
Deep learning approach using spatio-temporal information for efficient identification of bacterial colonies using lens-free microscopy

Résumé

The identification and detection of harmful bacteria present in bodily samples such as blood, urine, and sputum is a vital step in expediting clinical diagnosis. However, determining these results quickly and accurately is difficult due to the complexity and size of the samples. Traditional methods, such as mass spectrometry and automated biochemical testing, often compromise speed for accuracy and can be costly and destructive. Additionally, these methods typically require overnight subculture on solid agar medium, delaying bacteria identification by 12-48 hours, hindering the rapid prescription of appropriate treatment and antibiotic susceptibility testing. To address these issues, this study presents lens-free imaging as a possible solution for quick, accurate, non-destructive, label-free detection and identification of a wide range of pathogenic bacteria in real-time using micro colony growth patterns and a two-stage deep learning architecture. Results were obtained using a live-cell lens-free imaging system and thin-layer agar media, and the proposed architecture yielded promising results on a dataset of seven different pathogenic bacteria. The detection network had an average 96.0% detection rate and the classification network had an average precision and sensitivity of 93.1% and 94.0%, respectively, both tested on 1908 colonies. The classification network even achieved a perfect score for one of the bacteria and very high score for another one. This method's success is due to a novel technique that combines convolutional and recurrent neural networks to extract spatio-temporal patterns from unreconstructed lens-free microscopy time-lapses.

Mots-Clés: Micro, biology, Artificial Intelligence, Data Science, Lens, free imaging, Bacteria