Embedded Vision Hardware for Medical Screening in Low-Resource Settings

Hauck, Ava (School: Dickinson High School)

Healthcare systems that operate with low-income and low-resource facilities encounter significant challenges which prevent them from diagnosing diseases due to their lack of enough skilled workers, their laboratory testing capacity is restricted, and their power supply system fails to operate consistently. Malaria alone caused an estimated 263 million cases and 597,000 deaths globally in 2023, with the highest burden in areas lacking diagnostic resources. The research project tests whether machine learning combined with embedded vision hardware will create an affordable portable solution for analyzing blood smears. The team created a prototype diagnostic device which combines a Raspberry Pi compute module with digital microscope camera technology and objective lens systems and battery-operated components. Blood smear images are captured and processed using a custom pipeline built in Python with OpenCV. The system detects red blood cells through edge and circular detection methods which separate the cells for evaluation by a convolutional neural network (CNN) that classifies cells into healthy and malaria-infected categories. Validation testing was conducted on 100 blood smears, producing 1,000 images. The system detected an average of about 950 red blood cells per run with cropping efficiency between 83–87%. The time to complete the task extended from 20 seconds to 200 seconds based on the number of cells present. The CNN achieved an AUC score of 0.98, showing strong classification performance. The results show that embedded AI microscopy systems deliver dependable diagnostic results through their use of inexpensive hardware which operates at a lower cost compared to standard laboratory tools which makes them suitable for testing in budget-constrained facilities.

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