Multi-Agent AI Framework for Self-Supporting Topology Optimization

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Introduction

Topology optimization is a powerful computational method used to design lightweight and high-performance structures. However, traditional workflows often require extensive manual setup and produce designs that are difficult to manufacture, particularly for additive manufacturing processes.

Recent advances in artificial intelligence and multi-agent systems offer opportunities to automate engineering workflows. By integrating AI into topology optimization, it is possible to reduce manual intervention, improve consistency, and generate designs that are both optimal and manufacturable.

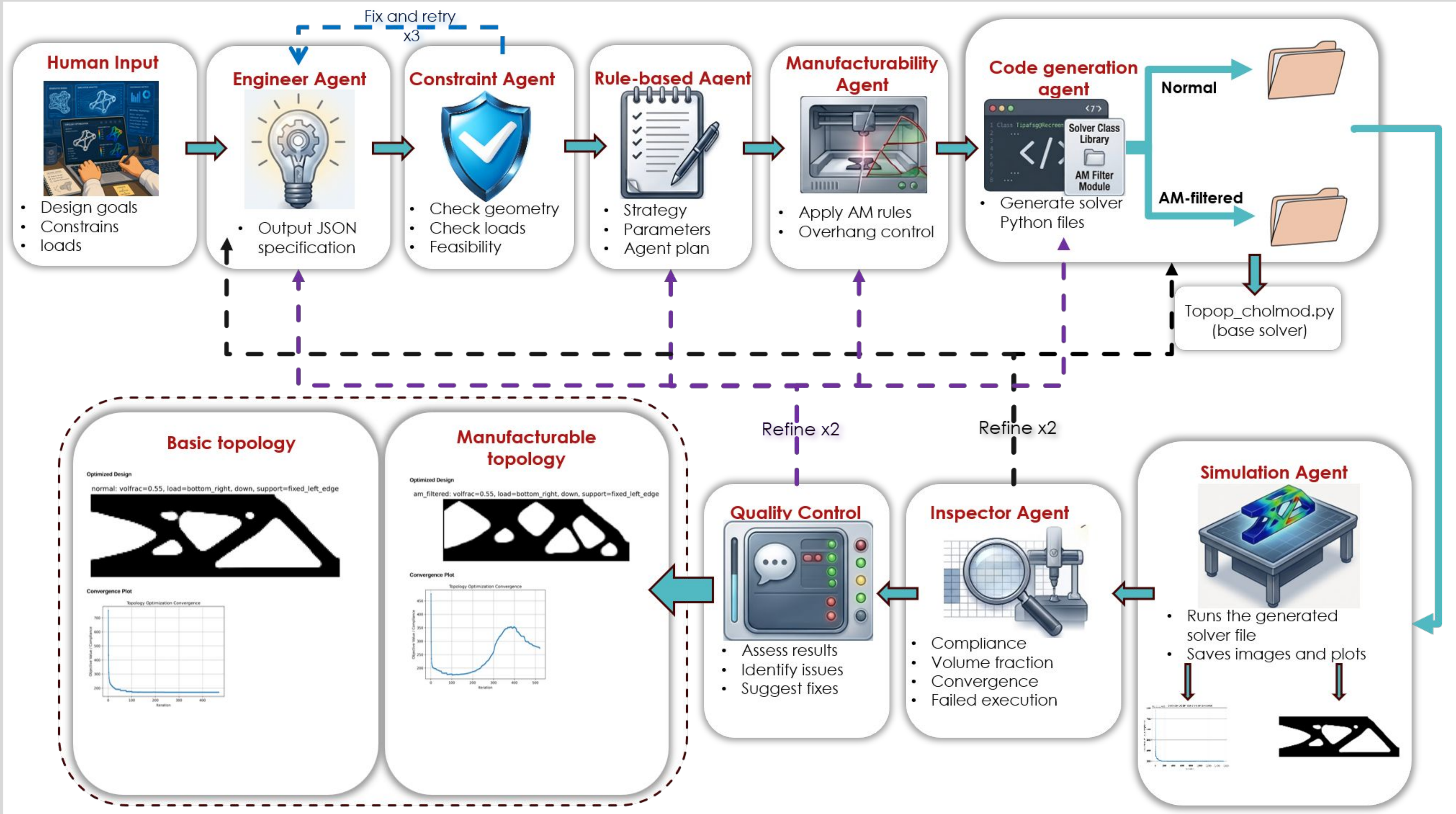
Method

The proposed system uses a multi-agent architecture to automate topology optimization:

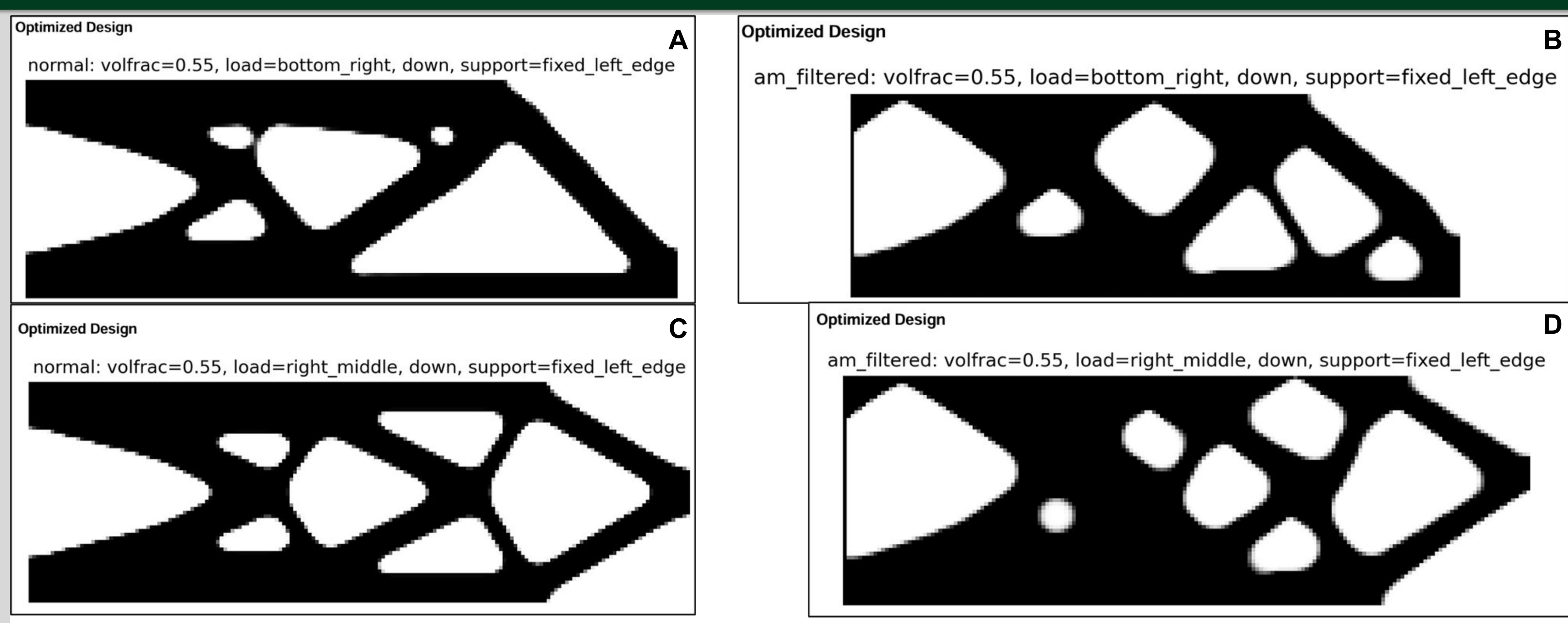
- ➢ Engineer Agent: Converts user input into structured problem definitions
- ➢ Constraint Agent: Validates geometry, loads, and feasibility
- ➢ Rule-Based Agent: Defines optimization parameters
- ➢ Manufacturability Agent: Applies AM constraints and overhang control
- ➢ Code Generation Agent: Generates Python solver files
- ➢ Simulation Agent: Executes optimization and generates outputs
- ➢ Inspector Agent: Evaluates convergence and performance
- ➢ Quality Control Agent: Identifies issues and suggests refinements

Objectives

- ➢ Develop an AI-driven multi-agent framework for topology optimization
- ➢ Automate the full workflow from user input to final design
- ➢ Incorporate manufacturability constraints for additive manufacturing
- ➢ Generate self-supporting structures without manual redesign
- ➢ Produce complete reports including geometry and convergence behavior

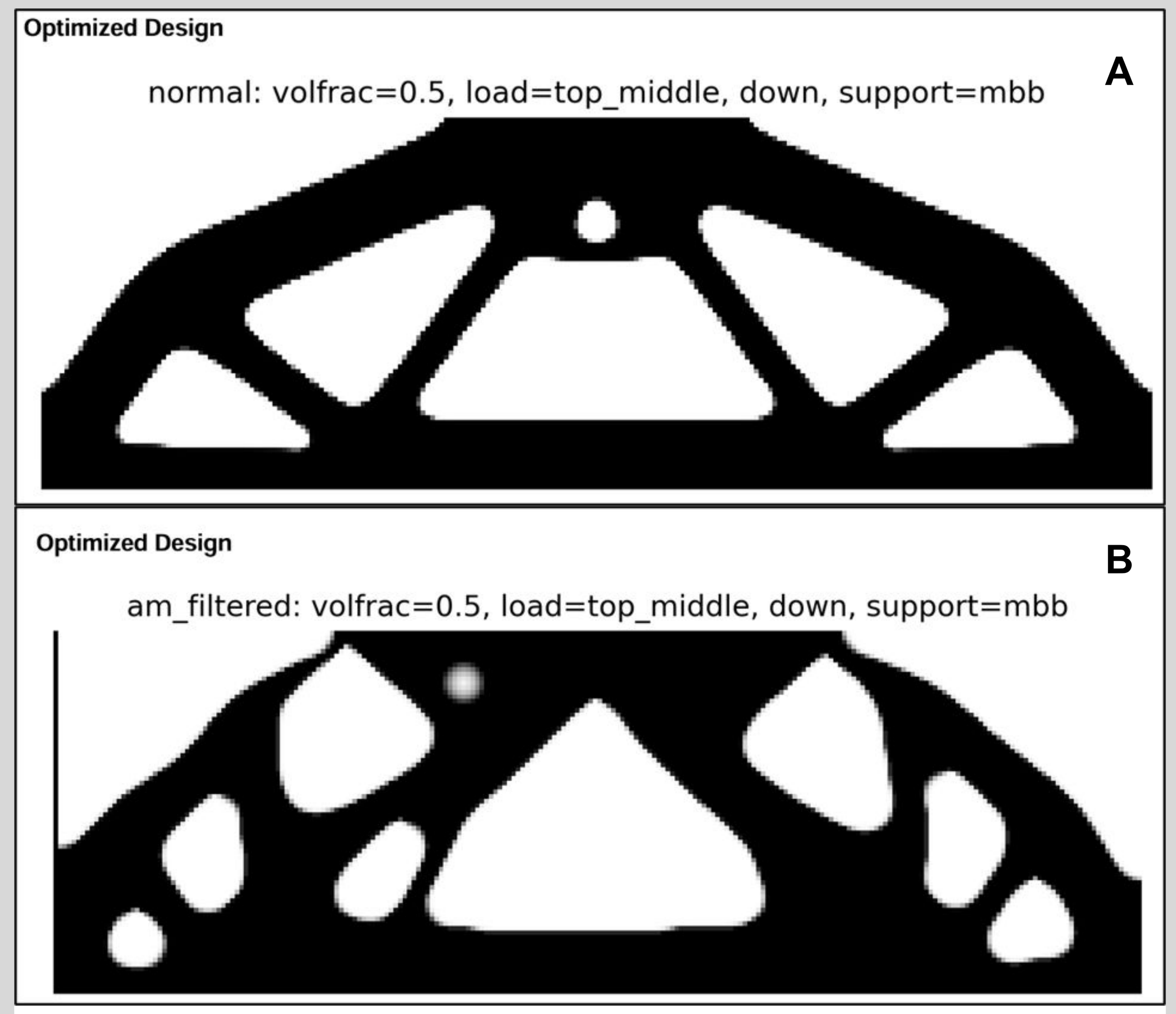


Results



Topology optimization results for cantilever beams under varying load positions. Standard designs (A, C) are compared with AM-filtered, self-supporting designs (B, D). The manufacturability filter reduces unsupported features while preserving the primary load paths and structural integrity.

Results



Comparison of standard and manufacturable topology optimization for an MBB beam. The AM-filtered design (B) reduces unsupported features while preserving the primary load paths observed in the standard design (A).

Conclusions

- ➢ Developed a multi-agent AI framework for topology optimization
- ➢ Automated the full design workflow
- ➢ Integrated manufacturability constraints for self-supporting designs
- ➢ Demonstrated adaptability across multiple scenarios
- ➢ Generated complete, interpretable outputs

References

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