MEP project: A neural network for 3D segmentation of fluorescent yeast images

Goal: Generating a suitable set of training data and subsequently training a neural network for the purpose of segmenting fluorescent images of budding yeast in 3D

Methods: Fluorescent imaging of stained yeast cells, applying classical segmentation algorithms, training and testing neural networks

Introduction

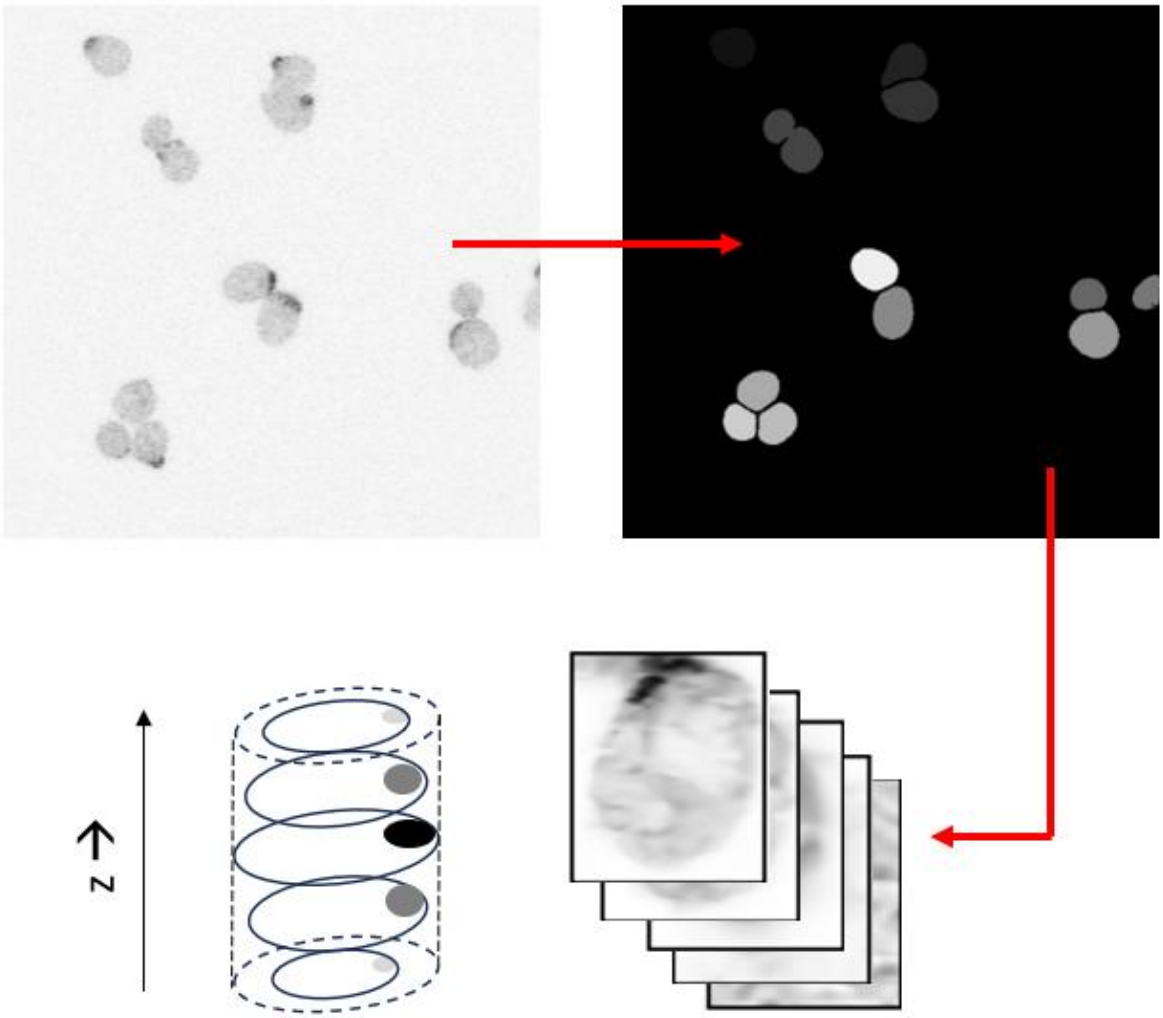
A significant part of the research in our lab relies on live cell microscopy of yeast cells, expressing fluorescently labelled proteins (McClure et al., 2016). Often, we are interested in the localization of these proteins on the membrane of the cell. To study this, it is crucial to know where in the fluorescent images the edges of each cell are exactly located. In a typical microscopy experiment, you may end up with a field of view containing tens of different cells, over hundreds of time points. To individually segment and track these cells is a huge part of image analysis.

Fortunately, many efforts have been made to tackle the problem of segmentation in budding yeast. Currently the most successful segmentation algorithms are based on neural networks trained specifically on yeast datasets, such as YeaZ (Dietler et al., 2020). However, many of these segmentation methods can only be applied in 2D, either to a single imaging slice or to a projection of the image stack. Since cell membranes are spherically shaped, tracking membrane localization often requires information in 3D. We obtain this information by recording multiple image slices along the z-direction of the sample. Since our fluorescent signal can be rather faint, reliably segmenting the higher- and lower-lying slices of these z-stacks is currently not yet possible.

Project description

In this project, you will work on enabling segmentation in 3D by combining existing segmentation methods with developing a new neural network. Since current 2D segmentation methods are already incredibly effective at separating different cells within a large field of view, your 3D segmentation algorithm would take these pre-segmented z-stacks as input to produce the segmentation in the remaining focal planes. To achieve this, a suitable set of training data will have to be produced. A possible way to approach this is by applying a strong fluorescent membrane staining and using traditional segmentation methods (such as thresholding) to generate a large collection of segmented cells. Using these segmentations, a neural network can be trained on our actual fluorescent images to hopefully predict the cell boundaries from these data.

This project will enable you to combine wetlab and drylab techniques. Our group has experience with staining and imaging of budding yeast and we have access to high quality microscopes. Accessible software to create training data as well as train neural networks is becoming more and more available (Park et al., 2022). The challenge will lie in generating a good training set, as well as properly executing and validating the training of the neural network.



Requirements

Some programming experience and ability to work with bash commands would be necessary for this project. Wetlab experience would be useful, but is not an absolute necessity.

Contact

If you're interested in this project or if you have questions/suggestions, feel free to contact me (Marieke Glazenburg) at m.m.glazenburg@tudelft.nl.

Dietler, N., Minder, M., Gligorovski, V., Economou, A. M., Joly, D. A. H. L., Sadeghi, A., Chan, C. H. M., Koziński, M., Weigert, M., Bitbol, A.-F., et al. (2020). A convolutional neural network segments yeast microscopy images with high accuracy. *Nat. Commun.* 11, 5723.

McClure, A. W., Wu, C.-F., Johnson, S. A. and Lew, D. J. (2016). Imaging Polarization in Budding Yeast. *Methods Mol. Biol. Clifton NJ* 1407, 13–23.

Park, C. F., Keshteli, M. B., Korchagina, K., Delrocq, A., Susoy, V., Jones, C. L., Samuel, A. D. T. and Rahi, S. J. (2022). Automated neuron tracking inside moving and deforming animals using deep learning and targeted augmentation. 2022.03.15.484536.