Frontend development of edge-based monitoring systems for additive manufacturing

Sumit Bhirud
Advisor: Dr. Philip Howell
Chair of Decentralized Systems Engineering
https://dse.in.tum.de/

15.11.2021 – 15.05.2022

Outline

- Motivation

- Background

- Overview

- Implementation

- Evaluation

- Conclusion & Future Work

Motivation

- Layer by layer manufacturing with robot based Wire Arc Additive Manufacturing (WAAM) process

- Technical challenges like residual stress, deformation, crack occurs

- Multiple independent sensor required to monitor the process

- Efficient display of sensor data is essential to detect anomalies and guarantee better print quality
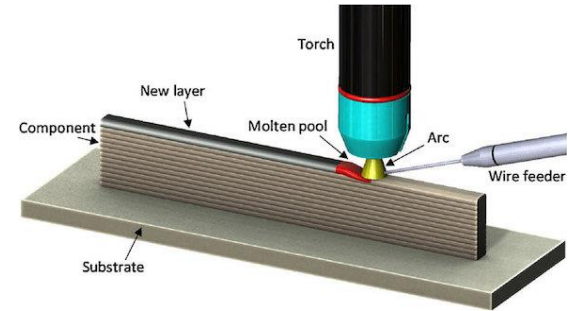
Working of WAAM system [1]
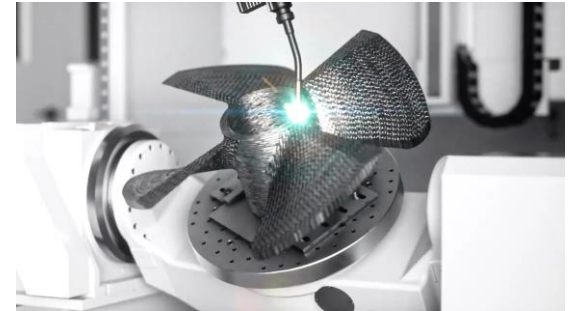
Example WAAM output [2]

Research gap

- Arc Analyzer is the most suitable monitoring system for WAAM.

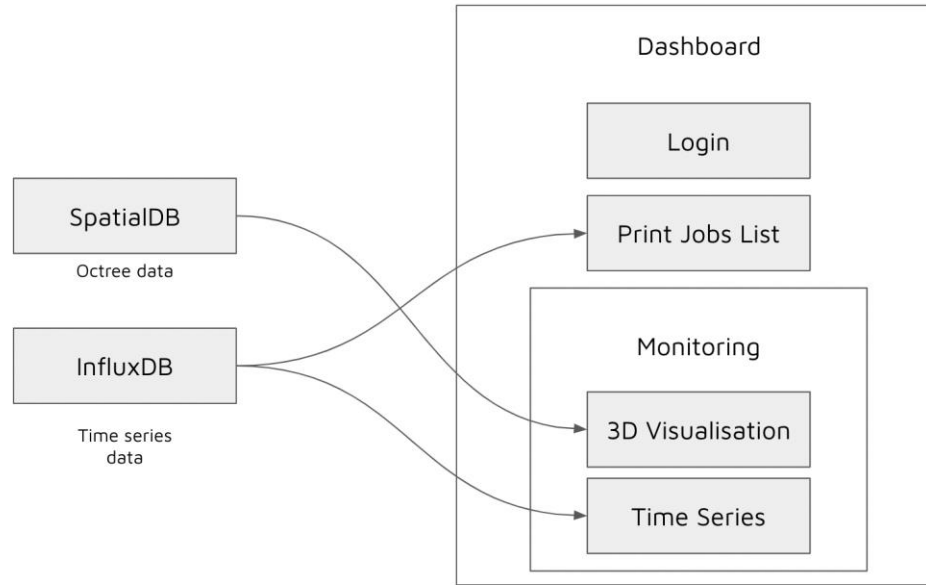| Factors	Arc Analyzer	Introduced Monitoring Dashboard
Time series visualisation	Yes	Yes
3D visualisation	No	Yes
Data extraction	No	Yes
Live monitoring	Yes	Yes
Anomaly Detection	Manual tracking of plots	Managed by the dashboard by displaying anomalies in visualisations and global navigator
Interactive UI	No	Yes
Multi sensor monitoring	Voltage, Current, Sound, Light intensity, Radio frequency, Temperature	Acoustic, Voltage, Current, Temperature, Wire feed, Velocity, Gas flow, Anomaly Voltage, Power Over Path
Analysis based on	Multi sensor plots	Multi sensor time series and 3D visualisation

P. Joshua. "Open Source Arc Analyzer: Multi-Sensor Monitoring of Wire Arc Additive Manufacturing". In: (2020).

Outline

- ~~Motivation~~

- Background

- Overview

- Implementation

- Evaluation

- Conclusion & Future Work

Background

- The WAAM process is complex and defects like cracks, delamination, oxidation occur frequently.

- Problem:
    - Vast amount of data generated by monitoring sensors
    - Difficult to detect anomalies without proper visualization

- Approach:
    - User-friendly monitoring system including time series and 3D visualizations
    - Easy debug functionality to detect anomalies in sensor readings
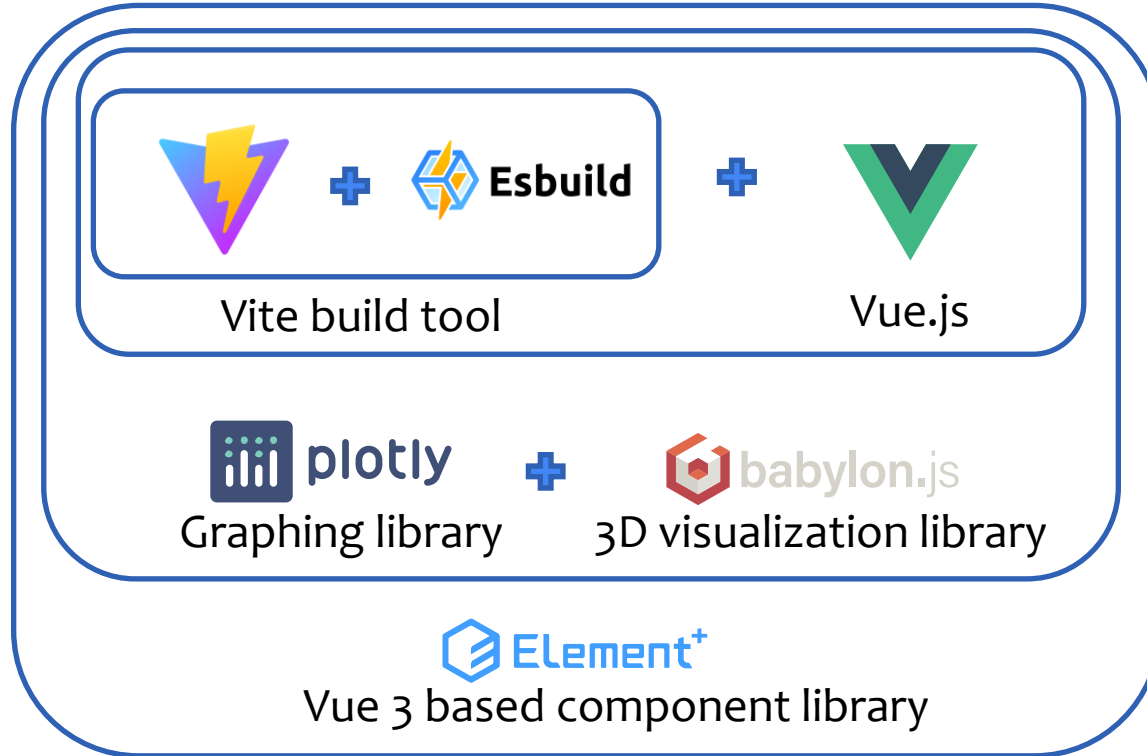   - Configuration options to manipulate visualizations

Outline

- ~~Motivation~~

- ~~Background~~

- Overview

- Implementation

- Evaluation

- Conclusion & Future Work

System overview

- System is split in data layer and views layer.
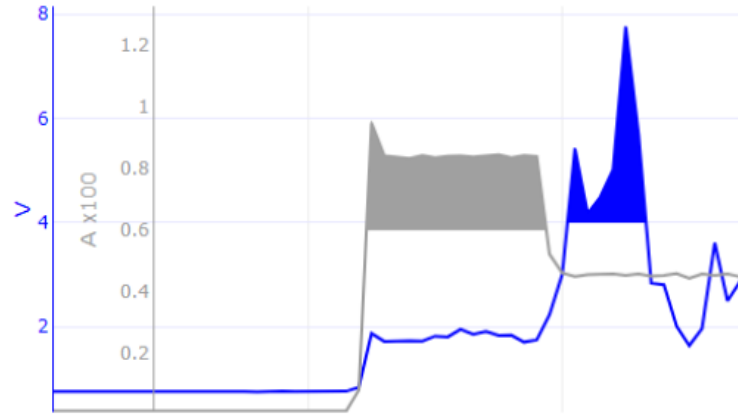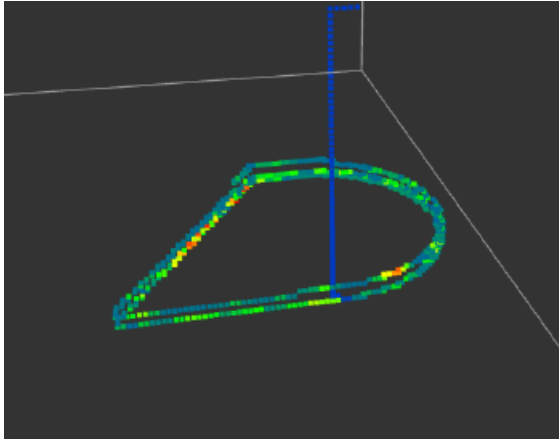- Architecture is based on parent-child relationship between components.

Design overview

Vite build tool

Vue.js

Graphing library

3D visualization library

Vue 3 based component library

Data overview

- Spatial DB serves octree data used in 3D visualization
- Influx DB serves timestamped data used in time series visualization
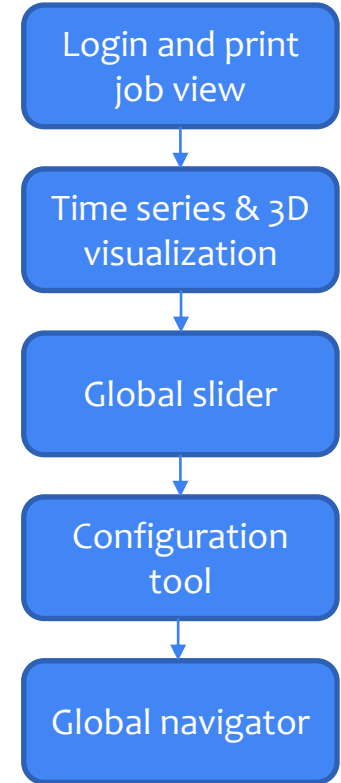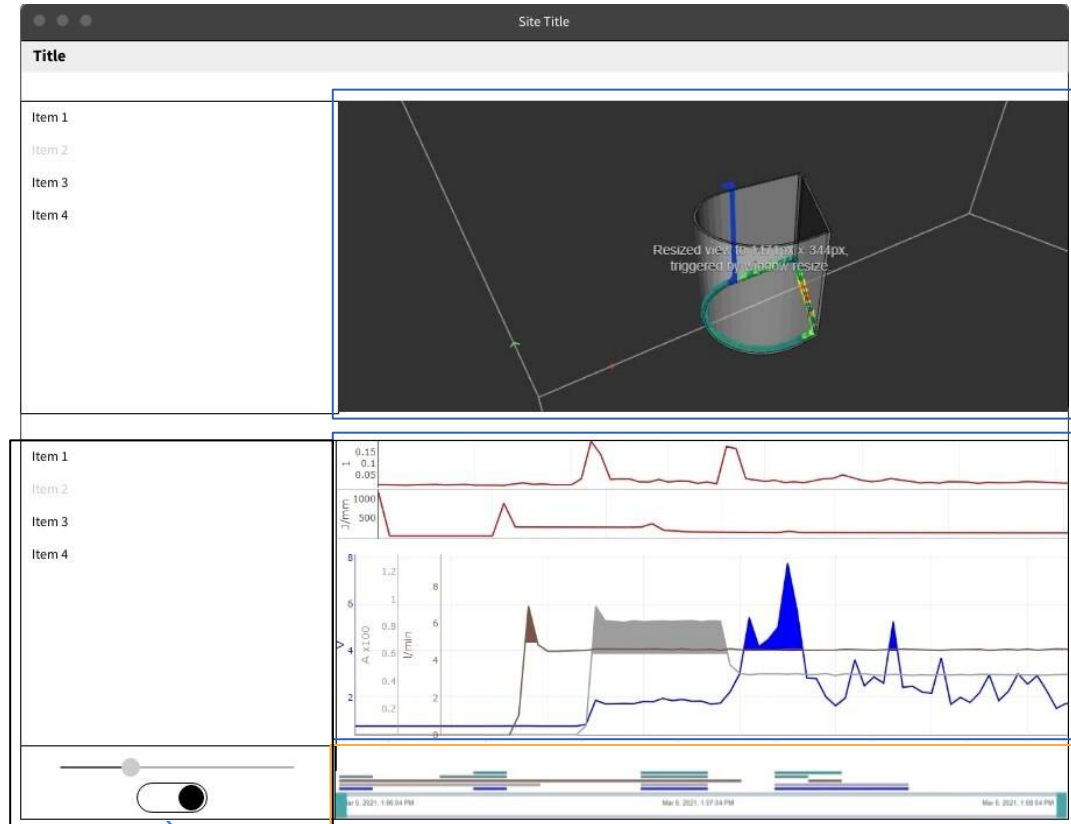
Outline

- ~~Motivation~~

- ~~Background~~

- ~~Overview~~

- Implementation

- Evaluation

- Conclusion & Future Work

Implementation

1. Development of login and print job view

2. Monitoring view with time series and 3D integration

3. Global slider to manipulate monitoring duration

4. Configuration tool with sensor list and aggregation level slider

5. Global navigator to indicate anomalies in sensor data

Login and print job view

↓

Time series & 3D visualization

↓

Global slider

↓

Configuration tool

↓

Global navigator

Implementation

3D visualization

Time series visualization

Configuration tools

Global slider & global navigator

Outline

- ~~Motivation~~

- ~~Background~~

- ~~Overview~~

- ~~Implementation~~

- Evaluation

- Conclusion & Future Work

Evaluation

Tested the working of the dashboard with product owner and stakeholders

Print job view

- List of jobs with columns like ID, printer, begin, end, and progress

- Sorting individual columns and search feature

- Save CSV button to export that job data

Monitoring view

- Time series and 3D visualization

- Global slider and global navigator

- Sensor list and aggregation level

- Live and Analyze mode

Outline

- ~~Motivation~~

- ~~Background~~

- ~~Overview~~

- ~~Implementation~~

- ~~Evaluation~~

- Conclusion & Future Work

Conclusion

Proposed system based on multiple complementary components is capable of monitoring WAAM process efficiently.

Included components:

- Time series visualization

- 3D visualization

- Global slider

- Global navigator

- Configuration tools

Future Work

Improvement ideas for better performing monitoring system:

- View parametrization

- Global navigator selector

- Transparent anomaly indicator

- CSV imports

References

[1] A. R. McAndrew, M. Alvarez Rosales, P. A. Colegrove, J. R. Hönnige, A. Ho, R. Fayolle, K. Eyitayo, I. Stan, P. Sukrongpang, A. Crochemore, and Z. Pinter. "Interpass rolling of Ti-6Al-4V wire+arc additively manufactured features for microstructural refinement". In: Additive Manufacturing 21 (2018), pp. 340–349. issn: 2214-8604. doi: https://doi.org/10.1016/j.addma.2018.03.006.
url: https://www.sciencedirect.com/science/article/pii/S2214860417306085

[2] WAAM! What Is Wire Arc Additive Manufacturing? 2022.
url: https://all3dp.com/1/waam-what-is-wire-arc-additive-manufacturing/.