

Engineering Project 1: Manufacturing Scratch Detection: Pixel Analyzer

Problem Statement:

Defect map images often contain:

- Thousands of randomly distributed defect markers (colored circles)
- Different defect types represented by color
- Occasional **scratch defects**, which appear as **linear chains of closely adjacent defect markers**

What solution the script brings:

This project provides an **end-to-end automated solution** that:

- Detects scratches defined as **>100 adjacent non-white pixels** (connected defect markers)
- Filters out random noise and small clusters
- Classifies scratches by **orientation**:
 - `v` → vertical
 - `h` → horizontal
 - `d` → diagonal
- Segments the panel into **left / center / right regions**
- Annotates images with **clean, minimal bounding boxes and labels**
- Outputs structured results in a **CSV file** for downstream analysis
- Generates **synthetic defect maps** for testing and validation
- Runs seamlessly in **Google Colab, Jupyter Notebook, or local Python environments**

Applications:

- Wafer defect map analysis
- Package and substrate inspection
- Scratch detection caused by handling, CMP, or process tools
- Inline quality monitoring and yield analysis
- Panel and surface defect inspection
- Root-cause analysis of linear defect patterns
- Defect pattern recognition
- Defect density and spatial correlation studies
- Rapid testing of scratch detection logic using synthetic data
- Benchmarking defect detection algorithms
- Extensible foundation for ML-based defect classification