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Automated Parasite Classification of Malaria on Thick Blood Smears

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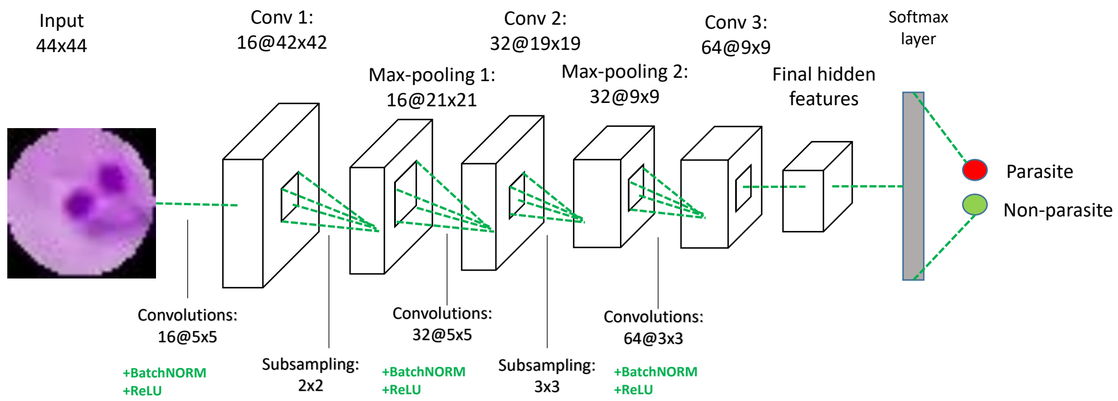
Introduction

Goal:
Develop an automated system to aid in malaria diagnosis on thick blood smears.

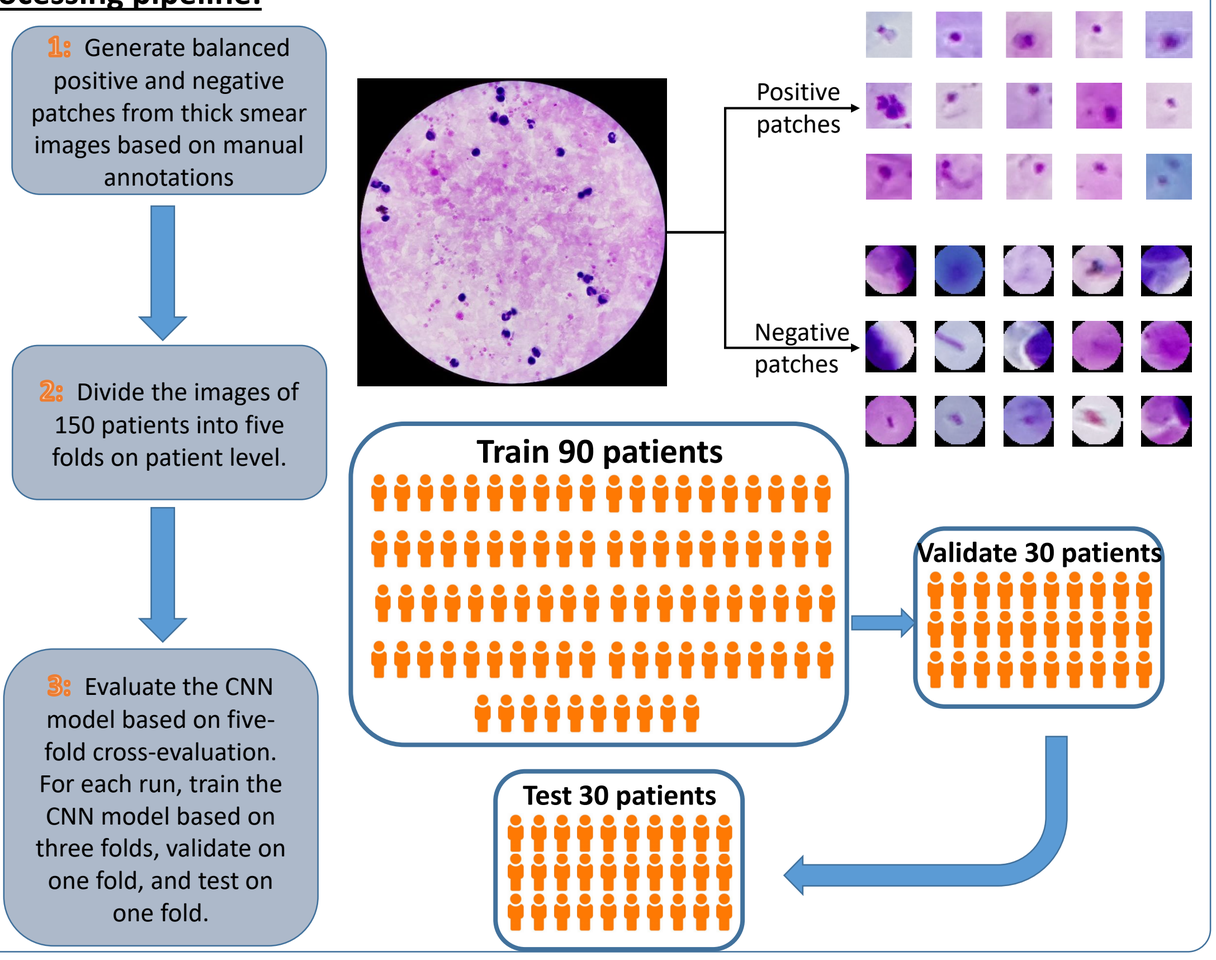
- According to the WHO malaria report in 2017, an estimated 216 million malaria cases were detected in 2016, causing approximately 445,000 deaths.
- Microscopy is the gold standard for malaria diagnosis.
  - Thick blood smears are used to detect the presence of malaria parasites; Thin blood smears are used to differentiate parasite species.
  - Microscopy examination is of low cost and is widely available, but is time-consuming, and the effectiveness of microscopy diagnosis depends on the parasitologists' expertise.

Methods

We propose a customized convolutional neural network (CNN) model including three convolutional layers, two fully-connected layers and a softmax classification layer. Following each convolutional layer, a batch normalization layer, an activation layer, and a max-pooling layer are introduced to select feature subsets.



Processing pipeline:



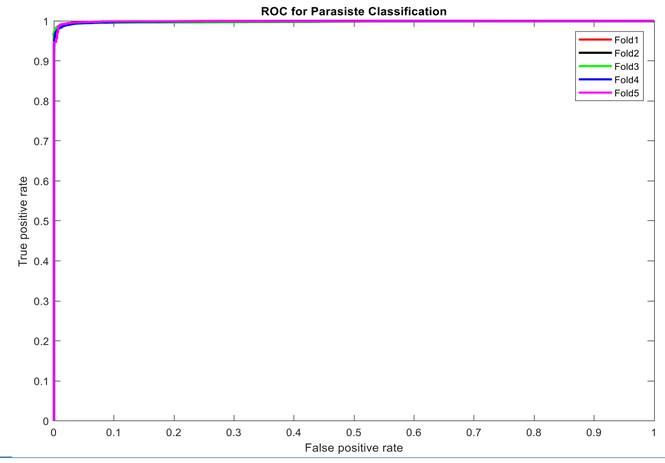
Experimental Results

- We have in total 1817 thick blood smear images from 150 infected patients, which we acquired via Mahidol-Oxford Tropical Medicine Research Unit, Bangkok, Thailand. Each image has been annotated by an experienced parasitologist.
- For training, a total number of 84,894 positive parasite patches are cropped from the images based on the experts' annotations, and an equal number of negative patches are generated using an intensity-based greedy method.

Experiment	Accuracy	AUC	Sensitivity	Specificity	Positive-Prediction	Negative prediction
1	98.73%	99.92%	99.18%	98.28%	98.30%	99.18%
2	98.75%	99.91%	98.82%	98.68%	98.68%	98.82%
3	98.79%	99.79%	97.76%	99.82%	99.81%	97.80%
4	98.67%	99.87%	98.12%	99.23%	99.22%	98.14%
5	98.98%	99.91 %	99.03%	98.93%	98.93%	99.03%
Average	98.78% ±0.12%	99.88% ±0.05%	98.58% ±0.61%	98.99% ±0.58%	98.99% ±0.57%	98.59% ±0.60%

Based on five-fold cross evaluation, we observe:

- The customized CNN model is effective
- The customized CNN model is robust



Conclusion & Future Work

- Deep learning is an accurate and reliable model for malaria parasite classification on thick blood smears.
- Future work will first focus on the combination of parasite candidate preselection and classification using our customized CNN model.
- Future work will also perform white blood cell counting.

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