Erasmus Mundus Joint Master in Manufacturing 4.0 by intElligent and susTAinable technologies

MASTER's Degree Thesis

AI-Supported Automatic Recognition of Component CAD Data for CAM Programming

Candidate: *Clinton Ikechukwu*
Supervisors: *Manuel Norberger (Technical University of Chemnitz/ Arc Solutions GmbH), Dr Matthias (Technical University of Chemnitz), Dr Cédric Courbon (Ecole Centrale De Lyon, ENISE) Prof. Danielle Ughues (Politecnico di Torino)*

Abstract:

This thesis examines the application of deep learning for automatic machining feature recognition (MFR) from both clean and noisy CAD models, a crucial step in bridging the gap between design and manufacturing within an intelligent production pipeline. The traditional methods were limited and struggled when handling noisy, real-world data, creating a gap between idealised CAD environments and actual industrial applications. Also, recent deep learning approaches such as FeatureNet and Inception-based 3D CNN have demonstrated high accuracy on synthetic CAD data, but they rarely test robustness on noisy or scanned meshes, and this leaves a crucial gap. To address this, three voxel-based 3D convolutional neural networks were investigated: a FeatureNet-inspired model, a Pre-activated ResNet, and a

lightweight InceptionLite architecture. Experiments were conducted using synthetic CAD models and artificially noise-injected data, mimicking real-world datasets. Results showed that while FeatureNet-inspired and InceptionLite models achieved near-perfect accuracy (>99%) on synthetic datasets, performance dropped sharply when models were tested on noisy scans. InceptionLite model, however, demonstrated architectural and structural advantages that make it the most robust candidate for adaptation. After which, transfer learning was applied to fine-tune InceptionLite on noisy data, successfully restoring accuracy from ~38% to ~99%.

The findings indicate that synthetic training alone is insufficient for reliable industrial deployment. Robustness and domain adaptation are important for practical CAD feature recognition. This thesis research contributes an evaluation of 3D CNNs for machine feature recognition, demonstrates the effectiveness of transfer learning in bridging the synthetic-to-real gap, and identifies InceptionLite as the most strategically viable model for advancing toward real-world applications.

Keywords: Machine Feature Recognition, Artificial Intelligence, CADCAM, Synthetic Data, Intelligent Pipeline

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