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YOLO-Based Object Detection for the Automatic Classification of Intestinal Organoids

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Abstract : The intestinal epithelium serves as a pivotal model for studying stem cell biology and diseases such as colorectal cancer. Intestinal epithelial organoids, which replicate many in vivo features of the intestinal epithelium, are increasingly used as research models. However, manual classification of organoids is labor-intensive and prone to subjectivity, limiting scalability. In this study, we developed an automated object-detection algorithm to classify intestinal organoids in transmitted-light microscopy images. Our approach utilizes the YOLOv10 medium model (YOLO10m), a state-of-the-art object-detection algorithm, to predict and classify objects within labeled bounding boxes. The model was fine-tuned on a publicly available dataset containing 840 manually annotated images with 23,066 total annotations, averaging 28.2 annotations per image (median: 21; range: 1–137). It was trained to identify four categories: cysts, early organoids, late organoids, and spheroids, using a 90:10 train-validation split over 150 epochs. Model performance was assessed using mean average precision (mAP), precision, and recall metrics. The mAP, a standard metric ranging from 0 to 1 (with 1 indicating perfect agreement with manual labeling), was calculated at a 50% overlap threshold (mAP=0.5). Optimal performance was achieved at epoch 80, with an mAP of 0.85, precision of 0.78, and recall of 0.80 on the validation dataset. Classspecific mAP values were highest for cysts (0.87), followed by late organoids (0.83), early organoids (0.76), and spheroids (0.68). Additionally, the model demonstrated the ability to measure organoid sizes and classify them with accuracy comparable to expert scientists, while operating significantly faster. This automated pipeline represents a robust tool for large-scale, high-throughput analysis of intestinal organoids, paving the way for more efficient research in organoid biology and related fields.

Keywords : intestinal organoids, object detection, YOLOv10, transmitted-light microscopy
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