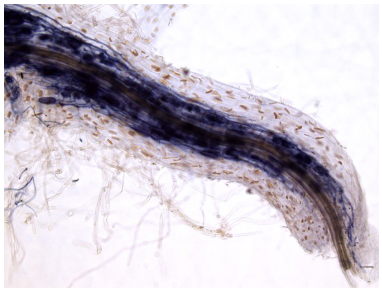
Scientific Computing in Computer Science
Department of Informatics
Technische Universität München

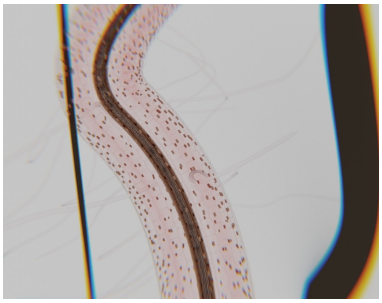
Light Microscopy Image Simulation and Analysis

Abstract

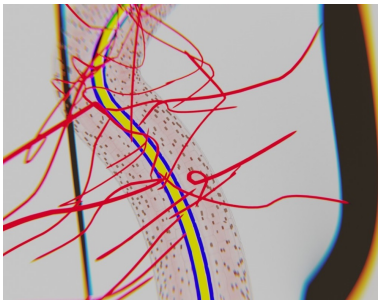
In this project, conventional light microscopy images have to be simulated in the 3D modeling environment Blender (Version 2.90+). Specific parts of the simulated image then need to be highlighted through the Blender render pipeline to produce segmentation training data for a convolutional neural network (for example, UNET).



Real microscopy image of a root (brown), with a fungus growing around it (dark purple). Image by C. Gutjahr, C. Cardoso.



Simulated image of a root without a fungus. Image created in Blender by F. Dietrich.



The same simulated image, but overlayed with a different material to highlight the root stem (blue, yellow) and more intricate parts of the root (red). Image created in Blender by F. Dietrich.

Time line

The project is designed to be completed in three to six months. Adjustments are possible.

Requirements

The following items are sufficient to start and successfully complete the project.

- Minimum degree: Bachelor in Informatics, Mathematics, or related.
- Knowledge about image analysis, object recognition through machine learning tools.
- Experience with Blender (ideally...).
- Soft skills: analytical thinking, intrinsic motivation.

Tasks

Light microscopy images of a few roots are available through the Life Science department at TUM (see left image). The main task in the project is to develop an understanding of the three-dimensional structure of the root, to then simulate it in the modeling software Blender (Version 2.90+), and to produce useful segmentation training data for certain parts of the simulated image (see right image for an example).

After an initial phase with literature review about the biology of the root and the neural network architectures used to segment and detect objects in images, you have to familiarize yourself with the given, real microscopy images (see example image on the left).
Then, you have to familiarize yourself with the provided environment in Blender, that is already set up to simulate rudimentary microscopy images of roots (see center image). The segmentation pipeline is also already set up (see right image).
The main task of the project then involves improvements of the given Blender project and setup of a wrapper software environment in Python, so that

1. roots with randomized shapes and orientations can be rendered,
2. the three-dimensional structure of the root is biologically correct,
3. an additional, symbiontic fungus is added to the current 3D model and is also correctly simulated (see dark patches in the real image on the left),
4. the images are correctly rendered and the segmentation data (rendered in a separate pass) is useful for image segmentation and object detection.

It is possible to also be involved in the actual object detection and image segmentation part with neural networks, but this is not the focus of this project.

Application process

Please apply by filling out the form at the following URL, and refer to this project in the section on “topic suggestion”:

https://www5.in.tum.de/lehre/thesis-application/

Note that gender equality and diversity is important at the Technical University of Munich. Applications by women and minority groups are especially encouraged.

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