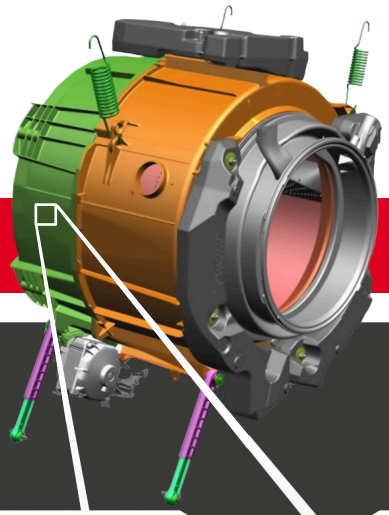
GeoDict

The Digital Material Laboratory



DigiLaugBeh – Digital design of a lightweight component

Numerical design of a lye tank (Laugenbehälter), regarding service life and ecological aspects

The goal is to develop a generation tool that automatically optimizes digital twins to accurately reflect the stochastic geometric properties of the original structure. This includes key parameters such as the diameter, length, orientation, volume fraction, curvature, and curliness of fibers. By ensuring these properties are precisely matched, the digital twin will provide a more reliable and realistic representation, enhancing the accuracy of simulations and analyses. This approach aims to bridge the gap between digital models and real-world structures, enabling more efficient material design and performance prediction.

Tasks:

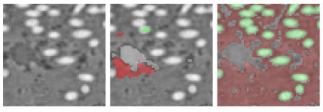
- Import and segment CT-data of fiber-reinforced composites
- Identify and analyze individual fibers
- Develop a GeoApp for generation of digital fiber twins
- Generate digital twins and validate GeoApp performance
- Enhance GeoDict fiber generation capabilities

Project members:
Olga Lykhachova[1*], Anne Blumer[1], Maximilian Luczak[1], Dennis Mosbach[1], Andreas Griesser[1], Erik Glatt[1], Oliver Rimmel[1]

[1] Math2Market GmbH, Richard-Wagner-Straße 1, 67655 Kaiserslautern, Germany
[*] Corresponding author: olga.lykhachova@math2market.de

Segment CT-Images of Fiber-Reinforced Composite

Marked positions of the four samples



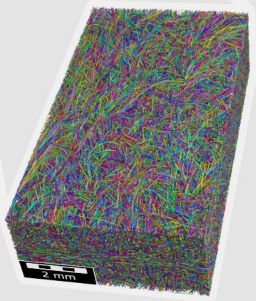
AI-Segmentation with ImportGeo-Vol using Boosted-Tree to separate three phases: fibers, matrix, pores

CT-Scan of the probe

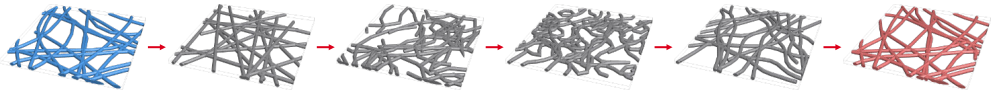
Segmented sample of fiber composite

Step 1: Digitalize Original Samples

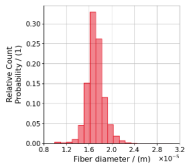
Individual fibers found with FiberFind-AI



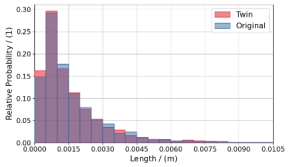
Generate Statistical Digital Twin using Optimization Algorithm



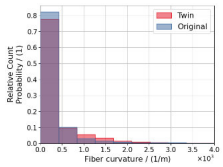
Optimization: From **target fiber structure** to its **digital twin**



Fiber diameter distribution



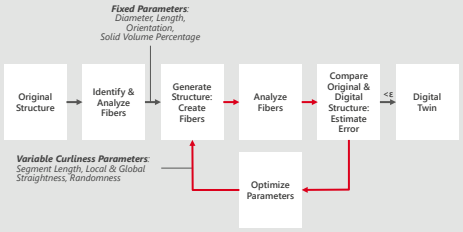
Fiber lengths distribution: FASEP (original) vs FiberFind (twin)



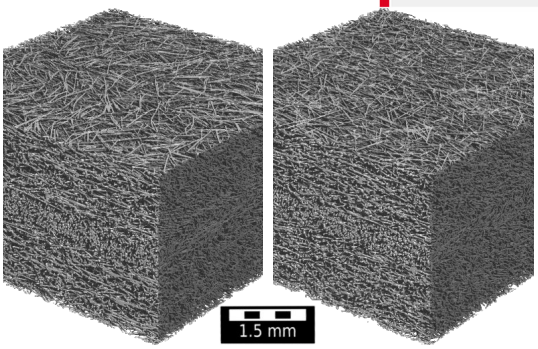
Fiber curvature distribution

Step 2: Create Statistical Digital Twin

Optimization implemented in GeoApp "Generate Nonwoven Statistical Digital Twin"



Predict Mechanical Properties and Validate with Labor Tests



Original scan provided by Bosch

Statistical digital twin created per layers

Fiber statistics used for twin generations

Fiber statistics (3099 x 2961 x 832 voxels)

Layer	Thickness, vls	Thickness, mm	SVP, %	Length, µm	D, µm	VL, µm
Top	328	1.082	13.02	559.7±482.6	17.21	3.30023
Mid	131	0.432	16.44	606.8±515.0	16.49	3.30023
Bottom	373	1.231	13.68	594.3±571.1	17.16	3.30023

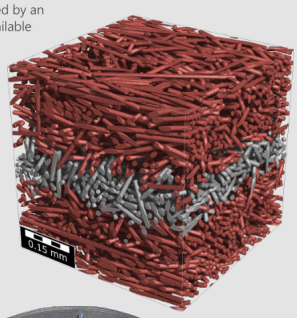
Mechanical properties validation

Effective Stiffness (1664 x 1664 x 832 voxels)

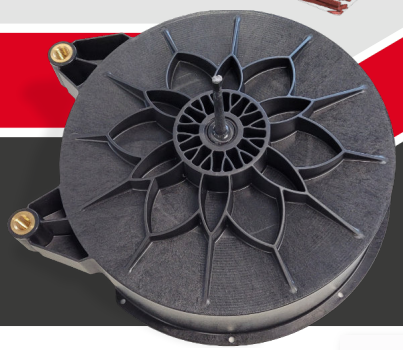
Angle	E_Original	E_Twin	E_Exp (IKV)	Error (exp)	Error (sim)
°	GPa	GPa	GPa	1	1
0 (Y)	5.4237	5.3603	4.7674	12.44%	1.17%
60 (XY)	4.6331	4.7846	3.4451	38.88%	-3.27%
90 (X)	4.0236	4.1017	3.1458	30.39%	-1.94%

Step 3: Design Next Generation Materials

Fiber structure generated with first GeoApp "FiberMath" developed by an external group from ITWM available in GeoDict.



DigiLaugBeh enhances the design of composites in GeoDict – from segmentation over statistical digital twin workflows to new structure generators



Our project partners:

- Robert Bosch GmbH (Project lead)
- Fraunhofer Institut für Techno- und Wirtschaftsmathematik (ITWM)
- Lehrstuhl für Kunststoffverarbeitung (IKV) an der RWTH Aachen
- Institut für Akustik und Bauphysik (IABP) Universität Stuttgart
- Institut für Siedlungswasserbau, Wassergüte- und Abfallwirtschaft (ISWA) Universität Stuttgart
- Plastic Engineering Group GmbH (PEG)
- BSH Hausgeräte GmbH (associated Partner)
- Celanese Services Germany GmbH (CELANESE) (associated Partner)

Supported by: Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag

Funding:

We thank the Federal Ministry of Economic Affairs and Climate Action (BMWK) for the ongoing funding under the funding code FKZ 03LB3044C

Math2Market GmbH | Richard-Wagner-Str. 1 | 67655 Kaiserslautern, Germany
☎ +49 631 205 605 0 | 🖷 +49 631 205 605 99 | ✉ digital-materials@math2market.de
WWW.MATH2MARKET.COM

MATH 2 MARKET