Preemptive Quality Control

Enabling more efficient production of BMW electric vehicles

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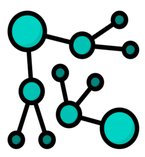
Project Overview

- **Battery costs** are a significant part of the costs of an entire car.
- **Removing** defective batteries at a **later stage** of production is estimated to cost BMW **€100 million/year**.
- Currently, defectiveness is caught at real-time by out-of-range measurements at testing stations.

Problem Statement:

How to identify **defective** units **early**?

Data



Knowledge Graph
Ontological data containing production line step order

Bill of Materials
Mapping of components to their sub-components

databricks

Measurements
Component level sensor measurements collected at each production step

Previous Test Bench Results
Component level test bench results collected on the production line

Use Cases

1. Preemptively Remove Defective Units From The Line

- **Reduce production time** by taking out and treating defective units as early as possible
- **Reduce production cost** on defective units that ends up being wasted

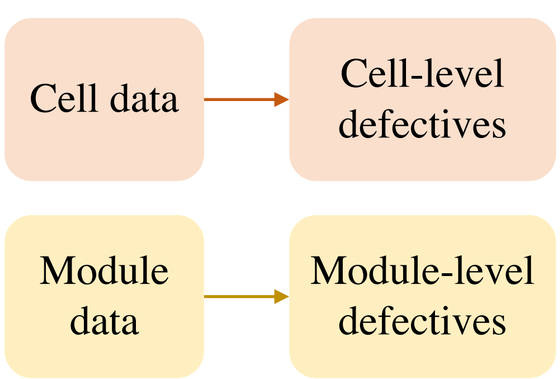
2. Skip Selected Test Benches for Safe Units

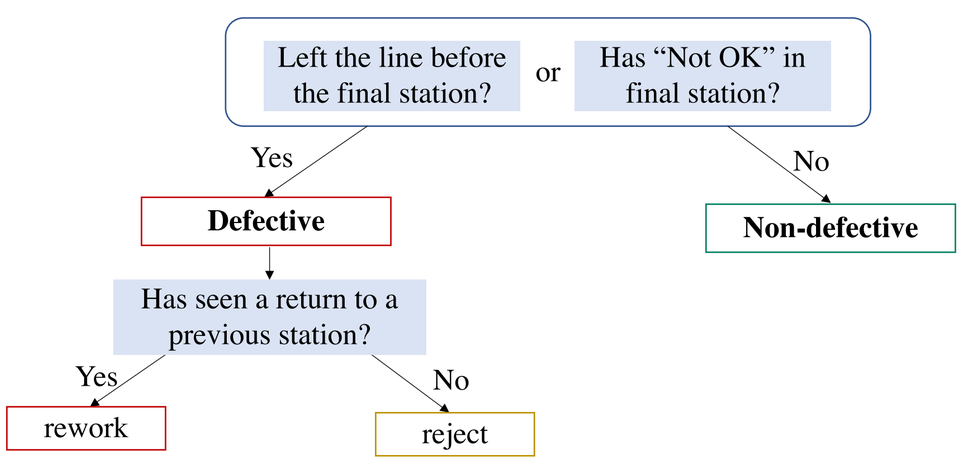
- **Increase production efficiency** by shortening total time spent on the production line
- **Reduce congestion** by allocating test bench budgets towards mandatory test benches (e.g. end of line tests)

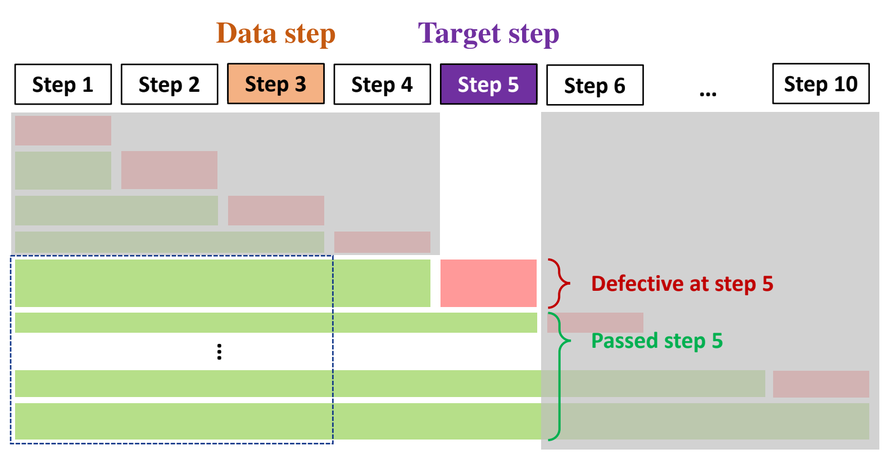
Remove and waste a perfectly good unit **(False Positive)** — **High Cost Scenario** — Fails to catch an actually defective unit **(False Negative)**

Data Preparation

CELL/MODULE SEPARATION → **QUANTIFY DEFECTIVENESS** → **ORGANIZE ACCORDING TO DEFECTIVE STEP**







Predicting Defectiveness

For Each Combination of Data Step & Target Step:

Input (103K Modules)

- **Past measurements**
- **Past test bench results**

Classifiers: **Random Forest** and **XG Boost**

80:20 train test split stratified on **defective step**

Metric: **F-beta Score** ($\beta \in \{0.01, 0.1, 10, 100\}$)

Output

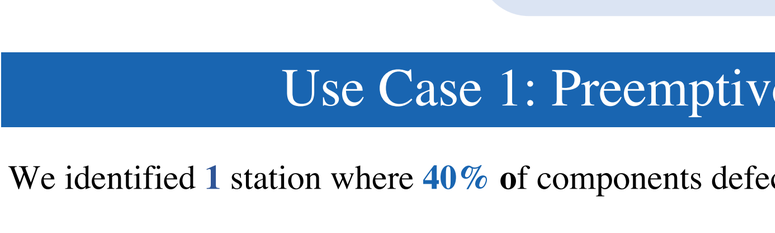
Does the component pass target step successfully or not?

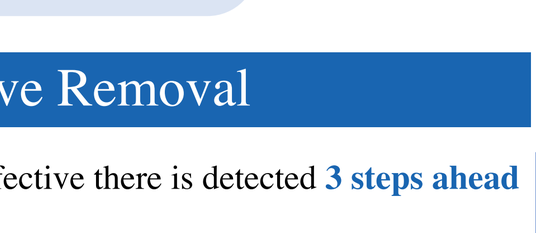
Use Case 1: Preemptive Removal

We identified **1** station where **40%** of components defective there is detected **3 steps ahead**

"Is this component going to be defective in the next three steps?"

Model: "Defective. Remove or rework."



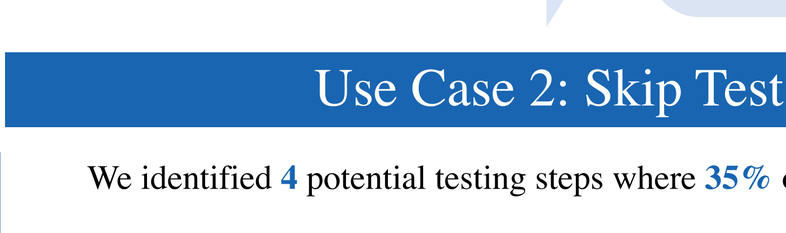


Use Case 2: Skip Test Benches

We identified **4** potential testing steps where **35%** of components can safely skip

"Is this component going to be defective in the next step?"

Model: "Not Defective. Skip this test."



Evaluation on Test Simulation

5.17% net savings compared to baseline

9.14% net savings compared to baseline