College of Design, Construction and Planning

UF DCP Research Agenda-Setting White Paper

Generative 3D Structural Forms

A Text-to-3D AI Generative Pipeline for Structural Design

Executive Summary:

This white paper presents an AI-assisted design framework that enables partial customization of 3D architectural models through natural language input. Unlike fully automated generative tools, the framework supports the early conceptual design phase, allowing designers to explore abstract and culturally diverse ideas. It integrates parametric generative algorithms, Natural Language Processing (NLP), and eye-tracking data to generate and iteratively refine models by capturing designers' visual attention and verbal feedback. This data builds a labeled dataset used to train AI systems that adjust specific form elements without regenerating the entire model. Rather than replacing human creativity, the AI functions as a semantic engine that translates diverse design intentions into expressive, structurally coherent forms. The result is a scalable, open-source platform that positions AI as a creative partner while preserving cultural and perceptual individuality. This work aligns with the Working Group's goals by advancing AI-driven generative design beyond visual aesthetics to support form-finding, functionality, and cognitive engagement.

WG Members:

Name	Title	Affiliation	Academia/ Industry/ Government
Lead: Karla Saldaña Ochoa	Assistant Professor	Architecture, UF	Academia
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Description of the Problem

Current AI generative design tools in architecture and engineering often prioritize image synthesis or entire-model generation, offering limited opportunities for iterative refinement or semantic control over model components. These tools frequently overlook structural validity and user-specific qualitative feedback in early design stages.

Key Research Areas / Priorities

- Natural Language Processing in spatial and structural design
- Human-AI co-creation frameworks
- Eye-tracking and cognitive modeling in design feedback loops
- Dataset creation and labeling strategies for 3D structural models

Primary Research Question

1. How can natural language be effectively used to control and customize 3D structural models?
2. How does culturally informed design perception influence AI-generated forms?
3. Can AI frameworks be trained to make localized, partial adjustments to 3D models?
4. How can eye-tracking data enhance model labeling and feedback accuracy?

Solutions and Methodological Considerations

To ensure that all generative outputs meet formal and functional requirements, the project leverages generative parametric algorithms. High-quality training data will be collected by combining eye-tracking measurements with think-aloud verbal responses from designers, generating a high-fidelity labeled dataset that reflects both cognitive focus and perceptual feedback. Using this dataset, the research team will train word embedding and generative diffusion models—such as Llama2 in combination with a modified Stable Diffusion architecture—to map natural language descriptors to GenAI parameters, enabling the generation of formal and functional sound 3D forms from qualitative input. A key deliverable is the development of a designer-centric AI interface that allows users to iteratively customize specific parts of the 3D model, rather than regenerating entire compositions, supporting a more intuitive and creative design workflow. To validate and refine the system, pilot workshops will be conducted in the

United States, engaging architectural and interior design students in hands-on testing and collaborative feedback.

WG's Strengths, Weaknesses, Opportunities, and Challenges:

Strengths	• Interdisciplinary team combining AI, and design • Experience in GenAI, NLP, and creative design methodologies	• Limited labeled datasets currently available for text-to-3D forms • High complexity of mapping qualitative language to 3D form variables • Requires extensive hardware/software resources for data collection	**Weakness**
Opportunities	• Define a new subfield within human-AI collaborative form finding design • Build an open-source platform and database for broader community use • Contribute to inclusive and culturally sensitive AI development in design	• Integrating perception-based feedback into machine learning at scale • Ensuring AI-generated models meet both creative and formal/functional design needs • Ethical concerns around personalization and bias in AI design tools	**Challenges**