LSAAT 2024 Poster Competition

Proposed Title: Towards closed-loop feedback control and multimodal data collection of wire-arc directed energy deposition via robot operating system 2

Authors: J. Logan Betts[1,2], Ryan M. Stokes[1,2], Matthew W. Priddy[1,2]

[1]Michael W. Hall School of Mechanical Engineering, Mississippi State University, Mississippi State, MS 39762
[2]Center for Advanced Vehicular Systems (CAVS), Starkville, Mississippi State University, MS 39759

Abstract (250 words max):

Wire-arc directed energy deposition (arc-DED) has enabled the creation of large-scale components due to higher deposition rates (1-5 Kg/hr) compared to other metal-based additive manufacturing methods. However, the process's complexity, including internal defects, geometric deviations, and thermally induced distortions due to cyclical heating and cooling, remains a challenge. The process parameters and component geometry directly impact thermal history since heat transfer and cyclical heating changes with each layer. Currently, sensors within a weld cell are operated independently, causing issues with data synchronization and potential human error when recording or aligning data. Using fixed inter-pass dwell times in arc-DED can cause varied microstructures and increased thermal distortion due to differences in cooling and heat dissipation across layers. Varying dwell times based on standardized interpass temperatures can lead to improved thermal histories, where the component experiences a more "uniform" thermal cycle with each new layer. A novel ROS2 digital twin of an ABB FlexArc 250 weld cell has been developed, capturing the robotic joint states, instantaneous welding parameters, two IR cameras, and K-type thermocouples facilitating robust multimodal data collection. Closed-loop feedback control, managed through ROS2, regulates the start of new layers based on cooling metrics captured by an IR camera. Implementing closed-loop feedback for dwell time management increases the deposition rate and enhances the quality of the final product by maintaining optimal thermal conditions. This novel application of ROS2 for managing the arc-DED process paves the way for broader interoperability within a digital twin, as the ROS2 messages are not sensor dependent.