ME 5984 Data-Driven Modeling and Materials Design
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Course Project-2: Data-Driven Design of Multi-Phase Materials

Additive manufacturing (3D printing) has revolutionized how materials are designed and manufactured. However, predicting the mechanical properties of 3D-printed parts remains a challenge due to the complex relationships between processing parameters, material properties, and external factors. In this project, you will leverage data-driven modeling/machine learning techniques to design the structural arrangement of a plate made of a two-phase composite material that can be 3D printed.

The arrangement involves 64 square elements that can be printed as two different material phases: a soft and a stiff phase. The soft phase has a stiffness that is 10 times lower than the stiffness of the stiff phase.

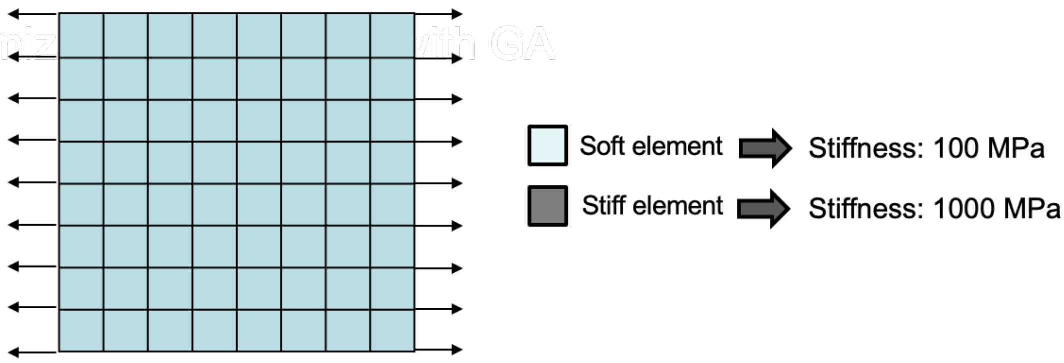

Figure 1. 2D view of the plate structure involving 64 square elements. Each element can be printed as a soft phase or a stiff phase during 3D printing.

<u>Assumptions</u>:

- All 64 elements are geometrically identical, and half of these elements (32 elements) should be printed as the soft phase.
- Both soft and stiff phases involve isotropic material properties. The stiffness values for stiff and soft phases are 1000 and 100 MPa, respectively.
- You can assume plane stress conditions (thin plate) and solve the problem in 2D.
- Apply displacement-controlled boundary conditions to perform an elastic simulation.

Use a <u>data-driven strategy</u> to find the optimum distributions of stiff and soft phases that maximize the stiffness of the plate. Consider the stiffness of the plate design along different directions. You can create data by performing finite element simulations for the given system.

Plot the optimum design (optimum distributions of the soft and stiff phases). Verify your data-driven design with physics-based simulations.

Grading Rubric

Category	Points	Description
Training Data Generation	20	Establishing the physics-based model, generation of sufficient and efficient training data
Model Development	30	Building the data-driven model, proper evaluation of models using metrics (e.g., RMSE, R^2) and demonstration of model performance.
Optimization	30	Logical and well-explained approach to finding optimum distributions of phases. Verification of result.
Interpretation	10	Engaging and clear presentation summarizing findings, with logical recommendations and interpretations.
Presentation Quality	10	Clear and concise structure with proper explanations, visualizations, and grammar.