Combined AI and Data solutions for DECISION SUPPORT

Challenge 3.3

Battery production digitalwork instructions & skill capturing

3 Combined AI and Data solutions for DECISION SUPPORT

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Challenge and context

Battery manufacturing processes combine automated inspection systems with human decision-making in critical steps such as electrode coating and quality control. In such contexts, inspection systems (e.g. camera-based solutions) can be used to detect defects during production, but detecting a defect is only the first step: Operators must determine which actions should be taken to correct the issue or prevent its recurrence, such as checking machine parameters or investigating upstream causes. In current production practice, the corresponding corrective actions remain dependent on operator expertise. These decisions rely heavily on operator expertise, which is often tacit, experience-based, and not systematically captured. At the same time, industrial initiatives such as electronic workstations (eWS) aim to centralize documentation and ensure compliance, but do not capture how experienced operators respond to specific production situations, such as defect occurrences. As a result, knowledge related to defect handling and process adjustments remains largely tacit, leading to variability in decision-making across operators and shifts. This impacts product quality, process stability, and scalability, particularly in fast-growing environments such as gigafactories. The challenge is therefore to capture, structure, and formalize operator knowledge related to defect handling and decision-making, and to integrate it into adaptive DWI that complement existing eWS systems by providing context-aware, actionable guidance to operators during production.

Use case and expected solution

The use case focuses on defect detection and operator intervention recommendation in battery production, particularly in electrode coating process where identified anomalies require human decision-making. When a defect is detected, operators must decide which machine parameters to verify, which corrective actions to perform, or whether upstream processes are the root cause.
The expected solution aims to capture (vision-based or sensor-based approaches) and formalize expert knowledge associated with defect handling and translate it into adaptive digital work instructions integrated with workstation-level systems. This includes:

- Linking detected defects to recommended corrective actions or parameter checks.
- Providing context-aware guidance based on process conditions and operational context.
- Supporting operators with relevant documentation, alerts, and task-specific instructions.
- Ensuring traceability between defect detection, decisions taken, and outcomes.

The proposed approach combines knowledge representation methods with AI-based techniques capable of modelling relationships between defect patterns, process conditions, and operator decisions/solutions for resolving the production problems. The solution should extend existing documentation systems (e.g., eWS) by enabling dynamic, situation-aware guidance rather than static instructions. The resulting system will demonstrate improved process consistency, reduced variability in defect handling, and enhanced operational efficiency, contributing to more robust and scalable battery manufacturing processes.

Specification for use case

The use case focuses on supporting operator decision-making in response to defects detected by inspection systems, while integrating with existing workstation-level documentation systems. The system shall support the following functional specifications:

<u>Defect-driven guidance:</u>

- Identification of defect types from inspection systems and mapping to recommended corrective actions or parameter checks
- Instruction handling and integration:

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- Transformation of expert knowledge into structured Digital Work Instructions
- Integration with existing documentation systems (e.g., work instructions, checklists, safety procedures)
- Delivery of alerts and updates when instructions or process conditions change

Skill and context awareness:

- Consideration of operator qualifications (e.g., training, certification) when delivering guidance
- Adaptation of instruction detail based on operator experience level

Knowledge capturing and modelling:

- Extraction and formalisation of expert decision-making practices
- Linking operator actions with process conditions and outcomes

Traceability and monitoring:

- Recording of actions taken and checks performed (e.g., process controls before/during manufacturing)
- Monitoring of compliance with required procedures

Development approach:

- Initial validation in a controlled lab environment (low TRL)
- Progressive integration and demonstration in an industrial pilot environment (TRL7)

Expected solution

The resulting solution will demonstrate improved process consistency, reduced variability in defect handling, and enhanced operational efficiency, contributing to more robust and scalable battery manufacturing processes.

Key Performance Indicators

Key Performance Indicators (KPIs) should clearly demonstrate the relevance and impact of the proposed solution. They must address at least two of the following dimensions: resource optimisation, Green Deal objectives, and social impact. All KPIs must be SMART (Specific, Measurable, Achievable, Relevant and Time-bound), ensuring they remain quantifiable throughout the project.

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