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Automatic Detection of Acute Lymphoblastic Leukemia Using ALNET Deep Learning Model

Doreen Ninsiima, BME[1,a]; Joshua Biryomumeisho, MSc[1]; Gabriel Irumba Rumwaya, BME[1]; Johnes Obungoloch, PhD[1]; William Wasswa, PhD[1]

[1] Mbarara University of Science and Technology, Mbarara, Mbarara, Uganda

Corresponding author
[a] Doreen Ninsiima, BME, Mbarara University of Science and Technology, Mbarara, Mbarara, Uganda
Email: dninsiima567@gmail.com

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Abstract

Background

Acute lymphoblastic leukemia (ALL) accounts for 75-80% of childhood leukemias, with low- and middle-income countries (LMICs) bearing the greatest burden. Uganda reports 2.67 leukemia deaths per 100,000 and a devastating 16.5% 1-year survival at the Uganda Cancer Institute. Diagnostic delays stem from scarce hematopathologists (<1 per 100,000), manual microscopy, and symptom overlap with malaria. No AI-based ALL diagnostic tool has been validated on African clinical samples. Hypothesis: A CNN-based smartphone-microscopy diagnostic tool validated on Ugandan clinical samples can achieve ≥90% accuracy, reducing diagnostic time from hours to minutes.

Methods

Using Design Science Research, we developed LeukNet, a CNN (ALNet architecture) trained on 260 ALL-IDB1 images (blast versus non-blast). Images were preprocessed (224×224px, normalized, augmented) with a 70-30 train-validation split. External validation used 30 blood smear slides (20 leukemic, 10 non-leukemic) from Mbarara Regional Referral Hospital, Uganda. Images were captured via compound microscope using two smartphones: Techno Camon 20 Premier (108MP) and Itel S23 (50MP), yielding 300 images/device. Two pathologists provided ground-truth labels. Performance metrics: accuracy, sensitivity, specificity, F1-score.

Results

Internal validation achieved 98% accuracy, 95.8% sensitivity, 97.1% specificity, and 96.3% F1-score. The confusion matrix showed 87% overall accuracy (blast precision: 0.96; non-blast recall: 0.97). External validation demonstrated 100% accuracy for positive smears on Techno and 90% on Itel; negative smears achieved 90% (Techno) and 80% (Itel). Errors correlated with lower resolution and reactive cell confusion. Overall external accuracy: 90%. The web platform with Mistral LLM summaries and QR verification proved operationally feasible.

Conclusion

LeukNet is the first AI-based ALL diagnostic tool validated on Ugandan clinical samples, achieving 90% external accuracy using widely available smartphones and standard microscopes. By reducing diagnostic time from hours to minutes without specialized equipment, LeukNet offers a scalable, cost-effective solution for LMICs,

supporting a multi-site pilot to improve childhood ALL survival in Uganda and sub-Saharan Africa.

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