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Artificial Intelligence Machining Based Axes Detection for Precise Depth of Cut in CNC Processes

Sekiteri Patience Sametu[1]; Ogunobo Romanus[2]; Umar Adam Isah[3]

[1,2]Mechanical Engineering Technology, Auchi Polytechnic Auchi, Edo State, Nigeria
[3]Mechatronics Engineering Technology, Auchi Polytechnic Auchi, Edo State, Nigeria

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Abstract: This research uses theoretical and machine learning approach to evaluate depth of cut. Comparison shows that when heat is high it increases axial stresses and percentage error increment value from 2.20 (µm) to predicted surface at 36.50 (µm). It shows positive response was higher at axial distance by 6% than radial distance with presorted decrease in machine removal rate by 2% error. The computed values were experimented at controlled variable relying on linear distance by the cutting and spindle axis. The input variable for the k Nearest neighbor shows 2mm/min ,4 mm/min and 6 mm/min feed rate alongside 146.4 N force threshold tooling.

Keywords: *Artificial Intelligence, Axes Detection, Depth of Cut, CNC Processes.*

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I. INTRODUCTION

Cutting is an act of removing part of a tool to produce specific proposed design. It also plays a vital role to ensure proper fitting, aesthetic values, waste reduction and ergonomic factor. Depth of cut involves replacing certain thickness in every cut per pass by cutting tool. Precise force of cutting is needed to decrease wear and product rejection in the market. To monitor level of energy usage is needed to minimize overheating and carbon accumulation (Zhao et al., 2021). Conventional method uses a fixed clamp which mostly not consistent with cutting force. Specific problems encountered by machinist consist of waist pain, prolong standing, noise vibration, inhaling smell of cutting fluid. While the generic problems are poor dimension, deflection and improper mounting of the cutting tool. Several machines have degree response to tool wear, machining data which depend on influence of machining energy usage (Liu et al., 2016).

This research intends to creative cutting-edge technology by developing certain algorithm that mimic human thinking to resolve difficult model layers of federate, dept of cut, force and thickness threshold. This would indirectly decrease intense temperature and excessive wear designed products. Computer numerical control machine is highly affected by non-uniform depth of cut. There is need to moderate Speedle speed, feed rate, rake angle and vibration. (Cao & Guan, 2018). Also to optimize the frictional influence seems difficult within product fitting consistently when compared to traditional equipment (Okokpujie et al., 2019).

Prolong cutting with workpiece contact generates elevated heat which changes with time when performing operation like milling, turning and drilling (Wu et al., 2020; Sihimbaev et al.,2014). In Nigeria, some of the imported computer numerical control machines are not adaptable with diverse weather condition. Especially electricity bills affect price per unit of product and decrease demand. Nevertheless, adjustment was formulated using coefficient model, cutting level and real energy consumption through orthogonal experiment, data processing and fitting methods (Zhong et al., 2017).

II. LITERATURE REVIEW

Depth of cut has been a critical issue in computer numerical control machine. Several conducted researches use different concepts arising from modelling, theories and simulation. Likewise, data driven energy forecast was made using learning algorithm (He et al., 2020).

This has helped to investigate good surface finishing; axis shift and with precise diameters deflections.

Further forecast was evaluated using a historical data collection from pre-existing machine tool operation (Shin et al.,2018). Sometimes, mapping of cut on tool using G code encounters flexural error prediction. This requires critical

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positioning of tool based on analytical comparison, stability, lobe diagram construction and experimental validations (Li et al., 2023).

Computation was analysed by improving and comparing geometric shapes, lines alongside angles as drills and cutting instrument change axes (Han et al., 2018). In contrast to model-based prediction and machine learning approach. Cutting force increment increases feed rate and depth of cut as presented in other conducted studies (Javidikia et al., 2020).

III. METHODOLOGY

Vibration sensor, strain gauge, vernier caliper and proximity sensor were used alongside resonant clip actuator (RCA). The system was interfaced with fluid dispense valve for cutting fluid delivery at given viscosity index. An ESP32 microcontroller allows prompt regression response for efficient axis swap. A mild steel material measured 10mm by 3mm having 30 Hz sampling rate was tested with depth of cut pattern. Six test run was performed with mild steel having three force axes representing x, y and z. The performance was steady with less dimensional errors at G17, G27 and G28 codes for complex shapes involving 4 and 5 axes when the mild steel about to be cut. The depth of cut was consistent due to flat surface workpiece holder. Instead of allowing the system to assumed kinematic switch pattern we prompted G80.1 and M117 code to terminate machine code. We developed K nearest neighbor (KNN) values to calculate the axes distance of cut across surface roughness and coefficient of friction coefficients to adjust relative speed for minimal chatter using external 0.12 mm thickness.

IV. RESULTS AND DISCUSSIONS

It was observed that mapping for accurate depth of cut with K nearest neighbor force 2N. Other has cutting force with highest values which started dropping from 4N. Initially, the assign k values were 1N in table 1 below.

Table 1 Comparison of Force Mapping Distance Factor

Runs	Axes	V_C (m/min)	F_r (mm/min)	N_S (rpm)	F (N)
1	X	106.00	135	750	12.00
2	X	106.00	135	750	8.00
3	Y	106.00	135	750	6.00
4	Y	106.00	135	750	4.00
5	Z	106.00	135	750	2.00
6	Z°	106.00	135	750	2.00

The essence of the constant feed rate is to investigate influence of force and cutting speed. We found that in table 1.10 below that actual, predicted rror increases stability of error rate are instable due to negligence of maintenance at 2.20 (µm). This seriously affect the compensation error at intense machining processes. Computations was obtained from the given equations below;

$$Vc = \frac{\pi Dn}{1000} \quad (1)$$

$$Fc = AxfxK \quad (2)$$

Table 2 Mean Absolute Error (MAE) for Six Depth of Cut Runs

Runs	Actual surface Error (µm)	Predicted Surface Error (µm)	Absolute Error (µm)
1	10.33	12.06	1.73
2	12.60	13.30	0.70
3	25.70	27.04	1.70
4	29.60	30.70	1.10
5	31.40	33.60	2.20
6	34.70	36.60	1.32

The calculated mean absolute error (MAE) of 1.50mm from table 2 above was used predict depth of cut for precise tooth path, decision and image mapping when the cutting operation is done. As the surface exhibit flow of conducted as the cutting losses viscosity. The predicted values increases as the absolute values increases. The peak values having 2.20 (µm) absolute error and high predicted surface at 36.50 (µm). This affects not only the surface finishing also intricate alignment path of the tool tip.

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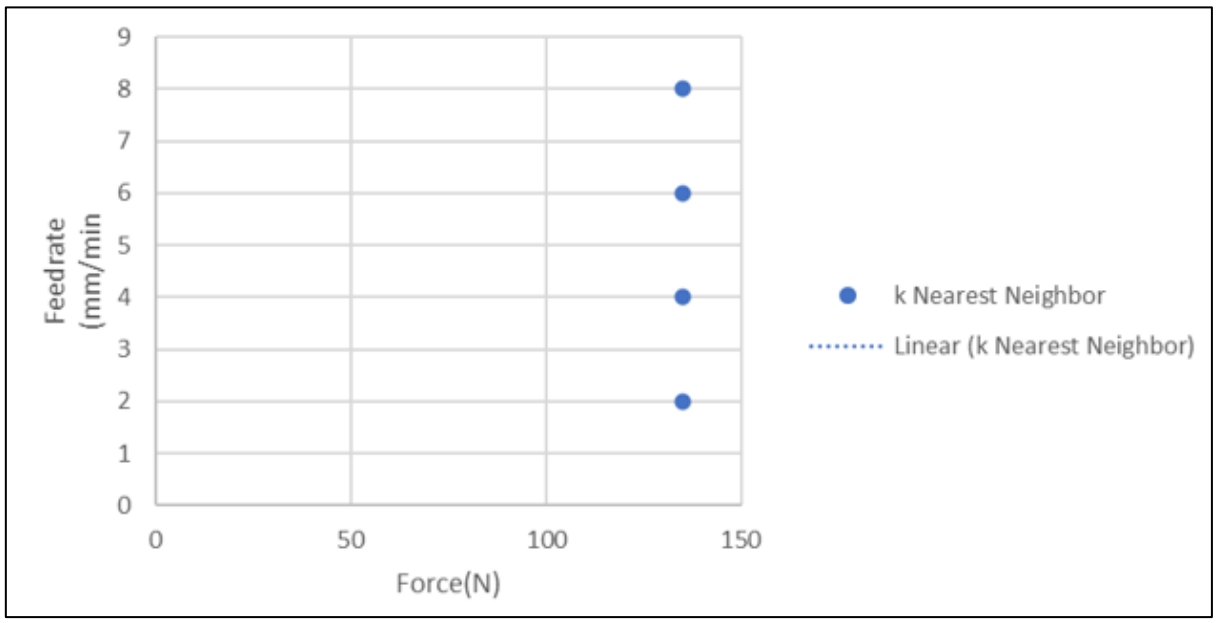


Fig 1 K Nearest Neighbor for feed rate (mm/min) vs Force (N)

Table 3 Estimation of Percentage Error

Runs	Actual depth of cut (mm)	Predicted depth of cut (mm)	Absolute Error	Error %
	12.44	13.60	1.16	9.00
	14.60	15.30	0.70	5.00
	26.31	27.60	1.29	0.04
	33.03	34.03	1.00	3.00
	40.70	41.70	1.00	0.03
	48.34	49.34	2.00	2.10

The average depth of cut error was 1.03mm used to validated next mapping of the tool life. The percentage error was high due to poor tool rigidity and increase in heat flux. The machine feedback system was adjusted to track chip clearance with tool repose angle figure 2 above . It shows positive response as the presorted cut increase with decrease in 2% error.

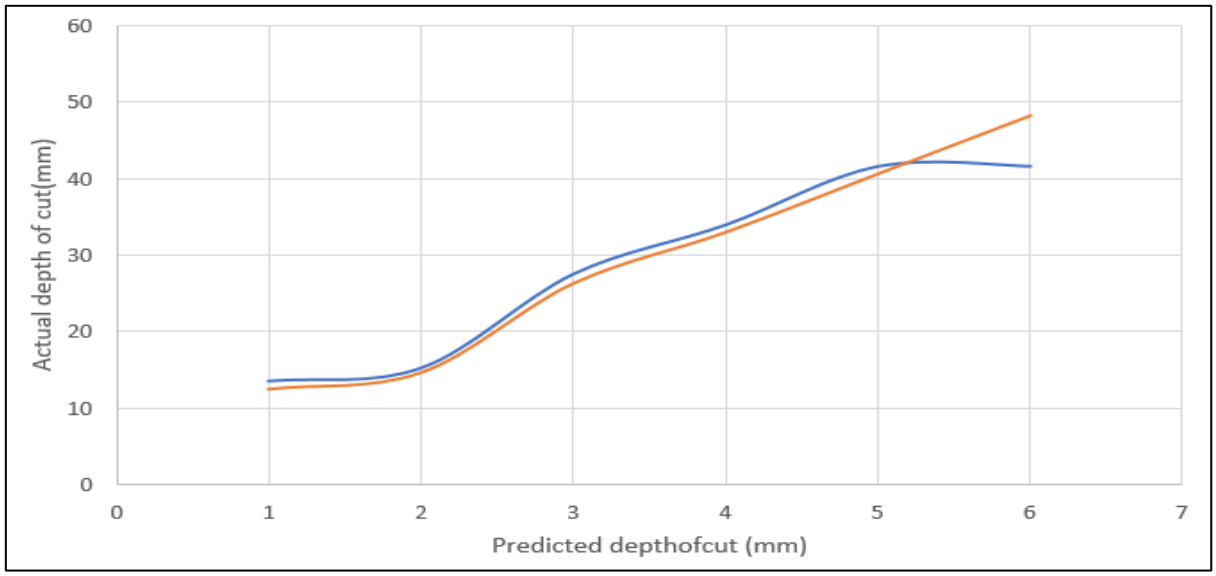


Fig 2 Material Removal Rate Correlation

It is observed that there is lower force which could have shifted the deoth of cut as shown above figure 2. Also there were slight shift within 6 mm and at 42.44mm and 49.50mm depth of cut (both for actual and predicted cut).At the initila stage will decrease the force to increase the fedd rate to optimise consistent material single pass rate.

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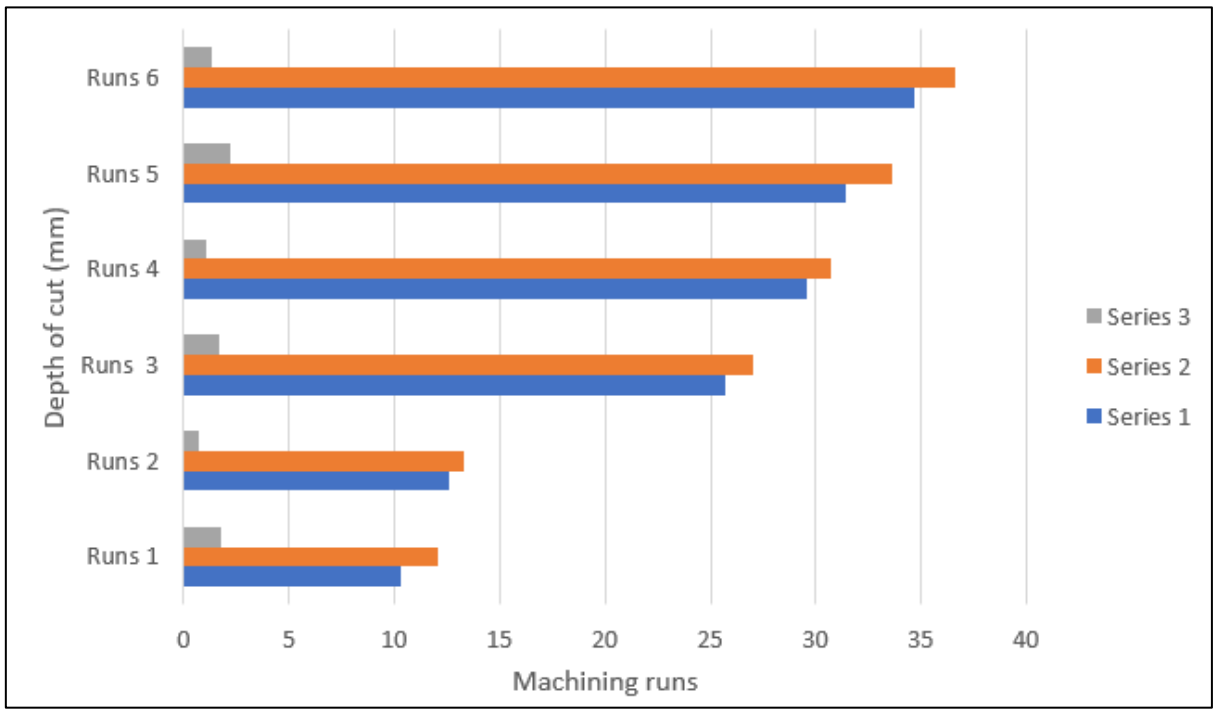


Fig 3 Estimation of Machining Run at Varied Thickness of Mild Steel

The mild steel was clamped using G-codes to test six machining runs. Series 1 was programmed depth of cut, series 2 was measured depth of cut in figure 3 above. While series 3 was depth of cut. From series 1 to 2, it has steady depth of cut due to timely predicted switch of code from the installed fanuc software G10.The federate slightly increases at 12mm/min during cancellation of coordinate x,y and z (G17,G19 and G18). In series 3, the machining decreases from 35mm to 37 within 25 seconds due to signal drift from the accelerometer, force sensor and dynamometer sensing.

V. CONCLUSION

This research uses induced vibration pulse effect to determine axes swap for precise depth of cut. The data processing unit signal should be conditioned such that loops can trigger intermittently 10 second set point to adjust driving system to map coordinate geometries.

RECOMMENDATION

The human machine interface should be modified to alert coolant switch to toggle when heat is above temperature threshold. This helps the machine to predict and compare thickness of workpiece to specific feed rate and cutting diameters.

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