Topic for a practical work / project work module:

Implementation of interactive tools for fitting plant organ shapes in the simulation platform GroIMP to 3D point clouds obtained from apple trees

GroIMP is an interactive 3D modelling platform based on Java and the XL language (eXtend L-systems). One of the most important applications of GroIMP and XL is functional-structural plant modelling (FSPM), a new paradigm in integrative biology providing exciting possibilities for interdisciplinary studies. In an FSPM, plant organs are represented by geometrical shapes: e.g., internodes by cylinders or frustums, fruits by ellipsoids, leaves by Bézier surfaces.
Structural data from tree surfaces, obtained by photogrammetric methods or by terrestrial laser scanning, consist typically of a large number of point coordinate triples ("point cloud"). Although a point cloud can be imported and visualized within GroIMP, it does not directly deliver the above-mentioned shapes which stand for organs, neither their interconnections (topological structure).

The goal of the internship is to implement tools (within GroIMP) which will help the user (who is expected to have some knowledge in plant morphology) to fit predefined shapes to visually-recognizable subsets of a point cloud by interactive shifting, rotation and scaling, and also to build up the topological connections between adjacent shapes on the basis of the point cloud. This task will comprise several subtasks:

- outlier detection and thinning of the point cloud,
- segmentation into point subsets which correspond to plant organs, partially by algorithms (density-based clustering) and partially by interactive selection techniques,
- fitting of shapes from a predefined plant-organ portfolio to the point subsets,
- definition and evaluation of a quality index for the best-fit,
- semi-automatic tracking of topological connectedness among the identified plant organs (e.g., following an axis from bottom to tip; branching...),
- support of organ labelling with identifiers (text strings),
- import of the generated geometrical-topological structures into the basic graph data structure used by GroIMP.

Existing, tested non-automatic workflows for translating point-cloud data into organs of an apple-tree branch will be analysed and their results can serve as benchmark for the tools to be developed. A report (preferentially in the form of a research paper) will finalize the project.

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Literature

Kniemeyer, O. (2008): Design and Implementation of a Graph Grammar Based Language for Functional-Structural Plant Modelling. Ph.D. thesis, University of Technology at Cottbus. http://nbn-resolving.de/urn/resolver.pl?urn=urn:nbn:de:kobv:co1-opus-5937

Project work for 1 student (Angewandte Informatik or Data Science)