COMPUTER VISION LEAD CASE STUDY

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CONCEPTUAL CASE STUDY: DESIGNING A COMPUTER VISION SYSTEM FOR BATTERY DISASSEMBLY AUTOMATION

Introduction:

As the lead computer vision engineer, you are tasked with designing a computer vision system for a state-of-the-art battery disassembly robot. The goal is to create a sophisticated and efficient system capable of autonomously recognizing, localizing, and assessing various features on batteries for disassembly purposes. This conceptual case study will explore the critical components of designing the computer vision algorithms (traditional methods and Deep-Learning-based) and integrating them with the robot's manipulation system to enable precise and safe battery disassembly.

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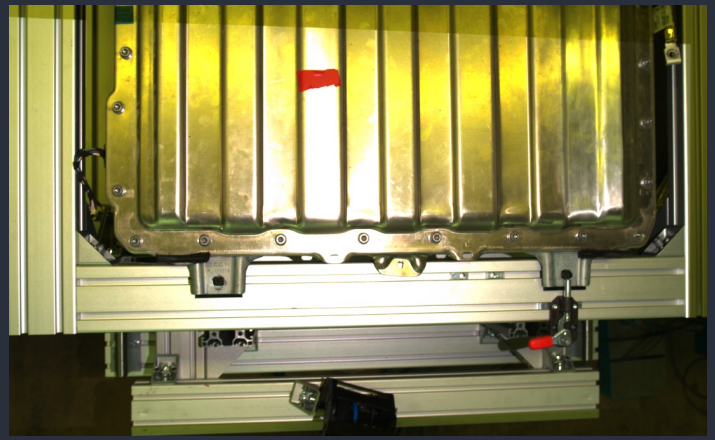

Image 1.1: Image of the screws that connect the lid of a BMW battery pack of the lid to the battery pack casing

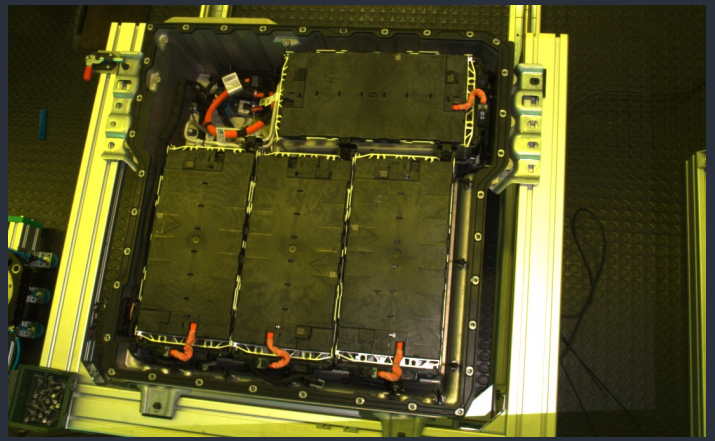

Image 1.2 This image shows the interior of a BMW battery pack, with the object of interest being the battery modules

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Requirement Analysis

Identify and analyze the ideal computer vision techniques and hardware required for battery disassembly. Consider variations in battery size, shape, and components. Focus primarily on object detection for identifying screws and battery modules and pose estimation for understanding their orientation and position accurately. Please include precise information on potential sources of error that could affect robustness of the vision system. Please clarify your choices of the hardware system.

Vision Capabilities:

Define the specific vision capabilities needed, including accurate object detection, classification, and pose estimation techniques to handle diverse battery structures. Please include a comparison between traditional and DL-based techniques, with a short discussion on how they could enhance each other. Discuss how these techniques will be adapted or learned to improve recognition of new battery types. Consider the integration of safety measures within the vision system to prevent accidents during the disassembly process.

Case Study

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Deployment:

What system architecture would you use to deploy the vision capabilities on a physical robot? Discuss the pros and cons of edge devices versus cloud computing in the context of real-time processing requirements and system scalability.

Sensor Integration:

Detail the types of sensors (e.g. cameras, depth sensors) required for optimal operation of the vision system. Explain how you would integrate these sensors' data with your computer vision algorithms to enhance object detection and pose estimation accuracy. Please indicate your precise thought process for ensuring industry-grade performance.

Continuous Improvement:

Please make a short comment about how we can leverage generative technologies to create synthetic datasets to improve our vision system. To improve our vision system, we require a lot of specific data which is expensive to get. Include a design for a synthetic data pipeline that could enhance our system. Details about the software are welcome!

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Coding Challenge: Simulating Computer Vision for Autonomous Battery Disassembly I/III

Objective: Develop a robust object localization and pose estimation method for testing and refining the computer vision algorithms used by an autonomous battery disassembly robot.

Requirements:

1. Environment Setup:
   - Based on Battery Pack images we have provided, either use a similar dataset of your choice to achieve this task or, if you are unable to find more images, please use our images to apply some of your Computer Vision methods as defined below. The development should be done in either Python or C++.
   - The setup should mimic real-world conditions as closely as possible, including varying lighting conditions and potential occlusions.

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Coding Challenge: Simulating Computer Vision for Autonomous Battery Disassembly II/III

2. Vision Capabilities:
- Demonstrate an example of the system accurately detecting and estimating the pose of objects. You may use any combination of computer vision techniques (e.g., deep learning-based object detection, traditional computer vision methods). Please ensure that inference time of the designed system is optimized for downstream robotic actions.
- **Bonus:** Objects should dynamically change their position and orientation within the environment. The system must adaptively recognize and estimate the pose of these objects without prior information on their new locations.

3. Testing and Evaluation:
- Design a series of test scenarios to assess the vision system's performance under various conditions.
- Collect metrics on detection accuracy, pose estimation precision, and processing time.
- Incorporate virtual safety protocols to ensure the vision system reliably identifies hazardous conditions or potential errors in object recognition and pose estimation

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Coding Challenge: Simulating Computer Vision for Autonomous Battery Disassembly III/III

Bonus:

Implement an assessment of uncertainty for the selected computer vision technique.

Submission:

Share the codebase and a detailed report through a version control system (e.g., GitHub) and provide a comprehensive presentation (slides) of the implemented features and results, emphasizing the vision system's contributions to the autonomous disassembly process.