The Hong Kong University of Science and Technology

Department of Mathematics

MPhil THESIS EXAMINATION

Machine Learning Inspection System for Anomaly Detection of Semiconductor Devices

By

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ABSTRACT

The semiconductor industry plays a key role in driving technological advancements in various fields. Ensuring the production of high-quality semiconductor devices is critical to maintaining reliability and performance. Traditional manual inspection methods are time-consuming and expensive, which lead to an increasing need to develop automated systems that can efficiently and accurately detect abnormalities in semiconductor devices. However, there are many challenges in developing machine learning inspection systems for real-world production, from ensuring high-quality training data to designing appropriate algorithms to solve specific problems in the data. When preparing datasets for data-driven solutions, manual labeling is prone to human labeling errors, which directly affects the accuracy of detection systems. Even if the inspection system is perfectly trained on a particular batch of data, when the distribution of the test data changes, such as a new fault type that has not been learned, the model will not work properly. The implementation of machine learning involves iterative cycles, requiring continuous training and evaluation.

This paper conducts a comprehensive study on the existing inspection system and analyzes the difficulties in it. The existing inspection system has a rejection rate of 0.5%. Due to the huge amount of semiconductors produced every day, more than one million semiconductors are discarded, but only less than 0.01% of them are actually defective. We aim to reduce the false positive rate and collected those "hard samples" that were rejected by existing inspection systems. We then address this problem using a variety of machine learning techniques, ranging from traditional supervised image classification, self-supervised contrastive learning, semi-supervised self-training, to unsupervised reconstruction-based learning, focusing on dealing with noisy labels caused by human factors and data drift caused by marking codes of different production batches.

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Thesis Examination Committee

Chairman	**:**	**Prof. Qifeng CHEN, CSE /HKUST**
Thesis Supervisor	**:**	**Prof. Yuan YAO, MATH/HKUST**
Member	**:**	**Prof. Can YANG, MATH/HKUST**

(Open to all faculty and students)

The student's thesis is now being displayed on the reception counter in the General Administration Office (Room 3461).