Cost-Effective MalariaX: An AI-Optomechatronic System Decoding Expert Reasoning Into a Sub-Micron, Pan-Species Clinically Traceable Pipeline

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Inaccurate malaria diagnosis in remote areas drives drug resistance and fatal treatments. Rapid tests miss the critical P. knowlesi, while standard Whole Slide Imaging (WSI) microscopes are prohibitively expensive ($35,000) and grid-dependent. Furthermore, existing AI lacks the morphological explainability required for clinical trust. This study presents Cost-Effective MalariaX, an AI-optomechatronic diagnostic platform addressing these barriers. Phase 1 (MALA-Sight) introduces an AI pipeline trained on 25,000+ images. To address the “black-box” limitation, it utilizes a Morpho-Species Map designed for explainability, providing WHO-aligned visual outputs. The model was optimized for edge-device deployment via INT8 quantization for localized inference in resource-limited settings. Phase 2 (XcopeRapid-Sight) engineered an automated scanner designed to approximate FDA WSI imaging guidelines. Key hardware adaptations include: (1) transforming low-cost unipolar stepper motors into a bipolar configuration for optimized torque, (2) designing a custom spindle-sleeve precision lead screw, and (3) a custom PCB bridging hardware-software synchronization, enabling the MALA-Sight AI to command mechanical motion on a localized Edge AI platform. These modifications achieved a 0.33 µm Z-axis mechanical resolution. At $257, this 4th-iteration hardware prototype represents a 99.27% cost reduction relative to commercial systems. Within a 1.93kg grid-independent, compact, and robust, IPX4-rated enclosure, the architecture enables autonomous diagnosis. Validated at two endemic field centers (98.80% Sp) and through cross-country samples (98.40% Sp), this study demonstrates a feasible engineering approach to assist volunteers in remote malaria diagnosis.

Awards Won:
First Award of $6,000