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IMAGE ANALYSIS IN THE NETHERLANDS

Document prepared by experts from the Netherlands

Image analysis for DUS in the Netherlands

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Overview

- History
- Hardware setup
- Image recording
- Image analysis platform
- Labeling
- Calibration
- Measurement modules
- Discussion

History.

- Before 2009
 - Conveyor belt system
 - Low resolution B&W camera
 - Proprietary image processing library
- After 2009
 - Static setup with high resolution DSLR camera
 - Software converted to Java based open source imaging library (ImageJ)

Hardware platform

Nikon D90 with 12
Mpixels resolution
Lens Model: AF-S
DX VR Zoom-Nikkor
18-105mm
HF Fluorescent back
light
HF fluorescent front
light (dimmable)

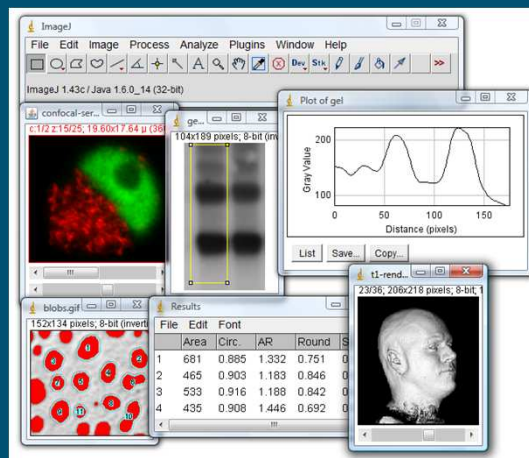


Image recording

- Images are captured with NKRemote that controls the camera and all its settings
- Images are transferred to a computer and per trial stored in a different directory
- Every image contains a unique identifying code, containing crop name, plot number and variety name
- Analysis is done after the recording

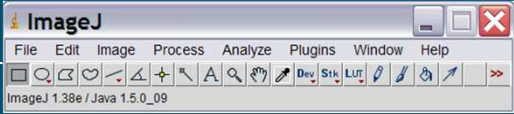
Image analysis platform

- ImageJ
 - a public domain Java image processing program inspired by [NIH Image](#) for the Macintosh. It runs, either as an online applet or as a downloadable application, on any computer with a Java 1.4 or later virtual machine





<http://rsbweb.nih.gov/ij/>

ImageJ features

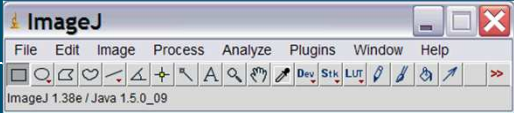


- **Runs Everywhere:**
 - ImageJ is written in Java, which allows it to run on Linux, Mac OS X and Windows, in both 32-bit and 64-bit modes.
- **Open Source:**
 - ImageJ and its Java source code are freely available and in the public domain. No license is required.
- **User Community:**
 - ImageJ has a large and knowledgeable worldwide user community. More than 1700 users and developers subscribe to the ImageJ mailing list.
- **Macros:**
 - Automate tasks and create custom tools using macros. Generate macro code using the command recorder and debug it using the macro debugger. More than 300 macros are available on the ImageJ Web site.
- **Plugins:**
 - Extend ImageJ by developing plugins using ImageJ's built in text editor and Java compiler. More than 500 plugins are available.


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ImageJ features



- **Toolkit:**
 - ImageJ is a very extensive image processing toolkit (class library) to develop applets, servlets or applications.
- **Speed:**
 - ImageJ is the world's fastest pure Java image processing program. It can filter a 2048x2048 image in 0.1 seconds (40 million pixels per second)
- **Data Types:**
 - 8-bit grayscale or indexed color, 16-bit unsigned integer, 32-bit floating-point and RGB color.
- **File Formats:**
 - Open and save all supported data types as TIFF or as raw data. Open and save GIF, JPEG, BMP, PNG, PGM, FITS and ASCII. Open DICOM. Open TIFFs, GIFs, JPEGs, DICOMs and raw data using a URL. Open and save many other formats using plugins.
- **Image display:**
 - Tools are provided for zooming (1:32 to 32:1) and scrolling images. All analysis and processing functions work at any magnification factor.

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ImageJ Cons:

- Not a particularly nice or intuitive interface
- Support isn't very well organized
- There is a large amount of functions available as third-party plug-ins, but it is difficult to judge which plug-in fits best to your needs and quality demands
- Plug-in programming model is somewhat restricted compared to java classes or functions.
- ImageJ 2 is under development. This will solve a lot of above mentioned problems. (<http://imagejdev.org/>)

Keeping control of the identity

- Good administration and labeling are very important to prevent errors and mix-up.
- Instead of putting the plot number or variety name in the name of the file we have chosen to label the image itself by putting a 2D barcode in each image.
- The well known QR-Code is used for this.



Labeling

- QR-Code and calibration disc in separate part in the image on blue background for automatic processing.



Calibration

- Discs of known size, labeled with holes, for automatic calibration in each image.

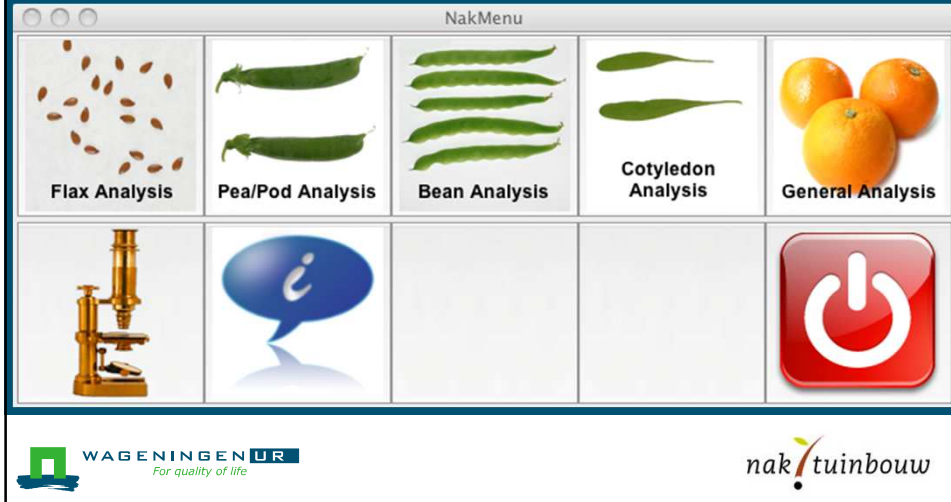


Label: BSU032010KN_0001_c

Scale: 0.184162

Measurement modules

User friendly menu



Measurement modules (flax)

- Measures:
 - length
 - Width
- Based on fitting ellipse



Measurement modules (pea/pod)

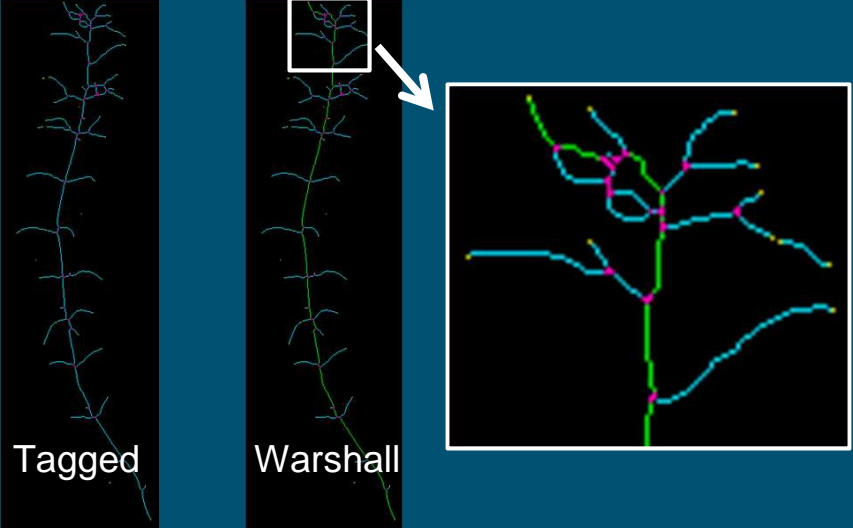


- Measures: length, width, bending.
- Uses: binary skeleton, distance map, and longest shortest path (from graph theory)

Implementation of shortest path

- Making graph using ImageJ plug-in Analyze-Skeleton (Ignacio Arganda-Carreras)
 - <http://bioweb.cnb.csic.es/~iarganda/>
- The shortest path calculation has been added to this plug-in and has been published :
 - G. Polder, H.L.E Hovens and A.J Zweers, Measuring shoot length of submerged aquatic plants using graph analysis (2010), In: Proceedings of the ImageJ User and Developer Conference, Centre de Recherche Public Henri Tudor, Luxembourg, 27-29 October, pp 172-177.

Example



The diagram shows two vertical images of a plant stem against a black background. The left image, labeled 'Tagged', shows the stem with small red and blue markers at various points. The right image, labeled 'Warshall', shows the stem as a binary skeleton. A white box highlights a section of the stem in the 'Warshall' image, with an arrow pointing to a larger inset image. This inset shows a detailed view of the stem's branching structure, with the main stem in green and branches in cyan and magenta.

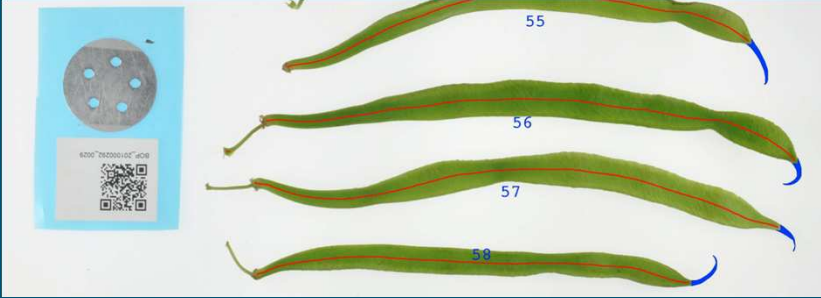
Tagged

Warshall

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Measurement modules (bean)



The image displays four bean pods, numbered 55, 56, 57, and 58, arranged vertically. Red lines are drawn along the length of each pod, indicating measurement points. To the left of the pods is a circular sensor module with four blue dots and a QR code below it.

- Measures: length, width, bending, beak length, total length.
- Uses: binary skeleton, distance map, and longest shortest path (from graph theory)

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Measurement modules (cotyledon)

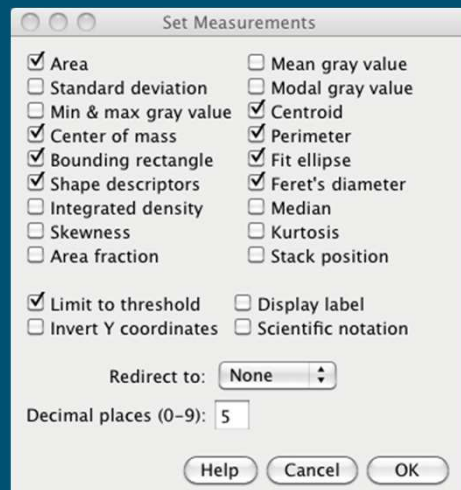
Label: BSU022010KN_0060_c Scale: 0.16556291390728478



- Measures: length, width, area.
- Uses: binary skeleton, distance map, and longest shortest path (from graph theory)

Measurement modules (general)

- Measures: Standard shape features provided by ImageJ
- Uses: ImageJ particle analyser



Measurement modules (future)

- Currently implementing shape measurement of carrots
- Uses: Inflection points of outer contour



Data analysis

- Results are stored in xls-files
- These files can then be analysed by standard statistical software

Conclusion/discussion

- Current High Resolution DSLR camera's considerably improves Feature measurements. It also enables acquisition of a large number of objects in one image.
- ImageJ as popular open source Imaging platform is a good choice for implementing DUS testing.
- In-image labeling and calibration improves image registration and administration.
- Skeleton based measures, using distance transform and graph analysis are ideal for shape measurements in DUS testing.

Thank you for your attention

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