Automated Process Planning for Multi-Material Manufacturing

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Background

Multi-material manufacturing:

- Allows for individual parts made with multiple materials and processes, such as milling, laser cutting, 3D printing, or casting
- Has the potential to create parts that include flexible joints, reinforcing materials, or integrated electronics
- Produces single parts that can take the place of entire assemblies made using conventional techniques
- Has applications in education for creating durable, low-cost robots

Problem

- The process for creating a part and the files needed to execute the process must be manually created
- Parts can require support features specific to the materials and processes used
- Specialized g-code files must be created for each machine
- Planning the process can be a barrier to students and teachers

Goals

Develop a framework and a software tool for:

- Representing and manipulating 3D objects with material data
- Creating required support features
- Generating a process for manufacturing a part
- Generating the g-code files needed by the process
- Generating a user-readable list of instructions

Verify the ability of the software to generate viable processes for different machines and identify potential manufacturing issues

Current Progress

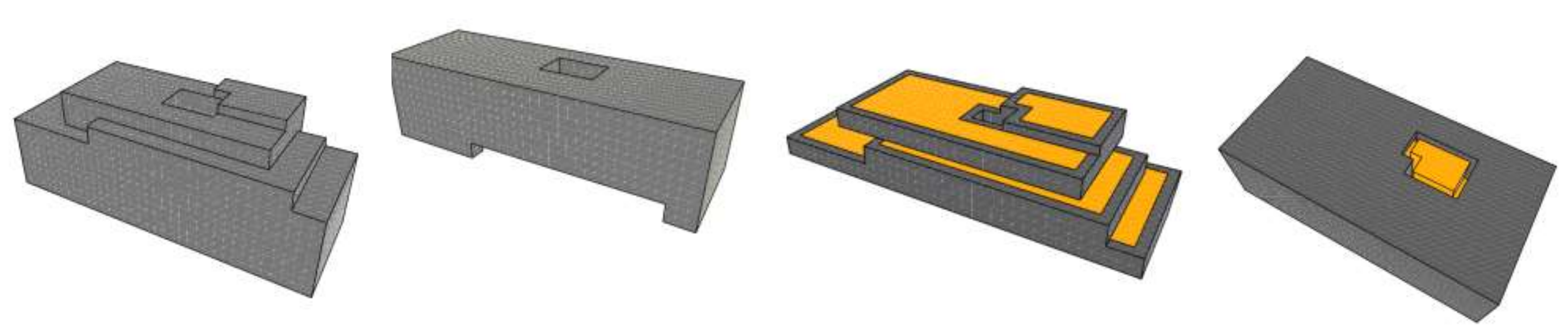
Mathematical Framework

A mathematical framework was first created to allow for the representation and processing of 3D models. This framework defines:

- A voxel-based approach for representing the properties of the material present at each point in a model
- Basic solid geometry operations
- Blurring operations
- Verification steps to check that all voxels have a physical meaning

Manufacturing Feature Algorithms

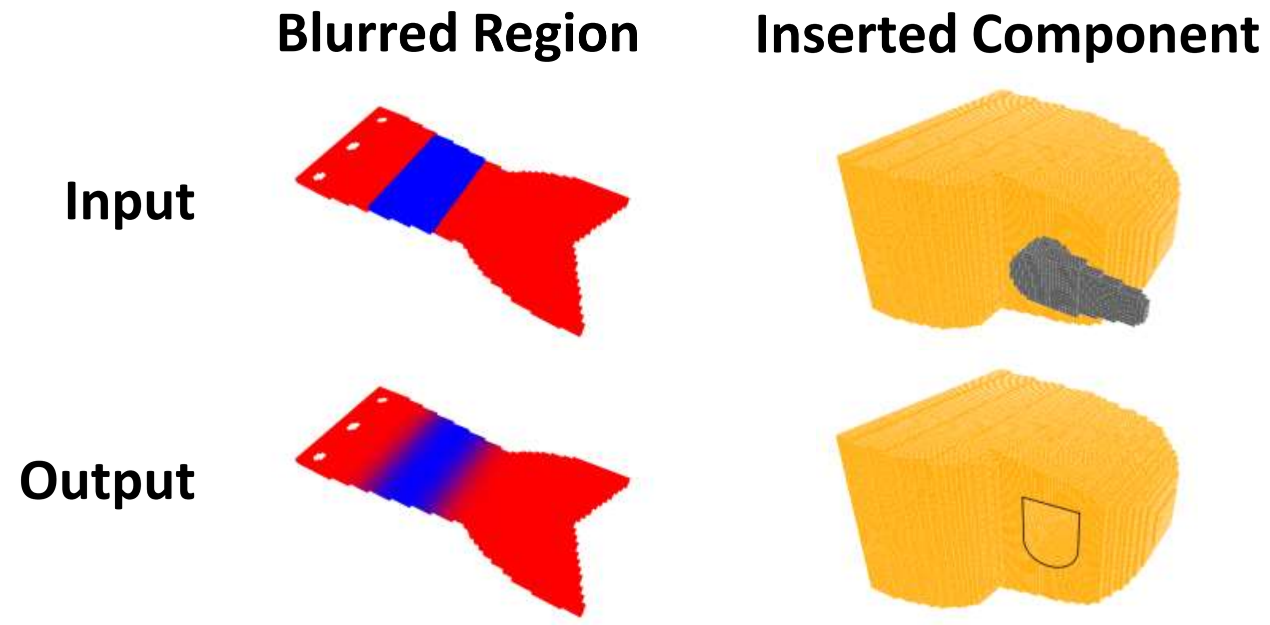
Algorithms were then created to generate various general features helpful for planning manufacturing steps. These features include keep-out, clearance, support, and web.



Exemplar Process Generation Algorithms

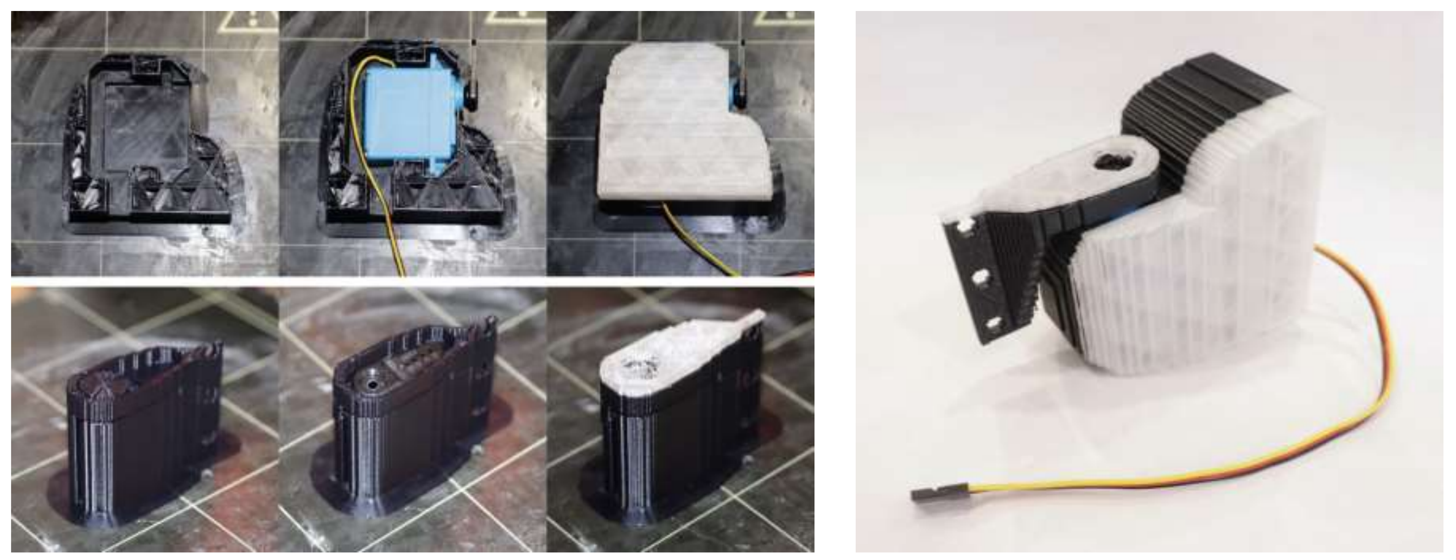
Using the framework and manufacturing features, algorithms were created to generate the files needed for manufacturing two classes of components. The first class of component was a 3D printed part with a blurred region. For this type of model, the gradient must first be generated, then each step in the gradient must be exported to a separate 3D model file.

The second class is a 3D printed part with an inserted discrete component. This type of part requires clearances around the inserted component to be added to the model, then pauses at the appropriate layers to be added to the g-code.



Implementation and Results

The framework and algorithms were implemented using Python. Two example models of a part with an inserted component were then manufactured based on the output of the algorithms. The resulting parts functioned as intended. Some dimensional errors were observed as a result of the use of voxels. Methods for correcting these errors will be considered in future work.



Future Work

- Expand framework with planning algorithms to support additional process types
- Develop algorithms for automatically selecting process steps
- Develop methods for improving dimensional accuracy
- Create software for producing user-readable instructions
- Optimize implementation to allow for greater speed and detail

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