Development of Automated Wire Arc Additive Manufacturing Capability Using Slicer, RoboDK, and Welding Robots

Samuele Fredella, Andrew Merry, Grayson Pedde, David Nygaard, John Hall
Faculty Advisor: Dr. Tao Dai

BACKGROUND

- Wire Arc Additive Manufacturing (WAAM) implements Fused Deposition Modeling 3D printing concepts into a welding process using welding robotics.
- Extensive digital processing is required to obtain robot-readable G-code that the welding robot can execute correctly. Software such as various slicers and RoboDK is required to convert the CAD model into this readable code.
- Offline programming (OLP) versus manual programming reduces robot downtime, saving time and money.

OBJECTIVE

- Learn RoboDK software and what is required to obtain robot-readable G-code.
- Test and standardize robot movement, offline programming, and required 3D printing specific parameters.
- Test generated JOB files through "simple object" creation to confirm robot capabilities and parameters.
- Begin printing "complex objects" and test maximum overhangs, layer height, contact tip to work distance, and continuous ARCON welding (Spiral Vase Mode) for heat input effects.

METHODOLOGY

Figure 1: Yaskawa Cobot

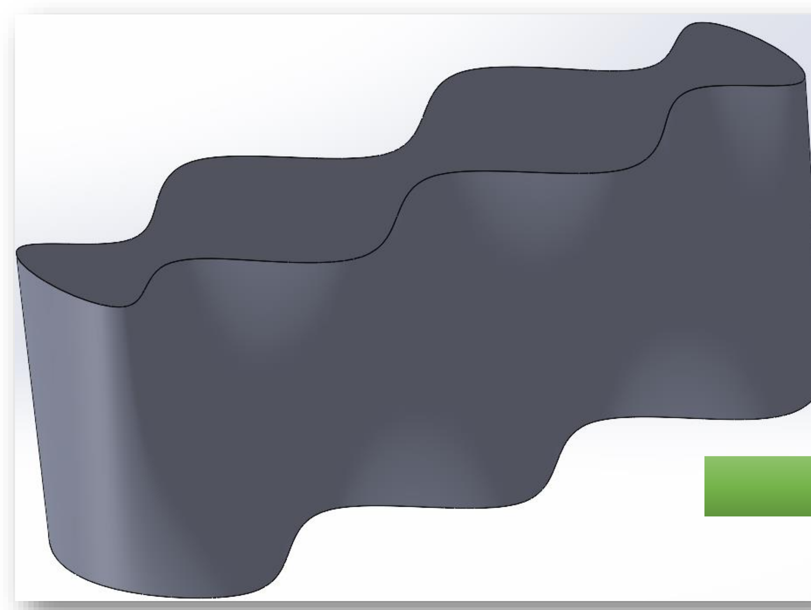
Figure 2: Yaskawa Industrial Robot

CAD Modeling and Path Planning
- A CAD model is first saved as an STL file, turning the object into many geometric patterns or "faces" of the object.
- Slicer then turns the STL file into individual stacked or "sliced" layers.
- G-code is then created from this, generating movement points for the robot to read and move to with embedded parameters.

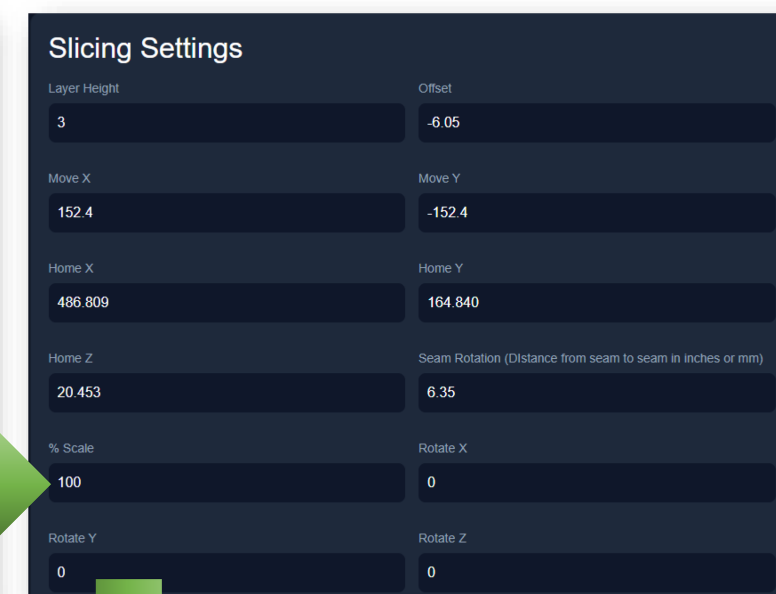
RoboDK and Offline Tool Programming
- The G-code is uploaded to RoboDK and positioned where desired in the simulation.
- RoboDK will then convert this G-code into a JOB file that the robot can execute.

From RoboDK to Welding
- Once the JOB file is uploaded to the robot's pendant, it can begin printing the object.
- This printed object is not the final part, but a near net shape of the final part. CNC machining may be required to smooth the part surface.

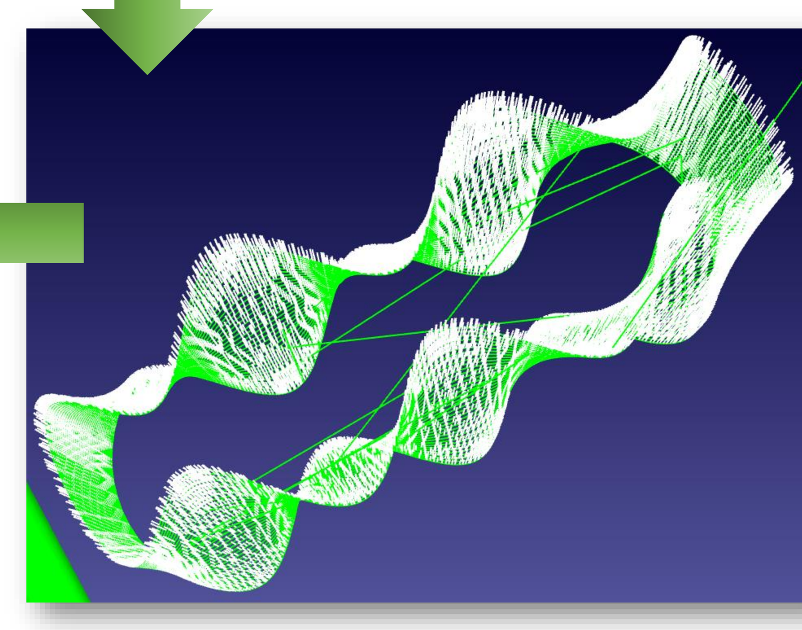
RESULTS & DISCUSSION



Step 1: Initial CAD Model



Step 2: STL File in Slicer



Step 3: Sliced G-Code in RoboDK

```
MOVL C00007 PL=1
MOVL C00008 PL=1
CALL JOB:JOBWAAM
MOVL C00009 PL=1
WVON WEV#(1)
ARCON ASF#(69)
MOVL C00010 PL=1
MOVL C00011 PL=1
```

Step 4: Generated JOB File

Step 5: Final Printed Object

ROBOTIC WAAM DEVELOPMENT

- Post-processor converts G-code to Yaskawa-specific robot language (INFORM), auto-generates ARCON/ARCOFF WVON/WVOFF functions, and sets MOV speeds to UNUSED.
- Custom slicer generates single-wall paths, allows seam rotation and continuous ARCON (Spiral Vase), and generates call jobs for pauses.

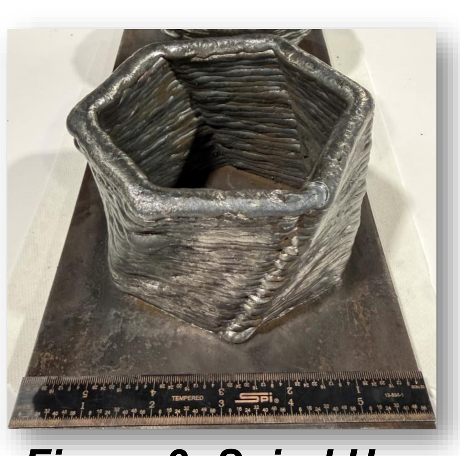


Figure 3: Spiral Hex

Figure 4: Circular Vase

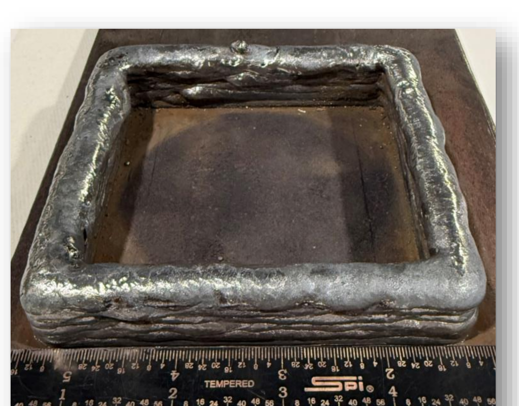


Figure 5: Simple Square

CONCLUSION

- Successfully created "complex objects" fully through a standardized digital process using RoboDK and slicer software.
- Achieved maximum overhang of 30 degrees and completed testing in continuous ARCON (Spiral Vase mode), seam stacking, layer height, and effects of heat input on layer stacking.

FUTURE WORK

- In-depth research into the metallography and mechanical testing of the printed objects.
- Introduce a more advanced active cooling system.
- Begin research on incorporating supports.
- Incorporate the adjustable table in the industrial robot cell.
- Parameter testing with aluminum instead of just various Steels.
- Begin machining down printed objects to obtain their final desired shape.

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