Trajectory Planner for Automated Freeform Construction

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https://sites.google.com/a/g.ornl.gov/k_swift-spong/

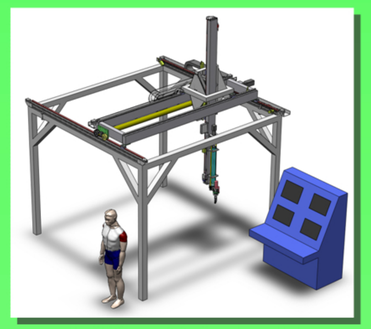

Figure 1. CAD model of gantry robot previously developed at ORNL.

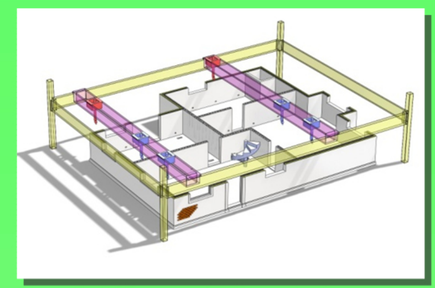

Figure 2. CAD model of AFC construction concept developed at ORNL.

Automated Freeform Construction (AFC)

- Current construction techniques
  - low tech
  - labor and resource intensive
- Poor energy efficiency and high greenhouse gas emissions large concern
- AFC techniques create stronger, more durable, and more complex structures with less waste
- Solid freeform fabrication process currently used for rapid prototyping can be applied
- Method of generating deposition trajectories from CAD models needed for ORNL AFC robot

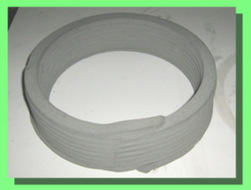

Figure 3. Circle outline previously created at ORNL.

Figure 4. Rectangular wall section with concrete fill previously created at ORNL.

Figure 5. Concrete deposition with ORNL robot.

Research objectives

- Survey available rapid prototyping software for possible freeform construction applications
- Test software to determine utility
- Use Matlab to
  - Read generated outline trajectories
  - Modify to fit with robot constraints
  - Output to trajectory file
- Test trajectory planner on ORNL robot

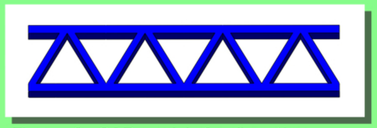

Figure 6. CAD model of wall section

Figure 7. Deposition nozzle on ORNL robot.

Software overview

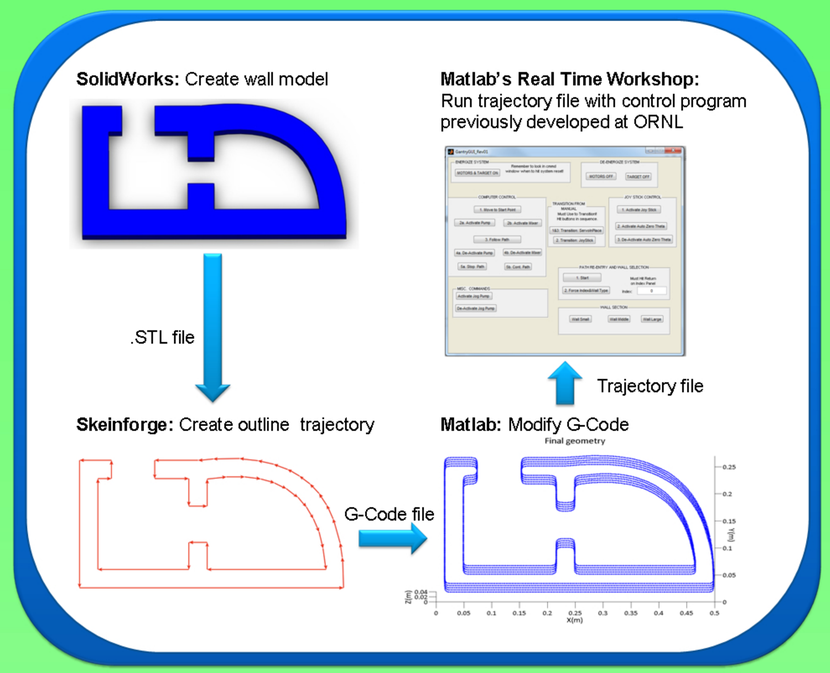

Figure 8. Flow diagram overview of software used for trajectory planning.

Interpreting and modifying G-Code

- Use Matlab
- Process data
  - Read G-Code file
  - Convert units
  - Linearly interpolate between points
- Create centerline pathway
- Round corners
- Add other variables
  - Create deposition head angles
  - Specify if pump on or off
  - Add time steps and velocity
- Output points in format (time, x, y, z, theta, pump, velocity)

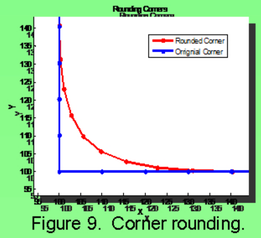

Figure 9. Corner rounding.

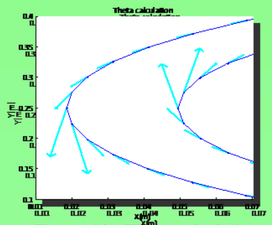

Figure 10. Theta calculation for each point.

Results

- Open source G-Code generation software, Skeinforge, used to generate shape outline
- Input trajectories generated with trajectory planning software successfully ran
- Pathway of robot deposition head corresponded to SolidWorks model

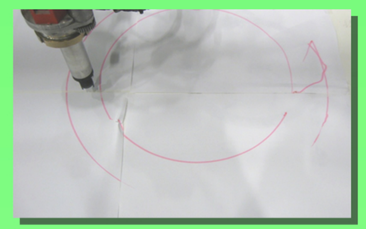

Figure 11. First layer of a column traced by robot.

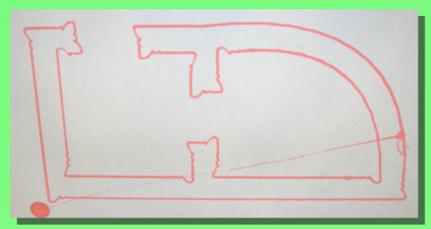

Figure 12. First layer of wall section traced by robot.

Future research

- Create more interior wall pathway types
- Improve user interface
- Incorporate wall model validation
- Improve pump flow control
- Use structured light scanning system for feedback
- Incorporate accelerators that harden concrete quickly

References

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