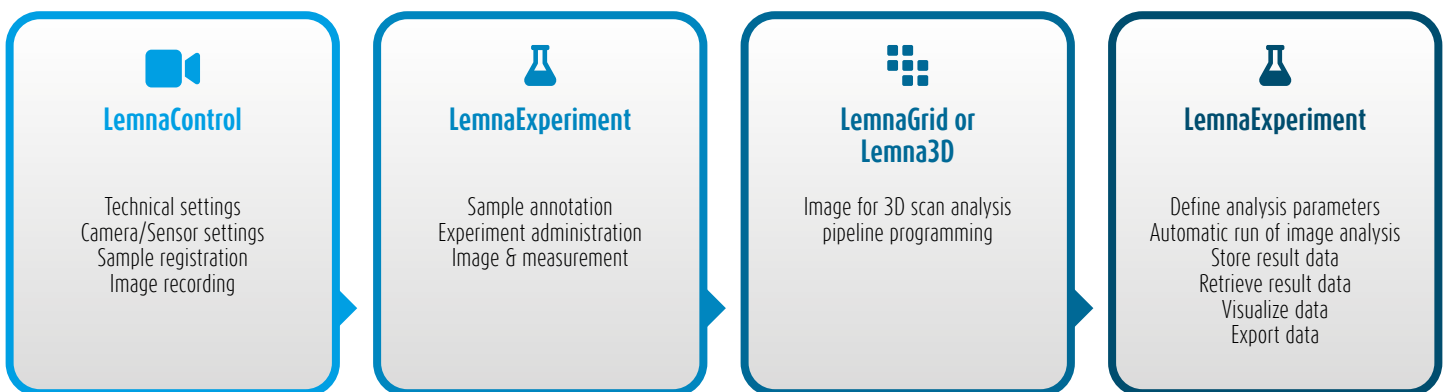# **SOFTWARE**SUITE

LemnaTec
Software Suite

- Image Analysis
- Phenotyping, Seed Testing, Toxicology, Bioluminescence, Fluorescence, and more
- Image and data recording, storage, and processing
- Hardware control and experiment scheduling

LEMNATEC SOFTWARE SUITE

From Experiment Planning to Analysis and Presentation

The LemnaTec Software Suite consists of different packages:
- LemnaControl for settings of the system and operating the process
- LemnaExperiment for experiment overview and for managing and analyzing experiments, as well as for browsing, exporting, and visualizing of the results
- LemnaGrid for programming analyses of images
- Lemna3D for programming analyses of 3D data

LemnaControl

Technical settings
Camera/Sensor settings
Sample registration
Image recording

LemnaExperiment

Sample annotation
Experiment administration
Image & measurement

LemnaGrid or Lemna3D

Image for 3D scan analysis
pipeline programming

LemnaExperiment

Define analysis parameters
Automatic run of image analysis
Store result data
Retrieve result data
Visualize data
Export data

Interaction of software parts in LemnaTec phenotyping system. The overall software has been designed for the following features:
- LemnaControl for settings of the system and operating the process
- LemnaExperiment for experiment overview and for managing and analyzing experiments, as well as for browsing, exporting, and visualizing of the results
- LemnaGrid for programming analyses of images
- Lemna3D for programming analyses of 3D data

LemnaControl

LemnaControl is the interface with which users operate the system. With LemnaControl, users carry out all settings that are required for image recording with the system. In particular, this comprises settings for the camera(s) and lights included in the system.

Moreover, it provides possibilities for setting all motorized moving parts according to their functions (if applicable). All settings can be combined and scheduled to configure recordings. The available functions are tailored to the corresponding hardware. Each hardware system delivered by LemnaTec comes with its own control software adapted for the functions of that system.

LemnaControl software for system control and settings
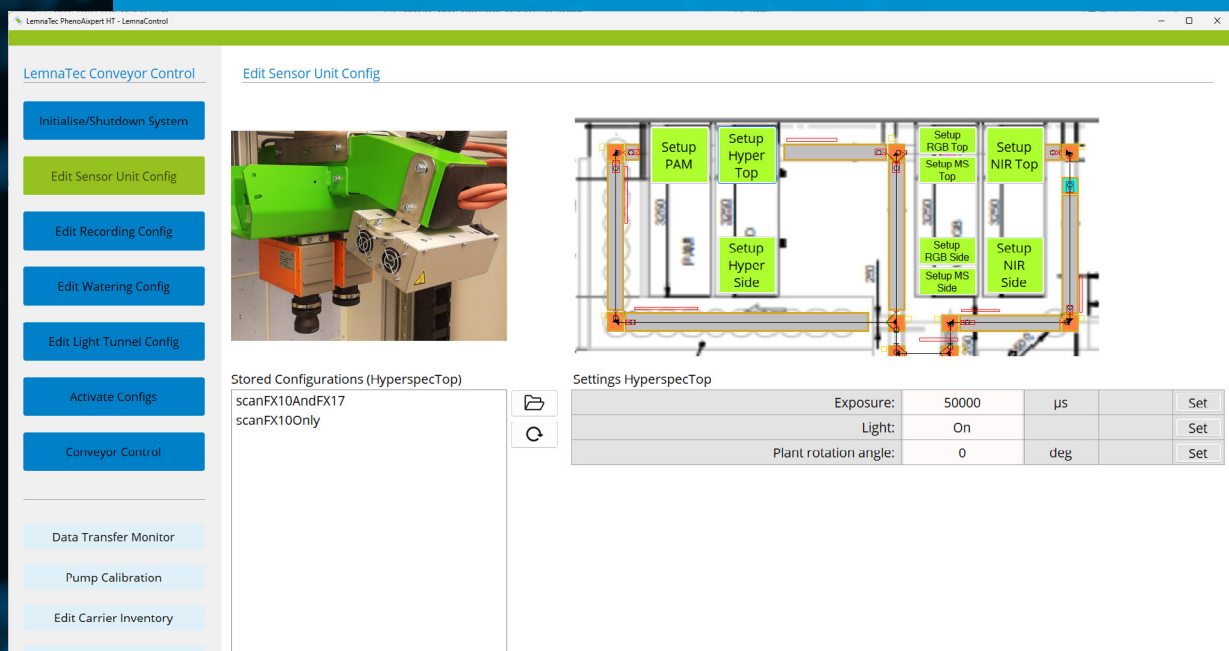
LemnaControl: Setting of light and exposure. (This screen will look differently depending on the device it controls)

LemnaExperiment

LemnaExperiment serves to manage experiments and measurements, and to schedule and run analyses. Moreover, it enables viewing, visualizing, and exporting results. It provides capabilities to access and browse through recorded images and to display metadata for samples and measurements. As core function, LemnaExperiment selects recordings for analysis and assigns an image analysis pipeline –written in LemnaGrid or in Lemna3D – to a given set of recordings. After assignment, the analyses are run in the background by the Analysis Executor. Parameters of interest can be selected in LemnaExperiment so that they are displayed in the analysis output.
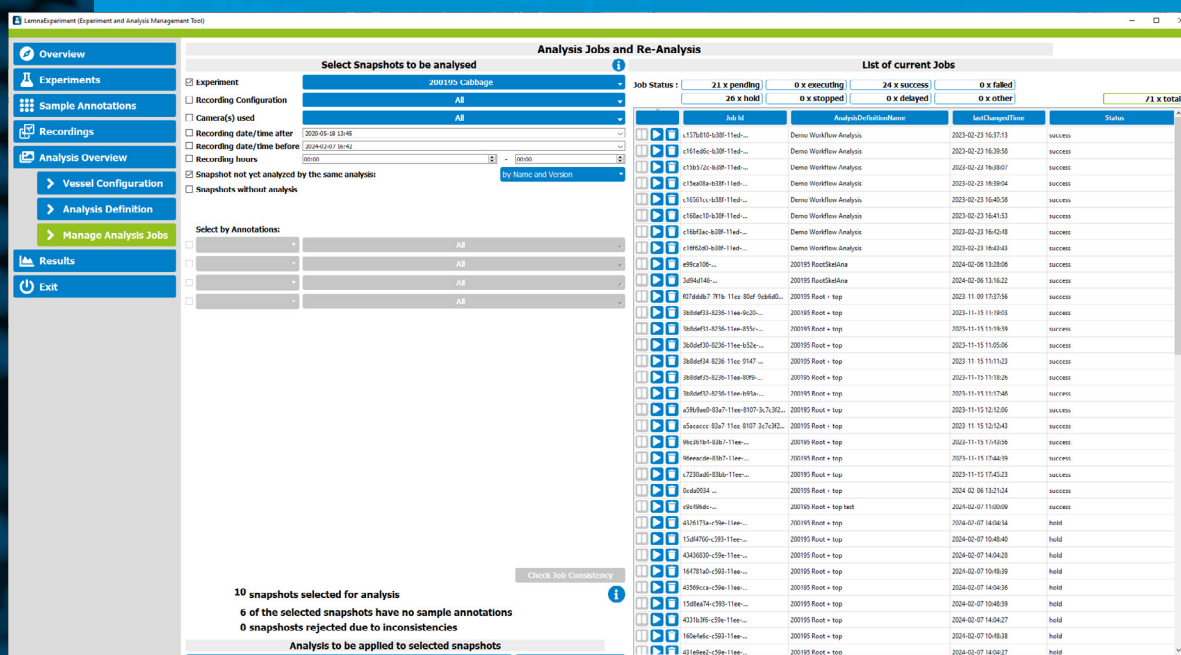
LemnaExperiment: configuration of analyses

After running analyses, LemnaExperiment can visualize and export the result data. It provides data tables and graphs for the numerical values derived from the images. Users can customize graphs with a range of settings. Furthermore, it is possible to browse through the result images. Users can export all numerical data in CSV tables.


LemnaExperiment: visualization of results

LemnaGrid - Image analysis and feature extraction

A complete package of phenotyping functions enables programming of freely definable image analysis pipelines and includes a broad range of functions relevant for phenotyping. Image processing tools are included for all types of cameras delivered with the system.

Library of functions for image handling and processing

Graphical programming by combining functions on surface
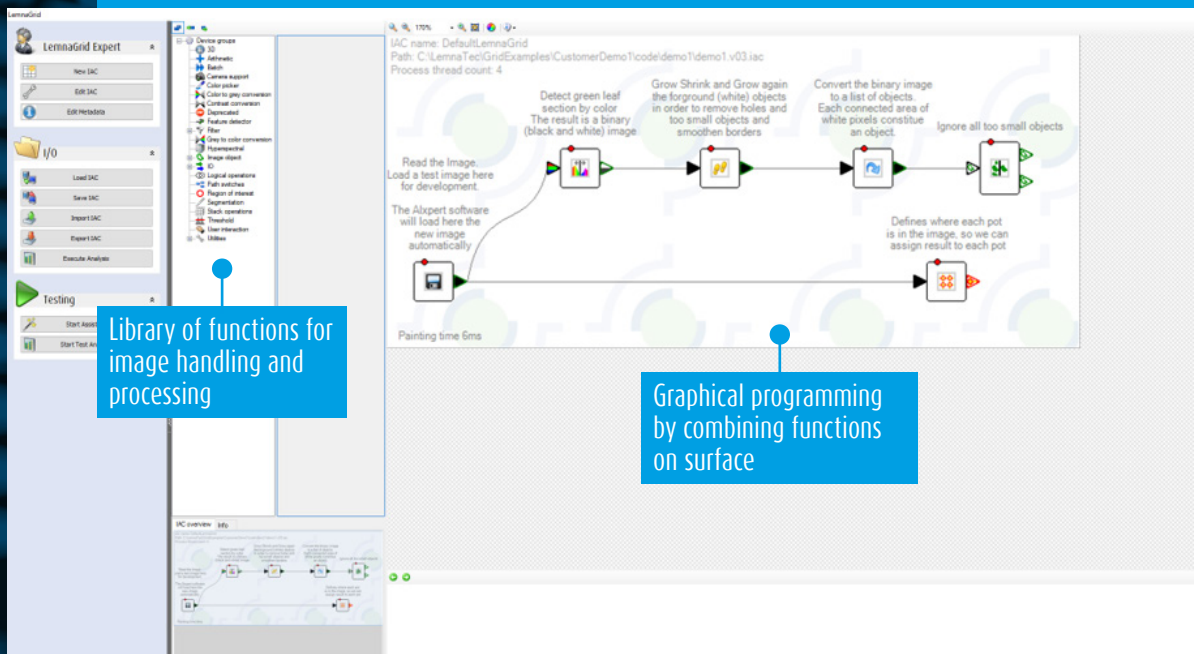
LemnaGrid: Example analysis pipeline as it is developed inside the graphical programming environment of LemnaGrid.

The LemnaGrid software module uses a graphical programming environment (similar to LabView or Microsoft Robotics Studio), which allows simple integration of different image analysis algorithms. Besides analysis pipelines delivered by LemnaTec, user-defined analysis pipelines can be programmed easily. Devices are available in a drag-and-drop toolbox and can be combined to set up workflows on the graphical interface. The image analysis pipeline extracts desired properties/features from the original image and saves their results. Programmed image analysis pipelines can be called via LemnaExperiment to run with sets of recorded images.

Combine devices from the library

Each device has a function in the image processing
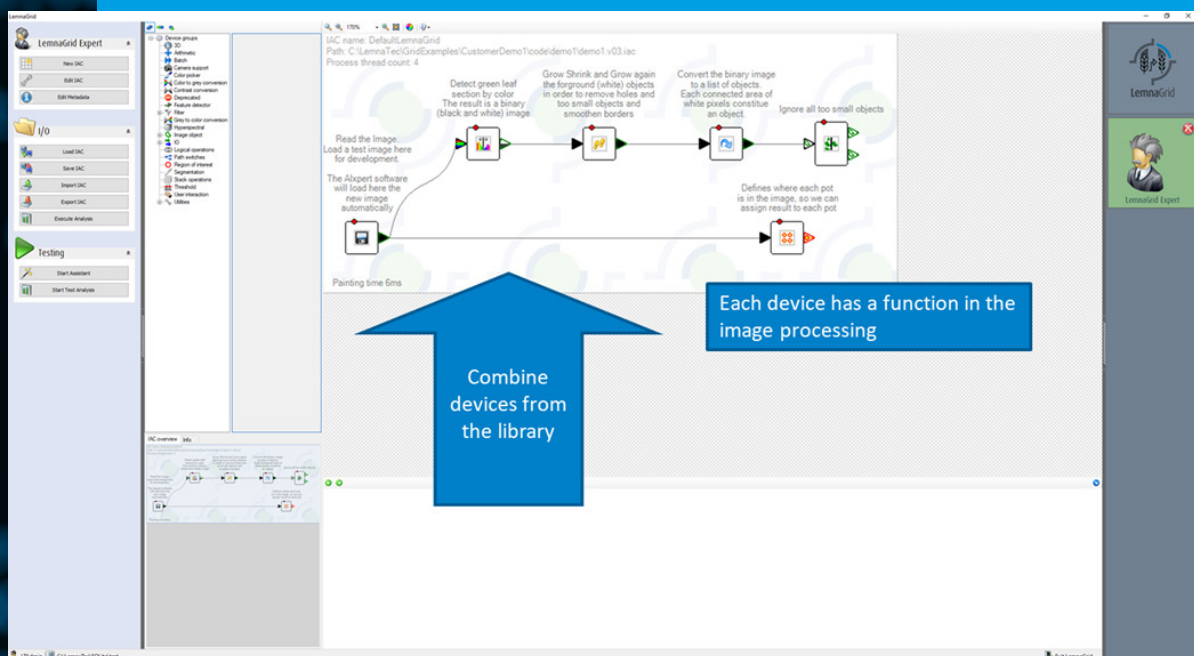
LemnaGrid: setting up an analysis pipeline for image processing

Phenotyping tools comprise - but are not limited to - the following functions:

Imaging and image processing with hardware and software		Data use in applications (examples) - derived biological information
Sensor	Measured parameters	
RGB VIS	count size shape colour	growth biomass development stress activity
Laser scanners	3D point cloud	height growth three-dimensional structure
Hyperspectral cameras	spectrally resolved images (VNIR, SWIR)	physiology pigments water status stress diseases vegetation indices
Multispectral cameras	images of reflectance by wavelength	physiology pigments stress diseases vegetation indices
PAM camera	chlorophyll fluorescence	photosynthetic parameters
Fluorescence cameras	emission of fluorescence light after excitation	abundance, localization of fluorescence pigments or fluorescence-labelled material
IR camera	surface heat emission / temperature	water stress transpiration
NIR camera	spectral reflectance at water band	water content
High sensitivity cameras	bioluminescence	abundance, localization of luminescence-labelled material