DATA-DRIVEN PICK-AND-PLACE MACHINE DEFECT DIAGNOSIS SYSTEM FOR SURFACE MOUNT TECHNOLOGY

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Zoom Link https://binghamton.zoom.us/j/99733299772

Abstract

This research aims to develop a defect diagnosis system for pick-and-place (P&P) machines by examining the link between machine errors and PCB assembly defects. The P&P process, the most critical step in Surface Mount Technology Assembly (SMTA), involves picking components with a nozzle and placing them on PCBs. Placement quality significantly affects overall assembly quality, with over 55% of PCB defects attributed to assembly issues. Misaligned parts, the primary defect in the P&P process, account for nearly 15% of all related defects. This study focuses on analyzing misalignment defects detected by pre-AOI machines, as no systematic study has yet explored the connection between machine errors and assembly defects. The contribution of this research can be summarized as follows. ***First***, to understand the impact of machine errors on placement quality, this research examines nozzle size issues, pick-up position problems, nozzle contamination, and board warpage. Experiments introduce these errors intentionally, and inspection data is collected for analysis. Statistical methods identify patterns linked to different errors. Using pre-AOI and Factorial Defense Control (FDC) data, which indicate machine performance, Support Vector Machine (SVM), Random Forest (RF), and Decision Tree (DT) algorithms classify the root causes of observed defects. ***Second***, as the number of machine errors increases, the complexity of classification models also rises due to additional labels and classes. To manage this, an integrated multi-output classification-based defect diagnosis (MCDD) model is developed, reducing computational complexity while achieving over 90% accuracy for individual errors and 84.5% overall accuracy. ***Third***, transferring the MCDD model between component types can be time-consuming, so a scale-free classification model has been created to streamline this process. This model, based on component similarity, enables efficient transfer to new component types, achieving over 80% accuracy when moving from C1005M to C0603M, and over 80% accuracy for nozzle contamination and 70.61% for nozzle pick-up issues in C0402M. ***Lastly***, the model's efficiency relies on sufficient training data, but machine error data is often limited. Conducting the design of experiments (DOE) is costly and time-consuming, making data scarcity a challenge. To address this, the study integrates principal component analysis (PCA) and the synthetic minority oversampling technique (SMOTE) to tackle class imbalance. The proposed method outperforms baseline techniques like SMOTE, SVMSMOTE, and Borderline SMOTE, with generated data yielding results comparable to those obtained with original data when used for model training and testing.