MalaScope - A Low-Cost Deep Learning Sensor for Label-Free Detection of Malaria

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Malaria is a deadly disease that claims the lives of over 460,000 children annually. Current diagnostic methods use labor-intensive microscopy to image Giemsa-stained blood smears, limiting accessibility for resource-constrained communities. To address this challenge, MalaScope, a low-cost, portable sensor integrating lensless microscopes with deep learning, was developed. In Phase I, Giemsa-stained thin blood smears were shadow-imaged with a white light-emitting diode. The area of coverage was 25 mm2, 800 times larger than a standard microscope, requiring one image instead of one hundred. Pathologist-taken images of commercially bought slides were segmented using superpixels to create a balanced dataset of 24,000 images of infected and healthy red blood cells. Transfer learning on four convolutional neural networks was studied using 5-fold cross-validation. 98% accuracy, 97% recall, 98% specificity, 98% precision, and 0.998 area under the receiver operating characteristics curve (AUC) were demonstrated. The results were similar to standard microscopy models at 1/5th of the cost. In Phase II, whispering gallery modes were used to excite resonances in healthy red blood cells to differentiate them from infected cells, eliminating the need for staining. Fourier analysis was used to decompose measured diffraction patterns into plane waves at different spatial frequencies, and back-propagation of these waves was used to predict cell shapes. It was discovered that the ellipticity of healthy cells was higher than that of infected cells, resulting in a 91% accuracy and a 0.976 AUC. MalaScope can help diagnose malaria in rural areas, providing hope in our battle against this deadly disease.

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