In the process of training the model, we performed the following operation as shown in the following workflow diagram (Fig 5).

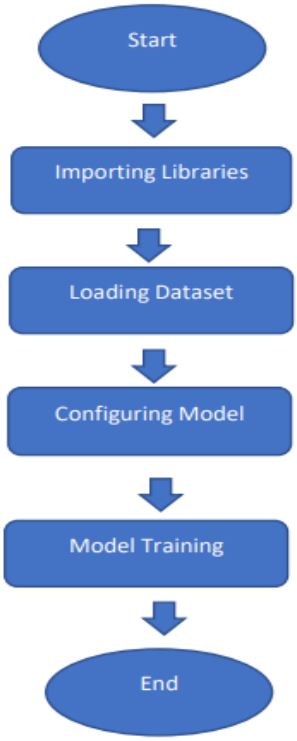

Fig 5

The proposed CNN model is trained and evaluated on Google Colab [11]. It is a cloud-based Jupyter notebook environment available free of cost by Google but there is also a paid version available known as Colab Pro that gives more options and support. And for developing the web app, we have used Visual Studio code.

4. RESULT

After performing training, using the model discussed above we got a training accuracy of 95.70% and we can classify cells as infected or healthy as shown in the following image (Fig 6).

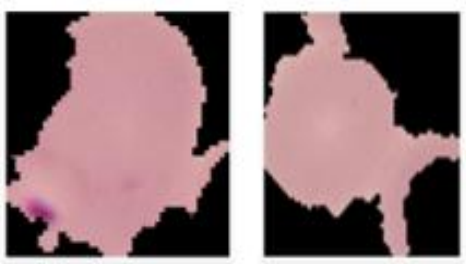

Fig 6

5. Conclusion

Malaria is one of the most common mosquito-borne diseases and a major public health problem worldwide. The preliminary signs of malaria consist of a headache, sweats, fever, chills, muscle aches or pains, vomiting, etc. At the start, those symptoms can start moderate and can be hard to pick out as malaria. Currently, the standard method of diagnosing malaria is to examine a blood smear Manually. Nowadays Machine Learning, specifically Convolutional Neural Networks (CNN) has been very effective at detecting malaria parasites in blood cells. We train our model using the methods and techniques mentioned above, after training, we successfully classified blood smear images as either healthy or parasitized. we used some popular Machine Learning libraries in Python in the process of training and got an accuracy of 95.70. To assist the trained model, we have also developed a web application using Flask (web framework).

In this case, Anyone can do some work in the future such as exploring other existing or new machine learning methods that can provide better accuracy, and there is no end to research in Machine Learning.

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