DEVELOPMENT OF A DATA SYNCHRONIZATION ALGORITHM AND VISUALIZATION FOR MULTI-STREAM DATA IN WAAM PROCESSES

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Modern manufacturing processes, including Wire Arc Additive Manufacturing (WAAM), generate large volumes of heterogeneous data, the analysis of which is critical for quality assessment and process optimization (Orlyanchik et al., 2025). This study addresses the challenge of synchronizing data streams originating from multiple sources during the WAAM process, with the goal of preparing them for subsequent analytical use.

The aim of this work is to propose a methodology for synchronizing spatial, temporal, and functional parameters of data that was collected both before and during the printing process. The types of data used include:

- Initial Data — parameters defined prior to the start of printing (such as the path coordinates and process-specific settings), structured in tabular format and saved as a CSV file;
- Processing Data — real-time data collected during printing. This data is acquired from multiple subsystems using custom software in C++, resulting in three separate CSV files, each representing a different aspect of the process. These include:

(1) process-specific data (Dataset 1), which consists of momentary robot position coordinates (X, Y, Z), energy parameters, and timestamp;
(2) the laser scanner data (Dataset 2), which contains measured 2D points of the observed in a given moment surface (X, Z), signal intensity, and timestamp;
(3) momentary robot position coordinates (X, Y, Z) and timestamp during the scanning process (Dataset 3), which is used for 2d to 3d scanned points translation and future synchronization.

The complexity of synchronization between these sources prevents a comprehensive analysis of the process on a layer-by-layer basis.

The developed synchronization algorithm performs spatial and temporal alignment of the datasets, merging them into a unified analytical space based on functional “layer” concept. The result is an interactive visualization that enables layer-wise analysis of printing parameters. This opens up new opportunities for detailed monitoring, anomaly detection, and the implementation of data-driven approaches in WAAM processes (Liu et al., 2018).

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References

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