

Developing AI Agents for Efficient Topology Optimization

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Introduction

Topology Optimization:

- Computational method utilized during the design process that minimizes material usage without compromising the structural integrity of a part based on applied loads and boundary conditions
- Vital tool for engineers but challenging to operate

Problem Statement:

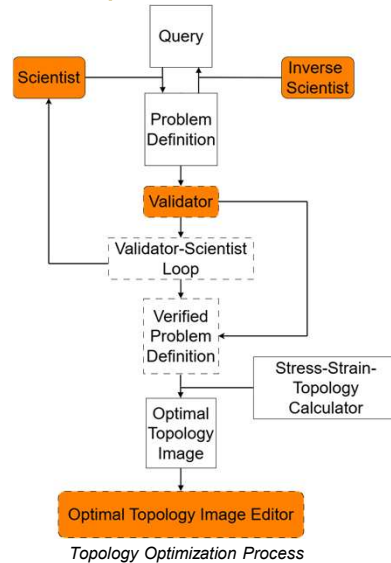
- Simplifies the interaction an engineer has with topology optimization, allowing them to increase their efficiency

Objectives

- To develop an **AI agent pipeline** to automate the topology optimization process by understanding and revising natural language queries and JSON script
- To use topology dataset to generate queries and optimal topology images
- To edit the images to handle user requirements outside of boundary conditions, forces, and a volume fraction (problem definition)

Method

Pipeline Overview:

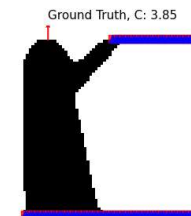


Description of Agents:

- Each AI agent exists as a separate **Python** file which are equipped with an **OpenAI large language model (LLM)** and a **system prompt** that send and receive information from one another
- Starting with the Scientist, it uses the user query as an input and outputs a .json file. Scientist output becomes Validator input which adds any missing information and checks consistency between the initial query and Scientist output
- Finally, problem definition is converted to an image using Python's visualization tools

Results

- Using a batch of topology data which contains **32 samples** (3 are shown below), the pipeline successfully generated topology optimized images of each sample with the correct boundary conditions and applied loads
- **0% error** between the numerical parameters in the user query and the problem definition created by the Scientist agent



Optimal Topology Images

Conclusions

Accomplishments:

- Scientist agent that converts user queries into a problem definition
- Inverse Scientist agent that generates user queries from a problem definition
- Topology optimized images developed from problem definition

Future Developments:

- Validator agent to check consistency between problem definition and user query
- Image editor for specifications (e.g. manufacturing and pixel-precise geometry) not addressed in pipeline

References

1. Chung, Hayoung., and Hyunjee Park. 2026. "Self-Refining Topology Optimization via an LLM-Based Multi-Agent Framework." arXiv.2605.23273v1 [cs.MA].