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Editorial

Advanced Applications of Artificial Intelligence in Metallic Materials Processing

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1. Introduction

As the name of this Special Issue indicates, its aim was to highlight advanced applications of Artificial Intelligence (AI) in metallic materials processing, containing a final total of 12 published papers. This closing editorial aims to present a summary of this research by initially grouping the papers according to application type and subsequently identifying the main techniques adopted, the main challenges and the main conclusions for each group.

2. Materials Characterization

In total, five papers in this Special Issue addressed the problems of materials characterization. The main challenges included predicting alloy properties [Contributions 1,2], interpreting complex microstructural data [Contributions 3,4], typically obtained through SEM imaging, and finally linking alloy composition to mechanical properties [Contribution 5]. Image analysis algorithms and supervised machine learning approaches were the preferred methods, and were used in combination with genetic algorithms for optimization purposes. The obtained conclusions show that it is possible to improve the accuracy of property predictions and furthermore to enable the design and development of alloys.

3. Process Optimization

Four papers dealt with process optimization over a wide range of manufacturing processes such as material removal [Contributions 6,7], welding [Contribution 8] and hot rolling [Contribution 9]. The adopted methods also varied, with the researchers mainly relying on neural networks and fuzzy inference, while reinforcement learning and particle swarm techniques were used to solve the optimization problem related to product quality and process efficiency.

4. Defect Detection

The last group of papers (a total of three) dealt with the problems of automated part inspection, focusing on the recognition of different types of surface defects. The investigated processes involved casting [Contributions 10,11] and aluminum extrusion [Contribution 12]. The typical approach consisted of training various types of neural networks (mainly CNN- and YOLO-based) with part images obtained under real production conditions so as to properly classify the defects. The main challenges were the limited dataset sizes and class imbalance, which were compensated by data augmentation methods including image translations, cropping, etc., as well as transfer learning. The main conclusion was that such machine vision-based methods can achieve high accuracy and be easily deployed.

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5. Closing Statement

In summary, the published papers cover a wide range of different manufacturing processes, material types and real-world applications, showcasing the versatility of the adopted methods. Metallic material processing has always been considered an interdisciplinary domain, building on engineering and materials science backgrounds, but this Special Issue emphasizes the fact that computer science can currently provide advanced tools to solve the complex problems of the domain.

Conflicts of Interest: The author declares no conflicts of interest.

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