Smart Industry Operations

2022-2023

Individual assignment

Production Quality Control in Electronics Manufacturing through Automated Optical Inspection

Overview

Variass supplies advanced electronics parts to a wide range of industries. An important part of their manufacturing system is printed circuit board assembly (PCBA) where a very large variety of products are produced. To ensure product quality, assembled products are inspected via an automated optical inspection system. The inspection system can identify different types of defects, and raises a flag once a product is marked as defective. The products that are marked as defective are then inspected manually. The manual inspection is conclusive and may validate (true-positive) or invalidate (false-positive) the defect. The management believes that product characteristics have a strong influence on the defect rate and aims to better understand this impact in order to improve operational performance.

In this assignment, you will help Variass in predicting the defect rates of assembled products based on their specifications. To that end, you will use the data related to production and quality inspection from last year.

Data

The following data files are provided by Variass:

- Order picklists.xlsx
  - Includes 68728 records of completed orders.
  - Establishes the correspondence between each order and the parts used to complete these orders along with their quantities.
  - The 'partnumber' is the unique identifier of a part.
  - Observe that a single product (package) may include multiple parts at varying quantities (for example multiple capacitors of certain type and multiple chips of certain type).
- VPL list.xlsx
  - Aligns each part with a VPL code that captures the specifications of the product (for further information on VPL codes, see VPL.png, Valor Pitch Codering.pdf, and Valor Package Naming.pdf).
- AOI defects last year.csv
  - Complete record of the output generated by the automated inspection system.
  - Nearly a million data records with 62 attributes.
  - Some of the attributes associated with the automated inspections are of obvious interest, yet other attributes might also be of value in your analysis.
  - The type of the defect is captured by 'Defecttypestring' (for further information on defect types, see AOI defect types.xlsx).

- Observe that the defects are marked at a part level and identified by the unique 'partnumber'.
- The result of the manual inspection is given by 'Reviewed' where 1 means that the manual inspection revealed that the defect was not actually present (false positive) and 2 means that the defect was validated (true positive).

The provided files are real and directly come from Variass. They may contain missing values and inaccuracies. Hence, they may need to be cleaned before being used. In doing that, you can rely on common sense, and, if necessary, pose questions to us during regular contact moments. You will be provided with a few other files besides the ones mentioned above. These are not essential to carry out the assignment, yet they may provide contextual information that may help make better sense of the data.

Report

The deliverable of the assignment is a complete report compiled as a Jupyter notebook. The organization and the content of your report should be in line with the following guidelines.

1. *Introduction (5% of assignment mark)*

The introduction should provide a brief overview of the problem, the methodology used to address the problem, and an outline of the report.

2. *Data Preparation (15% of assignment mark)*

The first step of the analysis is to collect the relevant data from different files and merge them in some form that facilitates your analysis. For instance, it should be clear that you need to match partnumber's with VPL codes to aggregate order- and defect-related data. In preparing your data, consider creating quantitative or numerical attributes out of 'coded' attributes.

3. *Estimation Tasks (15% of assignment mark)*

In this step, you will make descriptive estimations on the defect rates without considering any product specifications.

(a) Find the defect rate returned by the automated inspection system on the overall and per defect type.
(b) Find the true- and false-positive rates overall and per defect type, based on the information on both automated and manual inspections.

4. *Prediction tasks and Performance reporting (50% of assignment mark)*

In this step, you will scrutinize how to make effective use the available data to make predictions on defect rates considering product specifications. That is, you will propose, implement, and showcase a prediction model.

(a) Develop a single model that predicts the defect rate per defect type, based on the inspection data and product specifications captured in the VPL codes.
(b) Run your model using all inspection data for training and learning. Present your results and . Provide a critical analysis of your findings.
(c) Run your model using 80% of the inspection data for training and testing and 20% for validation. Present your results. Provide a critical analysis of your findings.

(d) *Bonus:* Run your model with 5-fold cross validation (e.g. average results for 5 randomized splits of the data 80% of the inspection data for training and testing and 20% for validation). Present your results. Provide a critical analysis of your findings.

5. Overall Quality, Conclusion and Recommendations (15% of assignment mark)

Provide a summary of your analysis and the choices you made along the way. Highlight the main results you obtained and make recommendations for further analysis.

A general remark on grading: Make sure your code is well-documented and your report is readable, such that what is done is clear and motivated. We will evaluate your code based on what is explained and documented in your report.