

Generative Parametric Design: Bridging Large Language Models (LLMs) and 3D Manufacturing

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The Challenge: Traditional product design is slow. A brainstormed idea must be manually modeled in CAD, checked for printability, and iterated upon—a process that can take hours or days. We are skipping the manual design phase entirely.



The Vision: We want to create the foundation for a "Star Trek Replicator" that instantly translates human intention into a physically realizable 3D object. You will design a system where a user simply *describes* the product they need, and the system **automatically generates a guaranteed 3D-printable CAD file** moments later.

The Goal: To successfully link a state-of-the-art **Large Language Model (LLM)** to a **code-based parametric CAD engine**. This project is about proving that we can accelerate the product development lifecycle from days to

minutes, turning natural language into executable manufacturing instructions.

Task 1: Intent Capture and Parameter Extraction (The LLM Interface)

This module handles the natural language input.

- Integrating with a powerful LLM (via API) to receive a user's prompt (e.g., "Design a remote control with 8 buttons and a wrist strap hole").
- Developing an **LLM prompt engineering strategy** to force the model to output structured, machine-readable parameters (e.g., JSON format specifying `product_type: remote_control`, `button_count: 8`, `feature_strap_hole: true`).

Task 2: Parametric Model Logic

- Developing the Python-based logic for a chosen product family (e.g., **Custom Enclosures** or **Ergonomic Handles**).
- Implementing a **parametric CAD script** using a library like OpenSCAD or CadQuery. This script uses the LLM's parameters as inputs to mathematically define the geometry.

Task 3: System Integration and Output

This module connects the AI brain to the manufacturing tool.

- Developing a simple Python application to manage the API calls, the parameter passing, and the execution of the parametric script.
- Generating the final, clean geometry as a standard STL file that is instantly ready for a 3D printer slicing software.

Keywords: Generative AI, LLM, Parametric Modeling, Computational Design, 3D Printing, Python, Rapid Prototyping.