Near-Infrared (NIR) hyperspectral imaging at high resolution and the difficulty to calibrate for the three main wood components

Nele Defoirdt Joris Van Acker Jan Van den Bulcke

Mapping properties on stem disks

Poplar disks with induced tension wood

Flatbed scan

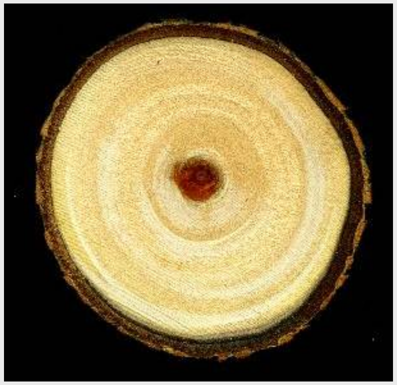
→ Tension wood visible with naked eye on not sanded disks

NIR scanning hardware specifications

- Detector
  - Line camera
  - Range 800-2500 nm
  - 320 spatial pixels & 256 spectral pixels
- Light source
  - quartz tungsten halogen lamps
- Scan
  - Spectral resolution 0.5 mm
  - Sample step size 5 or 10 degrees (rotational) or 0.5 mm (translational)
  - Exposure time 6 ms, 50 frames averaged for a single line scan
- Software
  - Camera control and sample movement implemented in Labview

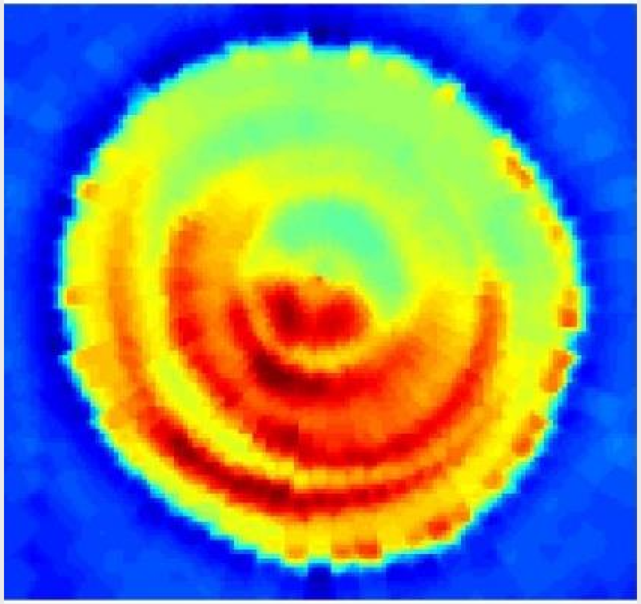
NIR scanning software specifications

- Corrections
  - Lens distortions
  - Light intensity correction (reference material in each scan)
  - Non-linear lens effects avoided by clipping the outer detector pixels
- Pre-processing to correct for detector noise
  - Normalization (reference material?)
  - Transformation to absorbance values
  - Noise filtering
- Pre-processing to correct for non-chemical bias
  - Detrending
  - Mean centering
  - Savitsky-Golay derivation or second derivative
- Model building by partial least squares

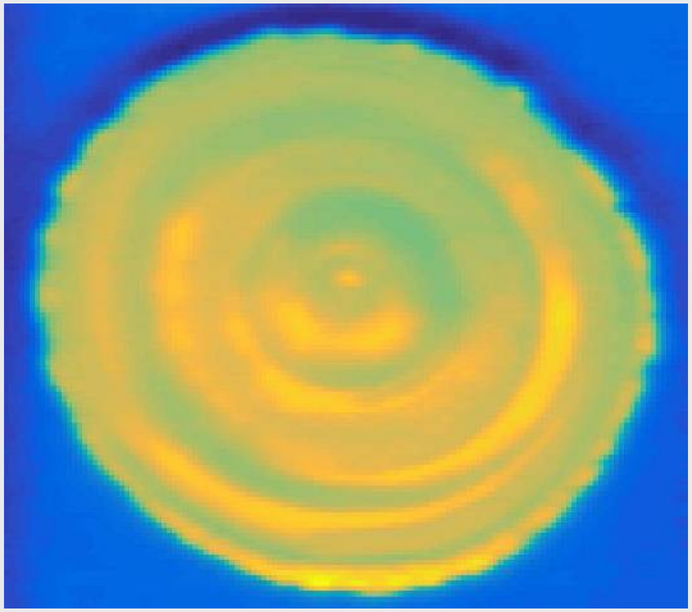


Slice from hyperspectral NIR image

Rotational scan

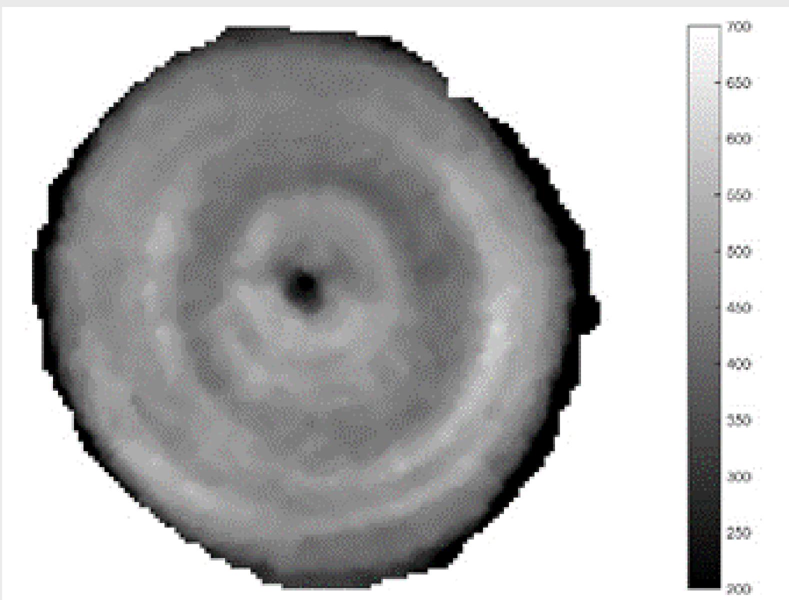


Translational scan

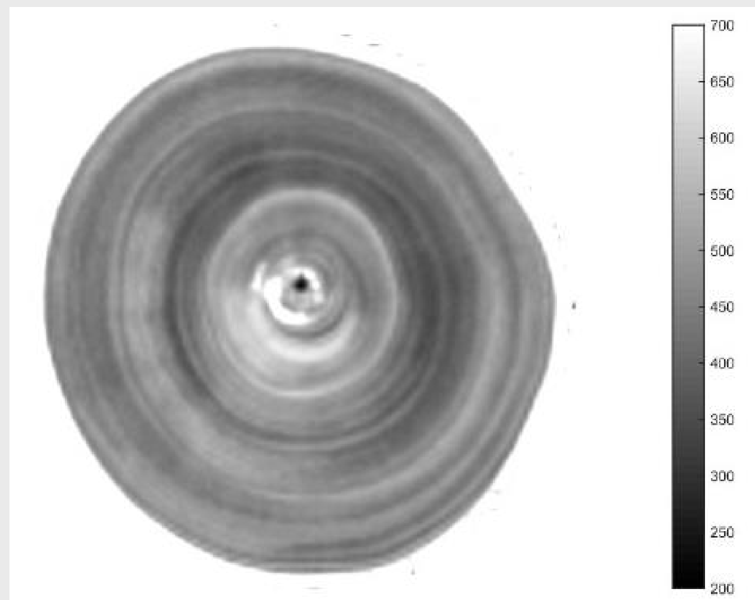


Mapping via modelling: density

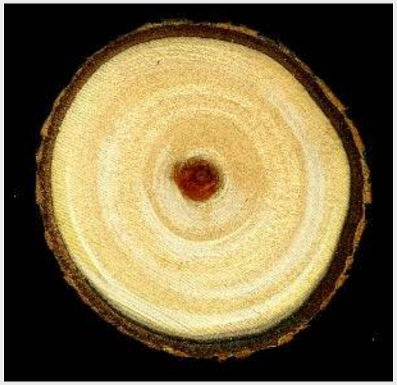
NIR derived density



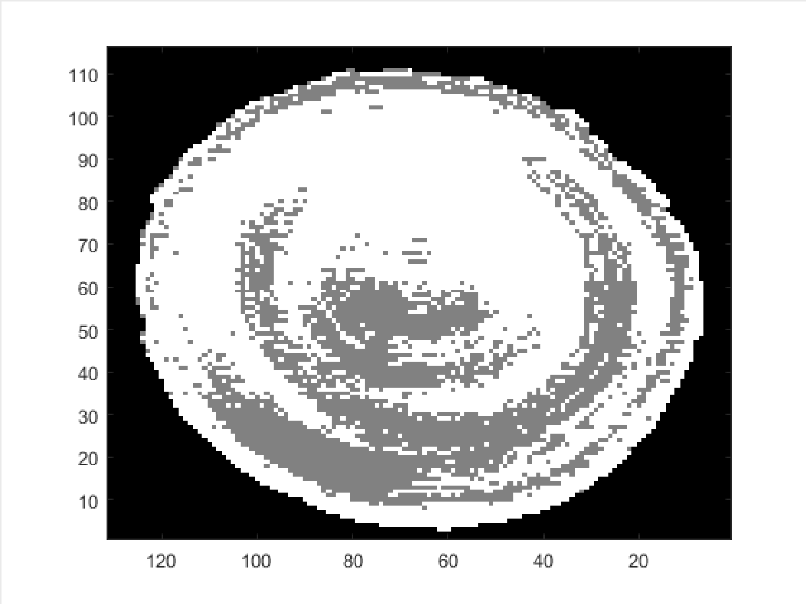
X-ray derived density

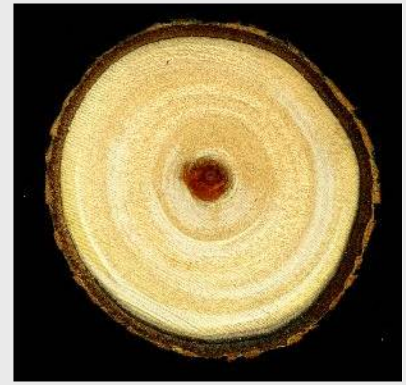


Mapping via modelling: tension wood



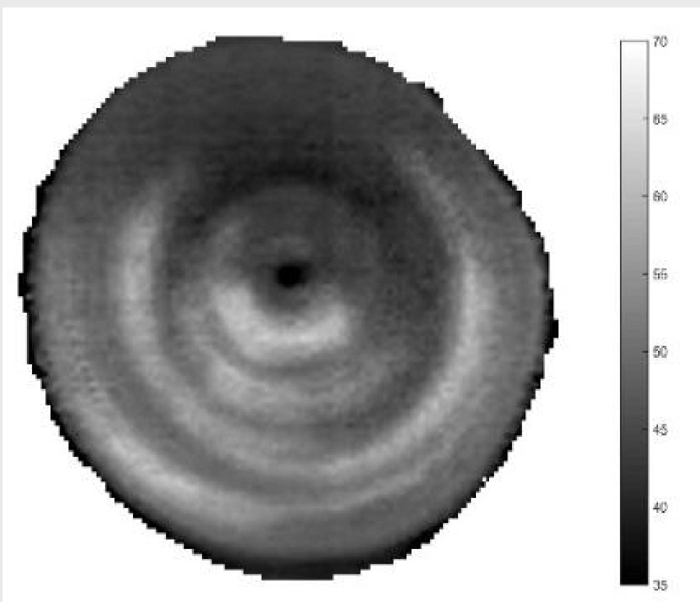
Binary



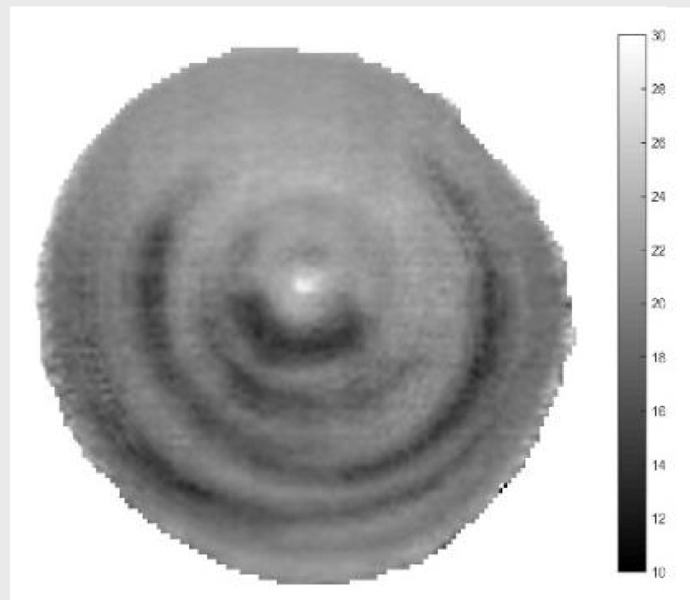


Mapping via modelling: chemistry

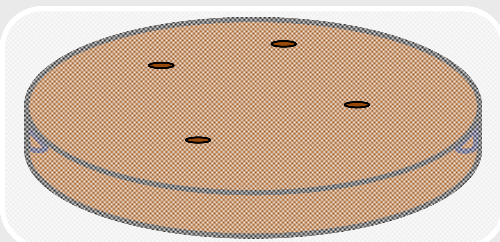
NIR derived α-cellulose content



NIR derived lignin content



Calibration



➔ X-ray tomography ➔ Density local spot

➔ NIR camera ➔ Hyperspectral image local spot

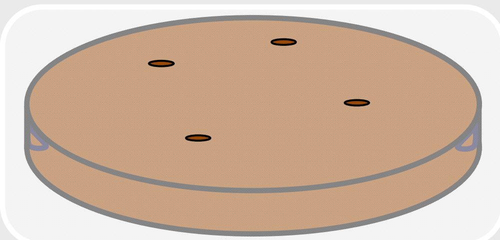
Model NIR vs. DENSITY

NIR camera
➔ hyperspectral image disk

Reconstruction disk with density values

Average density of specific region or entire disk

Calibration



➔ Tension wood colouring or visual inspection
➔ binary: tension wood or not

➔ NIR camera ➔ Hyperspectral image local spot

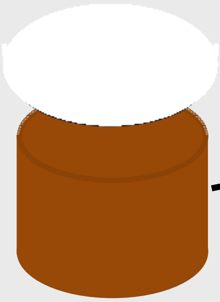
Model NIR vs. TENSION WOOD

NIR camera
➔ hyperspectral image disk

Reconstruction disk with probability to be tension wood

Binary reconstruction with tension wood zones

Calibration



➔ Wet chemical analysis → % cellulose, lignin, polysaccharides,…

➔ NIR camera → Hyperspectral image of pelletized ground wood

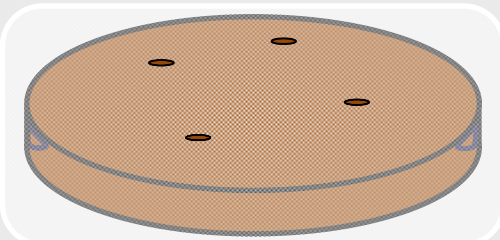
Model NIR vs. LIGNIN CONTENT

NIR camera
➔ hyperspectral image disk

Reconstruction disk with values of lignin content

Average lignin content of specific region or entire disk

Calibration



➔ ??????????????? → % cellulose, lignin, polysaccharides,… of local spots

➔ NIR camera → Hyperspectral image of local spots

Model NIR vs. LIGNIN CONTENT

NIR camera
➔ hyperspectral image disk

Reconstruction disk with values of lignin content

Average lignin content of specific region or entire disk

Calibration

- One-to-one relation between NIR-signal and properties to model
- The smaller the spot of the one-to-one relation the more pure the signals and the relation
- The more spots covering the potential variation of the NIR-signal and the wood properties, the better the model

Determining chemical composition of small amounts of wood

- Analytical pyrolysis…
  - ➔ Calibrated against wet chemical analysis
  - ➔ Accuracy of wet chemical analysis
  - ➔ Calibration is just as accurate as the data it is based on…
- Other options?

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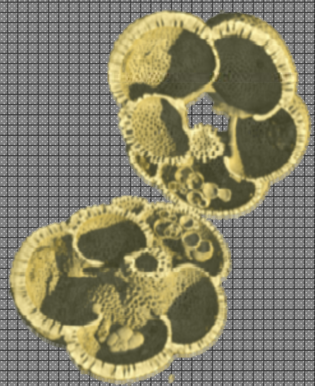

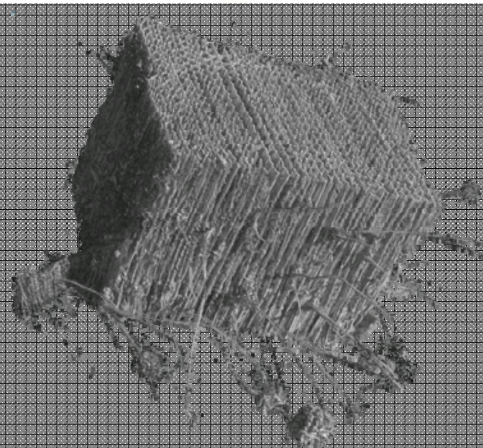

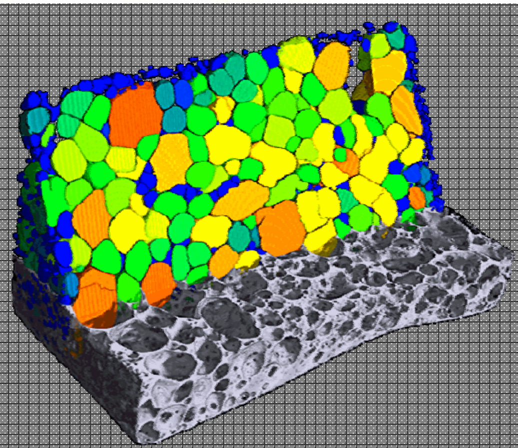

Joris.VanAcker@UGent.be

Jan.VandenBulcke@UGent.be

Nele.Defoirdt@UGent.be

www.woodlab.be

www.ugct.ugent.be

www.inCT.be (spin-off)

www.xre.be (spin-off)

UNIVERSITEIT GENT UGent WOODLAB

UGCT Centre for X-ray Tomography

Joris Van Acker, Luc Van Hoorebeke, Patric Jacobs, Veerle Cnudde, Bert Masschaele, Manuel Dierick, Jelle Vlassenbroeck, Yoni De Witte, Elin Pauwels, Matthieu Boone, Denis Van Loo, Loes Brabant, Marijn Boone, Tim De Kock, Pieter Vanderniepen, Jan Dewanckele, Dries Vansteenkiste, Nele Defoirdt, Imke De Windt, Wannes Hubau, Maaike De Ridder, Jan Van den Bulcke