Development of an AI Model Based on Deep Learning for Detection, Classification, and Counting of Urinary Sediment in Microscopic Images

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Abstract

Urine sediment examination is an essential process in medical diagnosis, as it aids in identifying diseases—particularly those of the kidney and urinary tract, or conditions accompanied by urinary changes—and constitutes a fundamental laboratory investigation. At present, urine sediment analysis still relies on microscopic examination by medical technologists, who must count and classify sediment types across multiple fields of a sample. This approach carries several limitations, including processing delays, inter-observer variability, and errors arising from human factors. In response to these challenges, and recognizing the advancement of artificial intelligence—especially deep learning models—the authors sought to develop a model capable of detecting and counting urine sediments from microscopic images. This was achieved by collecting and preparing a urine sediment image dataset, applying data augmentation, and annotating the location of sediments before feeding the data into a deep learning training pipeline using classification and object detection via the Roboflow Train 3.0 algorithm to localize and identify sediments, with output expressed as sediment type and count per field. The resulting model demonstrated effective performance: an optimal confidence threshold of 41% yielded an F1-score of 81.6%, with precision of 81.0% and recall of 83.1%, indicating a suitable balance between accuracy and detection capability. The mAP was approximately 79.4% and mAP@50:95 approximately 56%. Per-class analysis showed high accuracy for RBC and WBC, while low-data classes such as bacteria and yeast exhibited higher misclassification rates due to class imbalance and morphological similarity. Overall, the model shows strong potential for detecting, classifying, and counting urine sediments, and can be further developed in future work.

Keywords: Urine Sediment, Medical AI, Deep Learning, Object Detection, Microscopic Image