Learning Structural Dynamics with Graph Neural Network

Introduction

Graph Neural Networks (GNNs) / Message Passing Neural Networks (MPNNs) have shown impressive performance in various tasks ranging from molecule generation to computer graphics or even physics-based simulations. On the other hand, operations on structural meshes, such as condensation, are well established in the FEM community. Yet, the relationship between MPNNs and these structural operations remains largely unexplored. This thesis aims to formalize the equivalence between the message-passing scheme and operations on FEM matrices.

Keywords: graphs, geometric deep learning, structures, message passing

Description

This thesis aims to formalize the equivalence between message-passing neural networks and operations on structural matrices. The proposed research will contribute to the understanding of the underlying mechanisms of MPNNs and help develop more efficient and interpretable MPNNs as alternatives to structural simulators.

Desired competencies: Solid knowledge of Python and PyTorch. Experience and/or good knowledge about ML and structures (FEM).

Goal

This thesis aims to formalize the equivalence between message passing neural networks and operations on structural matrices. Specifically, the student will have the following objectives:

- Review the existing methods and literature.
- Become familiar with the PyTorch Geometric framework.
- Implement a first prototype, based on existing work from the literature.
- Develop a theoretical framework for formalizing the equivalence between MPNNs and structural operations.
- Formulate methods for sub-structuring/condensation schemes which exploit this framework.
- Demonstrate the method on a simple case study, exploring its advantages and limitations.

Involvements

Person	Role	Organization
Duthé Gregory	Host	Structural Mechanics (Prof. Chatzi) (ETHZ)

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Duthé Gregory	Host	ETH Competence Center - ETH AI Center (ETHZ)