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Deep-Learning Meets Microbial Live-Cell Imaging: Powerful Analysis Workflows from Annotation to Prediction

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Time-lapse microscopy in combination with precisely controllable microfluidic lab-on-a-chip systems allows observing the emergence of microbial populations starting from one single cell. Live-cell imaging is thus a powerful tool for studying heterogeneity of cell growth, morphological development, or cell-to-cell interaction. Such insights are door openers for predicting strain performances and engineering synthetic microbial cultures for industrial application. The key barrier to extracting spatiotemporal information from live-cell imaging experiments comprising hundreds of time-lapse image stacks each is an accurate and automated cell segmentation.

New deep-learning methods offer high quality and throughput for image processing of microbial time-lapses, scaling to hundreds of thousands of cells. To achieve top accuracy beyond specific imaging modalities and microbial morphologies, however, segmentation models require an enormous amount of ground truth data for training. Also, available approaches are difficult to handle due to heavy software and hardware dependencies. Within the SATOMI project, we developed two open access tools, microbeSEG and ObiWan-Microbi, that cover the full workflow of deep-learning methods in microfluidic live-cell analysis: microbeSEG facilitates the creation and management of ground-truth datasets and training of deep-learning segmentation, while ObiWan-Microbi provides a suite of semi-automated annotation tools and unlocks deep-learning execution in the cloud.

In our talk, we start with outlining the challenges arising in the analysis of large amounts of microfluidic image data from the different “user”and “developer”perspectives. We then present our deep-learning workflow for creating custom cell segmentation, which we showcase in action with a challenging example of a microbial consortia time-lapse imagery yielding results that were previously impossible to extract.
Although developed in the field of microbial live-cell imaging, the workflow is generally applicable whenever segmentation and image processing is employed.

I want to give an oral presentation.

I want to present a poster.

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