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Vision-based surface roughness accuracy prediction in the CNC milling process (Al6061) using ANN

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ABSTRACT

This paper proposed the methodology of identified the surface roughness accuracy rate in the CNC milling process by Artificial Neural Network. Al6061 preferred as job material for milling processes carried out in CNC milling machines. The various input parameters like speed, federate, and depth of cut used for the CNC milling process. The Artificial Neural Network modeling has consisted of different input parameters and a single output parameter. The surface roughness is fixed as an output parameter in an Artificial Neural Network. Based on the input parameter and the number of neurons, the surface roughness value was derived. The final accuracy rate of surface roughness was calculated by vision measurement value compared with the conventional stylus probe.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Newer Trends and Innovation in Mechanical Engineering: Materials Science

1. Introduction

In the industrial world, most of the manufacturing companies are competing with each other. If a company needs profit, it should provide a good quality of products and also have more buyers. During the high-quality component production, the time constraints may increase, especially in the inspection process. AISI 4140 Steel machined by CNC lathe with various input parameters such as cutting speed, depth of cut, and feed rate. The RSM methodology used to optimize the best roughness value through the regression equation [1]. This review study used to analyze the different parameters used to predict the surface roughness value [2]. The ANN consists of three layers, such as the input layer, output layer, and hidden layer. The grayscale, cutting speed, depth of cut, F1, and F2 are input parameters to Artificial Neural Network. Based on the training and testing method, the surface roughness value was generated by an Artificial Neural Network [3]. Surface roughness prediction on Al6063 by soft computing approaches like ANFIS and random forest classification [4].

Based on the above literature survey, the 6061 preferred as job material due to its machinability character. The ANN methodology is choosing for rapid surface roughness inspection. The final accuracy level also calculates by comparison of vision and conventional surface roughness value.

2. Materials and methodology

2.1. Artificial Neural Network

Artificial Neural Network modeling was built with an input layer, hidden layer, and output layer. The input layer is active. During the algorithm, the execution process can modify the input process parameters range. The hidden layer was filled with the number of neurons, which is used to boost up the accuracy of the output value. The output parameter assigns in the output layer (Fig. 1).

2.2. Materials

Aluminum 6061 Alloy preferred as the job material, due to its low corrosion and good machinability characteristics. Most of the engine components are manufactured by aluminum alloy. Tables 1 and 2 shows the mechanical and chemical properties of Al 6061 alloy (Fig. 2).

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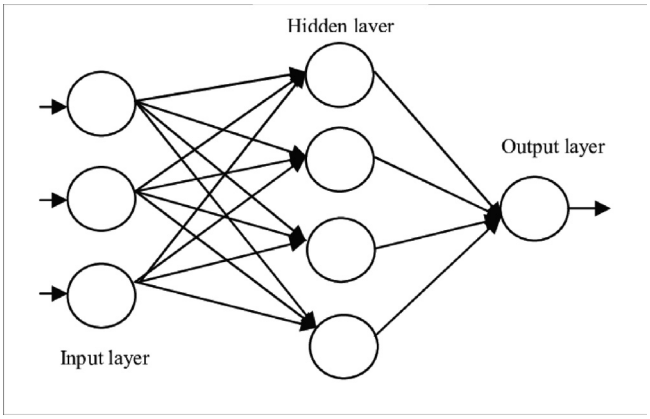

Fig. 1. The architecture of Artificial Neural Network.

Table 1
Mechanical properties of Al 6061.

Tensile Range	110–120 MPa
Yield Range	45–50 MPa
Shear Level	80–85 MPa
Fatigue	60–65 MPa
Poisson's ratio	0.333
Elongation range	26%
Hardness Strength	35

Table 2
Chemical properties of Al 6061.

Element	Content (%)
Aluminum (Al)	97
Magnesium (Mg)	1.1
Silicon (Si)	0.65
Copper (Cu)	0.29
Chromium (Cr)	0.23

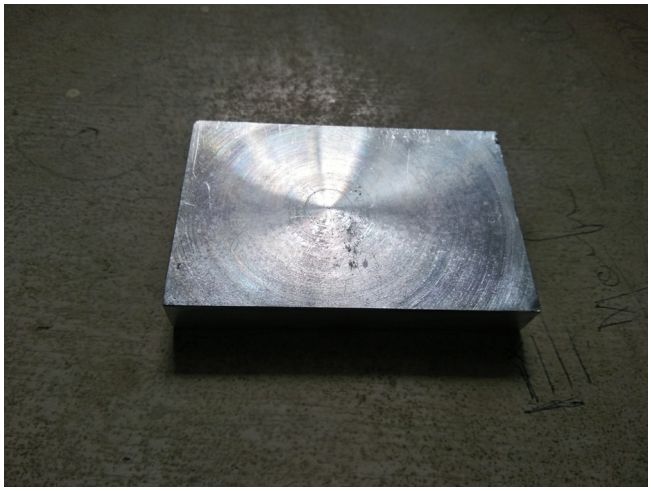

Fig. 2. The Al 6061 alloy for the CNC milling process.

2.3. Stylus probe

The stylus probe is used as a validating method in surface roughness measurement. All machining workpiece, the surface roughness value measured by stylus probe, three values took from the single workpiece, and then it means value to assign as the surface roughness value for the particular workpiece. Table 3 shows the training module of ANN (Fig. 3).

Table 3
Training experimental values.

S. No	Speed (rpm)	Feed Rate (cm)	Depth of Cut (cm)	Stylus probe Ra (um)
1	960	0.05	0.5	1.043
2	960	0.125	0.8	0.962
3	960	0.2	1.2	0.954
4	1200	0.05	0.5	1.021
5	1200	0.125	0.8	1.084
6	1200	0.2	1.2	0.937
7	1440	0.05	0.5	1.128
8	1440	0.125	0.8	1.15
9	1440	0.2	1.2	0.913
10	960	0.055	0.55	1.091

Fig. 3. Stylus probe instrument.

Table 4
Testing experimental values.

S. No	Speed (rpm)	Feed Rate (cm)	Depth of Cut (cm)	Stylus probe Ra (um)	Vision Measurement Value (um)
1	1200	0.055	0.55	0.996	1.346
2	1440	0.055	0.55	0.982	1.234
3	960	0.13	0.9	0.974	1.346
4	1200	0.13	0.9	0.965	1.276
5	1440	0.13	0.9	0.961	1.324

3. Result and discussion

After the training and testing process, ANN generates the surface roughness value is shown in Table 4. The result shows the difference between the conventional method and vision measurement.

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Table 5
Accuracy Range.

S. No	Stylus probe Ra (um)	Vision Measurement Value (um)	Mean Value	Accuracy
1	0.996	1.346	0.35	100–
2	0.982	1.234	0.252	1.648 = 98.352
3	0.974	1.346	0.372	
4	0.965	1.276	0.311	
5	0.961	1.324	0.363	

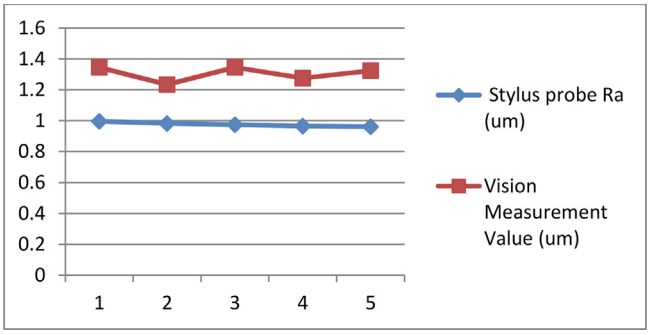

Fig. 4. Comparison Graph of Stylus probe and Vision surface roughness value.

Here Table 5 represents the accuracy range of surface roughness was calculated by comparisons of stylus probe and computer vision measurement method (Fig. 4).

4. Conclusion

In mass production, checking the surface quality of all machined components was difficult. So they follow the work sampling technique to measure the quality of the product. This work can replace the work sampling technique in mass production. The vision-based surface roughness measurement can be reduced the time of inspection in all machined components, So the scarp level can be reduced. Based on the above work can justify the ANN model produce the98.35% accuracy to predict the surface roughness.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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