university of groningen

Smart Industry Operations

Assignment 1: Production Quality Control in Electronics manufacturing through Automated Optical Inspection

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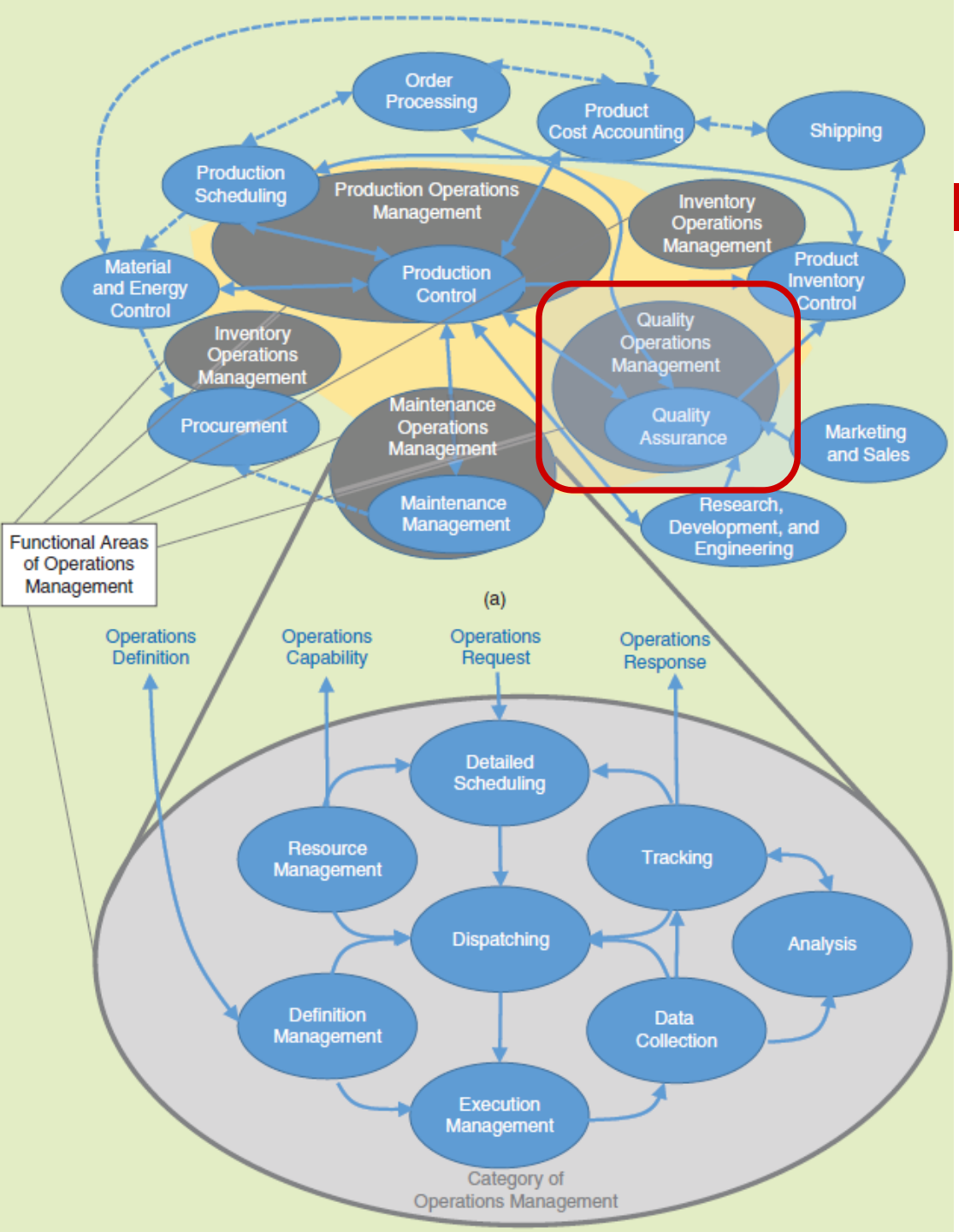
Industry Case

Electronics Assembly Line Quality Control

VARIASS www.variass.nl

Note: Please refer also to additional details on Brightspace



Manufacturing enterprise operations

VARIASS

Supplying with advanced electronics components:

- Defence & Security (high-mix, low- volume, high-complexity products)
- Medical (non-invasive medical and analytical products)
- Industry (wide-ranging industrial domains, offering from PCBAs and semi-finished products, to finished end products)

SMT (Surface Mount Technology) for Printed Circuit Board Assembly (PCBA)

State-of-the-art Pick & Place and THT (through hole technology) assembly lines.

Inspections occur via 2D and 3D AOI (**Automated Optical Inspection**), and where useful, via X-ray too.

Image Source: Jasperneite, J., Sauter, T. and Wollschlaeger, M. (2020) 'Why We Need Automation Models', IEEE Industrial Electronics Magazine, 14(1), pp. 29–40.

Automated Optical Inspection in PCB Assembly

DEFECT OPPORTUNITIES

COMPONENTS CATEGORY

ELECTRICAL DEFECT TYPE
- Functional
- Functional Out-Of-Spec
- Physical Out-Of-Spec
- Class 1-2-3

MECHANICAL DEFECT TYPE
- Functional
- Functional Out-Of-Spec
- Physical Out-Of-Spec
- Quality

OPTICAL DEFECT TYPE
- Functional
- Functional Out-Of-Spec
- Physical Out-Of-Spec
- Quality

PLACEMENT CATEGORY

ELECTRICAL DEFECT TYPE
- Missing
- Wrong
- Misoriented
- Misplaced
- Class 1-2-3

MECHANICAL DEFECT TYPE
- Missing
- Wrong
- Misoriented
- Misplaced
- Quality

OPTICAL DEFECT TYPE
- Missing
- Wrong
- Misoriented
- Misplaced
- Quality

TERMINATION CATEGORY

ELECTRICAL DEFECT TYPE
- Open
- Short
- Class 1-2-3

MECHANICAL DEFECT TYPE
- Functional
- Out-Of-Spec
- Mounting
- Quality

OPTICAL DEFECT TYPE
- Functional
- Out-Of-Spec
- Mounting
- Quality

SUBSTRATE CATEGORY

PCB DEFECT TYPE
- Functional
- Delamination
- Via Cracking
- Class 1-2-3

ASSEMBLY CATEGORY

PBA DEFECT TYPE
- Cleaning
- Interconnection
- Conformal Coating
- Excess Part
- Class 1-2-3

AOI defect types.png

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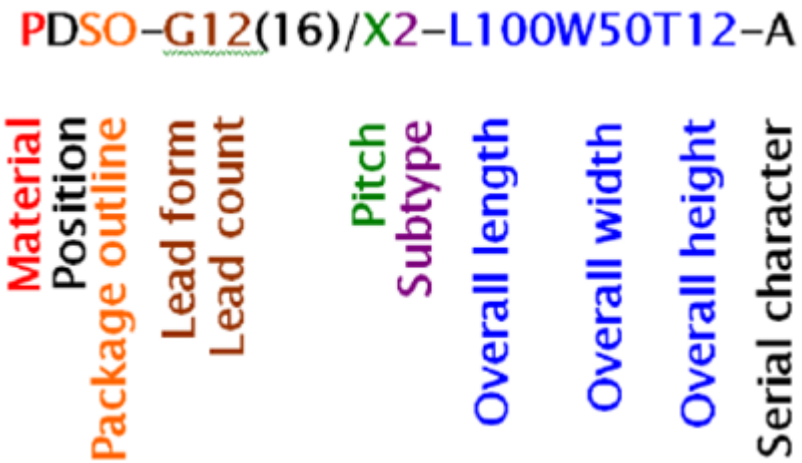
Defects-further details

AOI Code	AOI Description	Dutch description	Defect Category	Defect Type		most used
Mis	Missing	niet aanwezig	Placement	Missing		sometimes used
Tos	Tomstone	staat recht op	Termination	Open		almost not used
Sht	Shift	verschoven	Placement	Misplaced		
NoS	NoSolder	niet gesoldeerd	Termination	Open		
InS	InsufficientSolder	te weinig gesoldeerd	Termination	Insufficient		
ExS	ExcessSolder	te veel gesoldeerd	Termination	Excess		
Brd	Bridge	brug	Termination	Short		
SBa	SolderBall	Soldeer balletje (Opgedroogd tinballetje)	Assembly	Contamination		
LPa	LiftedPackage	Omhoogstaande verpakking	Termination	Open		
LLe	LiftedLead	Omhoogstaand pootje	Termination	Open		
PSc	PadScratch	beschading op de pad	Component	Physical Out-Of-Spec		
Tit	Tilt	aan een kant staat hij omhoog	Termination	Open		
WrP	WrongPart	verkeerd component	Placement	WrongPart		
ChF	ChipFlying	Chip ergens waar hij niet hoort	Placement	Misplaced		
LeS	LeadShift	Schuin pootje	Termination	Insufficient		
LiS	LiftedSolder	omhoog getilt soldering	Termination	Insufficient		
LSh	LedShift	LED component gedraaid/verschoven	Placement	Misplaced		
AlS	AlignShift	1 component in 1 rij niet meer juist/ verschoven	Placement	Misplaced		
PiS	PitchShift	afstand tussen componenten niet juist	Placement	Misplaced		
Por	Polarity	Polariteit niet juist/omgedraaid	Placement	Misoriented		
TuO	TurnOver	Omgedraaid, bovenkant ligt nu onder, onderkant ligt nu boven	Placement	Misoriented		
DCh	DoubleChip	2 componenten op 1 plek.	Placement	WrongPart		
Rot	Rotate	geroteerd, wel aanwezig geen juiste plaatsing	Placement	Misoriented		
XSh	XShift	verschoven in de xrichting(links-rechts)	Placement	Misplaced		
YSh	YShift	verschoven in de yrichting(omhoog-omlaag)	Placement	Misplaced		
Chp	Chipping	1 stukje ergens vanaf getikt.	Component	Physical Out-Of-Spec		
OOA	OutOfArea	Buiten de PCB, buiten het bord zit een component	Placement	Misplaced		
Cra	Crack	Scheur in het bord	Component	Physical Out-Of-Spec		
PiH	PinHole	gat is volgelopen met tin	Assembly	Contamination		
NoP	NoPin	er is geen pin aanwezig	Component	Physical Out-Of-Spec		
DBa	DoubleBall	2 balletjes op de plek van 1	Termination	Excess		
Dam	Damage	Kapot	Component	Physical Out-Of-Spec		
CoS	ColdeSolder	koude soldering	Termination	Insufficient		
FMa	ForeignMaterial	niet bekend materiaal	Assembly	Contamination		
PHO	PadHangOver	pad loopt door tot ver onder component	Component	Physical Out-Of-Spec		
Dcr	Discoloration	verkeerde kleur	Component	Physical Out-Of-Spec		
PaU	PadUncover	Pad is zichtbaar	Termination	Insufficient		

AOI defect types.xlsx

Valor Code / Valor Parts/Package Library (VPL)



VPL.png

this image

Valor Package Naming.PDF

Details for

- Assembly position types
- Package types
- Lead forms

Valor Pitch Coderingen

Correspondence between code and pitch size (quantitative)

VPL list.xlsx

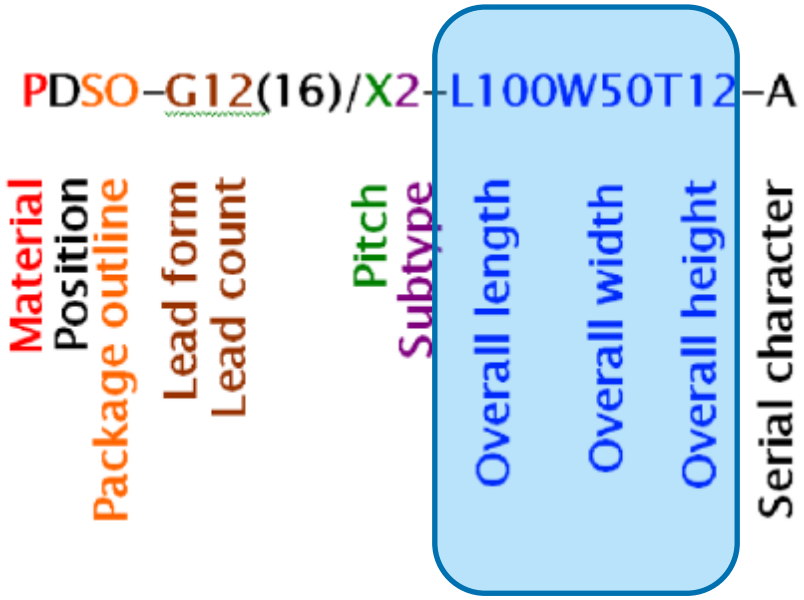
Correspondence between partnumber and VPL code

Valor-code generator Variass.xlsx

Specific VPL code, as applied in Varias

A deeper look

Quantitative information of the VPL code



L: length
W: width
T: height (tall)

There are indications that there is an association between such information and the defect rates

Pitch (Terminal Pitch Distance)		
Pitch (mm)	**TPD**	**Pitch**
0,508	A	20 mil = 0.020”
0,635	B	25 mil = 0.025”
0,762	C	30 mil = 0.030”
0,889	D	35 mil = 0.035”
1,016	E	40 mil = 0.040”
1.27	F	50 mil = 0.050” = 1.27 mm
1,778	G	70 mil = 0.070” = 1,778 mm
2.54	H	100 mil = 0.1” = 2.54 mm
3,175	I	125 mil = 0.125”
5.08	J	200 mil = 0.2” = 5.08 mm
0.95	K	0.95 mm
0.4	L	0.4 mm
0.5	M	0.5 mm
0.65	N	0.65 mm
0.8	O	0.8 mm
1.0	P	1.0 mm
1.5	Q	1.5 mm
0.6	R	0.6 mm
2.0	S	2.0 mm
1.3	T	1.3 mm
1.9	U	1.9 mm
2.5	V	2.5 mm
3.0	W	3.0 mm
All others	X	All others

Historical data

- Order picklists.xlsx
  - 68728 annual records of orders
  - Correspondence between order ID, part number and amount of parts
  - A single ‘product’ (PCB assembly / “package”) may include multiple parts at varying quantities per part (for example multiple capacitors of certain type + multiple IC chips of certain type)
- AOI defects last year.csv (warning! large file)
  - Historical record of a complete year AOI returns
    - Nearly a million data records (992953 records) with 62 attributes
    - Specific attributes of obvious interest (but others might also be of interest)
      - Defecttypestring: type of defect
      - **Reviewed**
        - 2 means that the manual inspection after 3D AOI did review and approved the fault
        - reviewed = 1 means a false call
      - Refid: reference identification = position at the PCBA
      - Partnumber = IPN (Internal Part Number) = link to order picklists.xls and VPL list.xlsx

Synonyms

- Alternatives.xlsx

Comprises 3069 records. Variass sources parts from different suppliers. The effect of this is that there are sometimes different partnumber names for the same part. In this file the ‘synonyms’ are listed in the ‘Original Part’ and ‘Alternative Part’. There may be multiple alternative parts for the same ‘Original Part’.

Assignment 1 content

Main question: predict the quality (rate of defects per defect type) based on a given Valor code (or list of Valor codes cq the bill of materials of a completely new product)

0. Introduction

(5% of assignment mark)

Outline of the problem, the methodology to solve it, and the overall structure of the report (Jupyter notebook)

Criteria

- Quality of introduction and problem description
- Ability to convey an accurate overview of the report and work done

Assignment 1 content

Main question: predict the quality (rate of defects per defect type) based on a given Valor code (or list of Valor codes cq the bill of materials of a completely new product)

1. ETL/ELT (Data Preparation)

(20% of assignment mark)

(You need this to answer later questions)

Aggregate parts with the same VPL code together

In AOI defects last year, associate partnumber with VPL code

Consider creating quantitative/numerical attributes out of ‘coded’ attributes

Q1. Deliver a data records set appropriate for machine learning (you will see what that means in later questions) [no unique answer]

Criteria

- Quality of analysis
- Effectiveness / correctness of data preparation and code quality

Assignment 1 content

2. Estimation Tasks

(20% of assignment mark)

Q2.1. What is the defect rate returned by the AOI system? [answer it overall, and per defect type]

Q2.2. What is the true defect rate? [answer it overall, and per defect type, taking also into account the 'reviewed' attribute] / also, similarly, what is the false positive rate, i.e. false rejections [answer it overall, and per defect type, taking also into account the 'reviewed' attribute]

Q2.3. State any issues you identify – for example findings that might give rise to concerns or point towards need for further exploration.

Criteria

- Quality of analysis
- Effectiveness / correctness of problem formulation and reporting and code quality

Assignment 1 content

3. Prediction tasks and Performance reporting

(40% of assignment mark)

Scrutinise the use of the available data to build a predictive model: propose how to use them more effectively for better generalisation and show (code+results) how is this done (see sub-questions in the word document that provide specific details on how to use the data).

Q3 ‘Learn’ a single model that predicts the quality (rate of defects per defect type, specifically for defects ‘Shift’ and ‘Rotate/Rotary’) based on the given data and using the VPL code

Criteria

- Quality of analysis
- Effectiveness / correctness of problem formulation (e.g., attributes, model usage and ‘learning’) and code quality
- Innovative elements / insights (e.g. identification of influencing factors / combinations of factors)
- Predictive performance of the model

Assignment 1 content

4. Overall Quality, Conclusion and Recommendations

(15% of assignment mark)

Offer a summary of the work done and relevant choices made, the main results obtained, and produce recommendations and open questions for further research

Make sure your code is documented throughout so that it is clearly explained how things are done, briefly, but still detailed enough to be sufficiently clear

Make sure your report (delivered in Jupyter notebook) is readable and attractive

Criteria

- Quality of conclusions and recommendations, including connection to the problem and obtained results
- Quality of code documentation
- Quality of the report as a whole

Note: Please refer also to additional details on Brightspace

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