Real-time Integration of Multi-device Networks to Optimize Wire Arc Additive Manufacturing Processes

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Introduction

- **Wire Arc Additive Manufacturing** automates **GMAW welding** to manufacture large-scale metallic components with high deposition rates and material efficiency.
- Current **WAAM** systems rely on disconnected interfaces, which limits manufacturing and **real-time monitoring** capabilities.
- This project utilizes a **multi-device system network**, including sensors, a collaborative robot, welder, ultrasonic generator, and thermal/vision camera.
- Development of a unified **virtual dashboard** enables **real-time** telemetry visualization and system monitoring.

Objectives

1. To enhance understanding of WAAM through interactive learning and review of different technologies.
2. Establish an overarching design of the system architecture and device connectivity.
3. Integrate communications between devices and sensors across the network.
4. To develop a virtual dashboard that will incorporate real-time monitoring of the WAAM process, and data visualization.

Methods

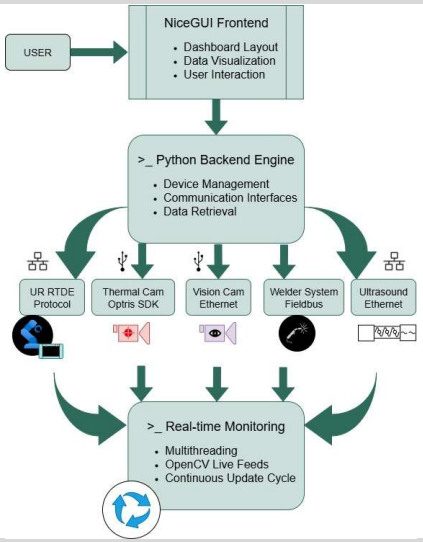
Software

- Python and NiceGUI, were used to create the dashboard, formatted with TailwindCSS.
- OpenCV and NumPy were used for the backend framework.
- UR RTDE Protocol and Optris SDK established communication with the robot and thermal camera, respectively.

Hardware

- UR30 Collaborative Robot
- OTC Welbee P400 Welder
- MPI2000 Ultrasonic Generator
- Optris PI 1M Thermal Camera
- Cavitar C400 Welding Camera

System Architecture



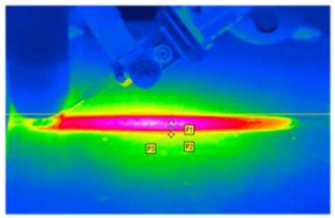
Implementation

Thermal Multithreading:

- Frame Acquisition was accomplished via continuous background threading of palette image and temperature data.
- Thread locking allows for these two threads to function independently. This method eliminates camera latency, allowing real-time monitoring.

RTDE Protocol Integration:

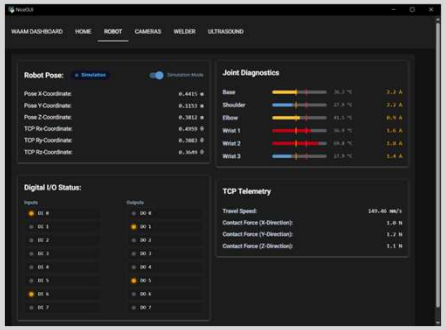
- Devices are defined as objects, with modular algorithm design.
- Two separate interface objects maintain data communication: Receive interface controls robot polling and data reception (up to 500Hz), and the Control interface allows users to monitor the robot digital outputs.
- Simulation mode is a robot status mode that simulates random values onto the feed. This serves as a useful tool for debugging.



Thermal Camera Feed: Optris PI 1M

Vision Camera Feed: Cavitar C400

WAAM Equipment Setup



WAAM Dashboard: Robot Telemetry

Conclusions & Future Work

- A Real-time Monitoring virtual dashboard was developed, allowing successful integrating of live data communication and camera feeds.
- This interface creates a monitoring framework that supports future development for the integration of digital twins and machine learning applications.

References

1. Williams, S. W., Martina, F., Addison, A. C., Ding, J., Pardal, G., & Colegrove, P. (2016). Wire + arc additive manufacturing. *Materials Science and Technology*, *32*(7), 641–647. https://doi.org/10.1179/1743284715y.0000000073
2. Shah, A., Aliyev, R., Zeidler, H., & Krinke, S. (2023). A review of the recent developments and challenges in wire arc additive manufacturing (WAAM) process. *Journal of Manufacturing and Materials Processing*, 7(3), 97. https://doi.org/10.3390/jmmp7030097