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OpenSCAD Batch Exporter: Automating Parametric Design Workflows for Research and Engineering

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Summary

The OpenSCAD Batch Exporter is an open-source tool designed to automate the generation of STL models using parametric designs in OpenSCAD. By leveraging parameter files in CSV or JSON format, the tool simplifies the creation of multiple design variations, making it invaluable for research, prototyping, and engineering. Users can rapidly generate tailored design sets, allowing for applications such as experimental analysis, mass customization, and combinatorial design testing.

This tool addresses critical pain points in research and engineering workflows, such as the need to manually create or export designs from code-based CAD systems. By offering batch exporting capabilities, it supports efficient testing and analysis, promotes the use of parametric models in low-resource environments, and reduces bandwidth requirements by allowing compact script distribution instead of large 3D model files.

Inspired by community contributions and existing batch exporting tools, this project provides a polished and user-friendly solution, bridging gaps in usability and scalability within the OpenSCAD ecosystem.

Statement of Need

Parametric design tools like OpenSCAD enable researchers and engineers to create highly customizable 3D models. However, exporting multiple designs based on varied parameter sets can be time-consuming and error-prone. The OpenSCAD Batch Exporter automates this process, enabling rapid generation of design variants, which is critical for:

1. **Research Applications**:
   - Supports iterative experimental setups, such as those used in agrivoltaics, chemical synthesis, and hardware prototyping (al., 2020; Cameron K. Brooks, 2022; Pearce, 2021).
   - Allows researchers to optimize designs by testing numerous parameter variations without manual intervention.
2. **Mass Customization and Low-Resource Settings**:
   - Facilitates the distribution of compact scripts that can generate large design libraries, reducing storage and bandwidth requirements. This is especially beneficial for researchers in low-resource environments.
   - Promotes distributed manufacturing and parametric design practices (Felipe Machado, 2019; Pearce, 2021).
3. **Ease of Use**:
   - Provides a straightforward interface for non-experts, allowing users to interact with pre-made parameter sets without coding knowledge.

- Bridges the gap between OpenSCAD's code-based environment and accessible design workflows for scientific and engineering applications.

This tool significantly extends the usability of OpenSCAD, making it easier for researchers, educators, and makers to integrate parametric design into their workflows.

Functionality

The OpenSCAD Batch Exporter allows users to:

- Batch export models using parameter files (CSV or JSON).
- Select specific parameter ranges or combinations for targeted exports.
- Convert between CSV and JSON formats for interoperability.
- Specify export formats (ASCII or binary STL) and customize OpenSCAD paths.

A command-line interface and an intuitive graphical user interface (GUI) make the tool adaptable for users of varying expertise levels.

Related Work

This tool builds on efforts by the OpenSCAD community to streamline batch exporting (O. Community, 2023; P. Community, 2023). It integrates and improves upon existing approaches, notably:

- OpenSCAD Batch Export STL
- OpenSCAD Bulk Export

Unlike prior tools, the OpenSCAD Batch Exporter offers a complete and user-friendly package, with added functionality for parametric design workflows, broader compatibility, and robust documentation.

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Figures

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