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NATIONAL COMPOSITES CENTRE

Bristol Composites Institute

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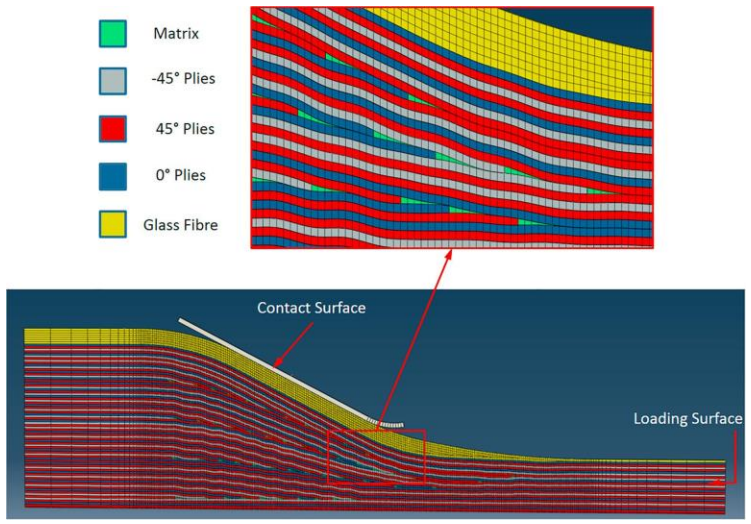
Artificial Intelligence for a New Generation of Composite Structures

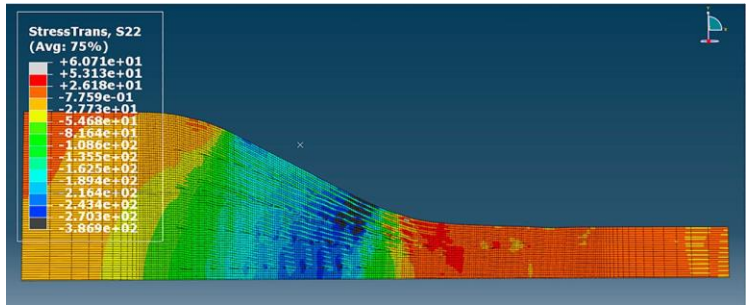
Multi-scale Challenges in Composite Materials

- Composite materials are hierarchal in nature.
- Linking the impact of material architecture and manufacturing processes from the fibre to the structural scale is a multi-scale modelling challenge.
- Material non-linearity (specially damage) and variabilities are the key design driver in most applications.

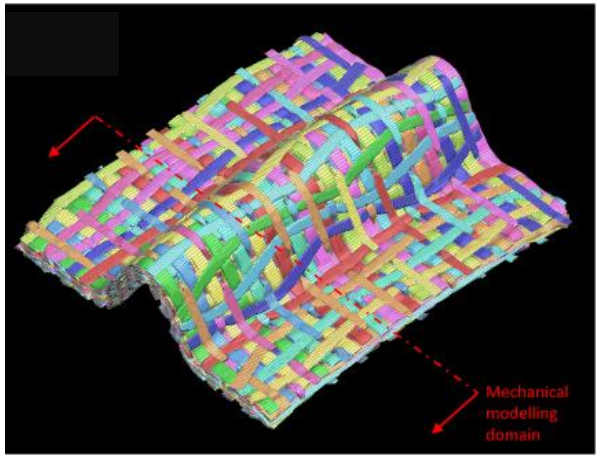
Laminated Composites

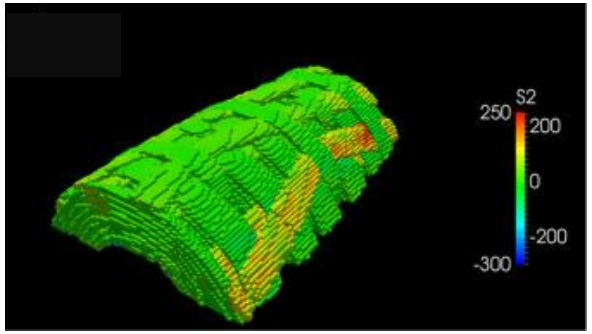


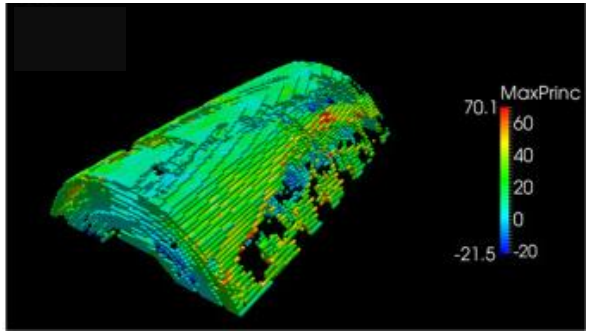
High-Fidelity Model



3D Woven Composites

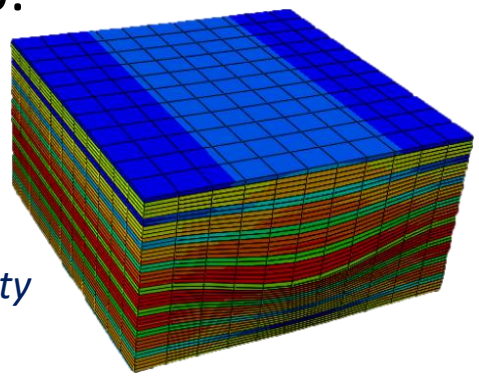




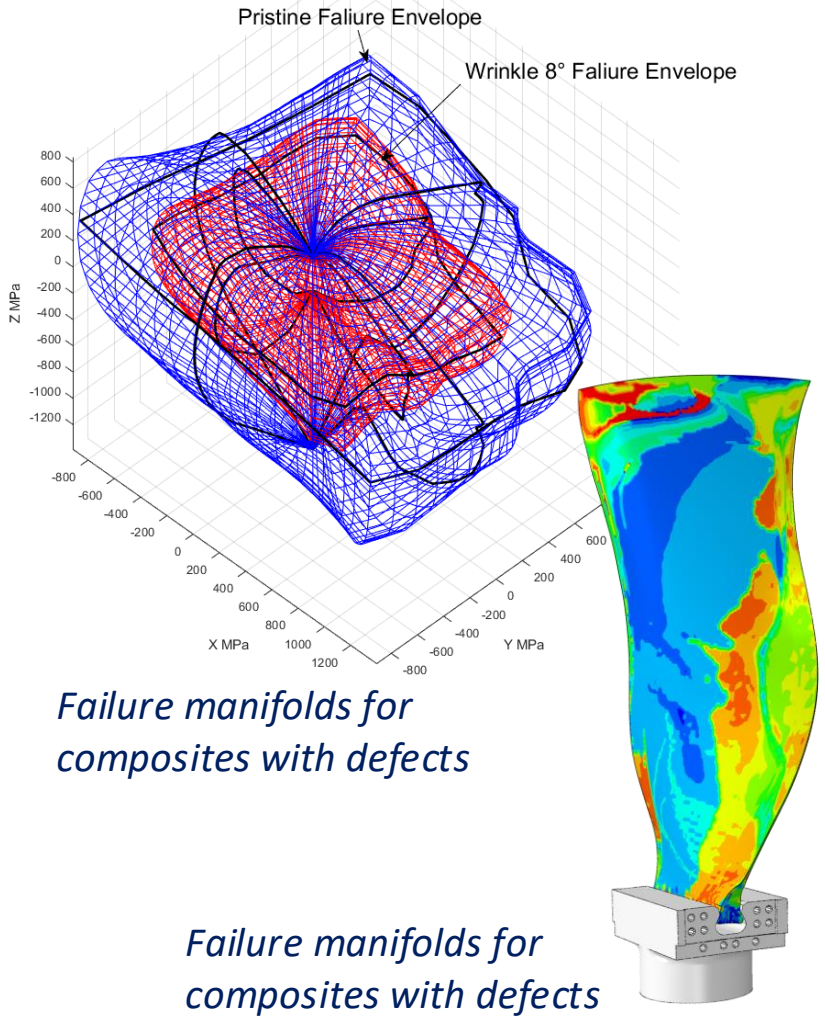


Data-driven Multi-scale Models

- Composites strength is dependent on loading conditions.
- Failure manifolds can describe the failure in terms of loading conditions and material layup.



High-Fidelity RVE



Failure manifolds for composites with defects

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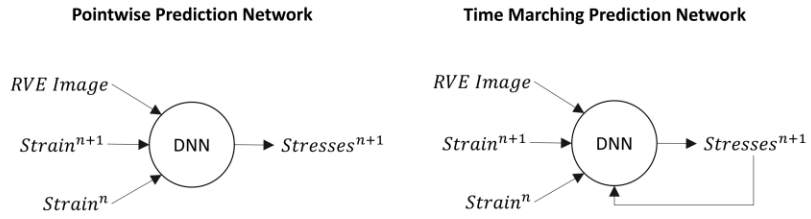
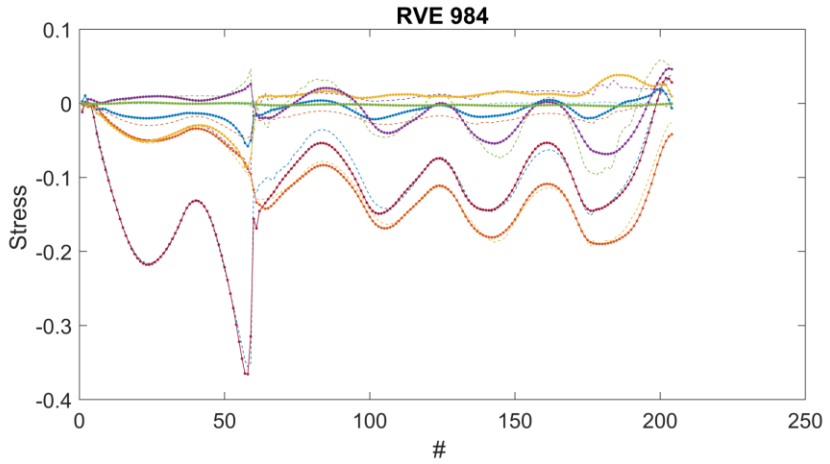


Deep LSTM/ CNN formulation

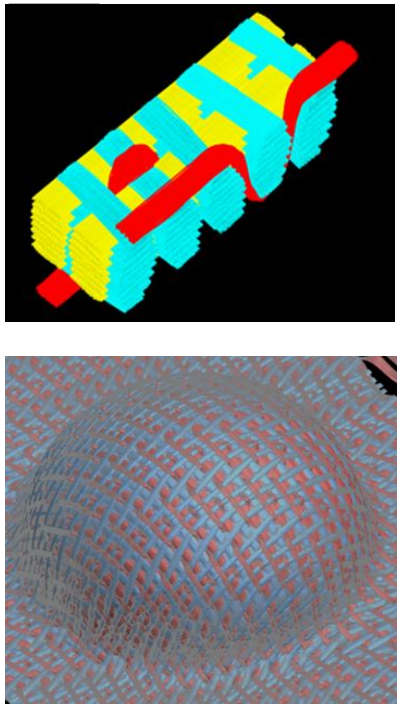


Deep CNN/ LSTM Output

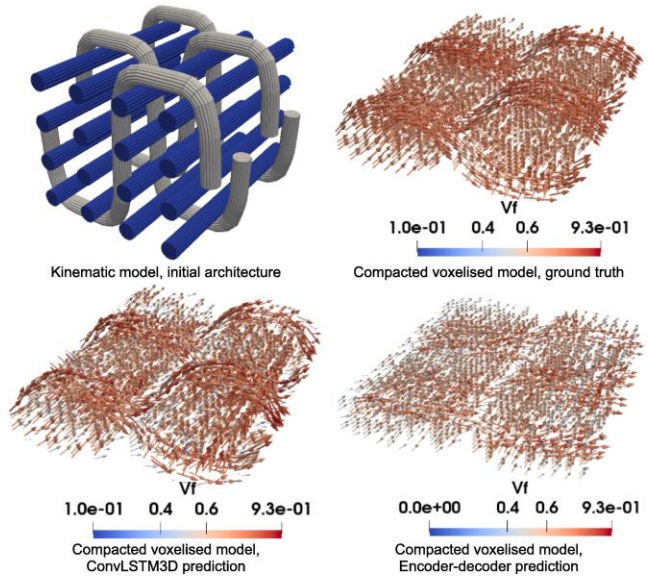
3D Woven Composites

- During manufacturing, 3D Woven, which are originally periodic, experience localised deformation leading to a non-periodic architecture.

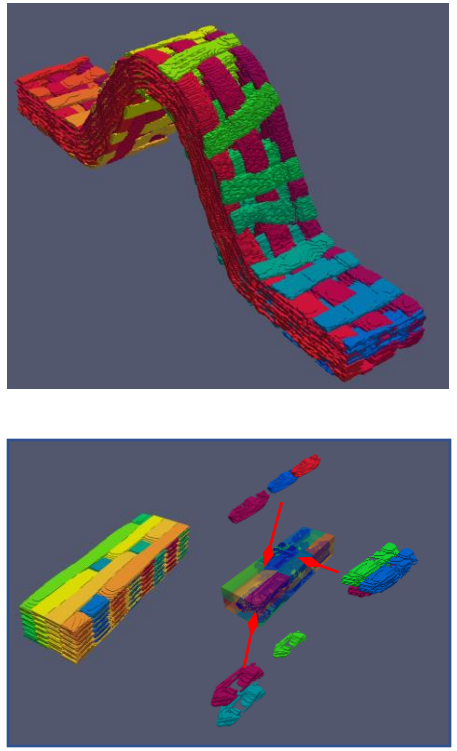
Manufacturing Simulation



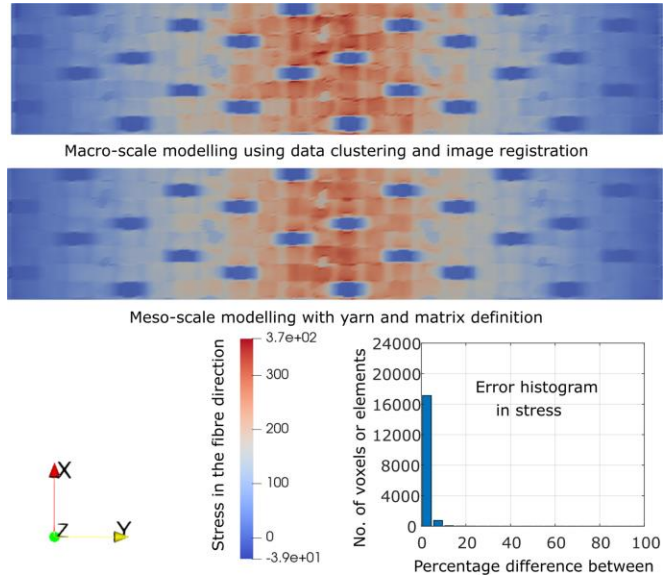
AI – Driven Manufacturing Simulation



Multis-scale Models



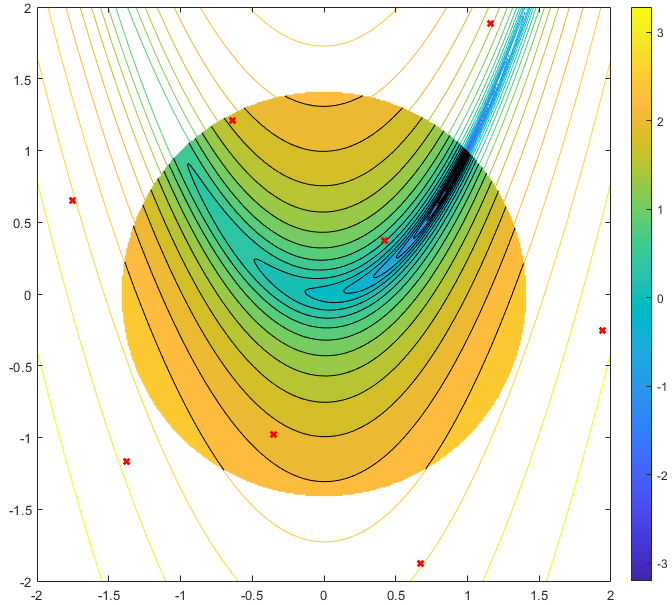
Data Clustering of Multis-scale Models



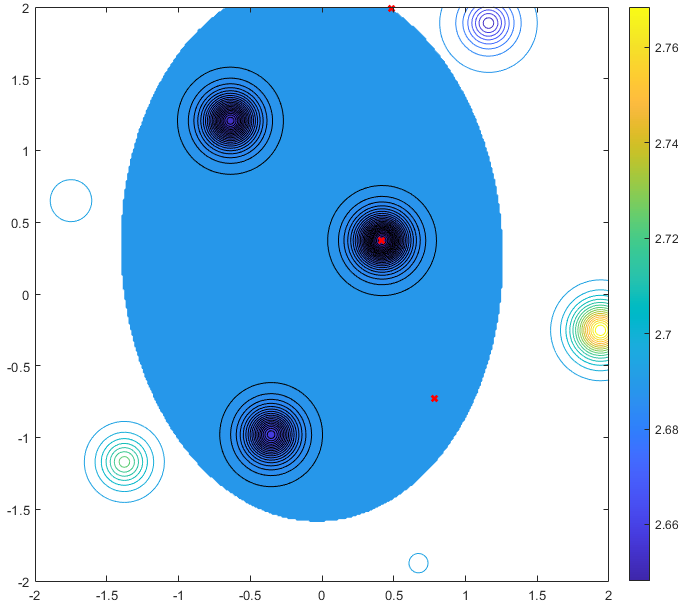
Perpetual Learning Artificial Intelligence

- Perpetual Learning enables an AI system to use a physics-based model to explore the composite response space.
- The system can be used for design, optimisation and quantifying the impact of variabilities

True Function



Perpetual Learning



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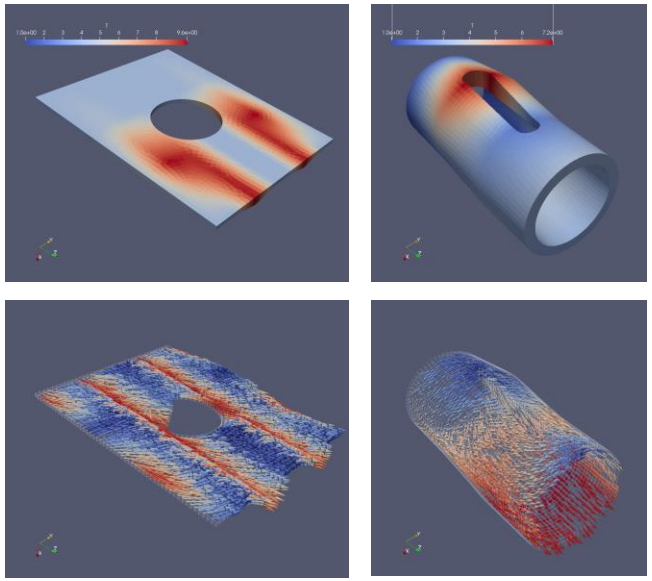
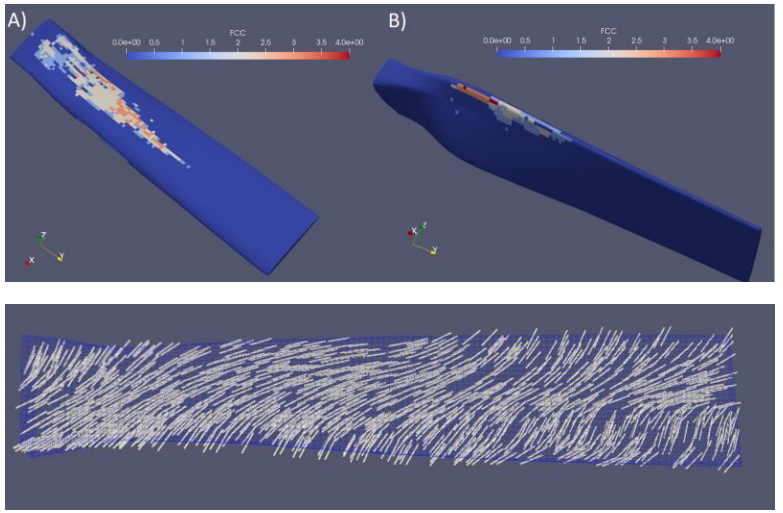
Design and Optimisation



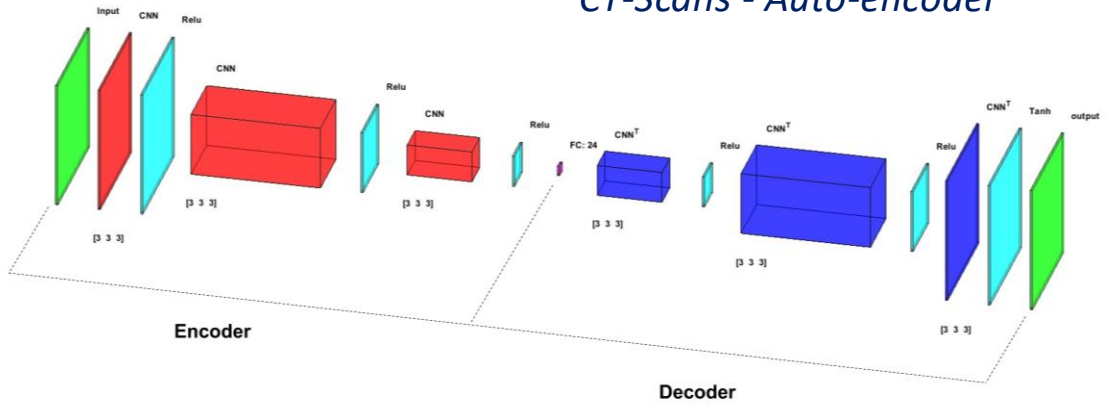
Impact of Defects

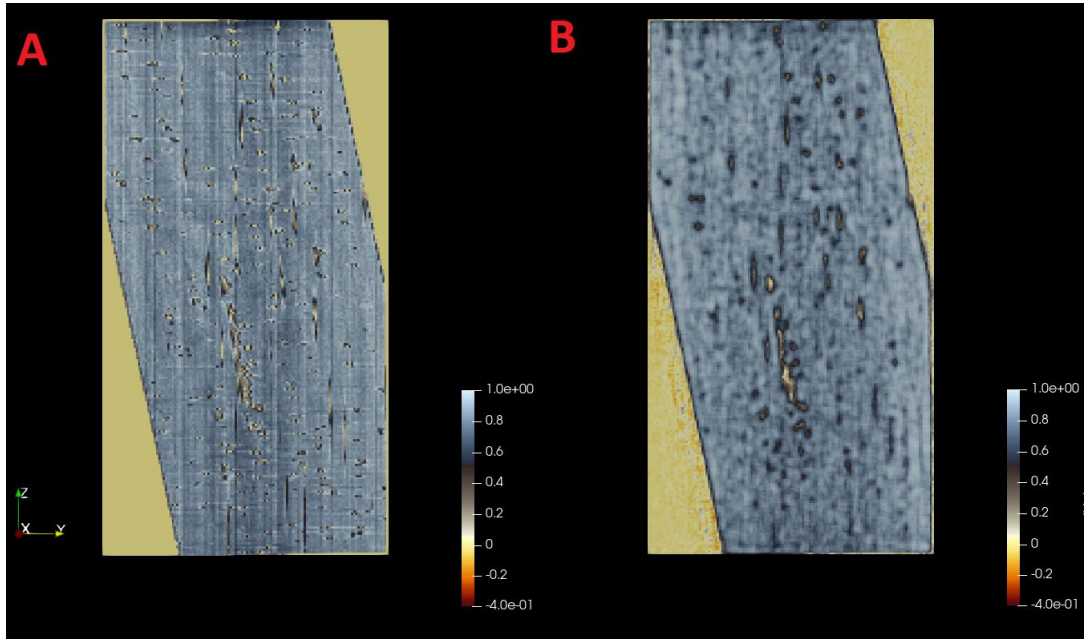


Explainable AI

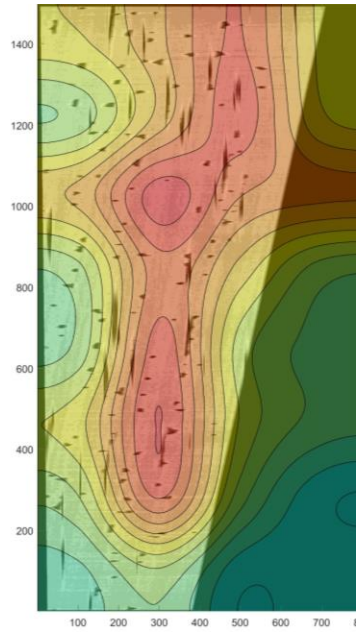
- AI can be used to extract key information from complex experimental datasets.
- A deep learning model was used to explain the impact of voids on composite strength.

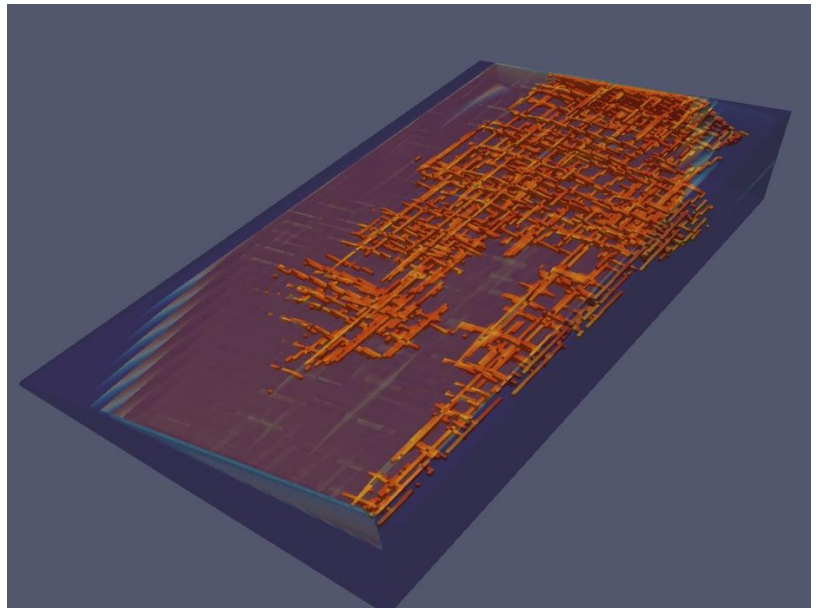
CT-Scans - Auto-encoder





Auto-Encoder Applied to CT-Scan of IM7/8552





GradCAM Analysis

THANK YOU FOR YOUR ATTENTION

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