Combined AI and Data solutions for AUTOMATION

Challenge 4.3

Semi-automated EV battery disassembly for recycling

4 Combined AI and Data solutions for AUTOMATION

4.3 Semi-automated EV battery disassembly for recycling

Challenge and context

Complex assemblies, such as EV batteries and motors, across manufacturers and vehicle models vary significantly. E.g., virtually each battery type has its own type of cables, bus bars, battery modules, and different types of cells. This variability makes the automation of EV drivetrain components dismantling for recycling challenging. Additionally, current EV batteries subjected to recycling are mainly Li-ion based, posing a multitude of hazards for recycling processes. Automating each process for each battery type is time-consuming and costly, if at all possible. Given the end-of-life state of such assemblies, there is often little to no reliable information on their internal composition, condition, or hazards. Therefore, battery recycling companies are (sub)consciously building a mental, written, or digital catalog of product-specific datapoints, based on the operator's experience. Capturing both operator actions and hazardous components (whether mechanical, electrical, chemical, or thermal) and subsequently registering them uniformly for each product type/variant would allow, on one hand, a more efficient manual disassembly for recurring models by integrating digital work instructions, and on the other hand, the opportunity to, where possible, automate specific hazardous, unergonomic, or repetitive tasks.

Use case and expected solution

A consortium partner has a laboratory for EV motor and battery dismantling available, with an industrial robot at TRL 4, specifically focusing on developing flexible human-machine collaborative demanufacturing processes. This partner has several technology blocks at TRL 4, leveraging computer vision and AI technologies from other areas, enabling the development of dismantling operations for different products without requiring specific robot programming for each. Another partner has significant knowledge and experience regarding, specifically, battery-related hazards and the required safety precautions. A missing key element is an operator interface that enables structured recording of manual operations, hazards, and status feedback, based on which the system can later present product-specific work instructions to the operator. All relevant product and process data should be logged in the Digital Product Passport (DPP), which can then be utilized to base future robotic/manual work instructions on. The consortium partners will support the selected SME by providing the following contributions:

- A suitable lab environment for the final demonstration, including a workbench setup with product clamping, a top frame for a projector and cameras, tool mounting, and demo case study products, including a dummy EV battery assembly and EV motors.
- A draft DPP data structure. The partner will demonstrate the use of the registered data in the DPP by the robotic disassembly system.
- In-depth knowledge and guidance in battery-related safety hazards.

Specification for use case

The consortium partners will guide and mentor SMEs to develop the operator's interface for a robot cell for semi-automatic dismantling of various EV component types, extending to overall mechatronic system demanufacturing approaches. In this solution, a human operator manually records operations on newly encountered products, of which some will later be performed by industrial robots and some, which a robot cannot perform, will still be performed by the operator, although supported by digital work instructions.

Expected solution

- Detection and logging of manual operations and hazards

Funded by the European Union

- Detect and evaluate the manually performed operations, using common/smart hand tools (e.g., screwdrivers, pliers, cutters) and hand tracking (e.g., component pickup and component drop off), also incorporating hazard logging.
- Storage of manual operations and product data in a Digital Product Passport (DPP)

All relevant parameters (such as fastener locations and types, and relevant hazards) should be saved in a standardized digital format so that they can later be used to perform human-robot cooperative disassembly tasks on the same model type. All disassembly operations should be registered in such a way that a reusable (chrono)logical disassembly sequence is compiled.

Digital work instruction visualization

Intuitively display digital work instructions by projecting them on the workbench (2m width and 1,2 m depth) and on the product itself to reduce mental overload and to align instructions directly with the product and setup. To allow for the projection of markers and instructions on the complex geometries of the case study products, 3D mapping and multi-angle projection are required.

Hazard warning and monitoring visualization

Clearly display relevant operator safety instructions during manual disassembly. For example, highlight electrical contacts of battery modules that may still hold a charge, sharp objects, unknown chemical substances, warm surfaces, and other potential hazards. Use clear and unambiguous pictograms to reduce language dependence and support a safer working environment. In addition, proposals that include complementary monitoring systems are encouraged. This may include the integration of thermal vision systems, not only to detect potential thermal runaway events and trigger both local (work cell) and plant-wide safety alarms, but also to support monitoring, testing, and validation activities during disassembly operations.

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.

Funded by
the European Union