Automated Process Planning for Multi-Material Manufacturing

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Background

Multi-material manufacturing combines multiple processes to produce individual parts that are made up of several different materials. These processes can include both additive and subtractive manufacturing methods as well as embedding other components during manufacturing. This yields opportunities for creating single parts that can take the place of an assembly of parts produced using conventional techniques. Examples include parts with integrated flexible joints, embedded reinforcing materials, or embedded electronics.

Problem

Multi-material manufacturing has applications in robotics because with it mechanisms can be built into a design without adding additional moving parts. This allows for robot designs that are both robust and low cost, making it a particularly attractive method for education or research. However, planning the process to create a part using multi-material manufacturing must be done manually and requires specialized knowledge of the tools used. The difficulty of the planning procedure can prevent many students and researchers from using multi-material manufacturing.

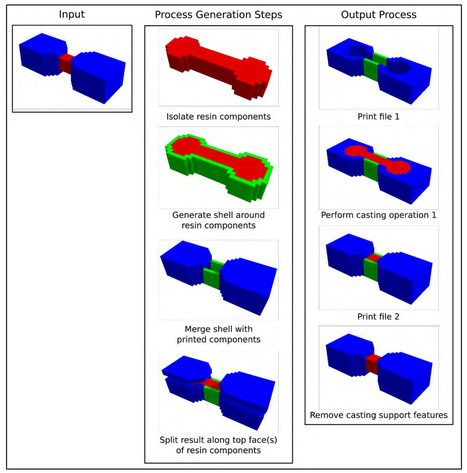
Goals

Develop and test a software tool to automate the planning of multi-material manufacturing processes. This includes:

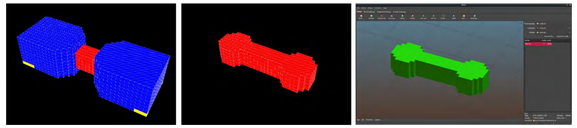
- Creating required support features
- Generating a process for manufacturing a part
- Generating the g-code files needed by the process
- Generating a user-readable list of instructions

Current Progress

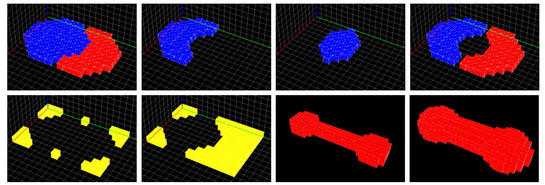
A voxel-based system has been selected for the representation of parts due to its ability to store the material at each point in a model. A simple joint design that combines rigid and flexible materials has been created using this system to act as a test case. This part and the desired output process are shown on the right.



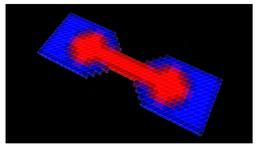
An open-source voxel painter program and corresponding Python library have been identified to allow designs to be created and imported into Python for processing. Functions have been created to allow the resulting models to be visualized and exported to the various 3D formats needed by the machines used.



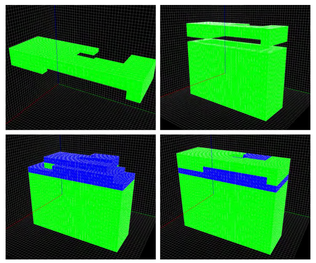
To support the development of planning algorithms, functions have been created to allow Boolean operations and dilate/erode operations to be performed on the voxel data.



Materials are represented by the RGB color values of voxels. 3D blurring functions have been created to allow new materials to be computed if adjacent resin materials are allowed to mix.



Software modules have been developed to generate features required for process planning including keepout, clearance, web, and support. These can accommodate for processes with and without depth control, such as milling and laser cutting respectively.



An additional software module has been created to allow for modifying the header information of g-code files and for inserting pauses in g-code at specified layers.

Future Work

- Combine software modules into a single program
- Verify that the software tool can create processes for producing a part given various materials and manufacturing methods
- Verify that the generated processes work as intended by executing them on the prototyping equipment in the IDEAlab
- Create software for producing user-readable instructions

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