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.

**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.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Accuracy</th>
<th>AUC</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive-Prediction</th>
<th>Negative prediction</th>
</tr>
</thead>
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<tr>
<td><strong>Average</strong></td>
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<td>99.88%</td>
<td>98.58%</td>
<td>98.99%</td>
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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.

**References**