**Deep Learning for Smartphone-based Malaria  
Parasite Detection in Thick Blood Smears**

**ABSTRACT**

**Objective:** This work investigates the possibility of automated malaria parasite detection in thick blood smears with smart phones.

**Methods:** We have developed the first deep learning method that can detect malaria parasites in thick blood smear images and can run on smart phones. Our method consists of two processing steps. First, we apply an intensity-based Iterative Global Minimum Screening (IGMS), which performs a fast screening of a thick smear image to find parasite candidates. Then, a customized Convolutional Neural Network (CNN) classifies each candidate as either parasite or background. Together with this paper, we make a dataset of 1819 thick smear images from 150 patients publicly available to the research community. We used this dataset to train and test our deep learning method, as described in this paper.

**Results:** A patient-level five-fold cross-evaluation demonstrates the effectiveness of the customized CNN model in discriminating between positive (parasitic) and negative image patches in terms of the following performance indicators: accuracy (93.46%±0.32%), AUC (98.39%±0.18%), sensitivity (92.59%±1.27%), specificity (94.33%±1.25%), precision (94.25%±1.13%), and negative predictive value (92.74%±1.09%). High correlation coefficients (>0.98) between automatically detected parasites and ground truth, on both image level and patient level, demonstrate the practicality of our method.

**Conclusion:** Promising results are obtained for parasite detection in thick blood smears for a smart phone application using deep learning methods. Significance: Automated parasite detection running on smart phones is a promising alternative to manual parasite counting for malaria diagnosis, especially in areas lacking experienced parasitologists.

**Index Terms—** deep learning; Convolutional neural networks; Computer-aided diagnosis; Malaria