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A Hardware-Independent Framework for Real-Time Arc Detection and Anomaly Alerting in Unfiltered Video Footages of WAAM Processes

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1 Objectives

This research aims to develop a hardware independent and deterministic framework for real time arc monitoring in Wire Arc Additive Manufacturing (WAAM). Existing studies mainly focus on sub millimeter arc length accuracy under controlled and filtered conditions [1], [2], often overlooking practical industrial needs. In particular, robust binary detection of arc existence, frequency, and duration is required to trigger real time alarms. To address this gap, the proposed framework prioritizes robust arc detection over precise geometric measurement. It avoids physical optical filters and instead relies on algorithmic strategies to handle extreme optical noise and sensor blooming. By shifting complexity from hardware to software, the approach provides a cost effective and practical solution for autonomous WAAM systems.

Keywords: WAAM monitoring

2 Methodology
The proposed methodology is organized as a multi stage image processing pipeline. The first stage addresses specular glare removal. High intensity artifacts are identified using a combination of high percentile thresholding and morphological white top hat transforms. These corrupted regions are then reconstructed through diffusion based inpainting, formulated using the Laplace equation, in order to preserve the underlying texture of the image.
The second stage focuses on deterministic decision logic for arc isolation. The current implementation uses an adaptive binarization scheme, supported by anti-inversion logic to stabilize Otsu's method under fluctuating contrast conditions. To evaluate performance, a custom collaborative annotation tool was developed, where at least three expert users independently label each frame as "Arc"or "No Arc", establishing a reliable ground truth dataset. To address the limitations of motion-based approaches in stationary phases [3], the framework is being extended toward a hybrid statistical and geometric strategy. This includes contrast gap analysis for detecting weak arcs and geometric distance filtering to distinguish the physically anchored arc from peripheral reflections.

3 Results
Preliminary testing on unfiltered WAAM footage, validated against a multi user ground truth, shows that the deterministic pipeline can reliably detect strong arc events and extract their temporal signatures, achieving an initial classification accuracy above 80 percent. Challenges remain during low intensity transitions and steady state phases, where the arc remains visually stable. In these cases, detection becomes intermittent due to the limits of purely differential logic, a known issue in classical thresholding methods [4]. Current work focuses on refining statistical thresholds to improve detection of weak arc segments. The framework already provides a reliable basis for estimating pulse frequency and duration, which are essential for triggering automated No Arc safety alerts.

4 Conclusion
The main contribution of this work is the shift from passive monitoring to an active safety interlock. By extracting temporal arc signatures, including pulse frequency and arcing duration, the framework enables a visual alarm system that can detect ignition failures in real time. This approach provides a scalable and cost-effective solution for industrial WAAM which is a replace expensive physical light filters. It helps maintain structural integrity by preventing dry run defects at the millisecond scale. It also reduces reliance on specialized optical hardware.

References

[1] M. Shi, J. Xiong, G. Zhang, and S. Zheng, "Monitoring process stability in GTA additive manufacturing based on vision sensing of arc length,"Measurement, vol. 185, p. 110001, Nov. 2021, doi: 10.1016/j.measurement.2021.110001.

[2] H. Mao et al., "Research on arc length control of unsupported bars in GTAW-based wire and arc additive manufacturing via vision sensing and adaptive fuzzy control,"Int. J. Adv. Manuf. Technol., vol. 142, no. 1–2, pp. 399–413, Jan. 2026, doi:10.1007/s00170-025-17103-4.

[3] L. Song, P. Zhang, K. Chen, Z. Li, H. Yan, and Y. Huang, "From classical algorithms to deep learning: a review of machine vision for monitoring welding dynamics,"Int. J. Adv. Manuf. Technol., vol. 140, no. 11–12, pp. 5885–5929, Oct. 2025, doi: 10.1007/s00170-025-16650-0.

[4] W. Jamrozik and J. Górka, "Assessing MMA Welding Process Stability Using Machine Vision-Based Arc Features Tracking System,"Sensors, vol. 21, no. 1, p. 84, Dec. 2020, doi: 10.3390/s21010084.

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