SimuStruct: Simulated Structural Plate with Holes Dataset with Machine Learning Application

João Alves Ribeiro[1234]
jpar@mit.edu

Supervisor(s): F. Ahmed[4], H. Penedones[2], J. Belinha[35], L. Sarmento[2] & S. Tavares[6]

1. Faculty of Engineering, University of Porto
2. Inductiva Research Labs
3. Instituto de Engenharia Mecânica e Gestão Industrial
4. School of Engineering, Massachusetts Institute of Technology
5. School of Engineering, Polytechnic of Porto
6. Department of Mechanical Engineering, University of Aveiro

MIT Portugal
2022 Annual Conference

MOTIVATION

Traditionally, **linear elastic simulation has been performed using the Finite Element Method** (FEM), which **despite being accurate in simulating the mechanical properties**, is usually **too computationally intensive and slow** to allow fast iterations over-optimization cycles. In order to alleviate this restriction, **several disruptive methods based on Machine Learning (ML) have been explored**. However, there are **two big challenges when using ML approaches** in structural analysis: **ML models are often specialized in solving only one type of geometric case**, and it is **not trivial to perform a fair comparison between all the various ML approaches**. **This work introduces the SimuStruct**, a **dataset of structural parts containing numerical solutions to characteristic case studies**, to help overcome the previous limitations.

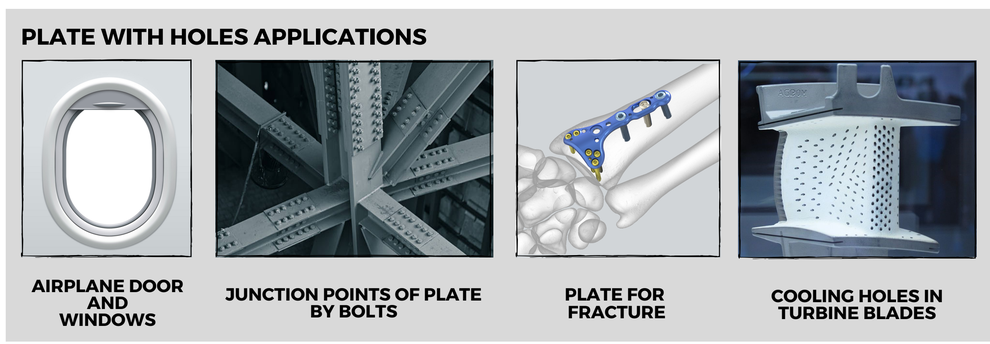
RELATED WORK

Datasets in Structural Analysis:

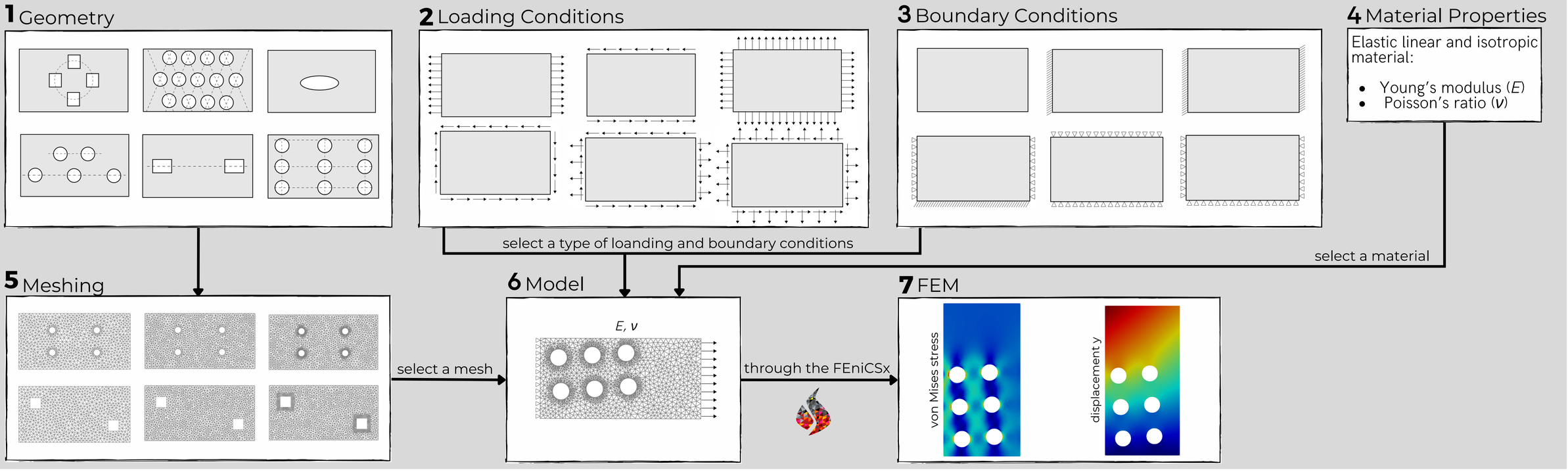
- **simJEB:** focused on only one application (jet engine brackets). Has consistency but is not scalable.
- **Mechanical MNIST:** uses handwritten digits. It does not represent a real case of structural design.

SIMUSTRUCT

There are many structural cases that can be used to develop this dataset. It was decided to start with the fundamental cases, since if these ones are successful, then we have real chances of solving more complex cases. The **first dataset** is a **classic case of mechanical engineering: plate with holes**, due to the **simplicity of a 2D problem**, and **can be found in various applications**. In future versions will be added other relevant cases.



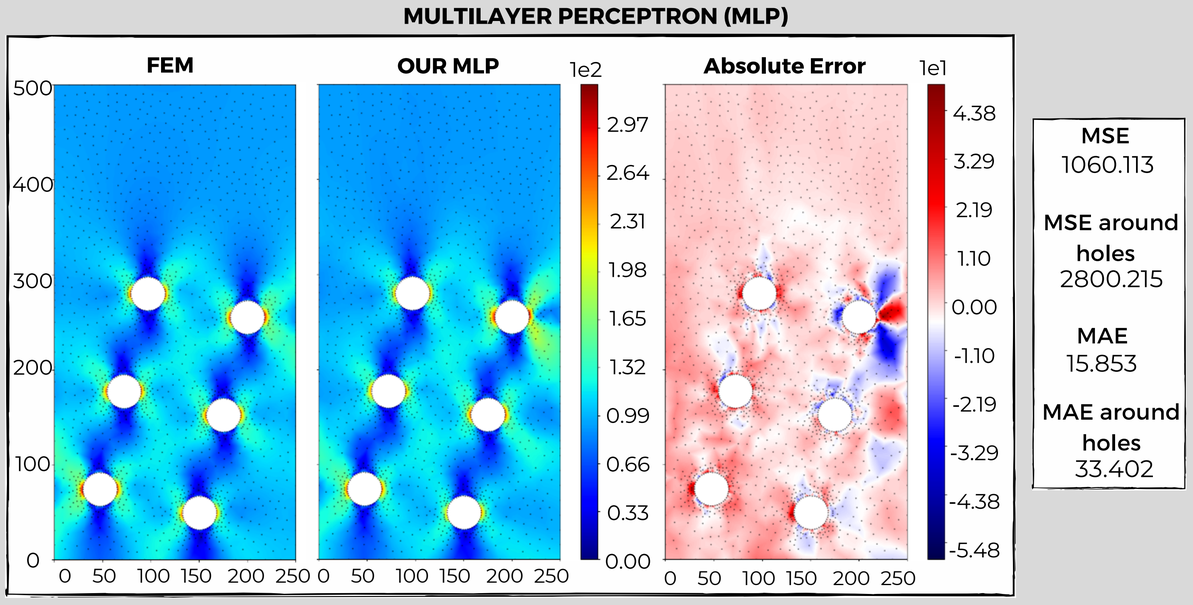
METHODOLOGY



APPLICATIONS

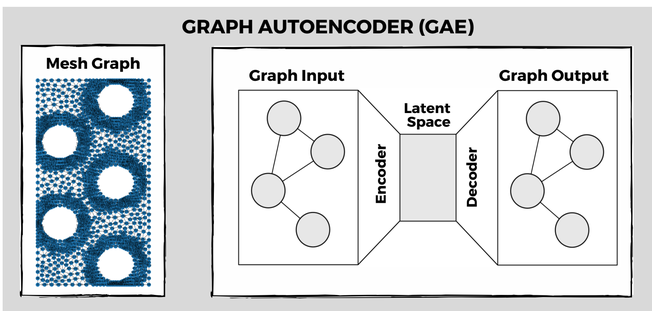
The case study is a rectangular plate with six holes loaded biaxially. Dataset generated through SimuStruct.

Our goal is to **predict the von Mises stress field**.



FUTURE WORK

The goal would be to **embed the geometry provided as a mesh graph through a graph autoencoder**. SimuStruct has already implemented the graph structure for the meshes.



CONCLUSIONS

The implementation of **ML-based methods on structural assessment has high potential**. However, **it requires datasets, representative of different problems** in order to be trained for stress-strain prediction, for enhanced mesh generation, and for faster optimization. **SimuStruct is open, aiming the collaboration from different groups, creating opportunities for innovative approaches for structural design**.

Funded by:

FCT Fundação para a Ciência e a Tecnologia — MIT Portugal

under the Doctoral Grant SFRH/BD/151364/2021 | Digital Transformation in Manufacturing