

Deep Learning-Based Real-Time Defect Detection for Automated Optical Inspection in Electronics Manufacturing

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Abstract

The rapid expansion of global data infrastructure has significantly increased the production of high-performance AI servers. These units are characterized by a high density of internal components, where the correct placement and seating of every part are vital for the system to function. Because these servers are visually crowded, traditional industrial inspection systems often struggle to distinguish between correctly installed parts and defects. This study presents an automated optical inspection framework using the You Only Look Once (YOLO) algorithm to solve this problem by verifying the final product assembly through computer vision. The methodology involves a comprehensive analysis of multiple YOLO model scales. Nano-, medium-, and large-scale algorithms are tested to assess their effectiveness in evaluating fully assembled products. This approach identifies the most reliable configuration for recognizing intricate component features and assembly defects in a high-density environment. Experimental results demonstrate that larger models provide the necessary accuracy, while smaller models offer the high throughput required for rapid line speeds. Ultimately, this framework provides a standardized verification protocol that minimizes human dependency in quality audits. By automating the identification of assembly defects, the system ensures consistent inspection throughput and prevents defective units from progressing to the final testing phase, thereby offering a scalable solution that improves the reliability of high-performance computing hardware relative to standard industrial methods.

Keywords

Deep Learning, Electronics Manufacturing, Quality Control, Industry 4.0, and Computer Vision.

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Biographies

Mohammad Matahen received the BS degree in mechanical engineering from the University of Jordan (UJ), Jordan, in 2022, and the M.Sc. degree in mechanical engineering from the State University of New York at Binghamton in 2024. He is currently a PhD student in industrial and systems engineering and a research project assistant at the State University of New York at Binghamton, where he conducts on-site research at Foxconn Industrial Internet. His research interests include Electronics Manufacturing, robotics, Deep Learning, and control systems.

Dr. Daryl Santos earned his BS from Cornell University and his MS and PhD in industrial engineering from the University of Houston. He is currently a SUNY distinguished service professor and the vice provost for diversity and inclusiveness at Binghamton University. With over 30 years of experience, he has served in various leadership roles, including director of the engineering design division and assistant director of the Watson Institute for Systems Excellence (WISE). His research focuses on production scheduling, engineering optimization, electronics packaging, and quality assurance.

Keng-I Lee received his MS in mechanical engineering with a concentration in control systems from the University of Florida. An experienced automation engineer in the manufacturing sector, he specializes in optimizing high-volume production lines. He is currently the lead automation engineer at Foxconn Industrial Internet (FII), where he focuses on improving machine yields and implementing strategic upgrades to components and processes. His professional expertise centers on leveraging control systems and automation technology to enhance operational efficiency and product quality in the electronics industry.

Xiyao Wang earned his BS and MS degree in mechanical engineering from Purdue University is a manufacturing and automation professional currently serving in a managerial role at Foxconn Industrial Internet (FII). His work focuses on advanced manufacturing systems, automation engineering, and process optimization within high-volume industrial environments. In his role, he supports cross-functional teams to improve production efficiency, implement smart manufacturing solutions, and drive operational excellence in large-scale electronics manufacturing.