Abstract

This dissertation contributes to the Additive Manufacturing (AM) field, particularly in quality control and defect management within Direct Ink Writing (DIW) processes. It proposes innovative algorithms and methodologies for leveraging domain knowledge data structures to enhance knowledge sharing in scenarios with limited samples. The research tackles two main challenges: optimizing a data structure for collaborative few-shot learning and automating attribute extraction to reduce manual efforts in ontology generation. The first challenge in Chapters 2 and 3 focuses on selecting and optimizing data structures to improve learning efficiency. Chapter 4 addresses the second challenge by automating attribute extraction, thus speeding up the ontology generation process and minimizing manual work.

Chapter 2 introduces an ontology-guided attribute learning methodology for identifying unseen defects in AM processes, integrating natural language processing and metaheuristics. This method demonstrates significant improvements in defect identification accuracy over traditional approaches. Chapter 3 explores a federated learning approach to defect identification that accurately balances data privacy, proposing a new differential privacy-federated algorithm. Finally, Chapter 4 proposes automating the extraction of attributes using self-supervised learning algorithms, which is crucial for developing structured data capable of recognizing new defects.

The dissertation presents a comprehensive approach to improving quality control in AM through ontology-based collaboration, federated learning, and self-supervised learning, marking a significant advancement in defect identification and quality control. Additionally, it outlines the broader implications of this research for the manufacturing sector, emphasizing the potential for cost reduction, process development acceleration, and the transition from lab-scale to production-scale AM. This work is expected to substantially benefit academic research and industrial applications, laying the groundwork for future advancements in the field.