Automated Malaria Classification System

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The use of digital blood smear images in combination with highly portable smartphones and the use of intelligent software based on image analysis and deep learning is a promising approach to fighting malaria by helping to achieve better treatments, development of new malaria vaccines, and mosquito control. The latest report of malaria cases by WHO informs that there were an estimated 219 million cases of malaria in 87 countries. The estimated number of malaria deaths stood at 435000 in 2017 and more than two-thirds of malaria deaths were children under the age of five. When malaria parasites enter the bloodstream, they infect and destroy the red blood cells. Through the bites of infected mosquitoes, between 10 to 100 parasites are injected into a patient's blood. When they get to the liver, they develop up to two hundred and fifty billion parasites in the patient's blood; therefore, it is important to catch malaria infection in its early stages. The current standard method for malaria diagnosis in the field is light microscopy of blood films. Microscopists examine millions of blood films every year for malaria. This involves manual counting of parasites (or infected red blood cells), which is a labor-intensive and error-prone process, especially if patients have to be tested several times a day. However, accurate counts are essential to diagnosing malaria accurately and are an important part of testing for drug-effectiveness, drug-resistance, and estimating disease severity.

To improve malaria diagnostics, we created an edge computing mobile application system, using an image recognition algorithm and attachable microscope that gives accurate counts of infected blood cells with 96% accuracy. The use of inexpensive, common light microscopy equipment makes our product well suited for resource-constrained settings, where malaria is prevalent. Our system would be a significant improvement over current standard Malaria diagnosis methods such as Rapid Diagnostic Tests and traditional microscopic tests which have several limitations -- RDTs are prone to errors and has limited reusability while traditional microscopic tests require human expertise and expensive equipment.

Comparing to the state-of-art results, our model has achieved noteworthy improvements over the state-of-the-art result while using significantly fewer parameters and computations that can help us reduce memory/hardware requirements to be able to deploy the model easily to edge and Internet of Things (IoT) devices. Our single, compact and efficient deep learning model has achieved 96% +- 0.07 with less than 18 MB of the serialized model file. We have validated our algorithm, deploying our deep learning model on an iOS device using CoreML and on Android smartphone using Tensorflow Lite. Both our mobile applications discriminate normal and parasites cells within 5 seconds. When using mobile applications, we first attach a smartphone to the eyepiece of microscopes with a 100x objective by means of an adapter. This setup would allow taking pictures of blood smears with the smartphone's built-in camera and processing these pictures directly on the phone. Ultimately, our proposed method can save 12-30 more lives per 400 patients by decreasing false negatives cases.