

VIVARIUM II

Visualization of welding data for anomaly detection



Pro²Future

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MOTIVATION & GOALS

Modern welding robots of our industrial partner Fronius generate large amounts of heterogeneous **data**, including high-frequency **time-series** and welded seam **images** that provide complementary information about process behavior and quality. However, these modalities are often analyzed separately, making it difficult to identify complex and context-dependent **anomalies**. Moreover, manually exploring and labeling large datasets requires substantial time and domain expertise. Our goal is to integrate **multimodal** data within a **visual analytics** approach that guides users toward relevant anomalies and supports their interpretation. By tightly coupling exploration and annotation, we aim to reduce **labeling** effort and enable efficient **human-in-the-loop** analysis.

Project FactBox

Project Name VIVARIUM II

Project ID MFP II A.3-1

Duration 12 Months

Area 3

Area Analytics

Project Lead

Dr. Belgin Mutlu

APPROACH

- Our approach combines ML methods with interactive visual analytics to analyze **time-series** signals and weld seam **images**.
- Both modalities (time series, images) are processed and integrated at a higher level to derive **anomaly scores** and support **multimodal** interpretation.
- A **calendar-based view** and **guidance** help users identify relevant welding instances, while a coordinated detail view enables in-depth inspection of temporal deviations and visual defects.
- **Labeling** is directly embedded into the **exploration** workflow, enabling an efficient **human-in-the-loop** analysis process.

CONTRIBUTION

Scientific contribution

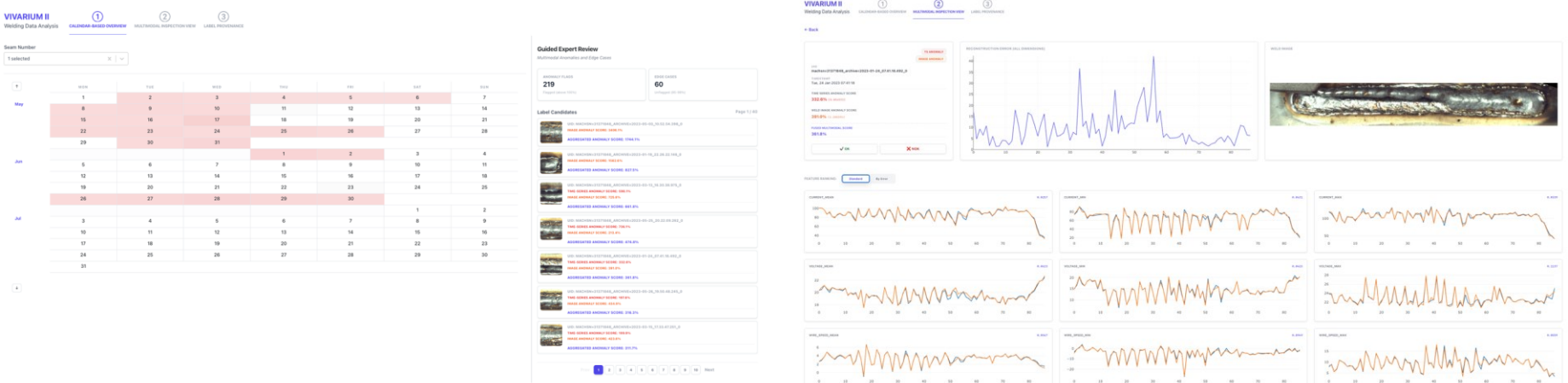
- Multimodal anomaly analysis of time series and images
- Guidance for efficient anomaly exploration
- Integrated human-in-the-loop labeling
- Progressive labeling create ground truth

Economic contribution

- Reduced manual inspection and labeling effort
- Faster identification of quality issues
- More efficient use of domain experts
- Data-driven quality inspection

PROTOTYPE

The workflow starts with a **calendar-based overview** to identify relevant time periods and potential anomalies. Users can then follow **guidance** to inspect welding instances and explore **time-series** and **image information** together in a detailed view. Finally, instances can be directly **labeled** during exploration, supporting iterative **human-in-the-loop** process.



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