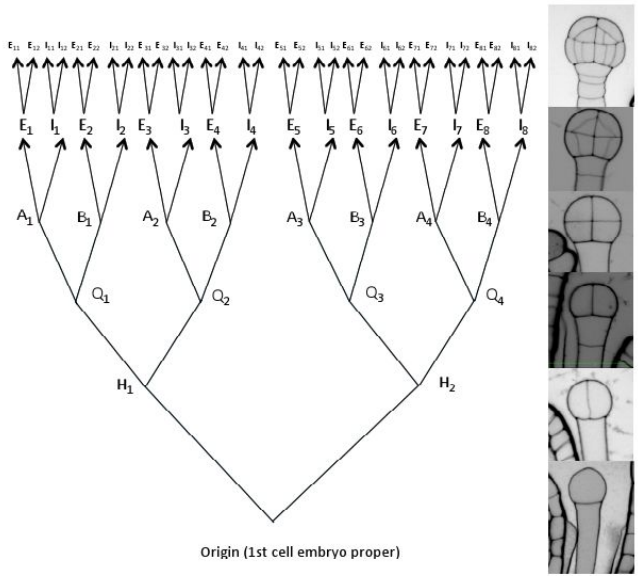
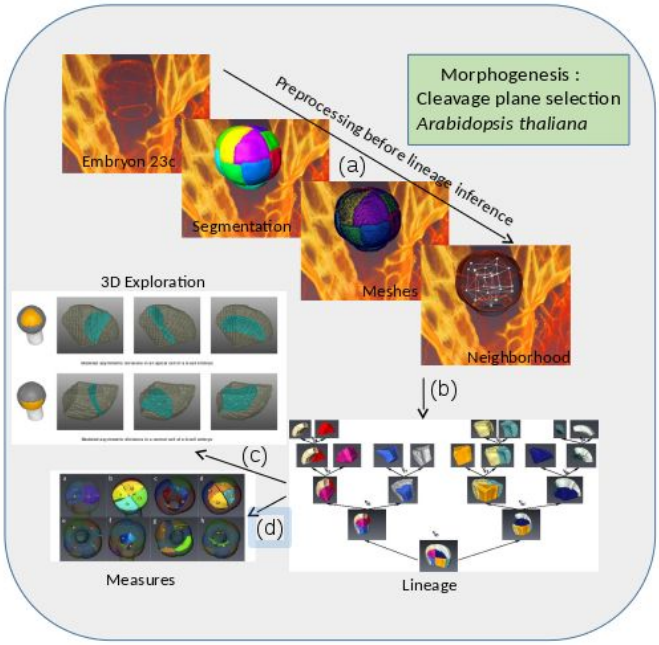
PhD research proposal:

Support of the Interactive Visual Exploration and Classification of Temporal Development in 3D Datasets using the Example of Cell Division Data



In this PhD project within the computer science domains of visualization and human-computer interaction (HCI) we want to investigate how to best support the visual exploration of temporal developments of biologic organisms. In a collaboration between Inria and Inra, we want to analyze segmented 3D datasets of plant embryos which have developed up to, at least, the 8th stage of cell division (256 cells; the datasets are roughly of size 300x300x100 voxels). In the project we want to investigate visualization techniques and interactive tools to classify cell types based on their shape, identify sister cells that originated from a single cell in the previous division stage, and thus construct a tree of cell division history from only a single 3D microscopy image.



For this purpose we need to combine several visualization and interaction techniques. In particular, the biologists need to be able to focus on a local neighborhood in the dataset to assess shapes and potential divisions, for example by using abstraction techniques from illustrative visualization. In addition, we need to be able to interact both with the 3D dataset as well as with the abstract data such as the inheritance tree or data about the shared surface between two adjacent cells. We also want to be able to visualize a progression of the classified cell division history to assess if the proposed division tree is plausible.

In addition to analyzing single datasets independently, we also want to exploit existing classifications for the annotation of new datasets. In particular, we not only want to be able to compare datasets with each other but also to employ machine learning techniques that allow us to assist the biologists by identifying similar situations and by suggesting potential division patterns based on the local segmented geometry. This suggestion should also provide a certain level of confidence such that the biologist can make use of the suggestion or decide differently if needed. The use of machine learning should also allow us to classify and analyze mutant embryos in which the cell division does not follow a normal path.

Ultimately, we thus want to investigate several important research questions within the scope of this proposed PhD work which are highly relevant to visualization and HCI: (1) how can we best combine both 3D and standard 2D interaction techniques for essentially time-dependent data that has both 3D and 2D aspects, (2) how can we use abstraction to allow the biologists to concentrate on local 3D neighborhoods, without losing the context of the entire dataset, (3) how can we best visualize alternative decision trees such that different potential division histories can be analyzed and compared to each other, and (4) how can we make use of machine learning techniques to support the interactive data analysis, without taking the human out of the loop.

The work will be conducted as a collaboration between Inria's AVIZ team at Inria Saclay who provides the necessary expertise for visualization and human-computer interaction and Inra's MaIAGE team at Jouy-en-Josas who conducts research on plant embryo development. In addition, this project part of the larger Naviscope research initiative which investigates image-guided navigation and visualization of large data sets in live cell imaging and microscopy.

Expectations:

- to collaborate with computer scientists, computer graphics researchers, and biologists to define the user interface for fast lineage of plant embryos,
- to create a functioning prototype implementation in a participatory design process,
- to document the prototype, and
- to conduct scientific research (including literature studies) and write a PhD thesis.

Requirements/skills:

- highly motivated student who has completed a MSc or equivalent degree in computer graphics, visualization, HCI, or related computer science topics,
- experience with software development, in C++ and/or Java,
- experience in modern computer graphics (GPU) and/or visualization programming,
- experience in the use of machine learning algorithms,
- able to communicate on a regular basis with supervisors and end-users,
- distribute time between the two labs (details negotiable),
- receptive to directions and feedback from supervisors, and
- able to clearly and concisely communicate in English in written and spoken form.

Environment/technical details:

- implementation in Unity (https:///www.unity3d.com) within the context of a shared Naviscope data exploration platform
- use of traditional (mouse/keyboard) and novel (touch, tangible, pen) types of input

- use of traditional (PC display) and novel (tablets, large displays, VR/AR) output platforms

Location of work/administration:

- shared between Inria Saclay (south of Paris) and Inra Jouy-en-Josas
- employed by Inria

Contacts/supervisors:

- Tobias Isenberg, Inria, <tobias.isenberg@inria.fr> https://tobias.isenberg.cc/
- Alain Trubuil, Inra, <alain.trubuil@inra.fr> http://maiage.jouy.inra.fr/

Application site:

https://jobs.inria.fr/public/classic/en/offres/2018-01191