Infineon Technologies

IE3100M SYSTEMS DESIGN PROJECT AY19/20

DEFECT CLASSIFICATION THROUGH MACHINE LEARNING FROM AUTOMATED OPTICAL INSPECTION DATA

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PROBLEM A (DEFECT CLASSIFICATION)

- Current quality control machines are only able to detect presence of defects but are unable to classify defects according to various defect types.
- Accuracy of KLA machine in detecting actual defects is very low (~20%).
- Requires operators to carry out manual classification which is highly inefficient and inaccurate as there is a lack of proper classification system to ensure consistent quality of checks.
- Lack of Data Visualization tool to effecively analyze data for root cause analysis

OBJECTIVES

1. Transform defect detection process to be more data-driven
2. To improve accuracy rates of defect classifications through convolutional neural network (CNN) model
3. To enable the machine to do automatic classification of defect on wafer chip
4. Perform data analysis on the performance of CNN model

METHODOLOGY

Understand process flow in current defect classification and effectively define the problem

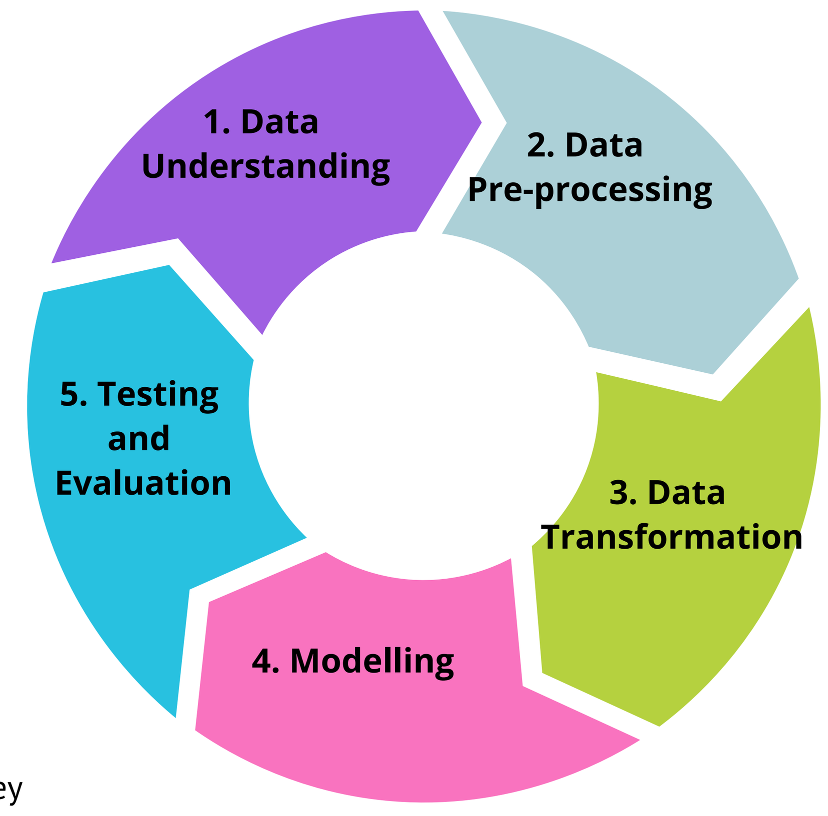
Identify and conceptualize how to modify deep learning concepts into defect classification problems

Perform data pre-processing and data transformation to ensure the quality of image training data

Build programme that pre-processes collected defect images and convolutional neural network model that predicts defect type classifications

Testing and evaluating the performance of convolutional neural network model through key performance indicators

PROJECT IMPLEMENTATION



KEY PERFORMANCE INDICATORS

	Model	Actual: Pass	Actual: Fail
Predicted	Pass	199 (True Positive)	8 (False Positive)
	Fail	11 (False Negative)	202 (True Negative)

Accuracy Rate = (True Positive + True Negative) / All Observations)

Specificity = True Negative / (True Negative + False Positive)

Sensitivity (Recall) = True Positive / (True Positive + False Negative)

Precision = True Positive / (True Positive + False Positive)

F1 score = 2 x Recall x Precision / (Precision + Recall)

Accuracy	Specificity	Sensitivity	Precision	F1 score
95.50%	96.19%	94.67%	96.13%	95.44%

Escapee Rate	Overall Reject Rate
1.90%	2.60%

Escapee Rate: Risk of customer receiving defective wafer chip

Reject Rate: Proportion of wastage in percentage

1.DATA PRE-PROCESSING

- Raw image data collected must first be converted into a clean, usable data set using data preparation techniques
- Upon analyzing the collected image with defect types, several problems are identified

DUPLICATE AND NOISY IMAGE DATA

Current Observations :
- Interferes with CNN model's algorithm in effectively classifying defect types
- Results in poor performance of CNN model

Remedies :
- Rigorous checks to identify and remove duplicate and noisy image data
- Improves training and testing accuracy of CNN model performance

LACK OF STANDARDISATION IN NAMING CONVENTION

Current Observations :
- Inconsistent naming conventions used for naming collected image data
- Missing criticall information related to the collected defect images

Remedies :
- Consistency in naming convention of collected image data
- Inclusion of critical information which facilitates easier tracking of root analysis

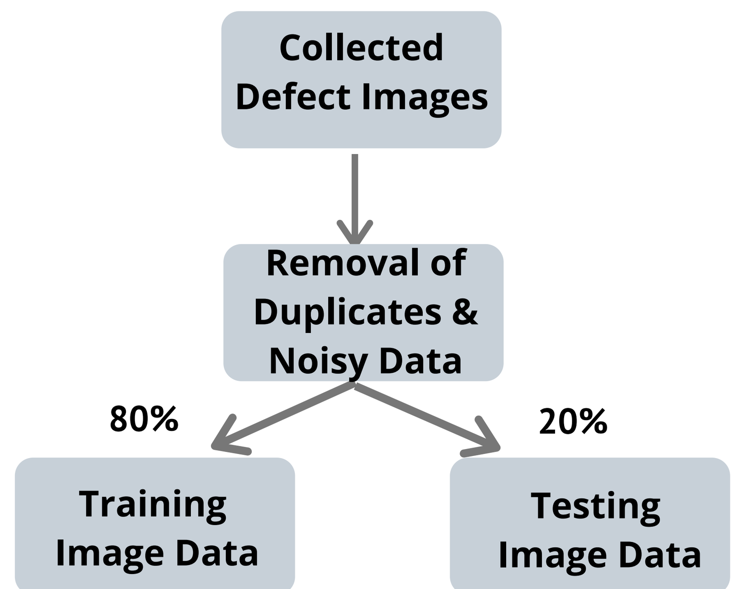
CRITERIA FOR SELECTING TRAINING IMAGE DATA

Current Observations :
- Significant number of lead bent defect type observed at the corner pins of wafer chips
- CNN model would associate lead bent
- defect type to only corner pins of wafer chips

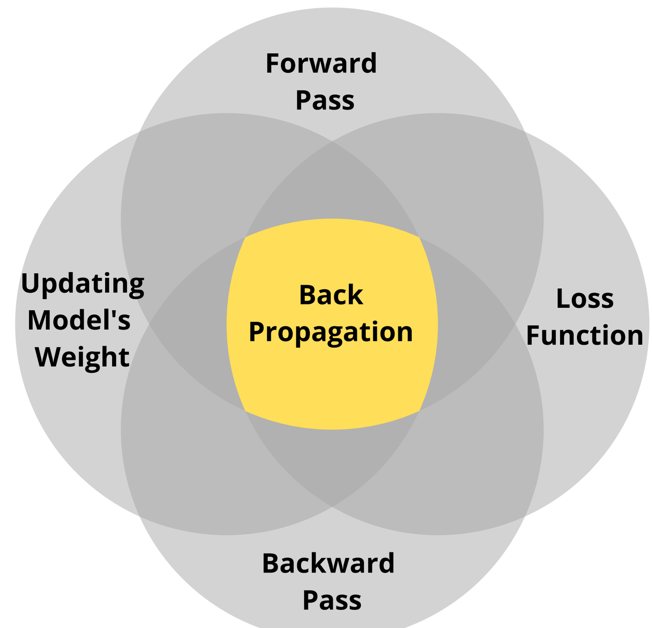
Remedies :
- Images with different pin locations of lead bent added into training data
- Ensures the CNN algorithm recognises and trains based on uniqure features of defect types rather than pin location of defect types

2.DATA TRANSFORMATION

- Annotation of defect types for training image data
- Annotated defect images highlights features specific to defect types which facilitates training CNN model
- Helps to effectively predict images of defect types with high accuracy during testing phase

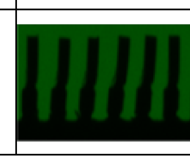
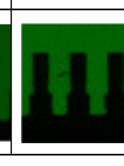
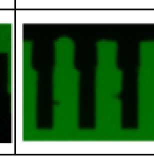
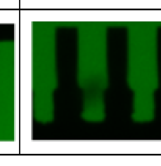
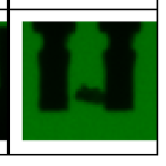


3. CNN MODEL FORMULATION

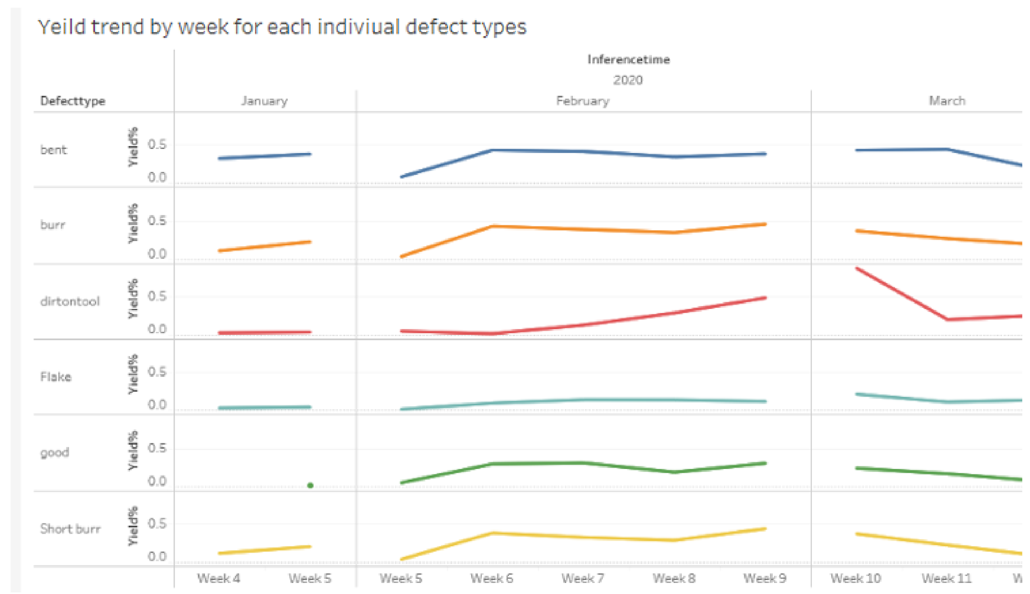


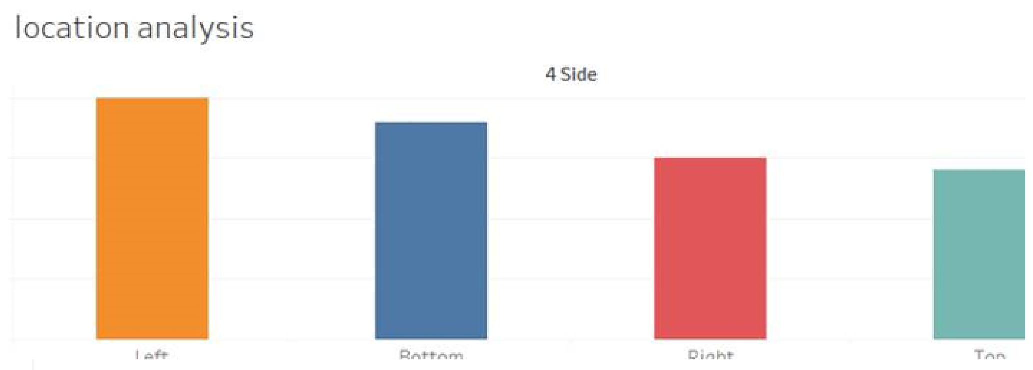
- Utilized back propagation, an algorithm used to train CNN model in supervised learning,
- Objective of minimizing loss function through updating model's weights

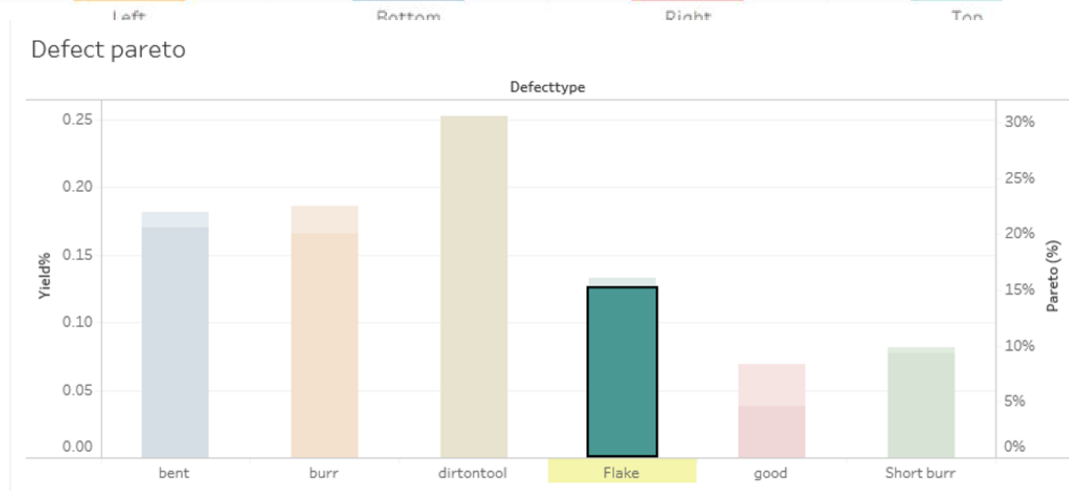
4.RESULTS DISCUSSION

Defect Type	Lead Bent	Burr	Short Burr	Dirt on Tool	Solder Flake
Accuracy	~ 90%	~95%	~90%	90%	90%
Image					

- Yield Trend: Tracks defect rates over time
- Location: Helps identify common defect locations
- Pareto: Determines overall spread of defects







5. FUTURE DISCUSSIONS

To roll out to different machines with different defect types classifications

Potential Benefits:
- Wider scale cost savings throughout company
- Higher quality of manufactured wafer chips
- Improved productivity as employees can contribute to activities that are more value-adding

6. ISE CONCEPTS APPLIED:

- Modelling and Analytics
- System Thinking
- Project Management
- Quality Engineering
- Statistics

7.OTHER SKILLS ACQUIRED:

- Classification
- Data Pre-Processing
- Image labelling
- Data Cleaning
- Testing and Evaluation
- Data Visualization
- Data Analysis
- Data Selection
- Basic Modelling

PROBLEM B (IFAME)

- Quality engineers utilize iFame, an internal defect database search engine to retrieve past defect reports based on similar defect images uploaded for analysis.
- iFame faces inaccuracies in results as the defect reports returned to engineers are inconsistent with image defect type uploaded.
- Delays engineer progress to reference to correct report for investigation to remedy related defect type.

OBJECTIVES

1. To investigate iFame's current performance through various key performance indicators
2. Gather feedback and observations during iFame testing and share them with developers to improve iFame's performance
3. Gain exposure to procedures involved in detailed testing and data analysis of key performance indicators

METHODOLOGY

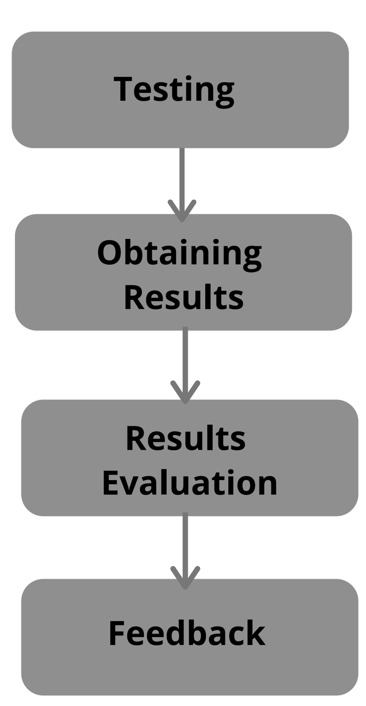
Understand process flow taken by engineers in iFame to retrieve defect reports and effectively define the problem

Identify and conceptualize proper procedures required to test the performance of iFame

Testing and evaluating the performance of iFame through key performance indicators

Gather insightful feedback and observations during iFame's testing and share them with developers to fine tune and improve iFame's performance

PROJECT IMPLEMENTATION



KEY PERFORMANCE INDICATORS

EIPD (Test Run 1)

		Abi_FM	CK_FM	Average	Abi_layout	CK_layout	Average
Case tested	13						
Hit Rate_accuracy		42%	35%	39%	10%	13%	12%
Hit Rate_Coverage		69%	62%	66%	31%	46%	39%

EIPD (Test Run 2)

		Abi_FM	CK_FM	Average	Abi_layout	CK_layout	Average
Case tested	37						
Hit Rate_accuracy		72%	53%	63%	33%	42%	38%
Hit Rate_Coverage		86%	81%	84%	65%	78%	72%

Coverage Value = 0 (Reports returned have no similarity in defect type or layout)
OR = 1 (At least one report returned have similarity in defect type or layout)

Failure Mode Hit Rate = Sum of Similar Defect Type Reports / Total Reports Returned

Layout Hit Rate = Sum of Similar Layout in Reports Returned / Total Reports Returned

1.TESTING

1) Create a test plan and test script to conduct testing on iFame
2) Upload image of defect chip onto iFame
3) Returns 20 defect reports based on similarities with defect image

2. OBTAINING RESULTS

1) Record number of failure mode hit, layout hit and coverage
2) Repeat for different defect type (30 images for each defect)
3) Calculate average hit rates (Failure mode and Layout)

3. EVALUATION AND FEEDBACK

1) Identify defects with low hit rate and coverage
2) Repeat the testing and obtaining results phase over many runs
3) Track accuracy and performance of model over time

4. ISE CONCEPTS AND SKILLS ACQUIRED:

Statistical analysis / Creating Test Plan and Script / Obtaining Insights from Data

PROBLEM C (DATA VISULIZATION)

- Engineers are required to record and upload performance and measurement data into the system
- Long, Laborious and Complicated to complete
- Charts are not reflective of the most updated data from the system
- Figures and charts are messy, complicated and hard to understand

OBJECTIVES

1. Design a simple and easy to read dashboard for data visualization
2. Real-time update of dashboard consisting of charts and figures
3. Automate the updating of the dashboard for convenience
4. Easy use and maintenance of dashboard

SOLUTION

- Implementation of Tableau, a data visualization tool that allows real-time updates
- Microsoft Query to automatically download the data from SharePoint and update the dashboard accordingly
- An operating manual to ensure use and maintenance of the dashboard

SKILLS ACQUIRED:

- Choosing the right data to visualise
- Design of Dashboard
- Microsoft Query