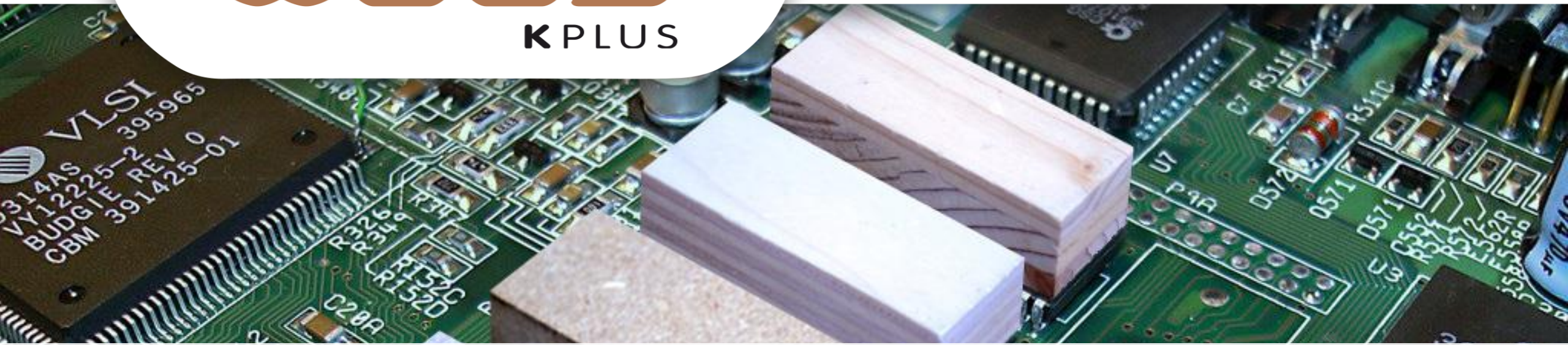


The Role of Bioinformatics in a Digitalised Bioeconomy

Digitalisation in the Bioeconomy: potentials for rural actors

SCALE^{UP} & EDIH innovate

online, February 6th 2024

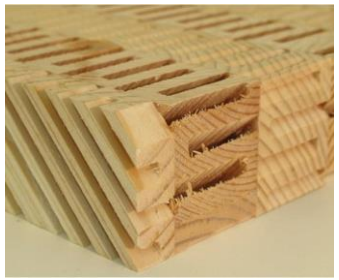
Dr. Martin Riegler

Wood K plus = Competence Center Wood

Key numbers:
- K1 centre (COMET)
- Non-profit
- foundation 2001
- >25 industry partners
- ~130 employees
- Budget: ca. € 10 Mio./a

companies ⟷ **knowledge transfer** ⟷ universities

Research topics (examples):
- Material science for renewable resources
  - Process analysis and engineering
    - **Digital tools for wood industry**



Example „macro fiber“ (laboratory to industry):

Team Digital Technologies & Sustainable Building

DI Birger Bartuska
PhD Student

Dr. Sarah Ritter
Post Doc

Dr. Martin Riegler
Team leader

Prof.
Wolfgang Gindl-Altmutter
Key researcher &
Scientific director

Prof.
Timothy Young
Key researcher

Prof.
Benjamin Kromoser
Key researcher

Mehieddine Derbas, M.Sc.
PhD student

DI Karl Zechmeister
PhD Student

Boris Möseler
Technician

Alexander Schneider, B.Sc.
Student assistant

Jannik Wirth, B.Sc.
Student assistant

Priv.Doz.
Peter Sykacek
Key researcher

Priv.Doz.
Michael Grabner
Key researcher

Alexandro Saliasi, M.Sc.
PhD Student

Sepideh Moradivandkolehjouei, M.Sc.
PhD Student

Geo Francis, M.Sc.
PhD Student

Virág Csank, MA
Junior researcher

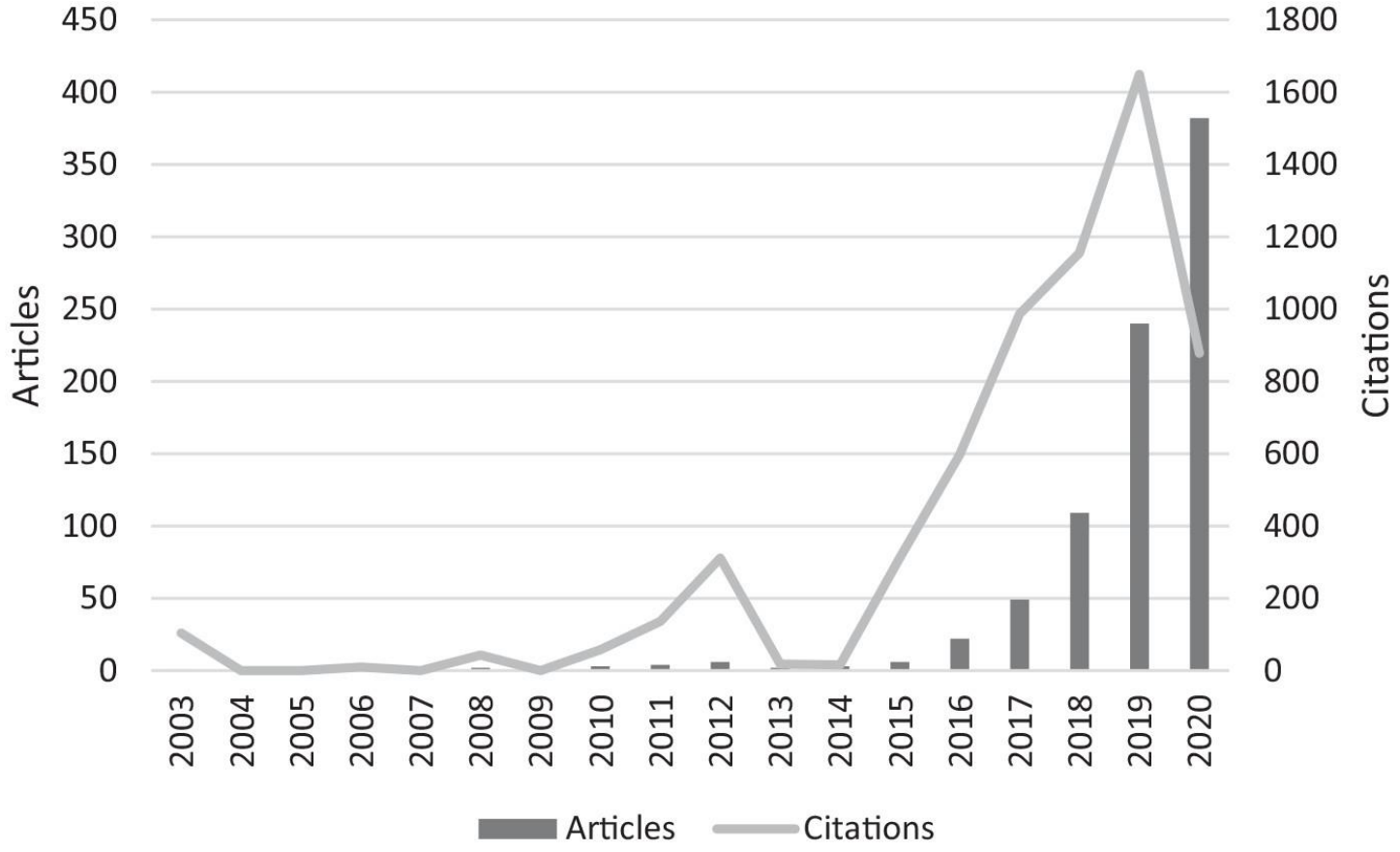
Prof.
Hans-Christian Möhring
Key researcher

Prof. i.R.
Alfred Teischinger
Key researcher

Development digitalisation in research

exemplary review:

- 832 articles in Scopus
- up to 2020
- terms used for search:
  - „Digital* Transform*“
  - “Digital* change*”



Kraus, S., Jones, P., Kailer, N., Weinmann, A., Chaparro-Banegas, N., & Roig-Tierno, N. (2021). Digital Transformation: An Overview of the Current State of the Art of Research. SAGE Open, 11(3). https://doi.org/10.1177/21582440211047576

„Digital approaches“ at Wood K plus

Methods:

- Machine learning
- Computer Vision
- Design Of Experiments
- Multivariate statistical models
- Statistical physical models
- Artificial Intelligence
- Chemometry
- Assistance systems
- Signal analysis (FFT, etc.)
- …

Hardware:

- Cobots
- 3D scanner
- Laser cutter
- 3D printers (1 continuous, 1 independent dual extruder)
- Prototype assistance system (spatial augmented reality)
- RGB cameras (Sony)
- Workstation
- AR glasses (Hololens 2)
- VR glasses (HTC Vive Pro 2)
- Optical microphone (ultrasonic airborne acoustic signals)
- Robust micropohne (high temperatures and humidities)
- …

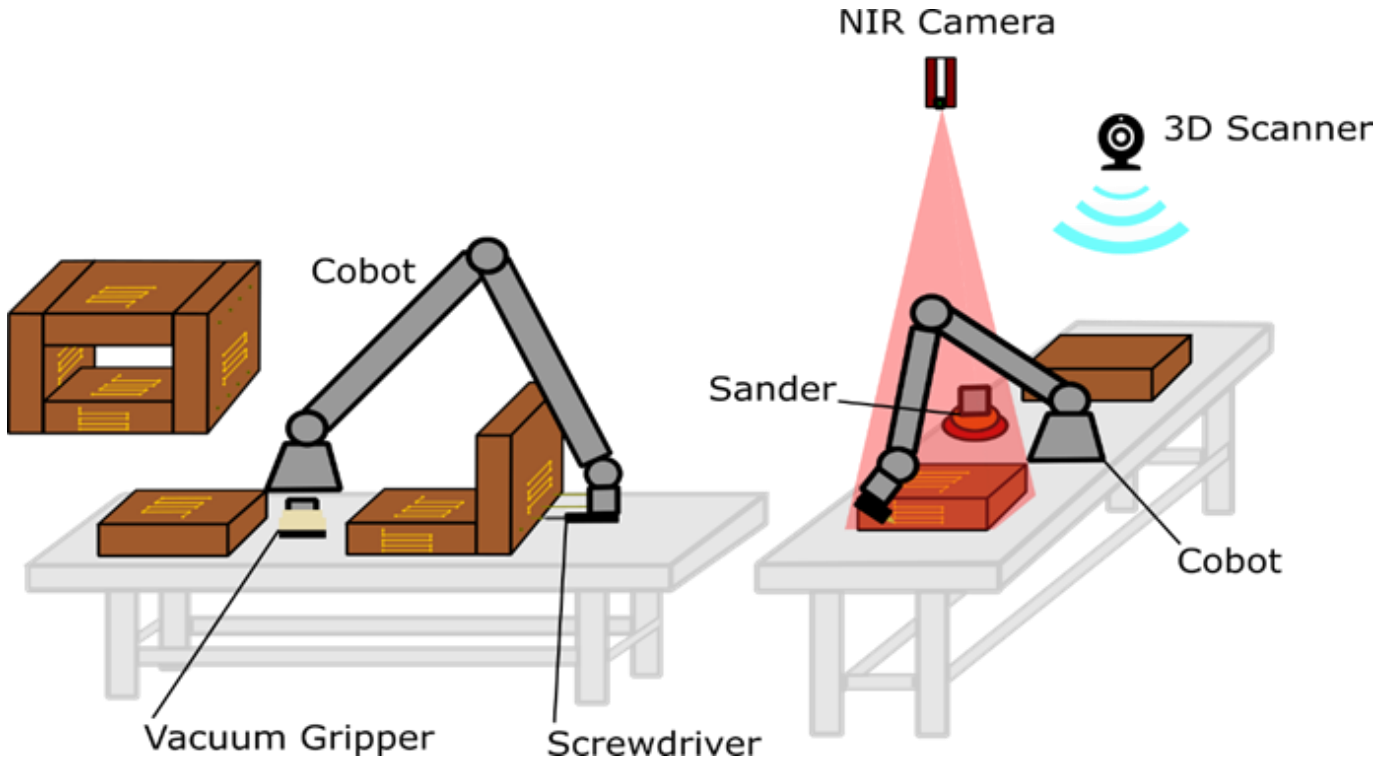
Software:

- MATLAB
- Python
- Abaqus
- Design Experts
- …

Research Lab for
Smart Production of Biomaterials and –structures

Highlights:

- **Cobot**
  - Max. load 12,5kg
  - Reach 1300mm
  - Repeatability +- 0,5mm
- **Cobot**
  - Max. load 20kg
  - Reach 1750mm
  - Repeatability +- 0,5mm
- **3D Camera**
  - Resolution XY (µm): 60 – 90
  - VDI/VDE accuracy (µm): 35
  - Field of view (mm): 71 x 98 - 100 x 154
  - Dist. to object (mm): 165
- **Hyperspectralcamera**
  - Wavelengths: 900 - 1700 nm
  - Spacial resolution: 640 pixel
  - Framerate: fullscale 670 Hz, 15000 Hz (fewer spectral bands)
- …



Austria‘s Digital Innovation Hub for Agriculture, Timber and Energy

INNO VATE

Austria:
DIH innovATE

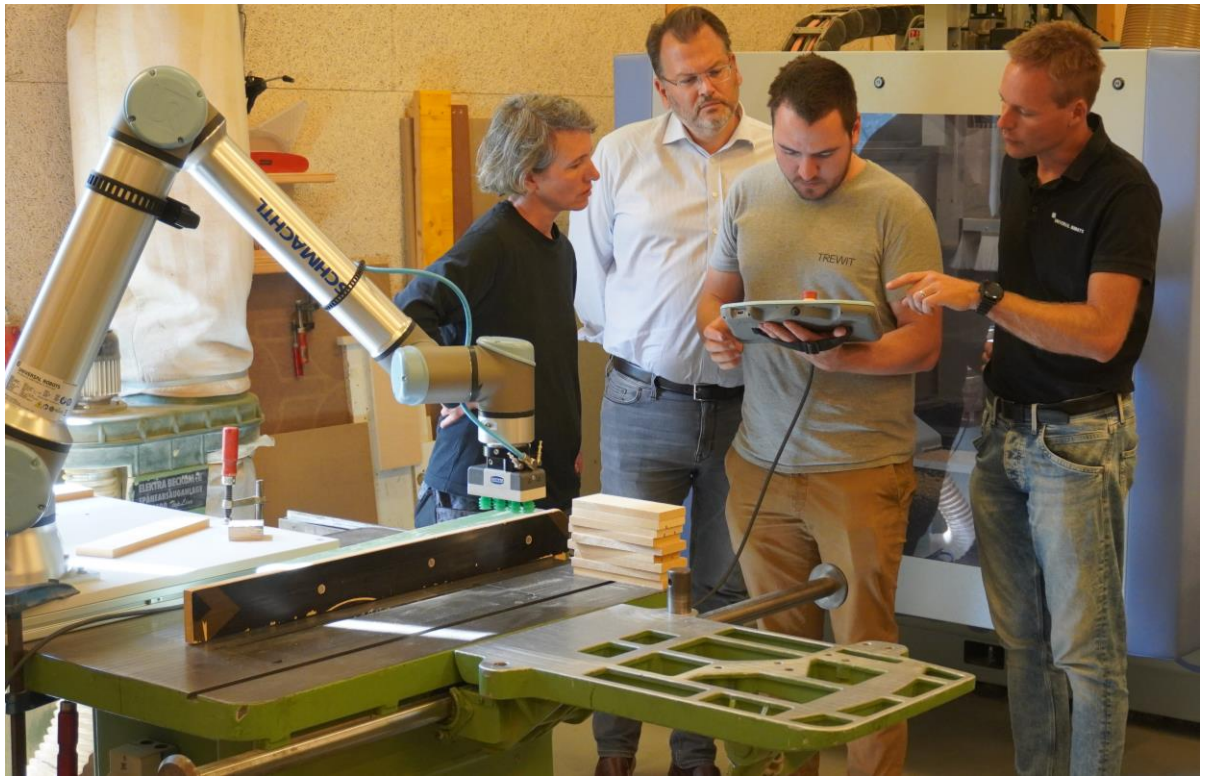
„Digital Innovation Hubs“
Run time: 2021 – 2024
Free of charge for Small and Medium Enterprises in Austria

Europe:
EDIH innovATE

„European Digital Innovation Hubs“
Run time: 2022 – 2025
Free of charge for companies with fewer than 3000 employees in Europe

Example: Cobots workshop for wood working

- **Sanding** of wood surfaces by defined pressure through sensors
- **Without safety fences** - easy to install in existing workshops
- easy to carry by one person or **flexible** use by mobile vehicles



Calls open for projects in EDIH

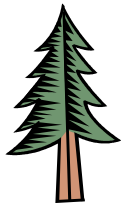
- Formats:
  - **Prototype bootcamp** (applied research question to be answered by digitalisation)
  - **Test before invest** (using infrastructure incl. support)

- **Ongoing submission** of topics possible!
  - E-Mail to m.riegler@wood-kplus.at
  - With title, specific question to be addressed, potential approaches

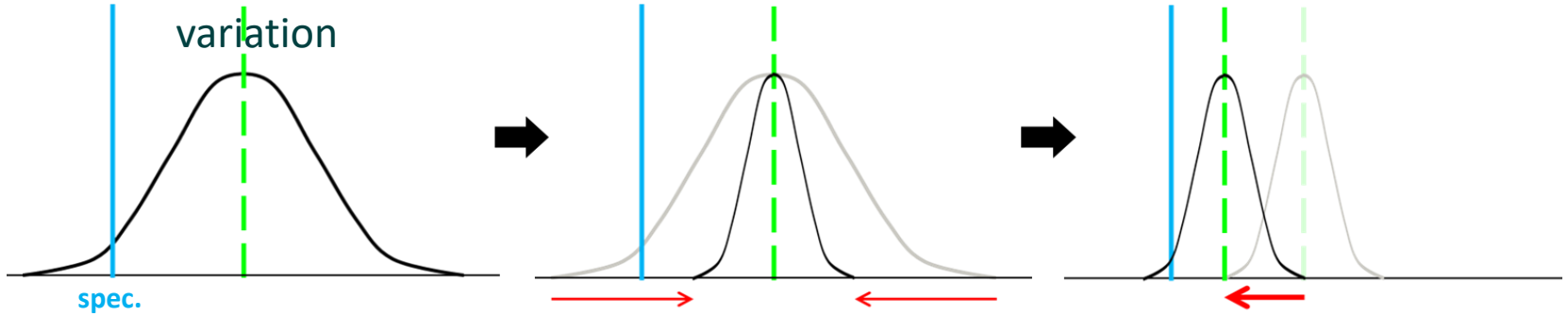
Machine learning for process adaptation in wood industry

M. Riegler, M. Weigl, B. Spangl, T.M. Young,
M. Gronalt, U. Müller

Motivation process modelling



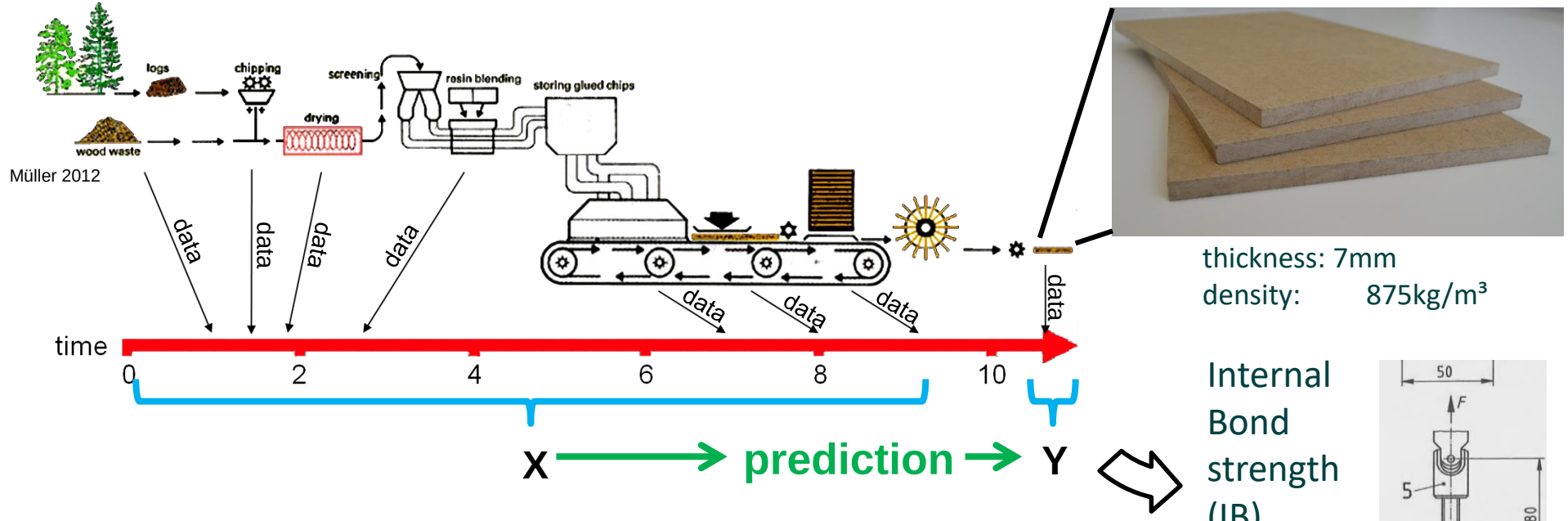
conversion



accuracy
enable flexible production with alternative raw materials and new products

cost savings
decrease variability to lower safety margins and minimize costs of production

Process modeling of fibreboard production

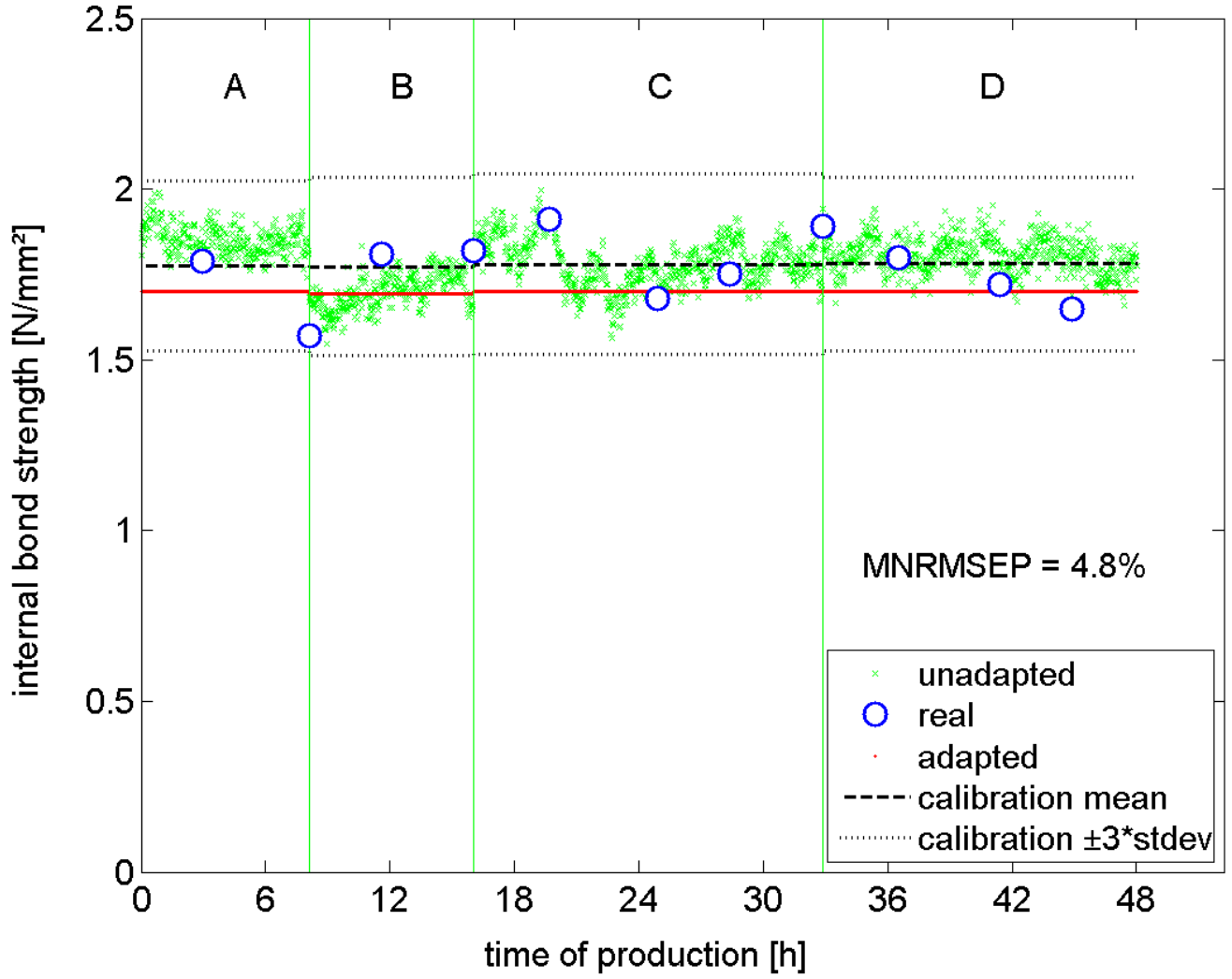


data mining:

- data collection from 804 variables (process, raw material and final panel) over one month of production
- considering time lags (markers and distances)
- database management (using *SQL, Prod IQ*)

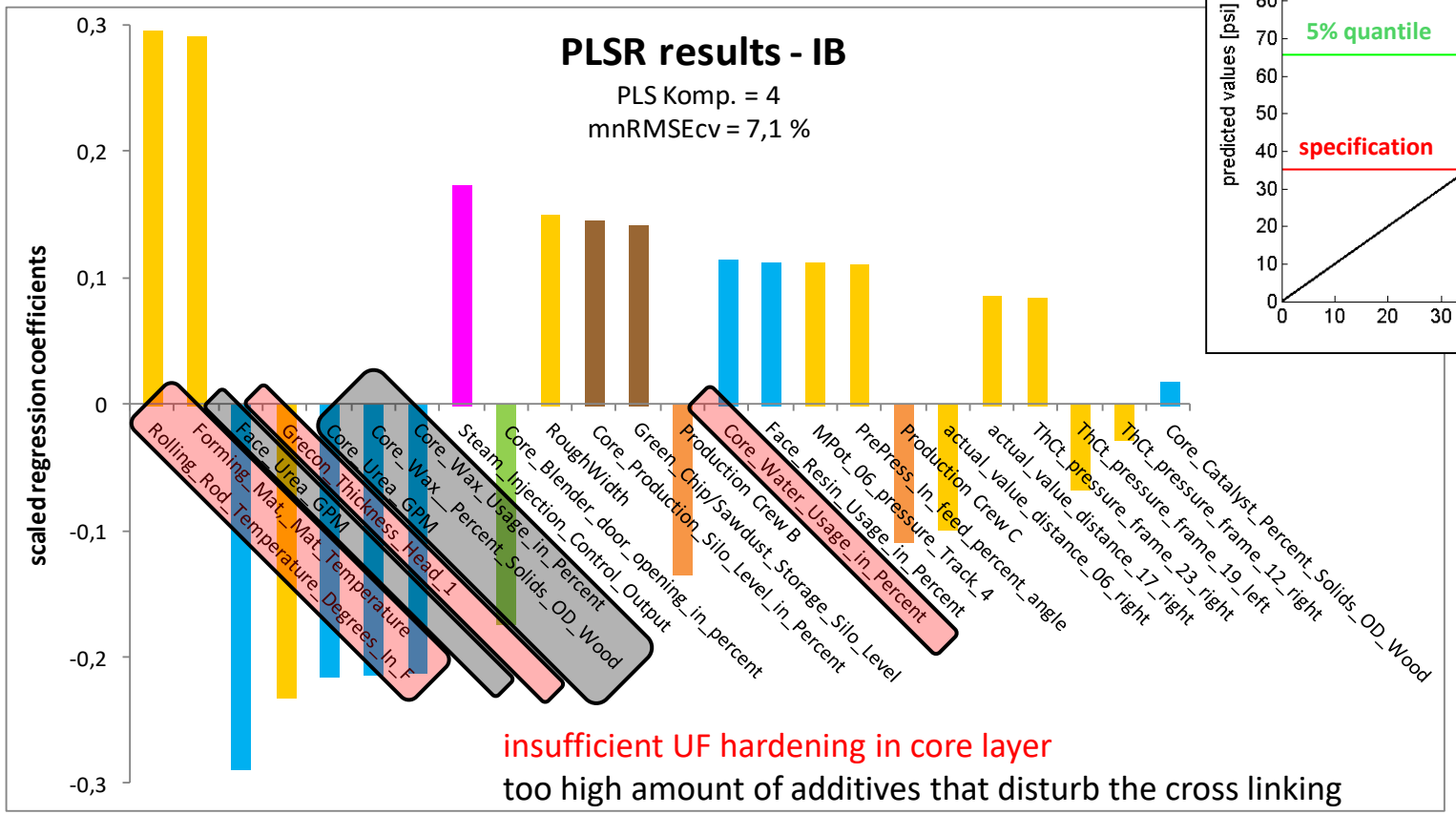
Riegler et al. 2012

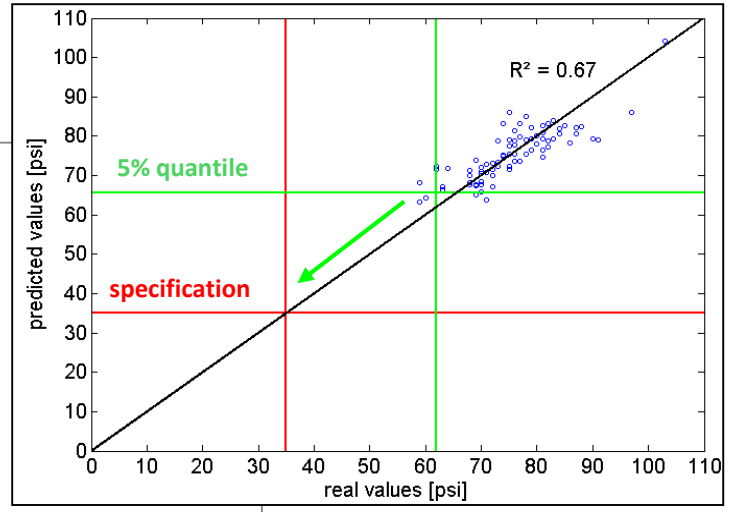
Real-time prediction of internal bond strength



Riegler et al. 2012

Interpretation PLSR model – internal bond strength





- press
- blending
- crew
- forming
- resin
- dryer

Riegler et al. 2012

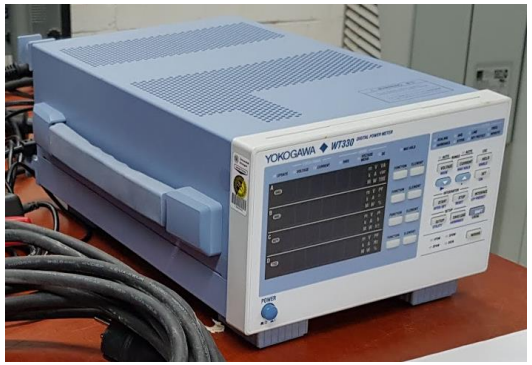
Acoustic emissions during wood machining processes for classification and ML

Mehieddine Derbas, Prof. Hans-Christian Möhring, Dr. Martin Riegler

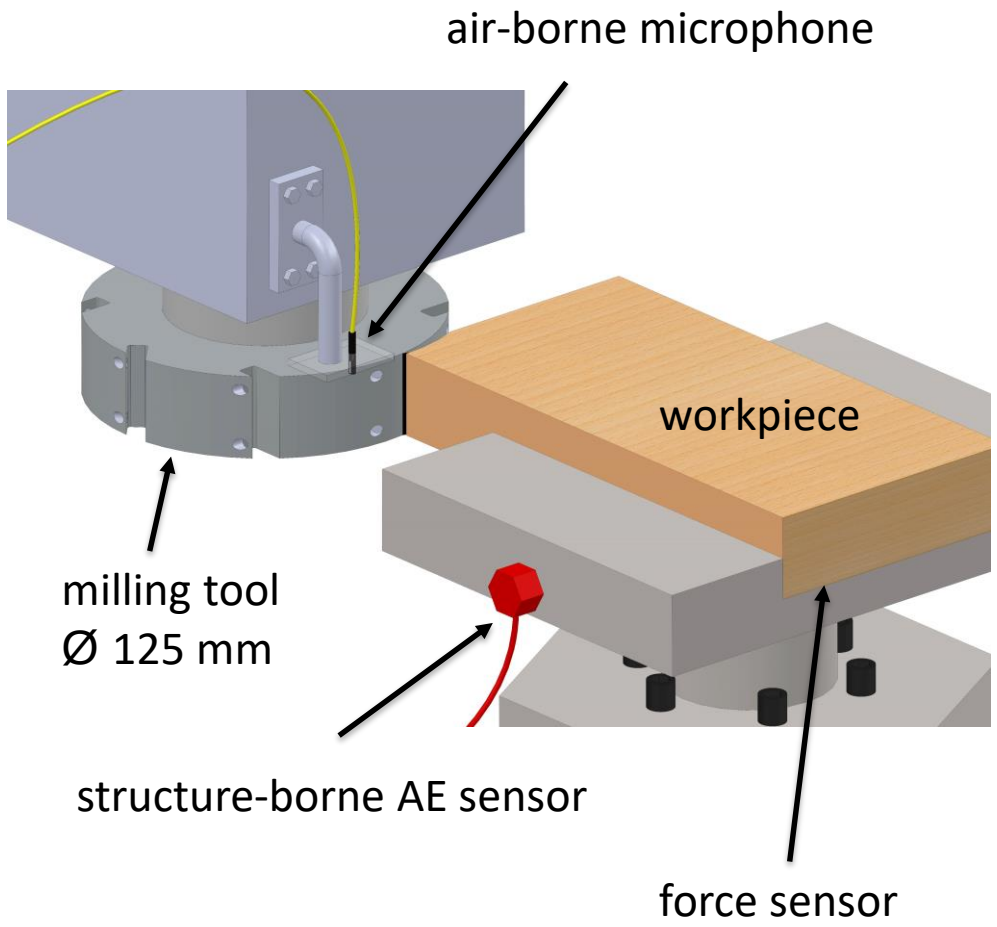
Universität Stuttgart
Institut für Werkzeugmaschinen

Experimental setup

MAKA PE 170 5 axis CNC machining centre

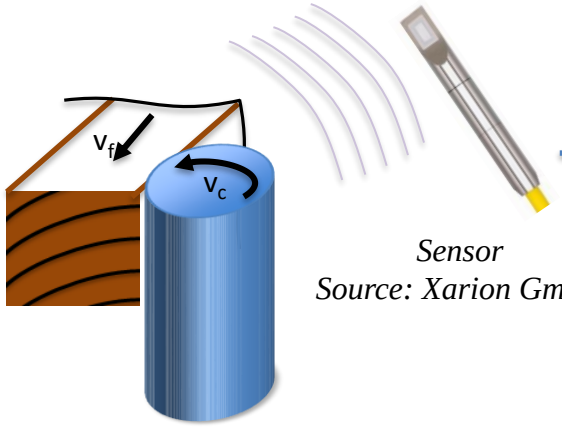


power meter



(Derbas et al. 2023)

Experimental setup



Sensor
Source: Xarion GmbH

Acoustic Emissions

Acquisition Systems

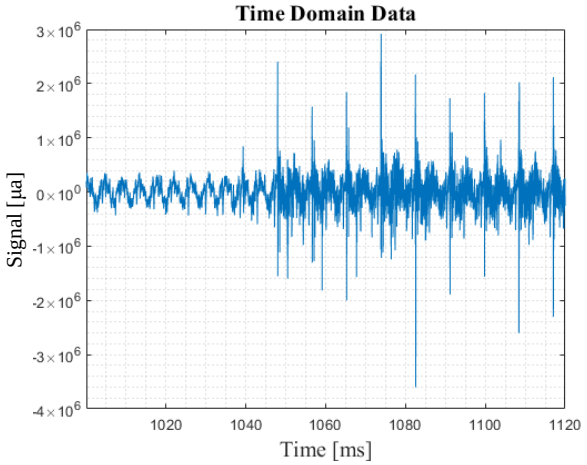
Optical Microphone

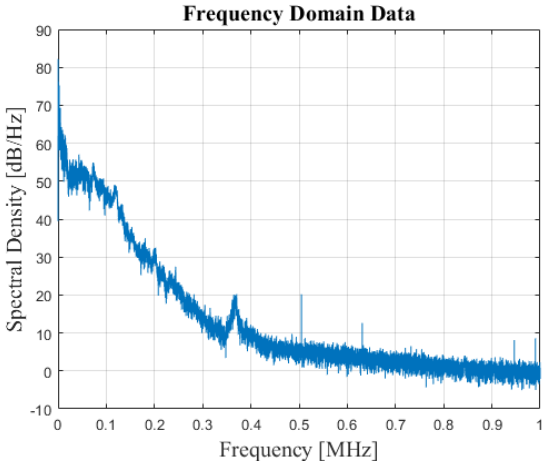
Signal Conditioning Unit
Source: Xarion GmbH

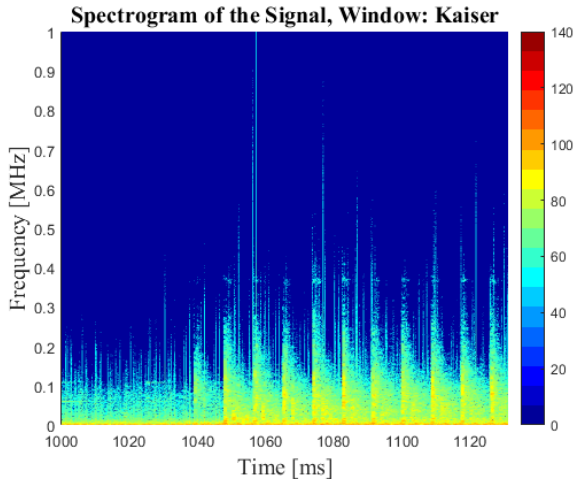
Sensor Data

Signal Processing Domains

Time Domain	Frequency Domain	Time-frequency Domain







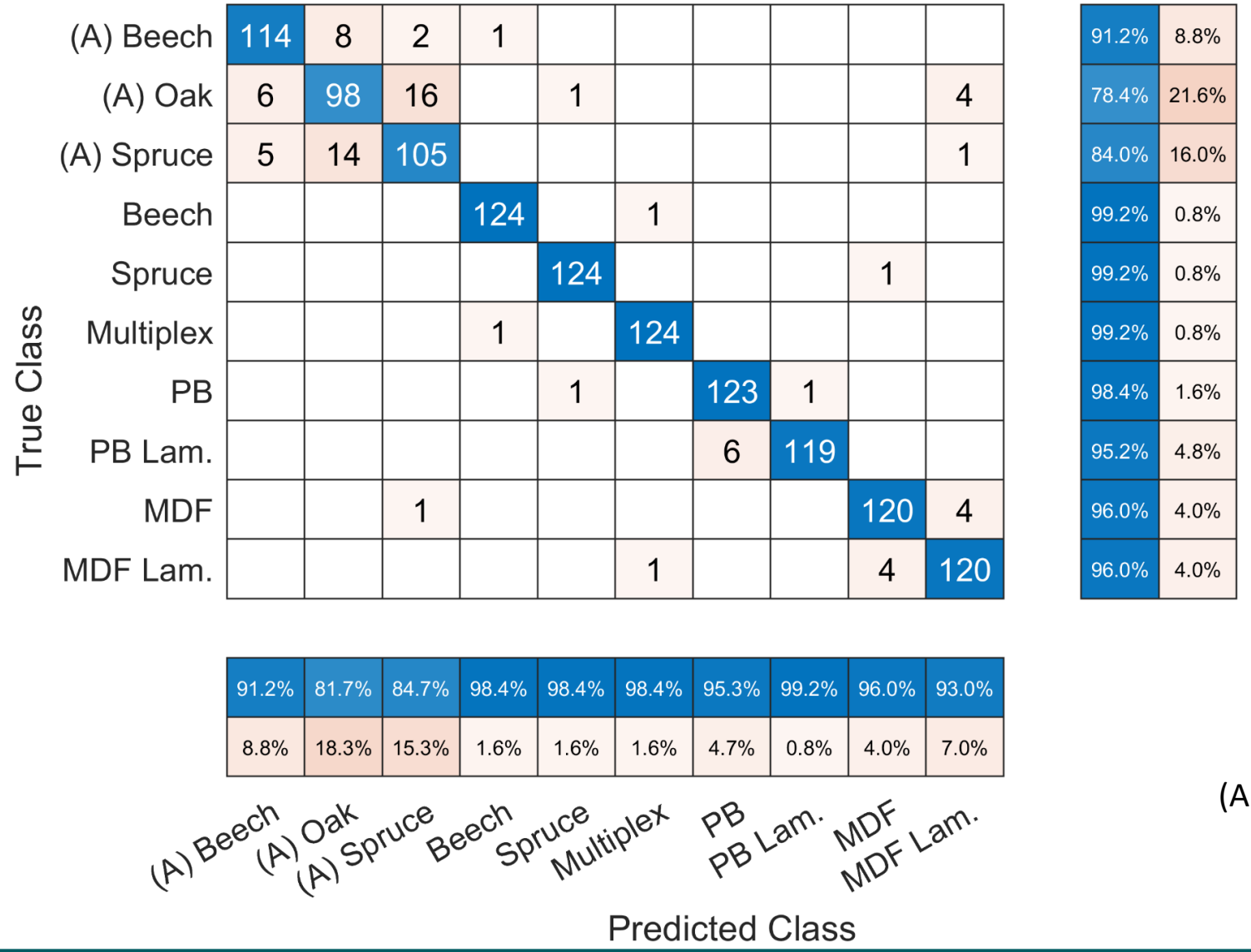
Derbas et. al 2021

Design of experiment

- Full factorial
- 2 levels of cutting speed: 60 and 80
- 10 levels of materials
- 5 repetitions each variation
- Total of 100 randomized runs

(Derbas et al. 2023)

confusion matrix

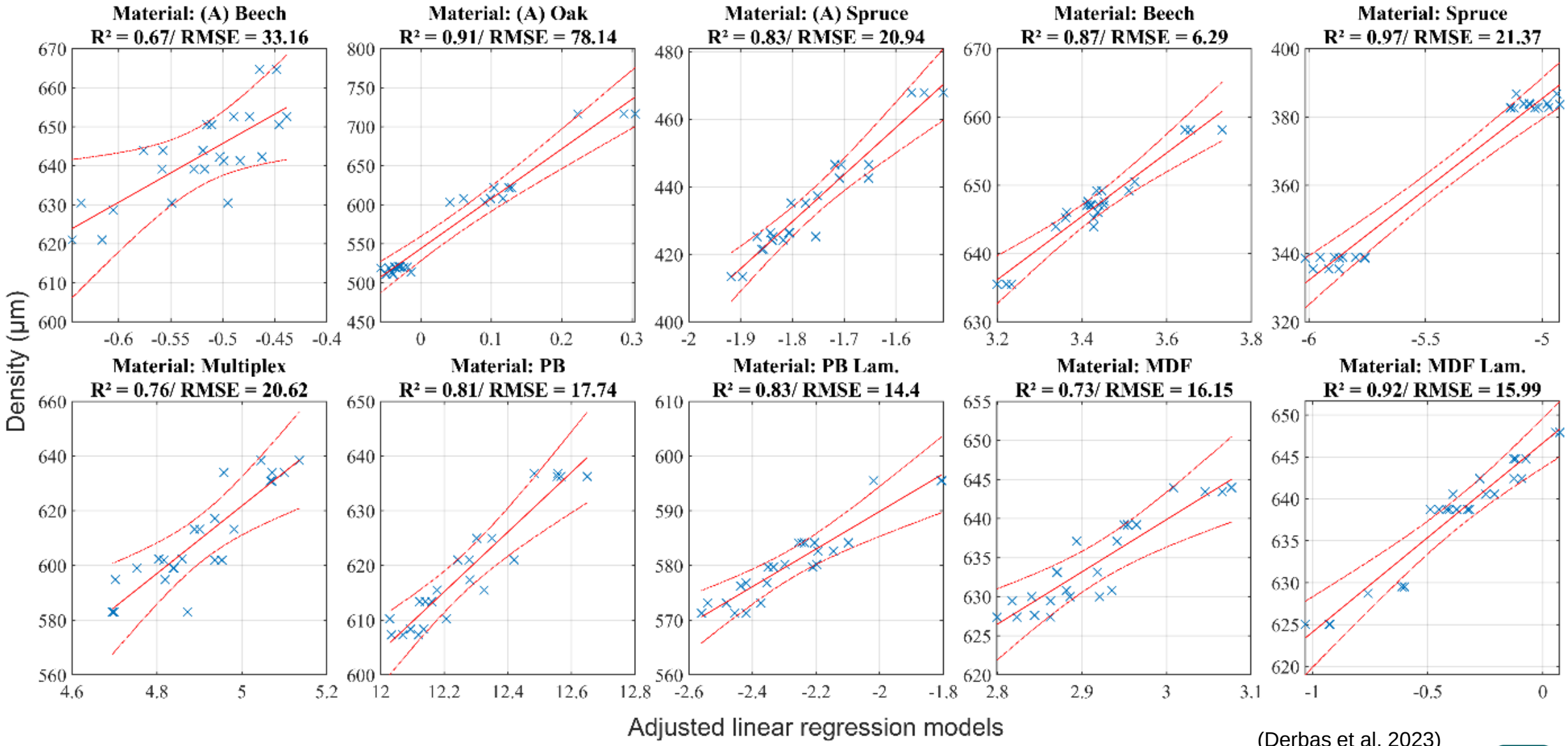


accuracy (val.): 92.16%

(A) … across the fiber

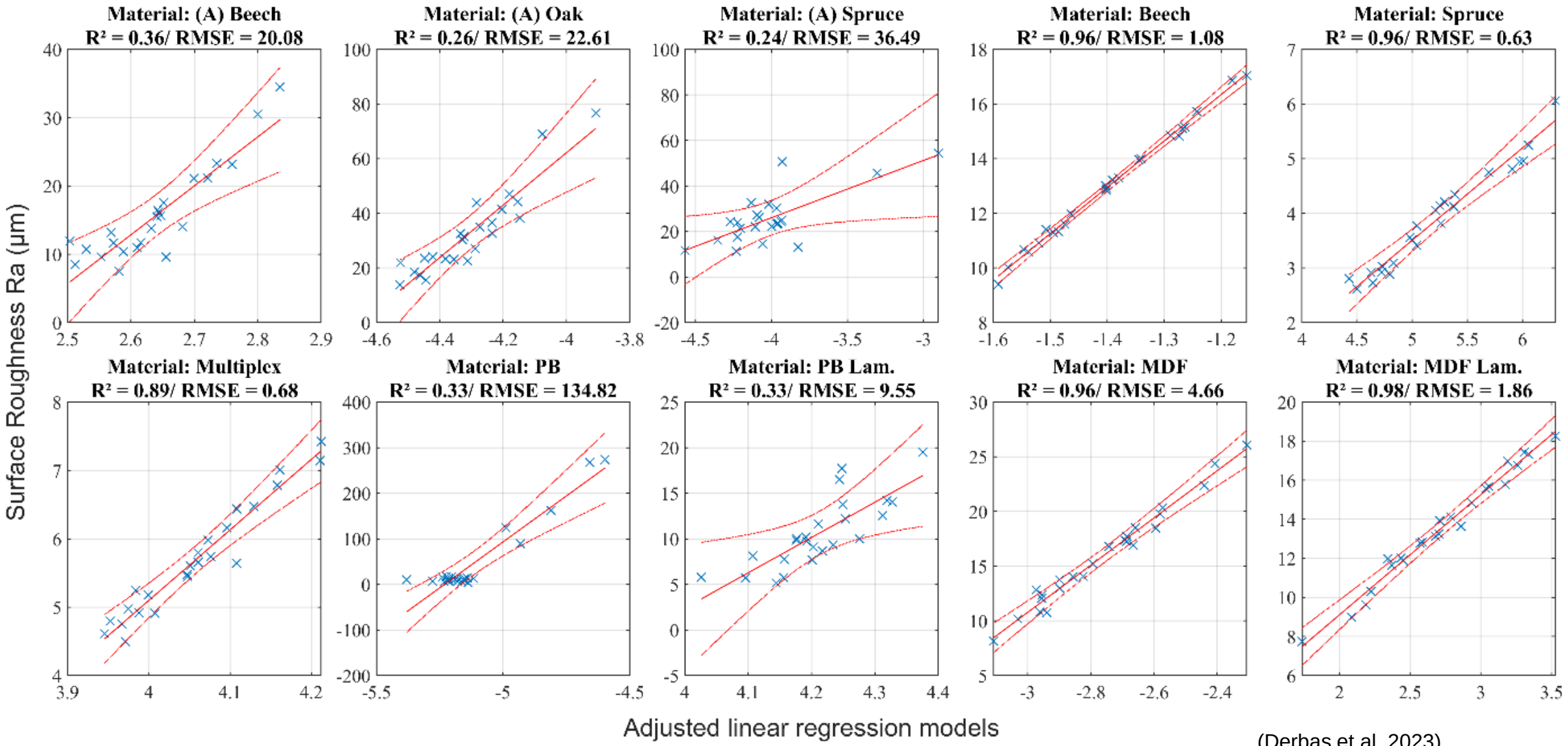
(Derbas et al. 2023)

Prediction of board density



(Derbas et al. 2023)

Prediction of surface roughness



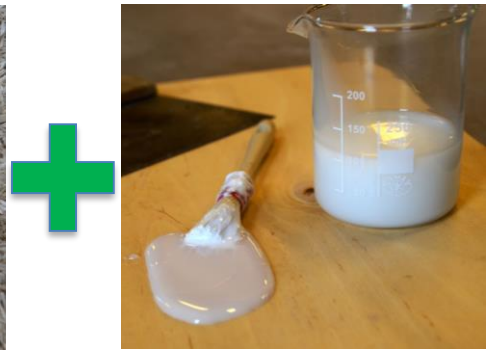
(Derbas et al. 2023)

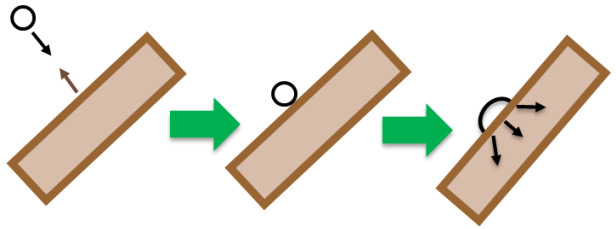
Modeling and Simulation the gluing of wood chips using Lattice Gas Cellular Automata and Random Walk

Carina Rößler, Felix Breitenecker, Martin Riegler

21.02.2018 – MATHMOD 2018, Vienna

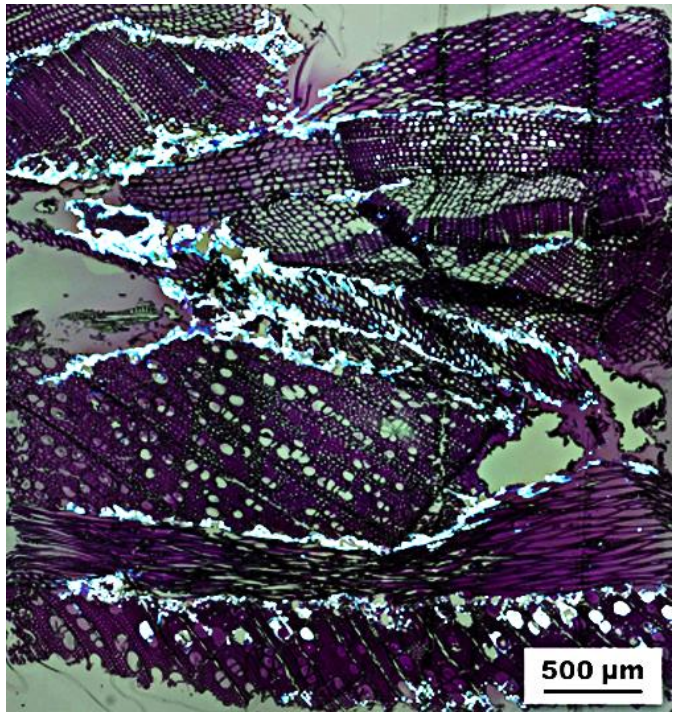
Principles of gluing



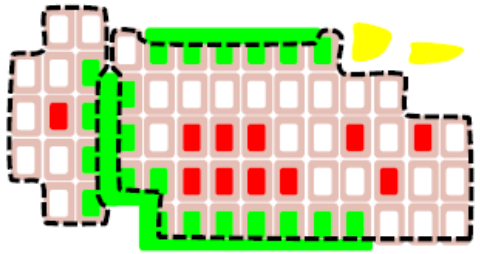


ploughshare mixer:
wood particles are homogeneously distributed
resin is sprayed using nozzles
⇨ equally distributed resin droplets on wood particles

Motivation - resin efficiency

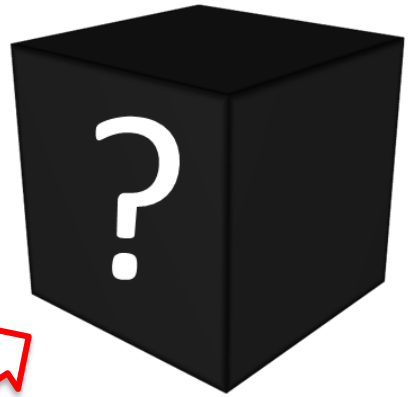


Mahrdt, E. et al. (2018)



knowledge from experiments

http://weknownyourdreamz.com/symbols/black-box-svmbol.html



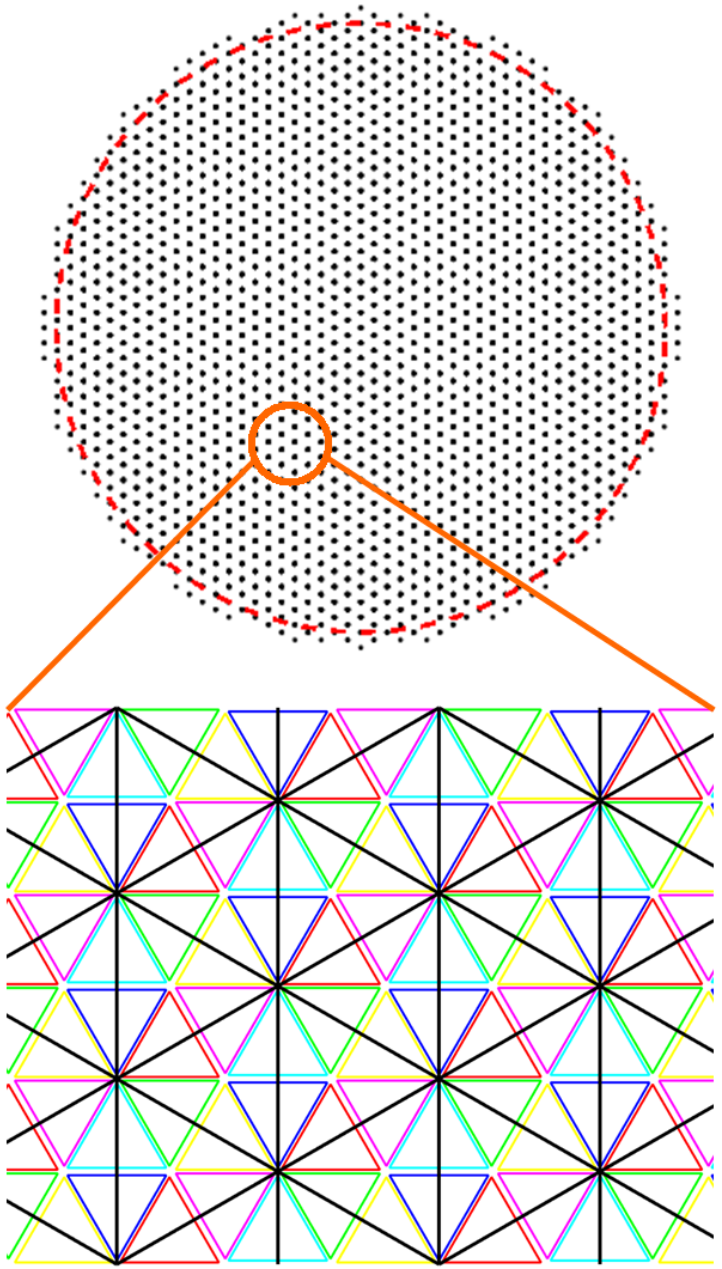
uncertainties lead to open questions

Benefits:

- adapt the process on varying raw material properties (softwood, recycling etc.)
- decreased production costs due to lower amount of resin

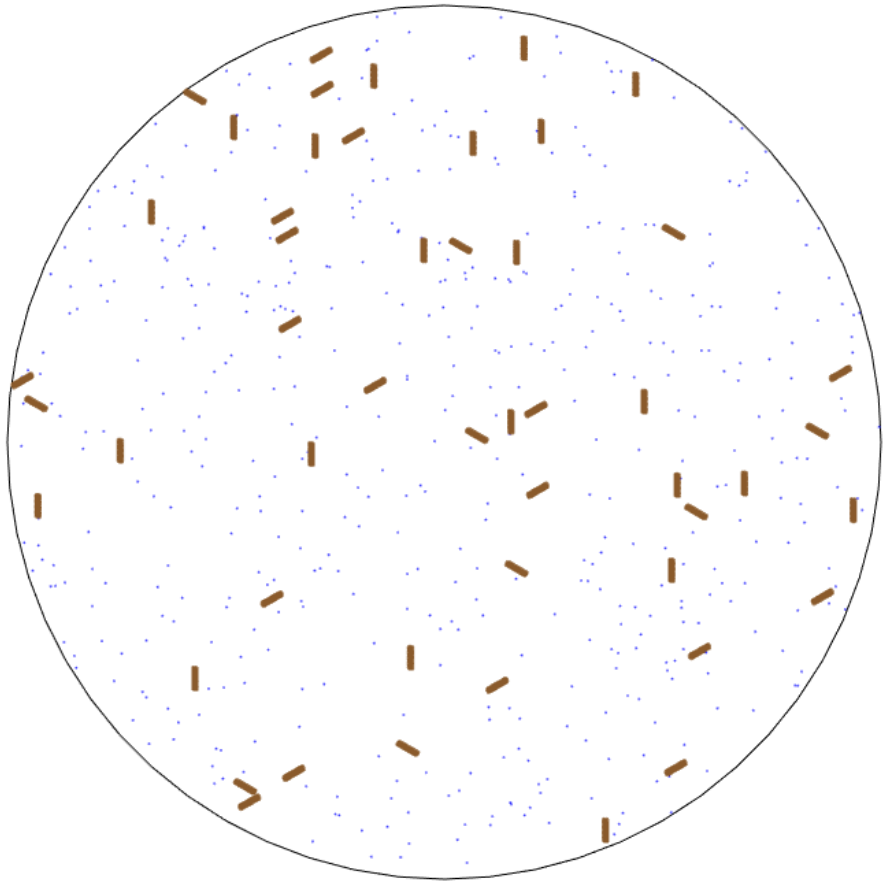
Lattice

- discretisation using triangles (black)
- different size of wood and resin particles
- resin particles moved by random walk
- wood particles occupy several nodes (hexagons)
- movement of particles according to edges of lattice (coloured triangles)

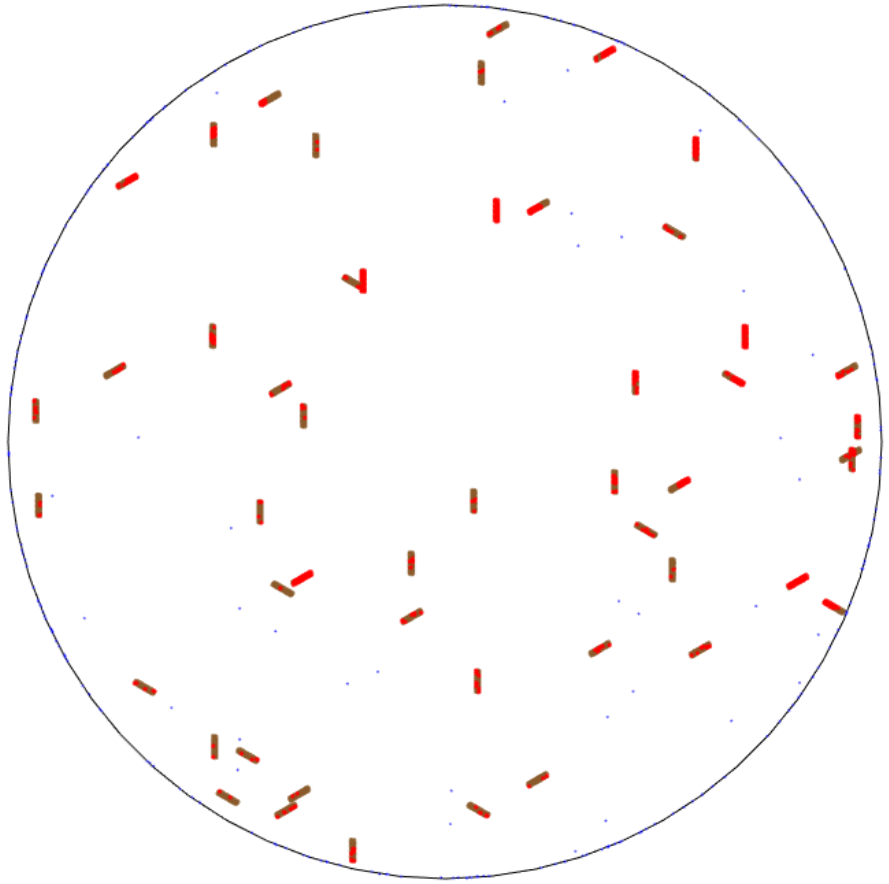


Simulation results I

initial location of wood chips (brown) and resin droplets (blue)



location of wood chips (brown), glued areas (red) and resin droplets (blue) at the end of the simulation



Finite Element Method for wood-hybrid construction elements

K. Zechmeister, R. Stingl, B. Kromoser, M. Riegler

Motivation

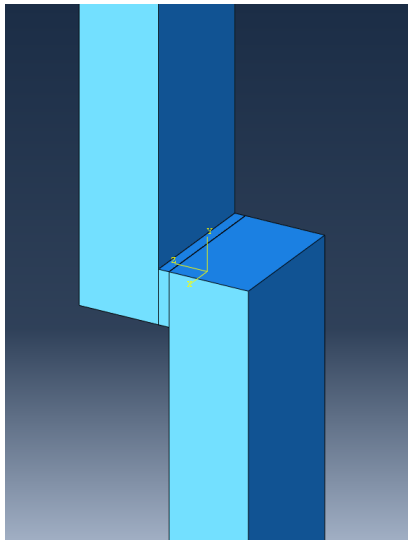
- Focus: building with wood
- Improve wood-hybrid construction elements

Source: https://www.hoho-wien.at/

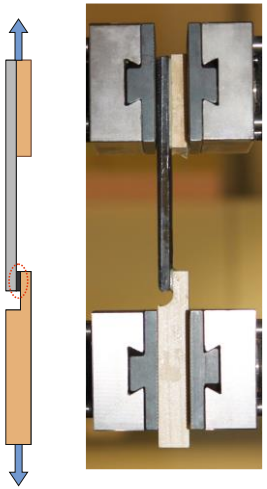
HoHo Vienna (Holz-Hochhaus)

FEM – **F**inite **E**lement **M**ethod

Geometric Data (CAD file)



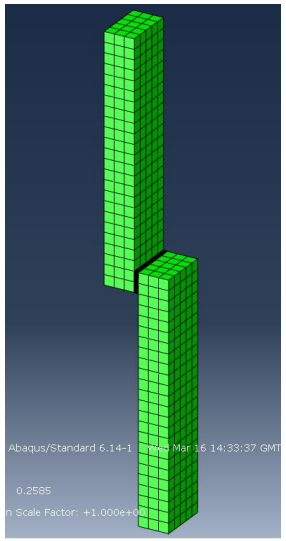
Material Data

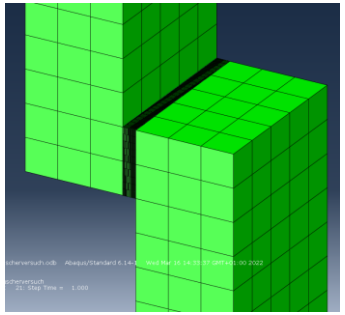


SIMULIA ABAQUS

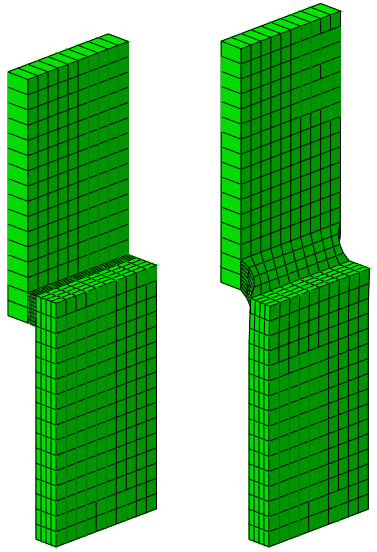
Software

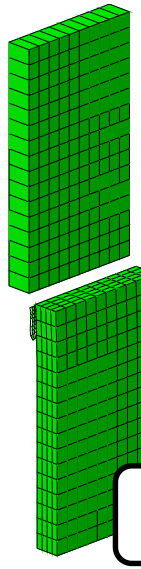
Mesh & Boundary Conditions

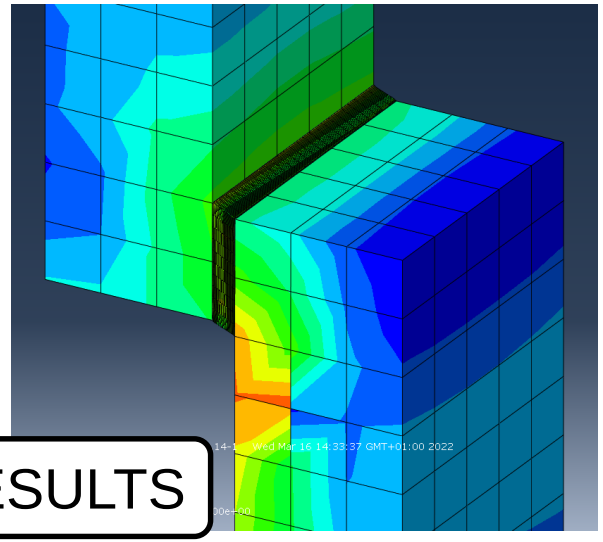




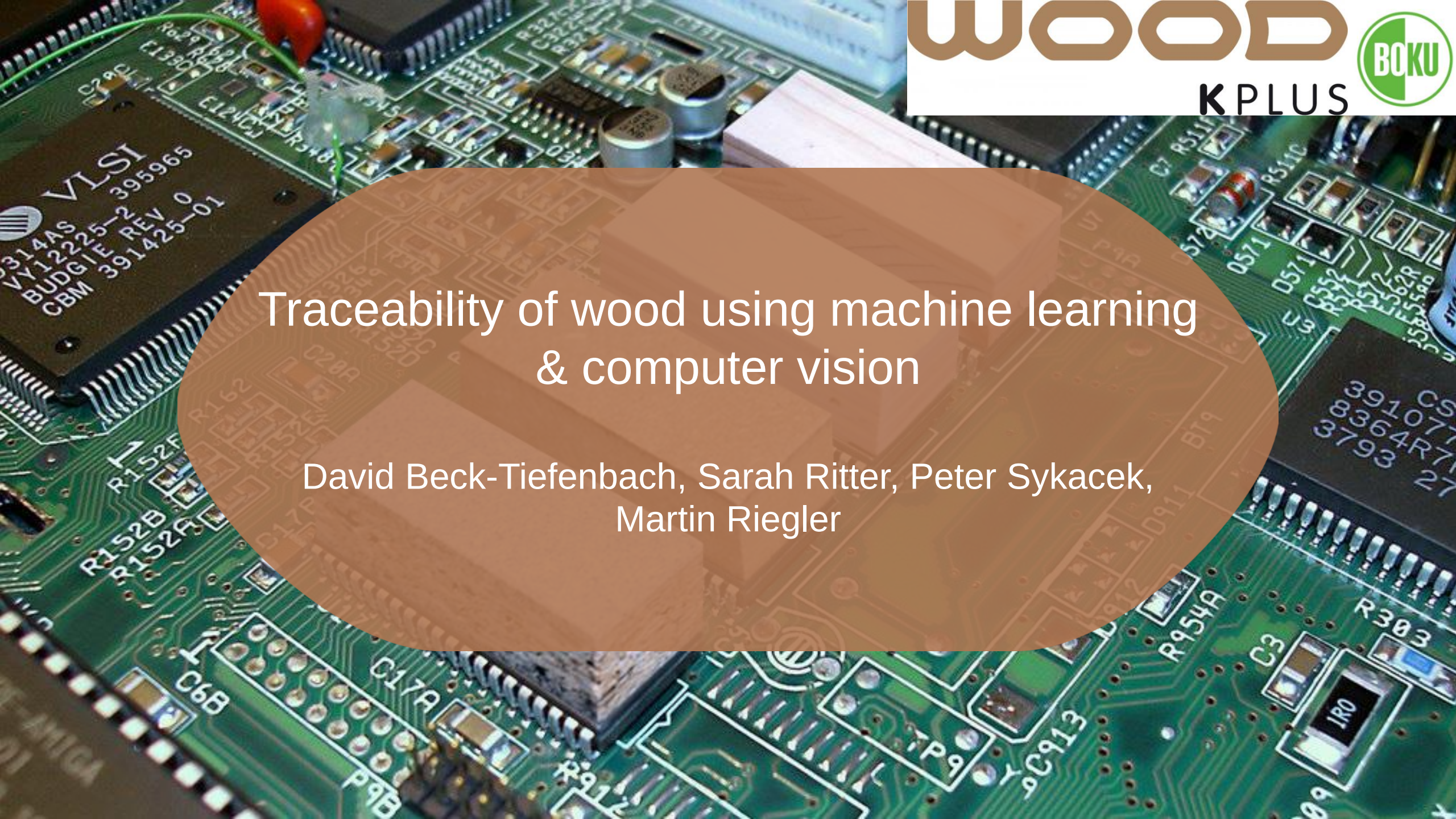
Solving DEs







RESULTS



Traceability of wood using machine learning & computer vision

David Beck-Tiefenbach, Sarah Ritter, Peter Sykacek, Martin Riegler

Why tracing wood?

Motivation

- Buyers of furniture cannot be sure that the wood used comes from sustainable forests
- New EU regulation on “deforestation-free products” since 2023

Goal

Forgery-proof material tracking from the tree to the finished product

Computer vision approach

Idea:

Annual ring = Fingerprint

(Classical) biometric methods

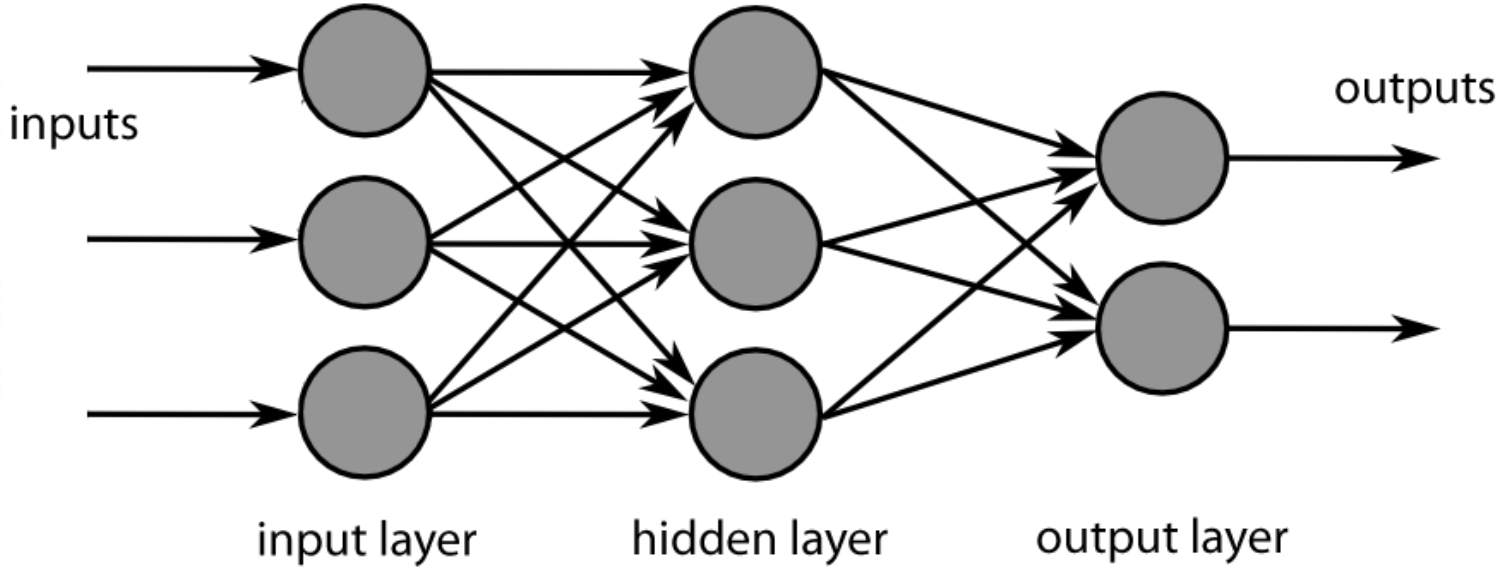
Gabor filters

Pith estimation

Hand-crafted features

Data-driven (ML) approach

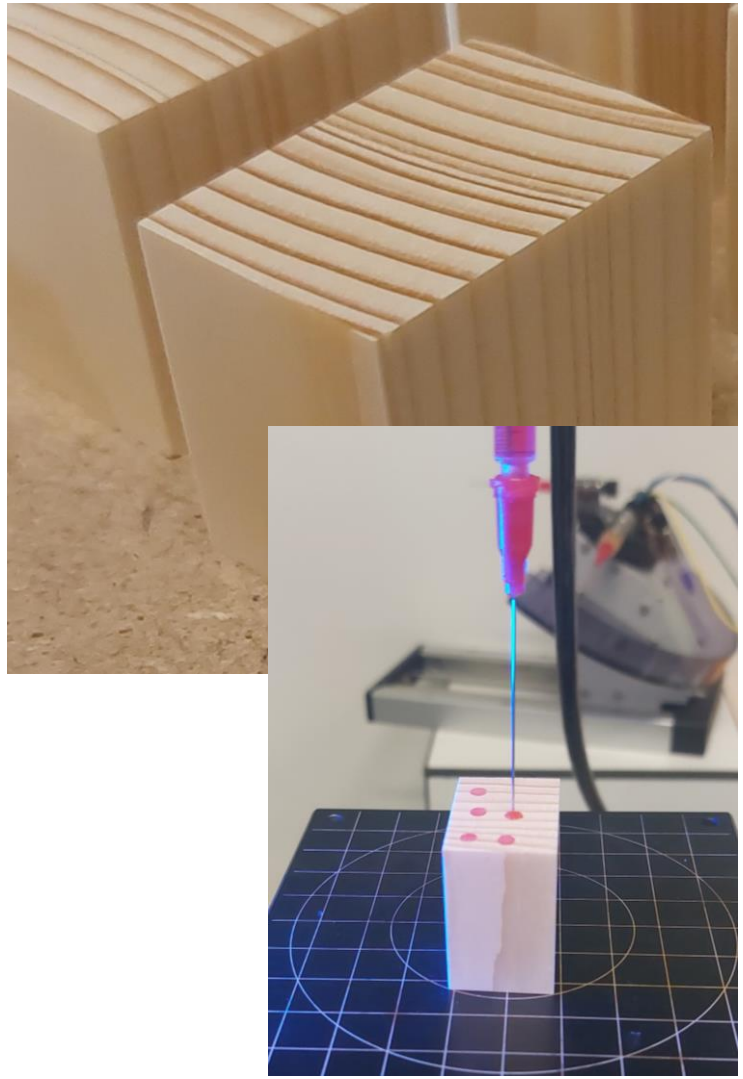
train a convolutional neural network to identify trees
→ using wood characteristics (year rings, knots, shape, etc.)



This is tree x

Marking approach

- Permanent marking technologies on wood surfaces throughout the entire value chain
- Development of suitable environment friendly dyes for wood surfaces on various species or surfaces
- Robust dyes in rough environments
- Using unique codes together with machine data in secure IT-architecture
- Linking with quality parameters of wood specimens
- Sharing data along wood value chain



Computer Vision & Assistance Applications in Wood Research

Birger Bartuska, Sarah Ritter, Carina Rößler, Martin Riegler

Image analysis for impregnated railway sleepers

- Crosssections were imaged with visible light and UV
- Sample area was measured and compared to “heartwood” area and non-impregnated area.

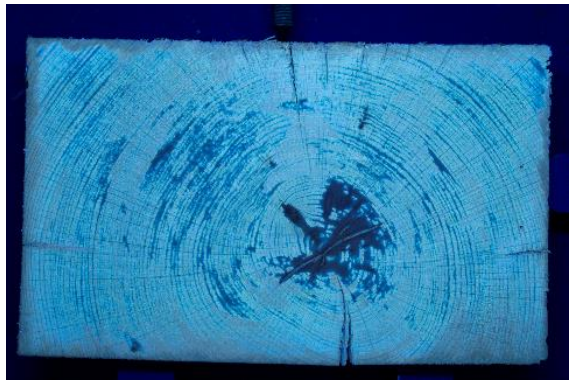
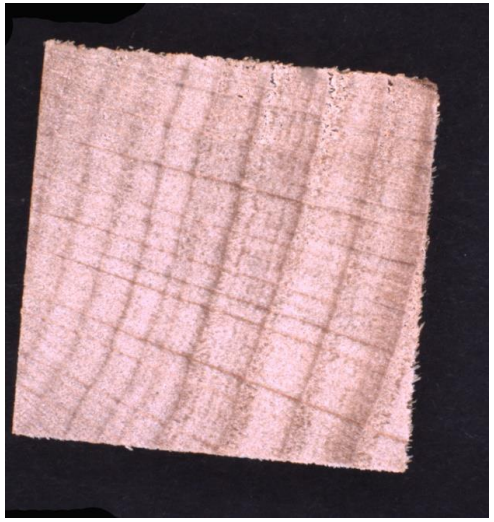
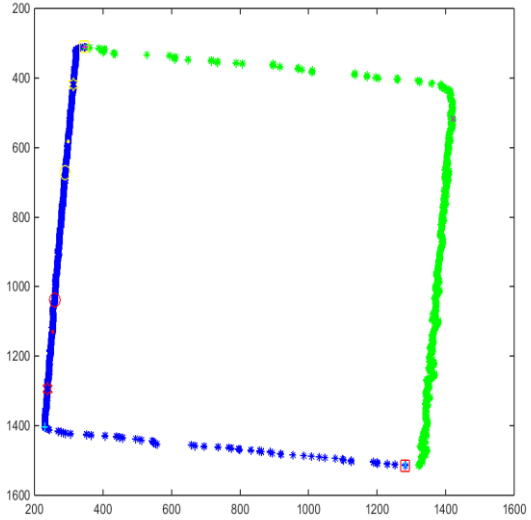


Image analysis - Swelling and Shrinkage of DVS Samples

- automatic measurement of sample dimensions
- Cooperation with Universität Hamburg



Original image



Automated angle detection

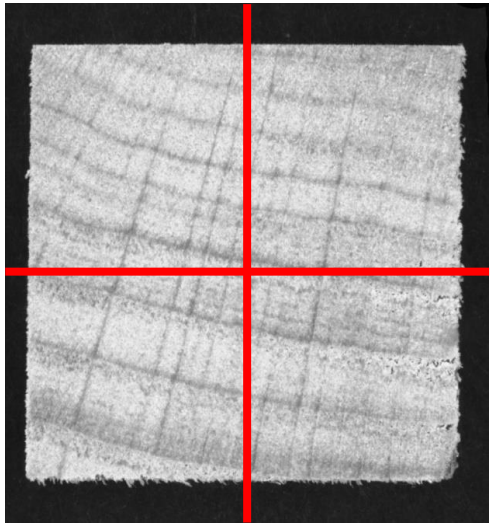
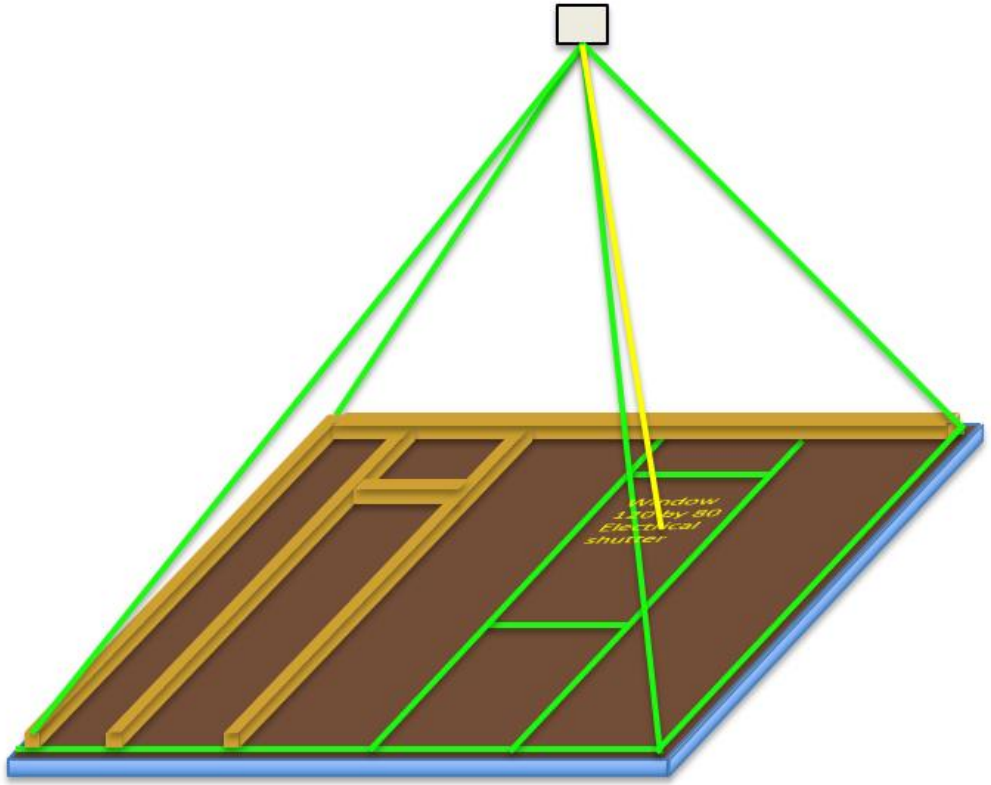


Image rotated for analysis

Nopens, M., Riegler, M., Hansmann, C., & Krause, A. (2019). Simultaneous change of wood mass and dimension caused by moisture dynamics. *Scientific reports*, *9*(1), 1-11.

Object Detection for Assisted Manual Assembly



[Link: video assistance system]

[Link: video research project „prefabrication 4.0“]

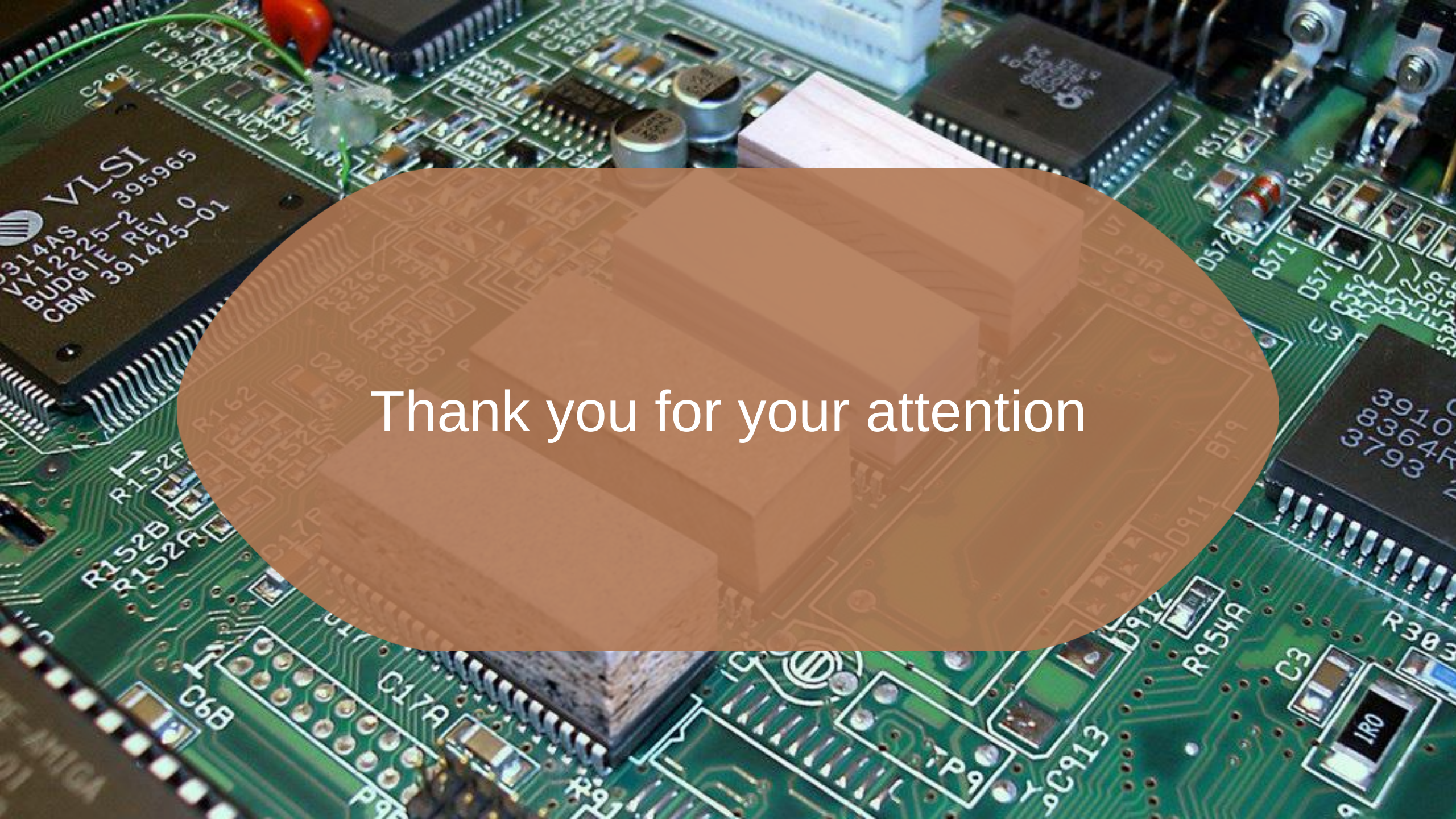
Bartuska, B., Teischinger, A., Riegler, M. (2022) Effects of Spatial Augmented Reality Assistance on the efficiency of Prefabricating Timber Frame Walls. Wood Material Science and Engineering DOI: 10.1080/17480272.2022.2085528

bibliography

- Derbas, M., Frömel-Frybort, S., Laaber, C., Riegler, M. (2021) Sound analysis of mechanical wood cutting processes as a basis for adaptive process control. In: 9th Hardwood Proceedings - Part II. with special focus on "An underutilised resource: Hardwood oriented research". Sopron, Hungary
- Derbas, M., Jaquenmond, A., Frömel-Frybort, S., Güzel, K., Möhring, H.C., Riegler, M. (2023) Multisensor data fusion and machine learning to classify wood products and predict workpiece characteristics during milling. CIRP: Journal of manufacturing science and technology, 47: 103-115
- Riegler, M., Spangl, B., Weigl, M., Kuncinger, T., Wimmer, R., Young, T.M., Müller, U. (2012) Real-time simulation of a feedforward control process adaptation at the manufacturing of fiberboards. 2nd Biennial International Conference on Processing Technologies for the Biobased Products Industries (PTF BPI), 6.-7.11.2012, Georgia, USA
- Riegler, M., Spangl, B., Weigl, M., Wimmer, R., Müller, U. (2013) Real-time process adaptation in the manufacture of high-density fiberboards using multivariate regression analysis and feedforward control. Wood Science and Technology, 47: 1243-1259
- Riegler, M. (2017) Closing the technological gap within statistical models for producing wood-based composites. 11th Annual International Conference on Statistics: Teaching, Theory & Applications, 26.06.2017, Athens, Greece
- Rößler, C., Riegler, M., Breitenecker, F. (2018) Modeling and simulation of moving wood chips and resin droplets within a resinating mixer using lattice gas cellular automata. 9th Vienna International Conference on Mathematical Modelling, 21.-23.2.2018, Vienna
- Nopens, M., Riegler, M., Hansmann, C., Krause, A. (2019) Simultaneous change of wood mass and dimension caused by moisture dynamics. Scientific Reports, 9(1): 10309

additional literature

- Riegler, M., André, N., Gronalt, M., Young, T.M. (2015) Real-time dynamic simulation of continuous bulk material flow to improve the statistical modelling of final product strength properties. International Journal of Production Research, 53(21): 6629–6636
- Pernkopf, M., Riegler, M., Gronalt, M. (2019) Profitability gain expectations for computed tomography of sawn logs. European Journal of Wood and Wood Products, 77: 619–63
- Rößler, C., Breitenecker, F., Riegler, M. (2020) Simulating the Gluing of Wood Particles by Lattice Gas Cellular Automata and Random Walk. Mathematics 8:988


Thank you for your attention

Contact:

Dr. Martin Riegler
Kompetenzzentrum Holz GmbH
Konrad Lorenz Straße 24
A-3430 Tulln

Tel.: +43 (0)1 47654 89125

E-Mail: m.riegler@wood-kplus.at
Homepage: www.wood-kplus.at