

Spatial-Textural Machine Learning for Noninvasive Detection of Malarial Anemia Using Conjunctival Images (Year 2)

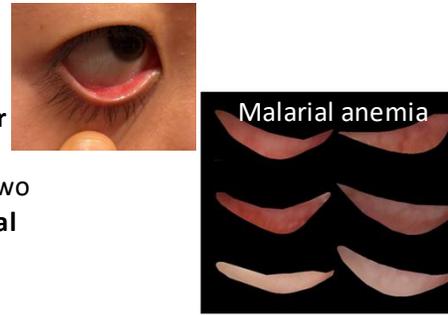
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Introduction

- **Malarial anemia:** A life-threatening medical emergency requiring rapid recognition in resource-limited settings, driven by Plasmodium-mediated red blood cell destruction and severe
- **Challenge:** No noninvasive, rapid, direct test currently exists for fast-track detection of malarial anemia. Current malaria and anemia diagnosis methods are invasive, require training, and require expensive equipment → *inaccessible*

Hypothesis

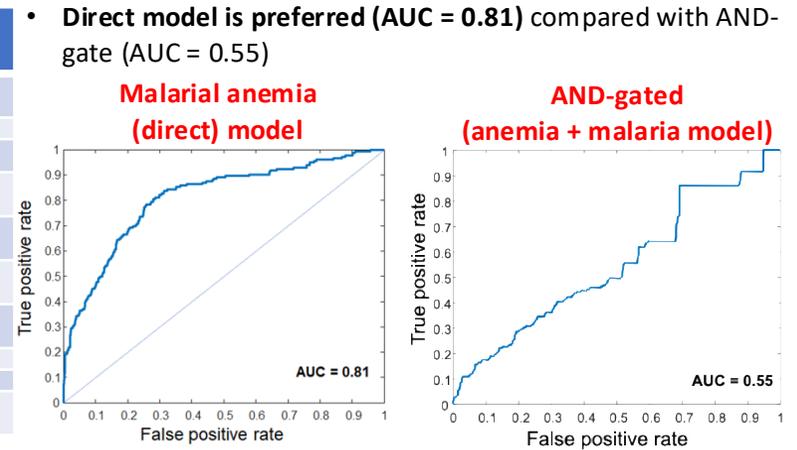
- A machine learning algorithm can be effectively trained to reliably detect malarial anemia using radiomic (spatial and textural) features extracted from palpebral conjunctiva (inner eyelid) photographs that correlate with malarial anemia
- Rather than relying on an AND rule to combine outputs from two separate tests (malaria test and anemia test), **one-step malarial anemia detection enables a clear, fast-track decision** that reduces errors and confusion from a two-step link



Results

Receiver operating characteristic (ROC) analysis for malarial anemia detection

	Top malaria radiomic features	Top anemia radiomic features
1	First order, root mean squared	Wavelet-H, GLDM, gray level nonuniformity
2	First order, mean	LoG, GLDM, dependence nonuniformity
3	First order, median	Wavelet-L, GLDM, dependence nonuniformity
4	First order, minimum	Wavelet-H, GLCM, informational measure of correlation 2
5	First order, 10 percentile	Wavelet-H, GLRLM, short run emphasis
6	First order, 90 percentile	Wavelet-H, GLDM, dependence nonuniformity
7	First order, maximum	Wavelet-H, GLDM, dependence nonuniformity normalized
8	First order, variance	LoG, GLSZM, zone variance
9	First order, energy	LoG, GLDM, dependence nonuniformity
10	First order, mean absolute deviation	LoG, GLSZM, large area high gray level emphasis



Methods

Study design

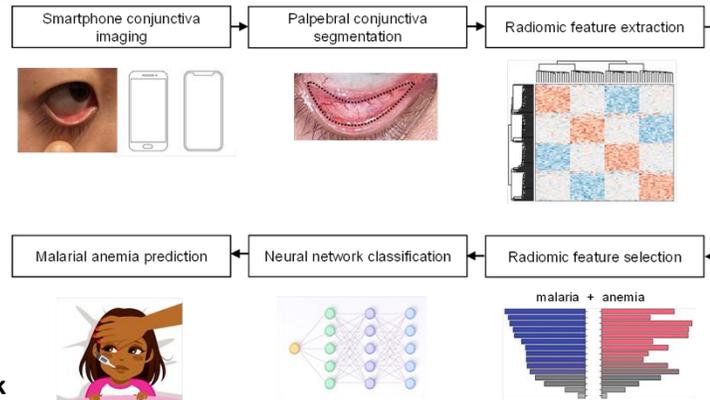
- Gakoma Hospital, Gisagara District, Rwanda
- Publicly available data and additional de-identified data

Radiomic extraction and selection

- Top 10 radiomic features associated with malaria and anemia (20 features total)

Bayesian optimization of neural network

- Identify optimal hyperparameters efficiently, reducing evaluation time
- Final hyperparameters: 2 hidden layers with 118 and 258 neurons, using tanh activation, stochastic gradient descent (SGD) with learning rate 0.001 for 100 epochs



Conclusion

- Optimized directly for the joint endpoint (malarial anemia), not separate malaria and anemia tests
- Even with strong individual models, an AND rule is suboptimal for detecting malarial anemia
- Uses standard built-in smartphone cameras for portable, low-cost, easy deployment in resource-limited settings
- Designed for rapid triage, large-scale screening, and risk stratification where delays can be fatal and urgent transfusion may be needed
- First radiomics-based study using smartphone palpebral conjunctiva images to identify children at elevated risk of malarial anemia
- Next steps: multi-device, multi-site validation and larger cohorts enriched for very low Hgb to enable severity-stratified/ordinal prediction (e.g., moderate vs severe)