Chapter 14
Machine Learning Applications for 3D-Printed Polymers and Their Composites

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ABSTRACT

Although the number of applications for 3D printing has substantially risen over the past several years, it is required to calibrate the AM processing settings. Various methods of AL are being applied in today's world in order to improve the parameters of 3D printing and to forecast the quality of components that have been 3D printed. An application of ML in the prediction of the properties and performance of 3D-printed components has been demonstrated in the current work. This research begins with an introduction to machine learning and continues with a summary of its uses in the 3D printing process. The majority of this chapter is dedicated to discussing the applications of ML in the forecasting of essential properties of 3D-printed components. In order to accomplish this objective, prior research studies that studied the application of ML in the characterisation of polymeric and polymer composites have been reviewed and addressed.

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INTRODUCTION

Products are being replaced and upgraded more frequently now than in preceding decades, and manufacturer competitiveness encourages the creation of new technology. Rapid prototyping techniques like additive manufacturing (AM) and three-dimensional (3D) printing use a consecutive layer of materials to build three-dimensional things underneath computer control. The benefits of additive manufacturing over traditional procedures have been demonstrated to include the opportunity to function with a large variety of materials and few limits in the manufacture of complicated shapes. Numerous industries, including aviation, automobile, communications, construction, and health monitoring (Kong L et al., 2016, Leal R et al., 2017, Khosravani M R et al., 2020, Murr L E et al., 2019, Machment T et al., 2019, Nasiri et al., 2020), have employed this production technique. The American Society for Testing Materials (ASTM) has categorized additive manufacturing into 7 procedures: vat photopolymerisation, binders spraying, sheet laminations, direct energy deposition, materials' extrusion, and powders' bed fusion (ASTM, 2012). Various engineering elements were researched in this area basis on applications of additive manufacturing. For example, current research studies looked into durability, tensile strength, ecological consequences, and various welding purposes (Colorado H.A et al., 2020, Palanikumar et al., 2020, Khosravani MR and Reinicke T, 2020, Karavel E and Bozkurt Y, 2020). Various options were used to optimize these variables and forecast the mechanical characteristics of printed parts (Ren D et al., 2019, Munprom R, Limtasiri S, 2019, Goh GD et al., 2020, Khosravani MR and Reinicke T, 2020, Saeed K et al., 2021, Pei S et al., 2021) because additive manufacturing operating variables (such as particle size of powders, deposition rate, film thickness, laser power, and raster angel) get a significant influence on the network authenticity and mechanical characteristics of three dimensional-printed components. For instance, the rigidity and strengths of three-dimensional-printed polymeric composite parts were recently assessed in (Saeed K et al., 2021) using a sequence of tensile tests. Additionally, it was shown that fiber orientations have an impact on the studied components' mechanical behavior. The article referenced (Pei S et al., 2021) looked studied the micro and macro influences of process variables on three-dimensional-printed composites manufacturing. In this instance, short materials extrusion-based carbon-fiber reinforcing polymeric composite materials were manufactured. Morphology characterization was done using an image-based statistical approach (e.g., fiber volume fractions). A Monte Carlo sampling technique was also employed to enhance the datasets. The observed results demonstrated that processing factors are important for void production and void volume concentration dispersion.

According to an analysis of relevant literature, mathematical modeling and other Artificial Intelligence (AI) methods have been utilized to explore the performance requirements of three-dimensional-printed parts (Yang J et al., 2017, Li Y et al., 2021, Trivedi A and Gurrala PK, 2021, Pazhamannil RV et al., 2020) in addition to experimentations. For example, three-dimensional FEM modeling has been used in (Chen Q et al., 2017) to assess the impact of process variables on the melt pool profile and beads forms in ceramic materials three-dimensional printing. A fundamental quantitative concept was established at the very same time to examine residual stresses in metal components made using additive manufacturing (Fergani O et al., 2017). To do this, the evaluation of the operation's thermo signature was done using the predicted temperature distributions. According to research, thermal stresses were employed as an input when calculating residual stresses. Those earlier investigations showed that models were exclusively focused on one or two facets of the additive manufacturing procedure. The use of data-driven

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