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Machine learning-enhanced LAMP-fluorescence assay for automated tuberculosis detection

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Abstract

Rapid and accurate disease detection is critical for effective clinical management and public health interventions, particularly in low-resource settings. Loop-Mediated Isothermal Amplification (LAMP) is a promising molecular diagnostic technique due to its simplicity, speed, and compatibility with real-time fluorescence detection. However, interpreting fluorescence images, especially in cases with low target concentrations or high background noise remains challenging and error-prone when performed manually or using basic threshold-based methods. This study proposes the integration of a Support Vector Machine (SVM) algorithm with the LAMP-fluorescence assay to automate and enhance the detection of tuberculosis (TB) at low concentrations. Using a dataset of fluorescence images, the model was trained with 5-fold cross-validation across 20 candidate configurations (100 total fits). The optimized model achieved a classification accuracy of 99.76%, effectively distinguishing true positives, false positives, and ambiguous amplification patterns. Diagnostic sensitivity and specificity improved to 95.0% and 97.0%, respectively, supporting earlier and more reliable detection. This enhanced approach demonstrates strong potential for developing robust, scalable, and fielddeployable diagnostic tools for TB and other infectious diseases.