Automatic ROI Recommender for Saw Singulation: Seamless Adaptation for Various Semiconductor Devices

How can we more conveniently
generate ROI using deep learning?

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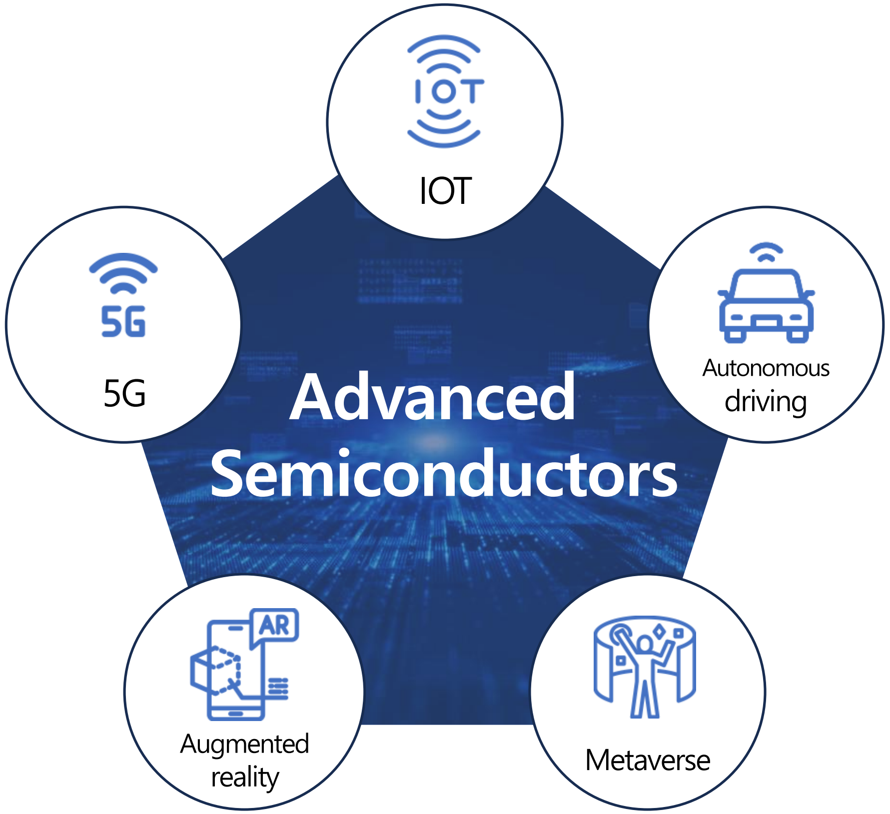
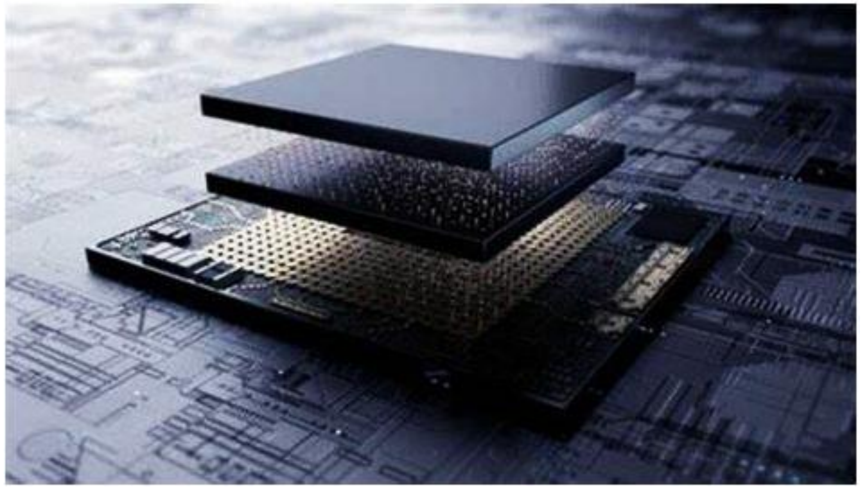
Outline

- Introduction
- Related work
- Method
- Experiment & result
- Discussion
- Conclusion

Surging demand for advanced semiconductors.

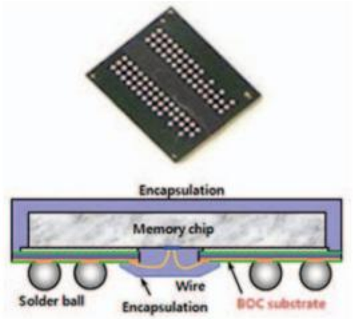
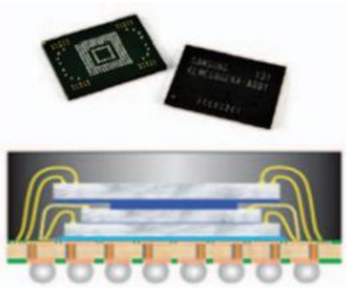
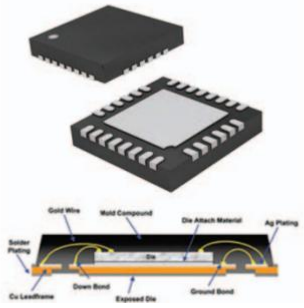
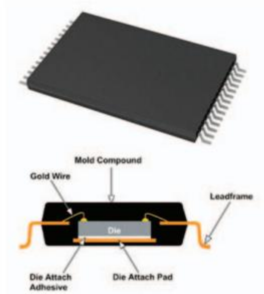
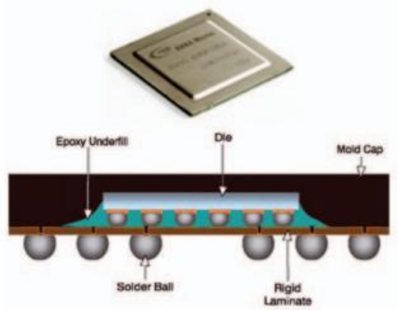
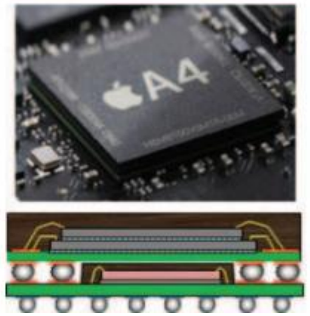
- Exploding demand for AI & IoT drives HBM growth, with the market expected to exceed $5 billion by 2027
- Semiconductors are becoming more complex and diverse over time.





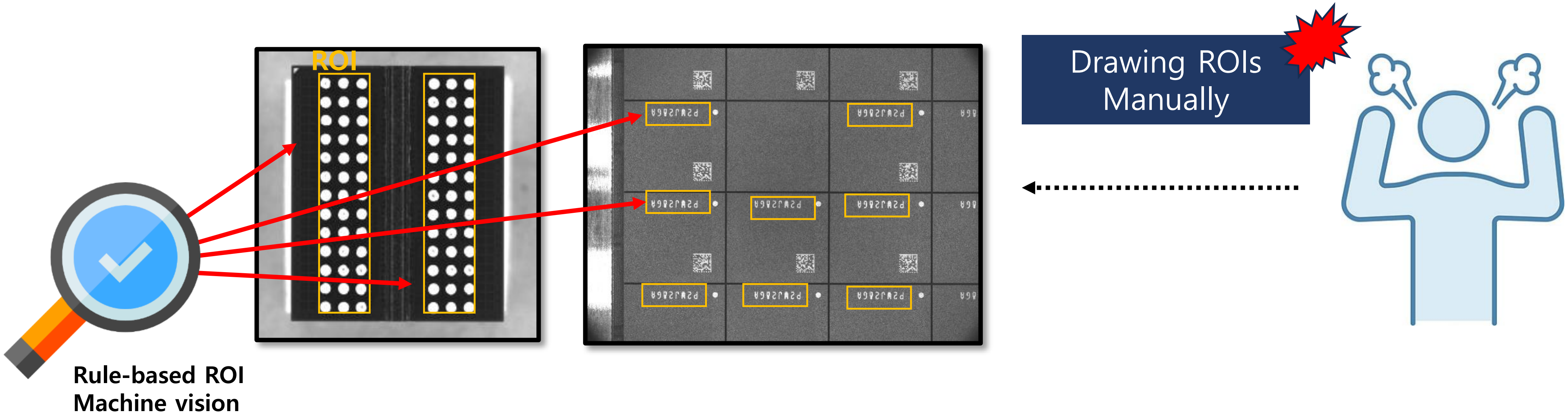
Various types of semiconductor packaging

- With the advancement of packaging technology, inspection items have become more diverse, leading to increased complexity.
- As a result, various parameters are required for inspections.

			
BOC (Board On Chip)	**MCP (Multi Chip Package)**	**QFN (Quad Flat No lead)**	**TSOP (Thin Small Outline Package)**
			.....
Flip Chip	**POP (Package On Package)**	**WLCSP (Wafer Level Chip Scale Package)**	

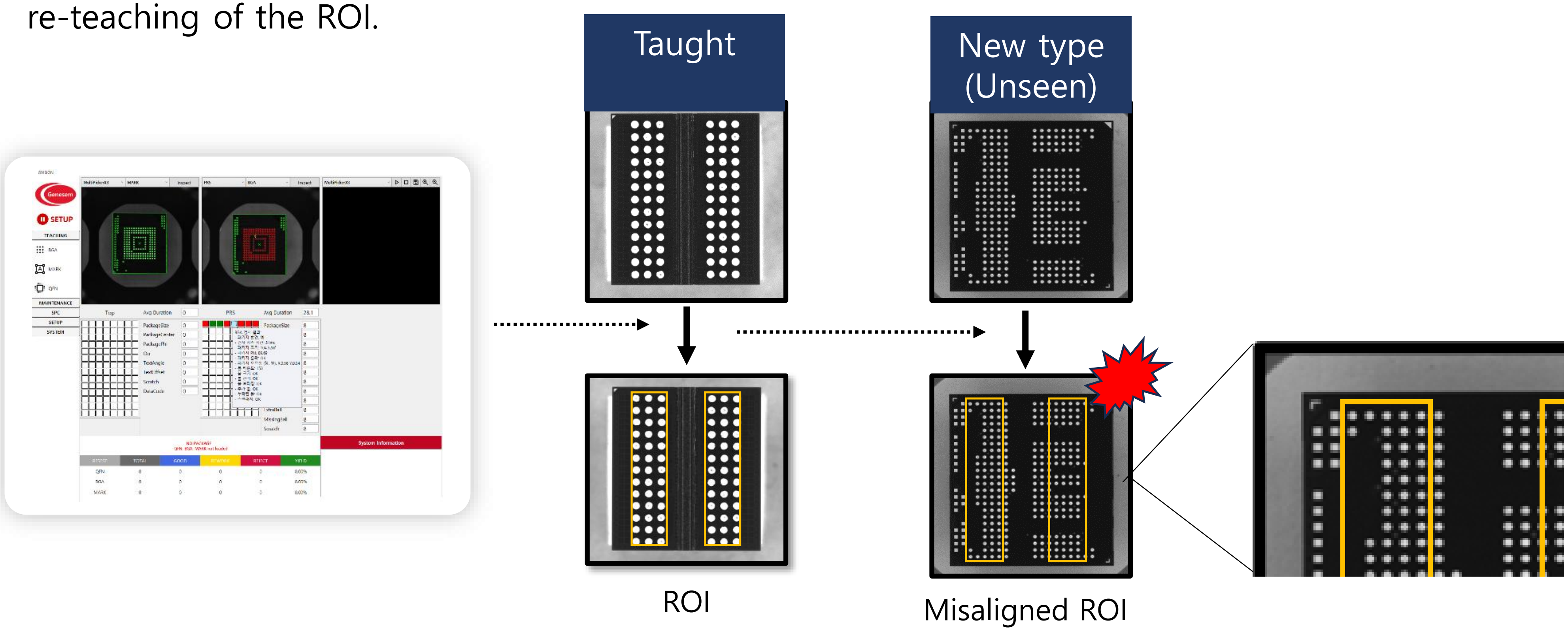
Challenges in creating ROI

- For vision inspection, it is necessary to define the Region of Interest (ROI).
- Although ROI is a key process for determining the inspection area, it must be manually created by the operator for rule-based inspections.
- This process requires significant effort and time



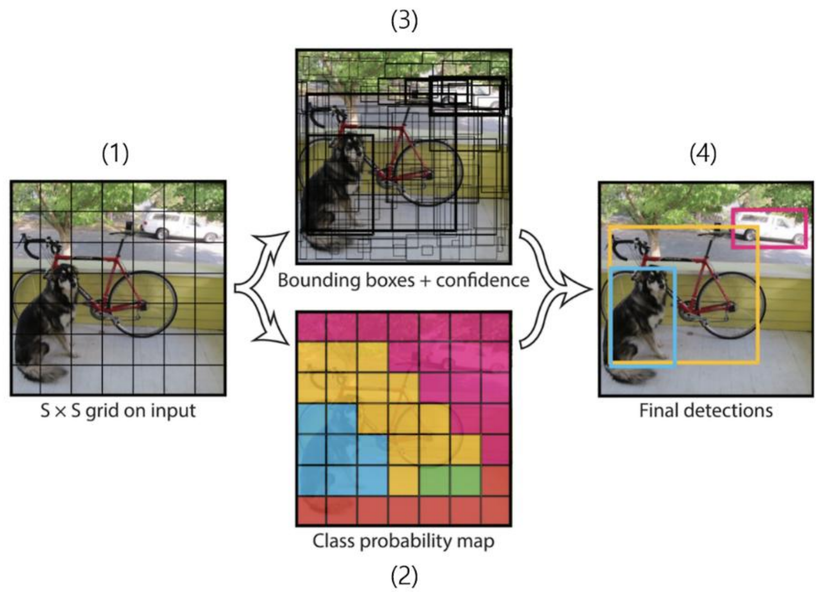
Limitations of rule-based ROI

- Machine vision-based inspection programs rely on operators to manually define the ROI, which is then used to perform inspections based on the same rules for identical package.
- However, it is challenging to use the previously taught ROI for new type package, requiring re-teaching of the ROI.



Object detection with Deep Learning

- Object detection identifies objects and their locations in an image.
- Deep learning-based object detection approaches solve the problem by using regression to predict object locations (bounding boxes) and classifications (class probabilities).

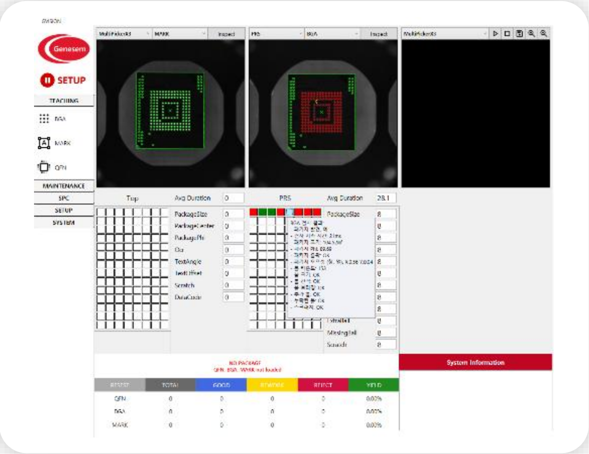


Yolo

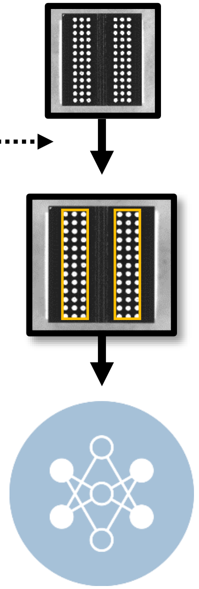
What? **Classification**

Where? **Localization**

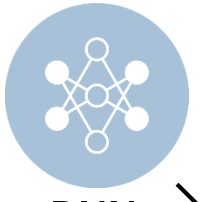
Research on an automatic ROI recommender enabling seamless adaptation



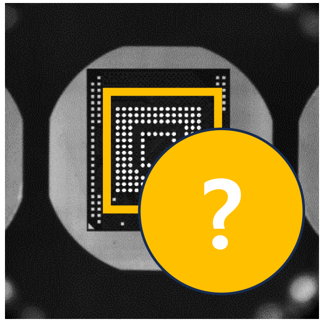
Inspection system



DNN



DNN (Trained)



Unseen data

Exploring the suitability of stored ROI information for DNN model training.

Exploring DNN model adaptability to unseen semiconductor package data.

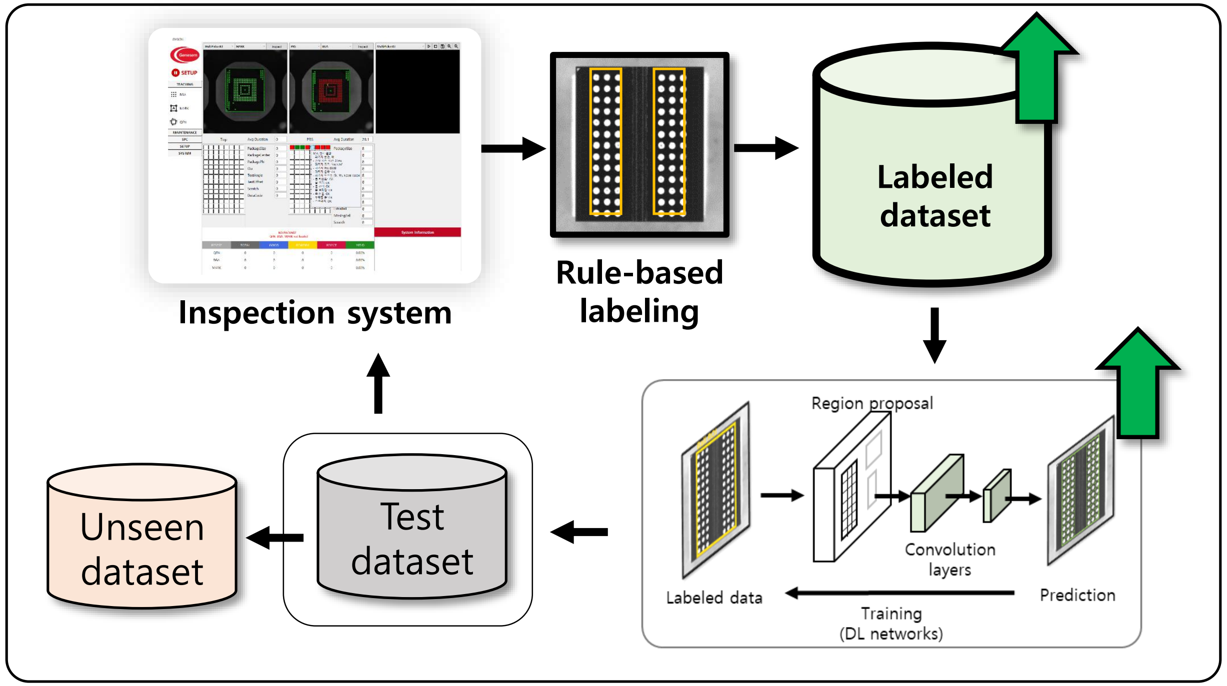
Developing an adaptive DNN model by continuously training with ROI data from the mass production process.

Proposed method - Overview

Research on continuous AI improvement using inspection systems.

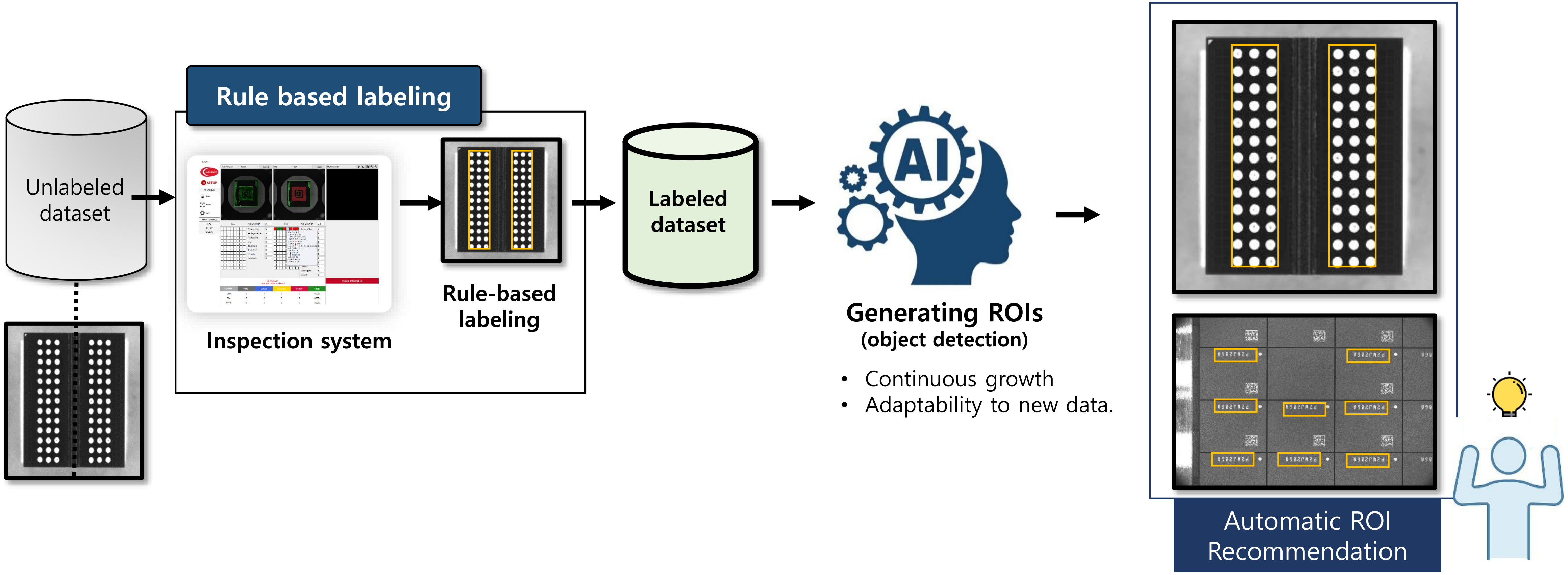
01. Rule-based labeling
02. Training models
03. Comparing & analyzing
04. Test (Unseen data)

Repeat several rounds

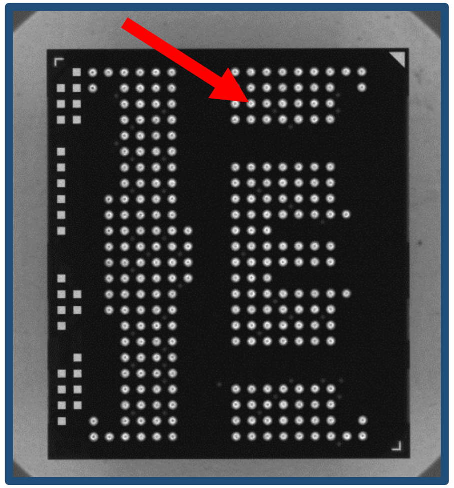


Solution concept

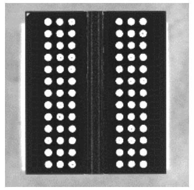
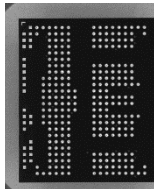
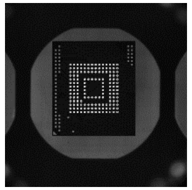
- The vision inspection system stores rule-based ROI labels during operation.
- This system enables continuous training of the DNN model.
- By Training various data, DNN model becomes adaptable to unseen semiconductors.



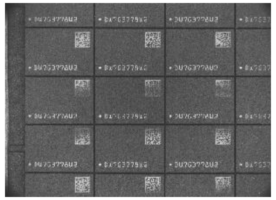
Dataset



Labeled dataset

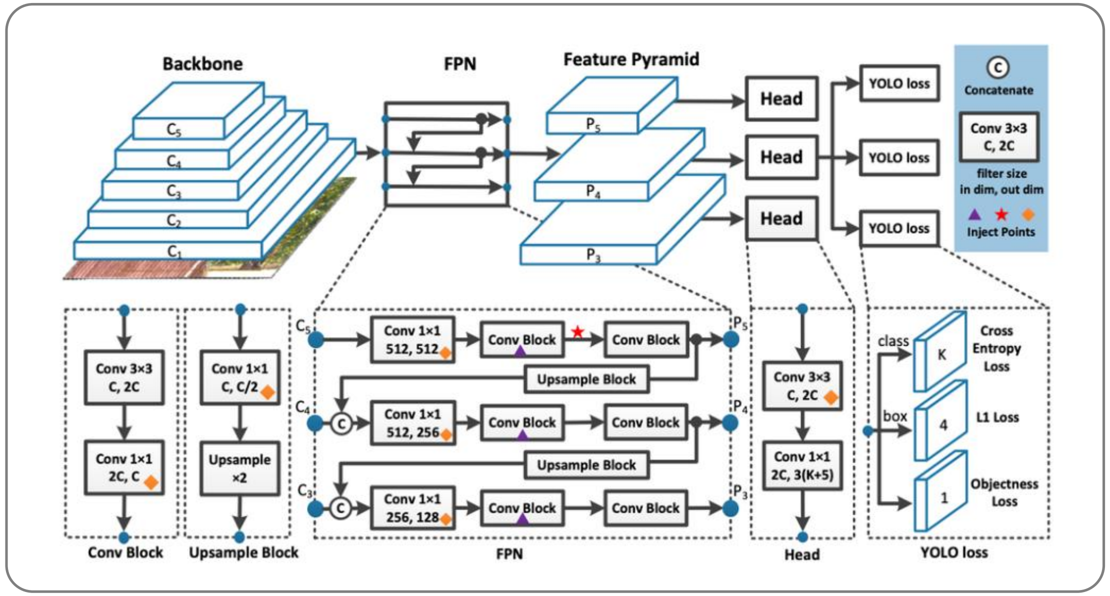
Ball	Type 1	Type 2	Unseen
Image			
Round 1	13	90	
Round 2	26 (+13)	180 (+90)	
Round 3	39 (+13)	270 (+90)	
Test dataset	33		
Unseen dataset			42

Labeled dataset

Character & 2Dcode	Type 1	Type 2	Unseen
Image			
Round 1	44	23	
Round 2	88 (+44)	46 (+23)	
Round 3	132 (+44)	69 (+23)	
Test dataset	25		
Unseen dataset			16

Implementation details

- No dropout
- Batch size : 2
- Epoch : 50
- Optimizer : SGD
- Loss function : BCE (binary cross entropy)
- Learning rate : 0.01
- Models:



<table>
<tr><th>#</th><th>DL network</th><th>Description</th></tr>
<tr><td>1</td><td>Yolo v7</td><td rowspan="2">is a real-time computer vision algorithm for object detection that identifies multiple objects in an image or video with a single pass through a neural network. It is known for its high speed and accuracy, making it widely used in various applications.</td></tr>
<tr><td>2</td><td>Yolo v11</td></tr>
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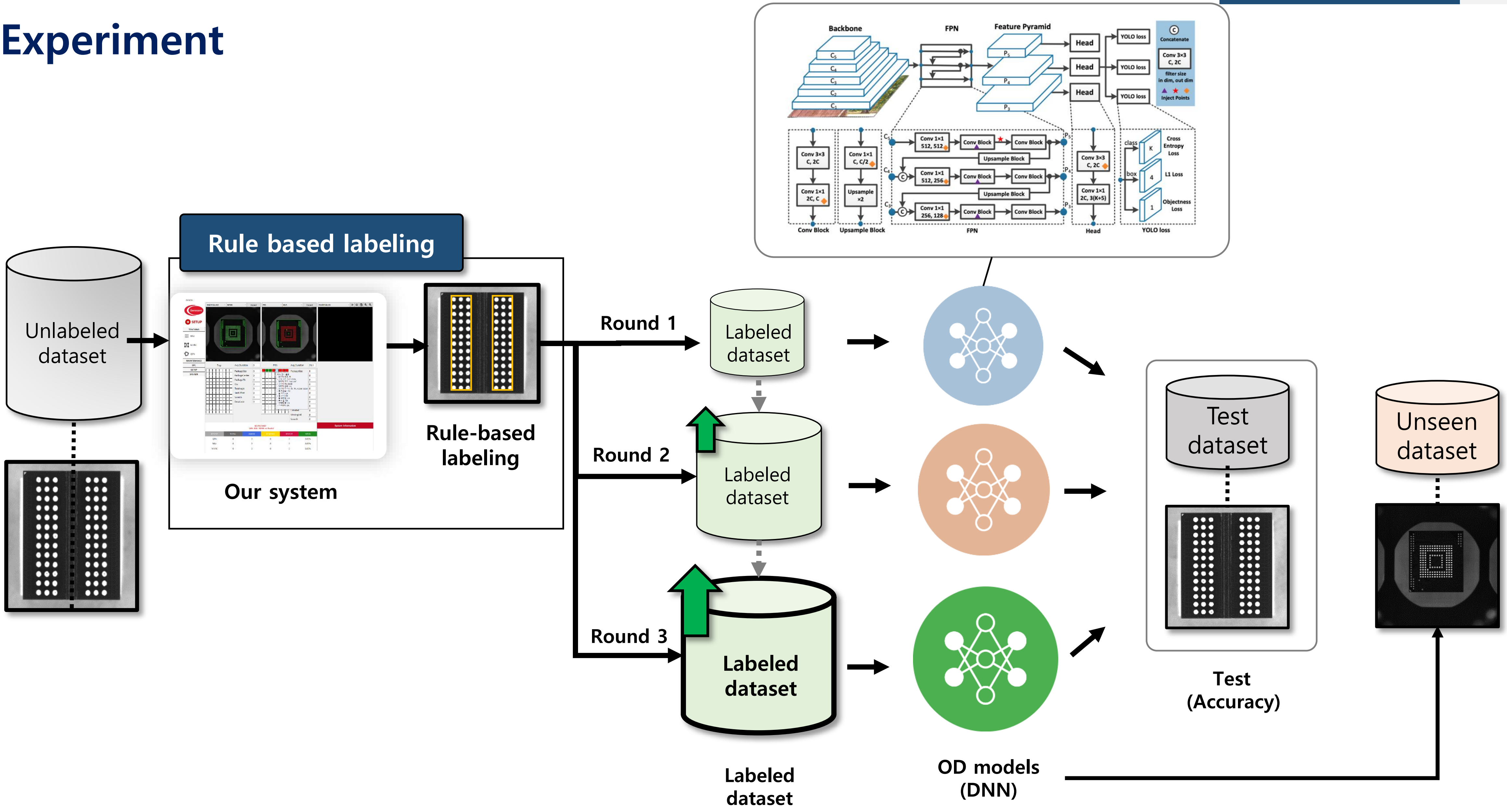
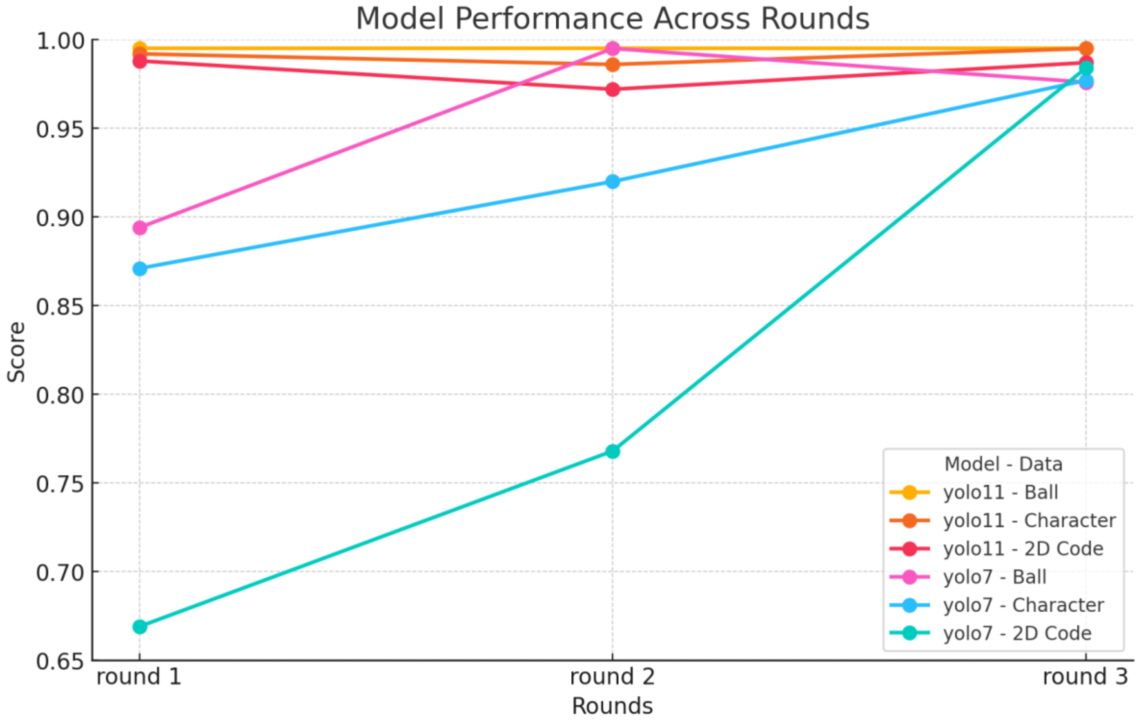
The proposed method was implemented in Python with the PyTorch library, with one NVIDIA RTX 4070 TI GPU.

Experiment

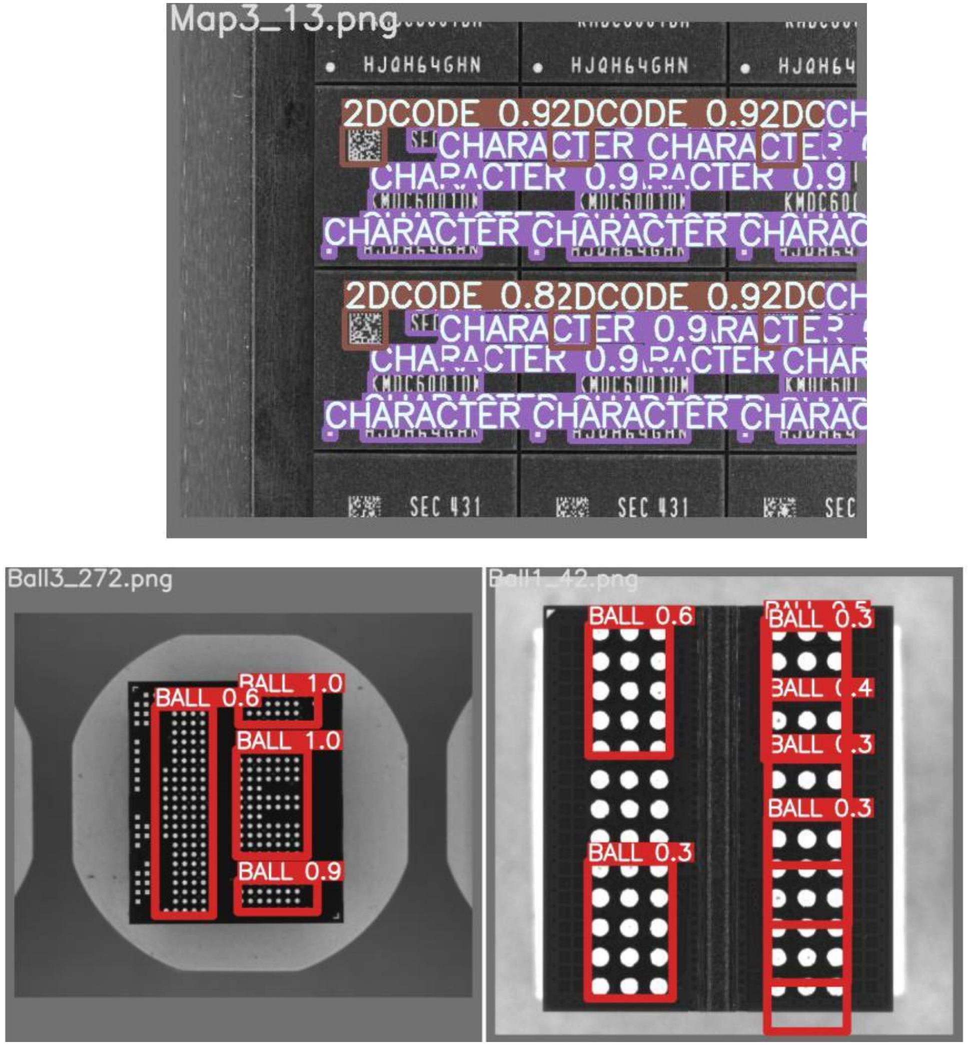

Backbone
FPN
Feature Pyramid
Head
YOLO loss
Concatenate
Conv 3×3 C, 2C
filter size in dim, out dim
Inject Points
Conv Block
Upsample Block
Upsample Block
Conv Block
Cross Entropy Loss
L1 Loss
Objectness Loss
YOLO loss
Unlabeled dataset
Rule based labeling
Our system
Rule-based labeling
Round 1
Round 2
Round 3
Labeled dataset
Labeled dataset
Labeled dataset
Labeled dataset
OD models (DNN)
Test dataset
Test (Accuracy)
Unseen dataset

Result 1 – Comparison (test data)

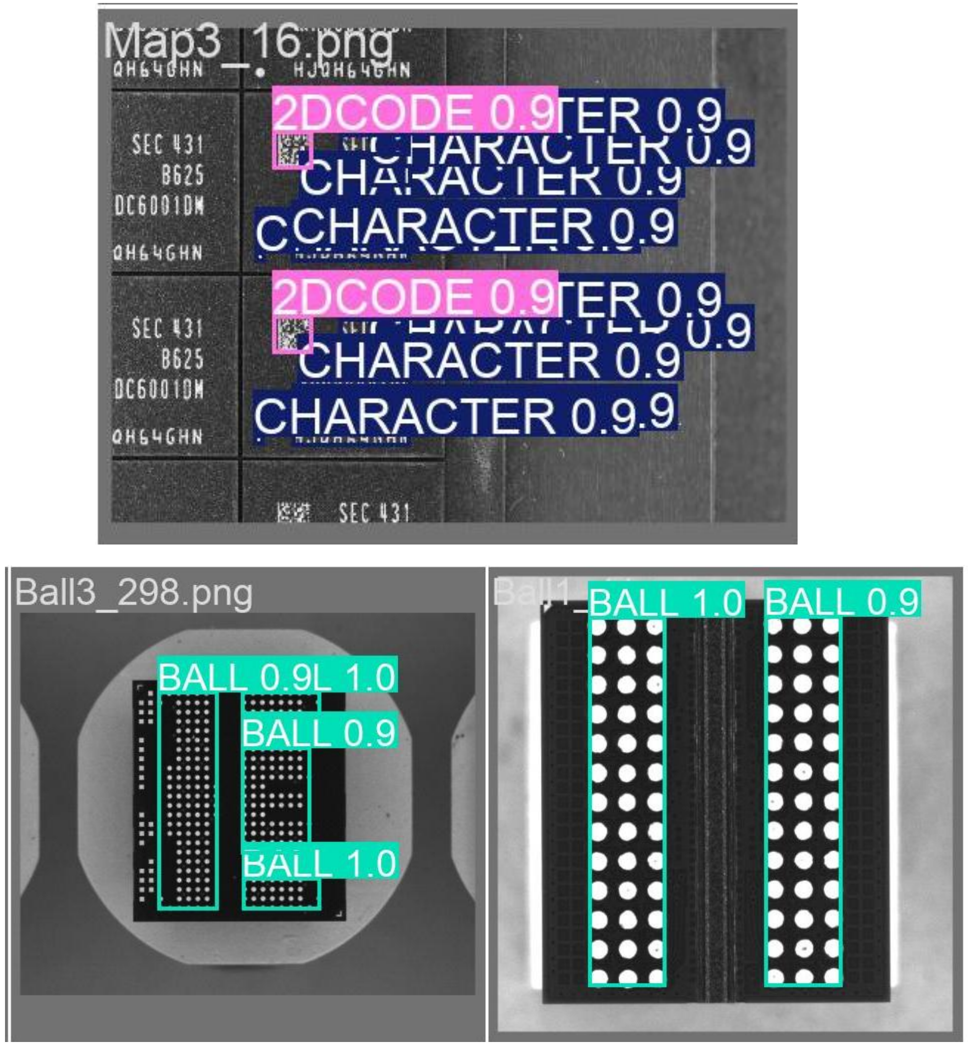
Model	Item	Round 1	Round 2	Round 3
YOLO v7	Ball	0.894	**0.995**	0.976
	Character	0.871	0.92	**0.977**
	2D Code	0.669	0.768	**0.984**
YOLO v11	Ball	0.995	0.995	**0.995**
	Character	0.992	0.986	**0.995**
	2D Code	0.988	0.972	**0.987**



Result 1 – Comparison (test data)

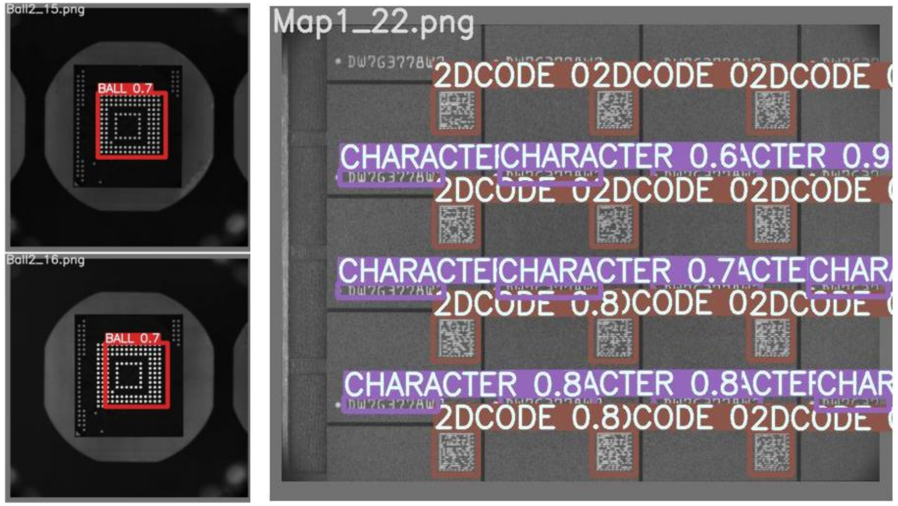


Yolo v7

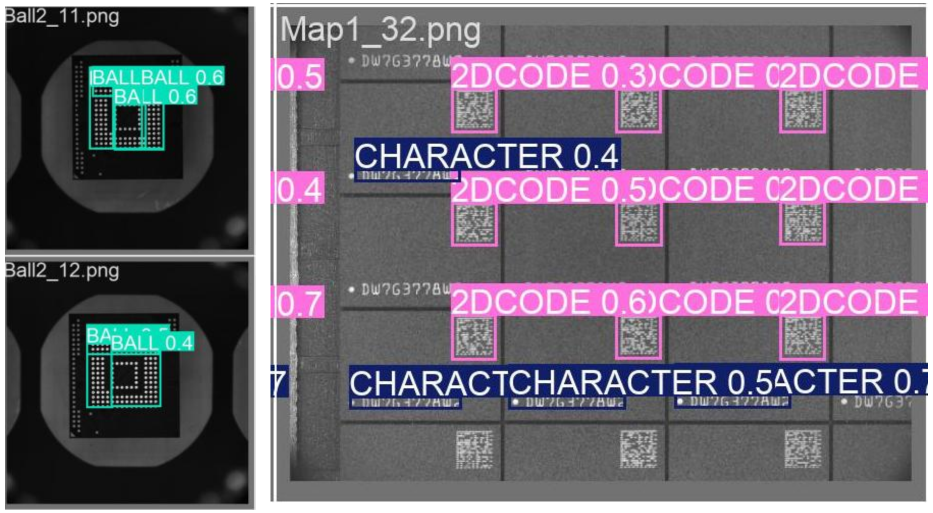


Yolo v 11

Result 2 – Comparison (Unseen data)



Yolo v7



Yolo v 11

	Ball	Character	2Dcode
Yolo v7	0.195	0.529	0.529
Yolo v11	0.12	0.452	0.452

Discussion

- The vision inspection system generates rule-based ROI labels, proving their value for DNN model training.
- The experimental results showed that YOLO v7 exhibited an increasing performance trend across rounds, achieving an AP of 0.984 for 2D code.
- For Character and 2D code, YOLO v7 demonstrated an AP of 0.529 on unseen data, while YOLO v11 showed an AP of 0.452, confirming the potential of the system as a Seamless Adaptation solution.

Conclusion

- This study explored the effectiveness of training object detection models using vision inspection data. Additionally, by evaluating the performance of the trained model on unseen data, the adaptability to changing semiconductor types was tested.
- Through this exploration, the following contributions are expected:
  - Reduced workload for operators during teaching, enhancing convenience
  - Development of a system capable of continuous performance improvement
  - Confirmation of the potential for creating an ROI recommender adaptable to changes in semiconductor types

Thank you