ADVANCES IN ADDITIVE MANUFACTURING TECHNOLOGIES

Edited by
P Gurusamy

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ADVANCES IN ADDITIVE MANUFACTURING TECHNOLOGIES

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Preface

We are delighted to present the proceedings of the 5th International Conference on Advances in Additive Manufacturing Technologies (ICAAMT 2023). This conference serves as a premier forum for researchers, practitioners, and industry experts to share their latest findings, innovations, and insights in the field of additive manufacturing. The rapid advancements and the increasing adoption of these technologies across various sectors underscore the importance of this gathering. The conference was held from November 27-29, 2023, in Chennai, India and organized by the Department of Mechanical Engineering, Chennai Institute of Technology, Chennai, India.

The ever-increasing demands for new products accelerate the growth of manufacturing technologies. Additive manufacturing is the most popular due to its ability to print complex customized geometries. Technological advancements and research take additive manufacturing to the next level of customized functional end-use products. The applications are diversified into various fields, including aerospace, medical, automobiles, etc.

Some of the critical features of additive manufacturing are lower start-up costs, ease of learning, reduced raw material wastage, customization to the individual, digital design integration, speed of prototype, speed from prototype to production, lower energy and environmental costs, low volume production runs, distributed manufacturing etc.,

We deeply acknowledge that the success of the conference is a collective achievement, a testament to the collaborative spirit of our community. We are grateful to our esteemed Patron, Chairs, and Principal for their invaluable guidance and support in organizing this event. The program committee's meticulous and timely review of the papers played a pivotal role in the success of this international conference.

We extend our heartfelt gratitude to the authors for their significant contributions, the reviewers for their insightful feedback, and the organizing committee for their relentless efforts in making this conference a resounding success. We are confident that the knowledge shared through these proceedings will not only inspire but also drive further research and innovation in the dynamic and rapidly evolving field of additive manufacturing.

We are optimistic that these proceedings will prove to be a valuable resource, enriching your work and contributing to the advancement of additive manufacturing. We hope you find them informative and insightful.

Sincerely,

Dr. P. Gurusamy
Organizing Secretary (ICAAMT 2023)
Professor & HOD, Mechanical Engineering,
Chennai Institute of Technology, Chennai-600 069,
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About the Editor

Dr. P. Gurusamy is a distinguished academician and a reputed researcher in Mechanical Engineering with a remarkable career spanning over two decades. He commenced his academic journey with a Bachelor of Engineering (B.E.) in Mechanical Engineering from the Government College of Engineering, Tirunelveli, in 1996. His educational pursuits continued with a Master of Engineering (M.E.) in Production Engineering from Thiagarajar College of Engineering, Madurai, which he completed in 1998.

Dr Gurusamy's quest for knowledge led him to Anna University, CEG Campus, Chennai, where he earned his PhD in 2014. His doctoral research, titled "Influence of Squeeze Casting Parameters on the Mechanical Properties and the Solidification Behaviour of the Al/SiCp Composites," received a 'Highly Recommended' rating from the examiner, highlighting the significant contribution of his work to the field.

With two years of Industrial Experience and a 25-year teaching career, Dr. Gurusamy has become a pivotal figure in Mechanical Engineering education and research. He is a recognized supervisor for guiding PhD and M.S. research scholars at Anna University, Faculty of Mechanical Engineering. Currently, eleven scholars are pursuing research under his guidance.

Dr. Gurusamy's research interests are diverse and impactful, encompassing Composite Materials, Foundry Technology, Nanomaterials, Surface Technology & Advanced Materials Processing, Carbon Nanotubes, and Polymer Nanoclay Composites. His prolific contributions to the academic community include 79 publications in International Journals and numerous participations in International Conferences across India and abroad.

In addition to his academic and research endeavours, Dr Gurusamy has also demonstrated his innovative capabilities by publishing many patents in Material Science. His professional affiliations include memberships in esteemed organizations such as the American Society of Mechanical Engineers (ASME), the Society of Automotive Engineers (SAE), and the Indian Society for Technical Education (ISTE).

Dr. P. Gurusamy's enduring dedication to education, research, and innovation continues to inspire his students and peers, making him a respected and influential figure in the field of Mechanical Engineering.

Advances in Additive Manufacturing Technologies – Gurusamy Pathinettampadian (eds)

1 A Process of Additive Component with Machine Learning

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ABSTRACT: Industry 5.0 has resulted in an explosion of machine learning (ML) frameworks, especially auto-ML techniques that are easy for non-experts to use. To do away with the trial-and-error process of determining the right input parameters in 3D printers. Specimens were prepared for the process using 3D printing and the Fusion Deposition Method (FDM). The result of the software was used to estimate which of the several machine learning algorithms was the best. Surface testing on the vehicle component specimen was used to forecast several output metrics, such as drilling accuracy and roughness, with the use of machine learning in 3D printing. The program has an accuracy of 93.56% and an error of 6.43%, according to the final results.

KEYWORDS: Machine learning, 3D printing, Algorithm, Accuracy with variance

1. Introduction

The most recent machine learning techniques used for clean data processing go beyond simple learning. Time series forecasting, supply chain management, energy, healthcare, sales, environmental research, manufacturing, agriculture, and many more fields have a wide range of industrial and scientific applications. Similar to this, a Python library is used for a uniform interface in machine learning, which makes it simple to carry out model building, inspection, and application. Many industries, including self-driving cars, space research, and medicine, use machine learning techniques. This study focuses on the area of additive manufacturing specifically related to 3D printers.

1.1 Artificial Intelligence

Artificial intelligence (AI) many subdivisions, including machine learning. AI is the fusion of machine intelligence and other components. Prominent AI researchers investigate “intelligent agents,” which include a feature to accurately assess the environment and optimize execution to successfully accomplish objectives. AI is used to explain machines that replicate cognitive processes like “learning” and “problem solving,” which are associated with the human mind. The basic ideas of AI research’s computer algorithms, which automatically get better with experience, are becoming more and more capable of handling machines

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1.2 Machine Learning

Machine learning that automatically advances through practice with data and an understanding of computer techniques. As a component of artificial intelligence, it is impractical to create traditional algorithms for the necessary computational statistics-based activities[1]. ktrain is a low-code Python module that uses machine learning to make machine learning (ML) more approachable and simpler to use. Created a unified interface that required only three or four "commands" or lines of code to swiftly solve a variety of jobs in his research, also noted that there has been a lot of attention focused on unified machine learning. [2] Because of the variations in the approaches, the many approaches that have been released are not well documented and unclear. The goal of this work is to construct a design that fills in the gaps and completes the missing links in the areas of auto machine learning, hyper parameter tweaking, and metal earning process. Darts can solve a Python machine learning framework for time series problems like forecasting. This can take the form of a series, meta-learning across several series, training on huge datasets, combining outside data, putting together models, and offering robust support for probabilistic forecasting. [3] With the help of strong parameter adjustment and Auto ML approaches, the ML frameworks can be used by systems that are not experts. The directed cyclic graphs utilized in mlr3pipelines are a foundation for defining both simple and complicated non-linear machine learning operations. [4]. The framework uses bench marking, tweaking, and convenient resemblance components as part of the mlr3 ecosystem. A few engines, including the Knowledge Base, GUI, Visualization, and Human engines, were introduced by Penn AI. Even while these are intriguing ideas for creating a user-friendly auto ML system, they don't offer a significant contribution to the cutting edge of auto ML research. [5].

1.3 Deep Learning

Artificial neural networks, on which machine learning techniques are based, provide the basis for deep learning. The process of learning may be partly, fully, or not seen. Deep learning algorithms generate substantial credit assignment path (CAP) depth. The number of layers [6] is used to more precisely convert this data. Deep learning models in the medical field have grown exceptionally well as a result of the rapid advancements in machine learning, graphics processing technology, and medical imaging data. [7] The difficulties in applying 3D CNNs to the realm of medical imaging, deep learning models, and potential future developments. Machine learning uses a variety of techniques when there isn't a completely functional algorithm.

1.4 Researcher's Outlook

The biometric utility is necessary to identify facial analysis and run the systems, and it can also be helpful in removing low-quality data. This body of literature offers survey analysis using visible wavelength facial photographs within the face biometrics paradigm. [6] For instance, the picture selection and facial image quality evaluation that are covered in his research indicate the infrared quality assessment as a tendency towards deep learning. To provide high-quality and effective services, customer service is changed by converting from traditional to automated service using various computational data. [8] Big data is needed since it requires knowledge of data analysis. In small and medium-sized businesses, a lack of resources and scale leads to a lack of information and experience. In order to address this problem, open and automated customer service platforms like block chains, automated machine learning (AutoML), and the Internet of things (IoT) are suggested. This creates a third party dependency, which increases costs. These platforms take into account data collection, data security, and economic factors.AutoML has advanced neural network architecture significantly by using complex, expertly-designed layers as building blocks [9]. By proposing a unique framework, we may eliminate human bias through a generic search space of two-layer neural networks trained by back propagation.

2. Materials and Methods

Additive manufacturing, also known as 3D printing, is the process of creating thin layers. Above the resources by lying down, we can eventually obtain a 3D digital replica of the physical object. Layer by layer of materials, it transforms the computer object of the CAD model into a real form. The reagent, powder, filament, and pellets are the materials delivered in various states and employed for this purpose. There are numerous production methods available for the AM process. In this undertaking, the merged. The specimen is made using the fused deposition modeling (FDM) technique. This procedure is conducted using temperature-controlled head sequentially extrudes thermoplastic material, allowing the path using 3D CAD information. Starting with the model's STL file, pre-processing software is used. Mathematically divided horizontal layers with thicknesses ranging from +/- 0.137 to 0.264 mm.When necessary, support structure is required. A 3D model is produced using the tool path and data.

The specimen used is printed using the following setup parameters. 1. Layer Height: 0.01mm, 2. Fan Speed: 25%, 3. Nozzle temperature:250 deg 4.Bed temperature 50 deg, 5. Print speed: 120 (mm/s), 6. Materials: Polylactic Acid (PLA)

Figure 1.1 shows the specimen created by the AM method as well as the experimental procedure. The Fused Deposition Modelling (FDM) procedure is used to 3D print the object.

Fig. 1.1 Specimen created by AM method

3. Results and Discussion

The 3D printing technology' Fusion deposition method was used to prepare the specimen. Next, a surface roughness tester was used to measure the specimen's roughness value. Roughness testing was also done at a few drilling locations on the sample. Using the appropriate machine learning program, the algorithm was created. The process's appropriate algorithmic approach was predicted with accuracy and error value. This is measured in real time and compared. Additionally, ML code was designed and implemented successfully utilizing a Python coder.

The sequence of the machine learning algorithm (MLA) is as follows:

(a) Bringing in the necessary packages.
(b) Importing the dataset and determining which values are NULL
(c) Maintaining the variables, both independent and dependent partitioning the dataset (d).
(e) Maintaining a variable containing machine learning algorithms (MLA)
(f) Making a box plot to assess how accurate they are
(g) Evaluating every algorithm for machine learning.

The above mentioned procedures are taken when creating a program and designing an algorithm. There was testing and comparing done The above steps are followed in the part program formation and algorithm was designed. The testing and comparison was carried out.

3.1 Calculation and Algorithm

Define Cost Function

$$.J(\theta) = \frac{1}{2n}\sum_{i=1}^{n}(\hat{y} - y)^2 \tag{1}$$

$.J(\theta)$ - Cost function

n - Number of samples

y - True value

$\hat{y}$ - Predicted value

Θ - weights (trainable parameters)

$$\hat{y} - \theta_0 + \theta_1 x_1 + ... + b_k x_k \tag{2}$$

b_0 - Y-intercept

b_i - Slope of the i th variable

x_i - value corresponding to feature i

$$\theta^{n+1} = \theta^n - \alpha\frac{\partial J(\theta)}{\partial\theta} \tag{3}$$

θ^{n+1} - updated weights (weights at next step)

θ^n - previous weights

α - learning rate ($0 < \alpha < 1$)

$\frac{\partial J(\theta)}{\partial\theta}$ - change of cost function $J(\theta)$ with respect to α

$$0 \le J(\theta^{n+1}) - J(\theta^n) \le t \tag{4}$$

t - Threshold value ($0 < t < 1$)

$J(\theta^{n+1})$ - Total cost of updated weights

$J(\theta^n)$ - Total cost of previous weights

Algorithm

- Establish the cost function $J(\theta)$, which quantifies the discrepancy between the expected and realized results.
- Set the model's random weights to zero.
- Using the gradient descent technique, update the weights θ iteratively: $\theta := \theta - \alpha * \nabla J(\theta)$.
- Using a stopping condition, repeat the weight update until convergence is reached.such as the cost function difference threshold or the maximum number of repetitions

4. Conclusion

According to the project's goal, the FDM method for creating 3D printed specimens was tested by gathering surface measurement data, which is displayed in Fig. 1.2 at 0.84 nm and 0.0.87. Which information is contrasted in the MLA result. The last window is created using the 3D printer data set following training. To train the data set, multivariate linear regression is employed. Referring to Fig. 1.3, the model predicts the valueon the training data set with a variance of 2.0840360280300282e-26% and an accuracy of 100%. The program yields 0.095, however the average roughness measured with the "Surface Roughness Tester" is 0.0855. The program has an accuracy of 93.56% and an error of 6.43%, it may be inferred.The accuracy

Fig. 1.2 Roughness check

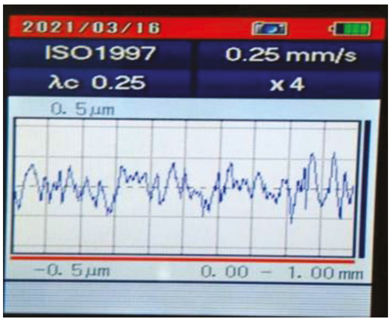

Fig. 1.3 Roughness graph

computation was reported along with the percentage of error.

Figure 1.2–1.3 : Roughness Measurement (a) Position one on Auto Specimen (b) Positon two (Drill hole area) on Specimen. (c) Roughness graph for position one.

Accuracy calculation:

- Average roughness value = 0.087 + 0.0842
- Average roughness value = 0.0855 µm
- Accuracy = 100 – 0.091 – 0.0855
- Accuracy = 100 – 6.43 Accuracy = 93.57%.

The bar chart of variance s in Fig. 1.4 for several machine learning algorithms, including K-nearest neighbour, decision tree classifier, Gaussian Naive Bayes, Random Forest classifier, and adaptive boosting classifier, is displayed in the graph that compares the various algorithms. We may deduce from the above chart that the decision tree classifier is most appropriate for the prediction phase because it has the lowest variance.

Comparably, Fig. 1.4 displays an accuracy bar chart for several machine learning algorithms, including Gaussian Naive Bayes, Random Forest, Adaptive Boosting, K-nearest neighbour, and decision tree classifiers. The decision tree classifier is the most accurate and, thus, most appropriate for the prediction phase, according to the above figure. Figure 1.4 displays the accuracy vs. variance scatter plot for a variety of machine learning algorithms, including Random Forest, Adaptive Boosting, K-Nearest Neighbour, Decision Tree, and Gaussian Naive Bayes.

The decision tree classifier is the most accurate and least variable, making it the most appropriate for the prediction phase, according to the above figure. The Decision Tree Classifier has a low variance with good accuracy, according to the data analysis of the algorithm selection. After that, a surface roughness tester is used to test the second spot on the specimen, and the results are compared with software that uses machine learning algorithms. The outcome as discovered in the drill bit data set. The program displays the appropriate algorithm and accuracy level.

The drill bit data set is used for the last window following training. Five distinct models are used to train the data set, and accuracy and variance are displayed. Additionally, the models' output is pooled using the maximum vote technique, increasing the average accuracy from 89.73% to 100%. The K-Fold cross validation approach is used to identify the optimal model.

Without any prior computer programming experience, a wide range of engineering areas can benefit from the machine learning project. using less than 10% variance, 90% accuracy may be achieved using the aforementioned

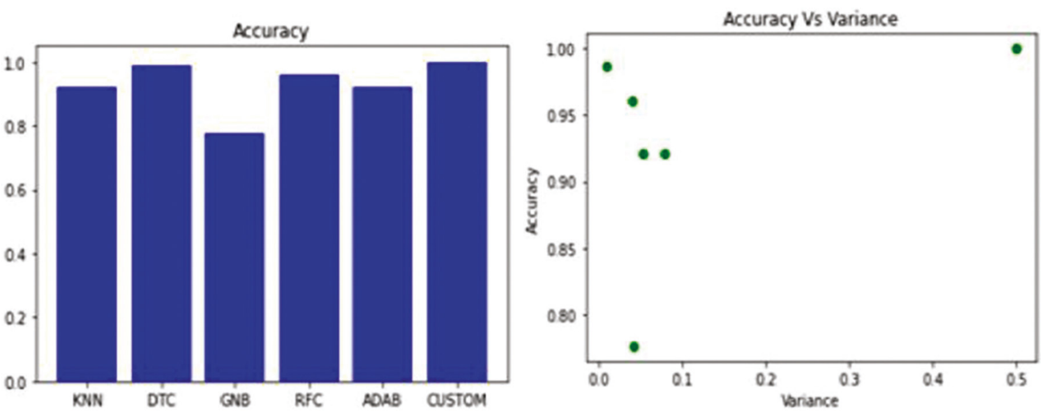

Fig. 1.4 Bar chart and scatter plot of a accuracy for different machine learning

program, and a 3D printed object is analyzed. While the program yields 0.091, the average roughness measured with the "Surface Roughness Tester" is 0.0855. The program has an accuracy of 93.56% and an error of 6.43%, it may be inferred.

It can measure a 3D printed object's roughness simply and without the need for trial and error. By employing this strategy, time is saved. Everyone can simply access it. to enable machine learning in fields other than technology. to use zero code to create machine learning models. to use machine learning with a 3D printer to get precise parameter settings.

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A Comparative Study on the Influence of Novel Neem Fiber on the Tensile Strength of Wood Fiber-reinforced Polylactic Acid Composite Materials

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Study on MRR of Epoxy Composite Incorporated with 15% Fiber and 5% Novel Nano Carbon Particles Made of Peanut Husk during Drilling Process

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A Comparative Analysis of Flexural Strength between 3D Printed Lattice Structures (PLA) Compared with and without the Silica Nanoparticle

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Comprehensive Review of Carbon Enabled Transistors for Ultra-Low Power Electronics in Integrated Circuits Over Silicon Devices

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