

ADVANCED TECHNIQUES FOR REMOVING EV LIB PACK LIDS

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Abstract

Automation in the disassembly of electric vehicle (EV) lithium-ion battery (LIB) packs is increasingly critical during both maintenance operations and end-of-life (EOL) processing. At EOL, functional battery modules can be extracted and repurposed for secondary applications, such as stationary grid storage systems, thereby extending their useful life and reducing environmental waste. Efficient removal of enclosure lids from EV LIB packs represents a critical bottleneck in the disassembly process, requiring advanced robotic manipulation and sophisticated computer vision techniques to ensure safe and effective execution. This work presents recent advancements in computer vision systems designed to support autonomous robotic disassembly of EV battery packs. A significant improvement involved replacing a dual-camera configuration—comprising a 2D RGB camera and 3D laser scanner—with a single integrated structured-light camera system. This hardware consolidation enabled fully automated registration and spatial alignment of 2D color images with corresponding 3D depth data, eliminating manual calibration procedures and reducing fastener extraction time by more than 30%. While the new camera lacks built-in machine learning processing capabilities, its direct access to raw sensor data enables highly flexible and customized algorithm development tailored to battery disassembly operations. The manuscript details comprehensive methods for processing 3D point cloud data to verify and precisely locate fasteners initially detected in 2D images through object detection algorithms. These methods include an approach for determining fastener plane orientation using first-principles geometric analysis, ensuring accurate robotic tool positioning for removal operations. Additionally, recognizing that modern EV LIB packs incorporate hermetically sealed lids with adhesive or polymer sealants to prevent water ingress and electrical short circuits, this paper introduces computer vision techniques for automated seam detection along lid perimeters. The work further describes a complete robotic approach to sealant removal, encompassing tool selection criteria, custom end-effector design, trajectory planning, and seamless integration of all components into a fully autonomous, end-to-end disassembly workflow for industrial-scale battery recycling operations.

Key words: computer vision, machine learning, robotics, LIBs, EVs