Predictioin Of Surface Roughness In Turning By Multiple Regression Model

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Abstract

In this research, we propose statistical package for social sciences (SPSS), to predict surface roughness in turning process. Two independent data sets were obtained on the basis of measurement: training data set and testing data set. Original length, diameter and selected length are used as independent input variables (parameters), while surface roughness as dependent output variable. On the basis of training data set, different models for surface roughness were developed by multiple regression model. The multiple regression model by using (SPSS) could predict the surface roughness (Ra) with average percentage deviation of 4.6%, or 95.4%, accuracy from training data, and from testing data set that was not included in the multiple regression analysis with average percentage deviation of 7.9%, or accuracy of 92.1%.

الخلاصة

في هذا البحث تم استخدام النظام الاحصائي (SPSS) للتنبؤ بالخشونة السـطحية فـي عمليـات الخراطة . كما تم اعداد بيانين مستقلين معتمدة على اساس القياسات:بيانـات تدريبيـة وبيانـات اختبارية. وتم اعتبار الطول الاصلي للمشغولة وقطرها والطول المختار في التشغيل كمتغيـرات داخلة مستقلة , بينما الخشونة السطحية اعتبرت كمتغير خارج معتمد. علـى اسـاس البيانـات التدريبية تم تطوير نماذج مختلفة من الخشونة السطحية باستخدام نموذج الانحدار المتعدد. حيـث تم استخدام برنامج (SPSS) بصيغة نموذج الانحدار المتعدد للتنبؤ بالخشونة السطحية مع نسـبة انحراف 4.6% او 95.4% دقة من البيانات التدريبية, ونسبة انحـراف 7.9% او92.1% مـن البيانات الاختبارية.

Introduction

Although the lathe is the oldest machine tool, it is still the most commonly used machining operation in the manufacturing industry. Many cylindrical parts are products of turning operations. Some of these cylindrical parts, such as shaft, axis, and bearing, are crucial in machining motions.[1]

Roughness plays a significant role in determining and evaluating the surface quality of a product. Because surface

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roughness affects the functional characteristics of products such as resisting fatigue, friction, wearing, light reflection, heat transmission, and lubrication, the product quality is required to be at the high level. While surface roughness also decreases, the product quality increases. [2]

The traditional way to monitor the surface quality of a machined part is to measure the surface roughness by using a surface gauge. The most used surface gauge is the stylus type surface

Multiple Regression modeling

Since multiple regression is used to determine the correlation between a criterion variable and a combination of predictor variables, the statistical multiple regression method is applied. It can be used to analyze data from any of the major quantitative research designs such as causal comparative, correctional, and experimental. This method is also able to handle interval, ordinal, or categorical data and provide estimates both of the magnitude and statistical significance of the

The Model Accuracy

Accuracy is a measure of the closeness of the predicted value to the measured one. For each single data set, the accuracy is the ratio of the absolute difference of the predicted and the

$$\mathbf{Ra = \beta_0 + \beta_1 L + \beta_2 D + \beta_3 \mathit{l} + \beta_4 LD + \beta_5 L\mathit{l} + \beta_6 \mathit{l}D + \beta_7 LD\mathit{l}} \quad \ldots \quad \mathbf{(1)}$$

Where

Ra – Predicted Surface roughness,

B – Linear constants.

L-Original length of workpiece

D- Diameter of workpiece

l- Selected length.

A statistical software program, SPSS version 10.0, was employed in model training.

gauge. It has a diamond stylus dragging along the test surface, of which, the up and down movement is recorded and calculated for the surface roughness. Since this measuring method requires that the stylus have direct contact to the measured surface, measurement cannot be conducted unless the test surface is in a stationary mode. In other words, the stylus measuring method cannot be applied to an in-process work piece on a lathe when the work piece is spinning. [3],

relationships between variables [5] .The goal of the multiple regression analysis is determine the dependency of surface roughness to selected variables (original length, diameter and selected length). The model was expressed as:[6]

$$\delta i = \frac{\left| Ri - Ri^{\circ} \right|}{Ri} \quad \ldots\ldots(2)$$

Where

if= prediction accuracy of data set i,

Ri= Predicted Ra by data set i,

measured R-values to the measured value. The accuracy is expressed in percentage (Equation 2). The model accuracy is the average of the accuracy values of all data sets (Equation 3). [7]

Ri^{o}= Measured R corresponding to data set i.

$$\Delta = \frac{1}{n} \sum_{i}^{n} \delta i \qquad (3)$$

where

Δ=model prediction accuracy,

n= number of data sets in the training data set.

Machine

The experimental work has been performed on (Harrison M300) Lathe, it has the following specification.

- Maximum horsepower HP=3.0
- Spindle speed (40-2500) r.p.m
- Feed rate (0.03-0.1) and (0.12-1) mm/rev

workpiece material

Carbon steel (1020) workpiece with a hardness of BHN 163 are used, the chemical composition and mechanical properties are given in table (1) and (2) respectively

Cutting tools

A coated cutting tool tips (WC) classified as (SNMA-9.525T312) type used at this work. These tools have a system-tool-compliances (C_{tx}=C_{ty}=1.1*10^{-6}mm/N) where C_{tx} (tool – system compliance in x-axis) , C_{ty} (tool – system compliance in y-axis) [8], and dimension (10*10*4) mm. during the tests, these tips are mounted in a tool holder of type mm. during the tests, these tips are mounted in a tool holder of type (PSBBR-2020K).

Machining condition

The machining condition using in this work as shown in table (3).

Results and Discussion

After 15 specimens were cut for experimental purposes, measured off-line with a (Talysurf-4) type profilometer to obtain the roughness average value (Ra). All original 15 samples as shown in Table (4) were randomly divided into two data sets - the training set and the testing set. The training set contained 10 samples which were used to build a prediction model as shown in Table (5) and the testing set contained 5 samples which were used to test the flexibility of the prediction model as shown in Table (6). Each sample contains four elements: original length of workpiece,

Experimental setup

diameter of workpiece, selected length, and measured surface roughness (Ra).

A statistical model was created by regression function in (SPSS) from the training data set. The R square (ability the independent variables to predict dependent variable) was 0.62 which showed that 62%of the observed variability in Ra could be explained by the independent variables. The multiple R (correlation value between dependent and independent variables) was 0.787 which means that the correlation coefficient between the observed value of the dependent variable and the predicted value based on the regression model is high. The value of F (value represent signify R^2 to Ra) was 2.928 and the significance of F was 0.077 in the ANOVA table as shown in Table (7). In Table (8) the coefficients for the independent variables were listed in the column B. using these coefficients the multiple regression equation could be expressed as:

$$\mathbf{Ra = 6.311*10^{-2} + 6.91*10^{-6}L - 1.13*10^{-3}D + 6.08*10^{-5}\mathit{l} - 3.76*10^{-6}L\mathit{l} + 1.12*10^{-7}DL\mathit{l}} \quad (4)$$

Where (*Ra*) was the predicted surface roughness. It was also apparent that selected length (*l*) was the most significant machining parameter to influence surface roughness (Ra) in equation (4).

The Scatterplot between the observed Ra and the predicted Ra of all 15 samples as shown in Figure (1) indicated that the relationship between the measured Ra and the Predicted Ra was linear.

From the diagram of the measured and predicted surface roughness as shown in Figure (2) , the error between predicted values and measured values is small, but there is a larger error between two values in (9,10,12,14 and 15).

The result of average percentage deviation (Δ) showed that the training data set (m=10) was 7.8% and the testing data set (m=5) was 11.95% .

Conclusions

The present work has reached to the following conclusions

1. The surface roughness (Ra) could be predicted effectively by applying original length, Diameter of workpiece, selected length, and their interactions in the multiple regression model.
2. The multiple regression model by using (SPSS) could predict the surface roughness (Ra) with average percentage deviation of 4.6%, or 95.4% accuracy from training data set .
3. The multiple regression model (SPSS) could predict the surface roughness from testing data set that was not included in the multiple regression analysis with average percentage deviation of 7.9% or accuracy of 92.1%.

This means that the statistical model could predict the surface roughness (Ra) with about 92.2% accuracy of the training data set and approximately 88% accuracy of the testing data set

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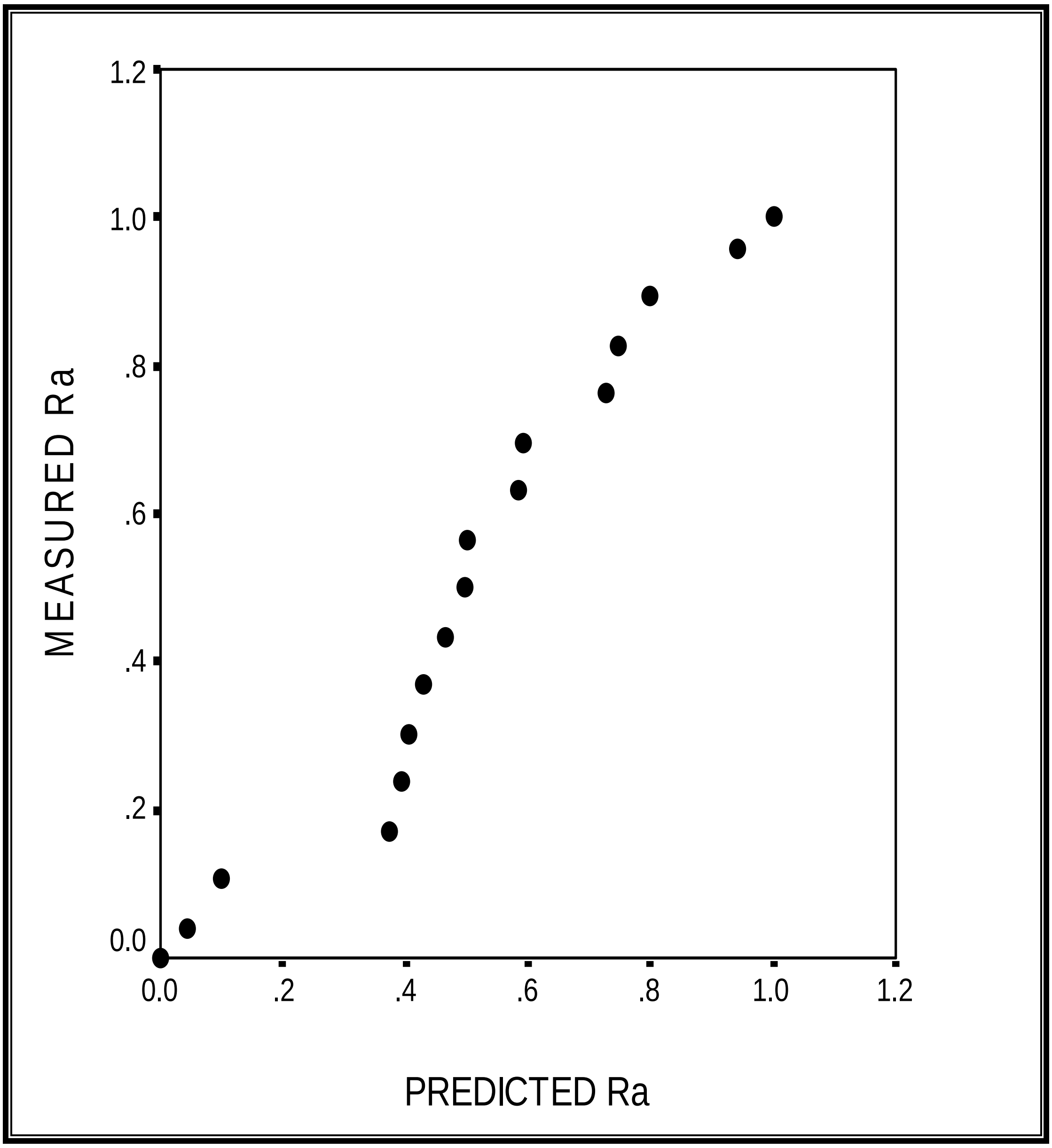

Figure (1): Scatter plot of the Measured Ra and the Predicted Ra of the Multiple Regression Prediction Model

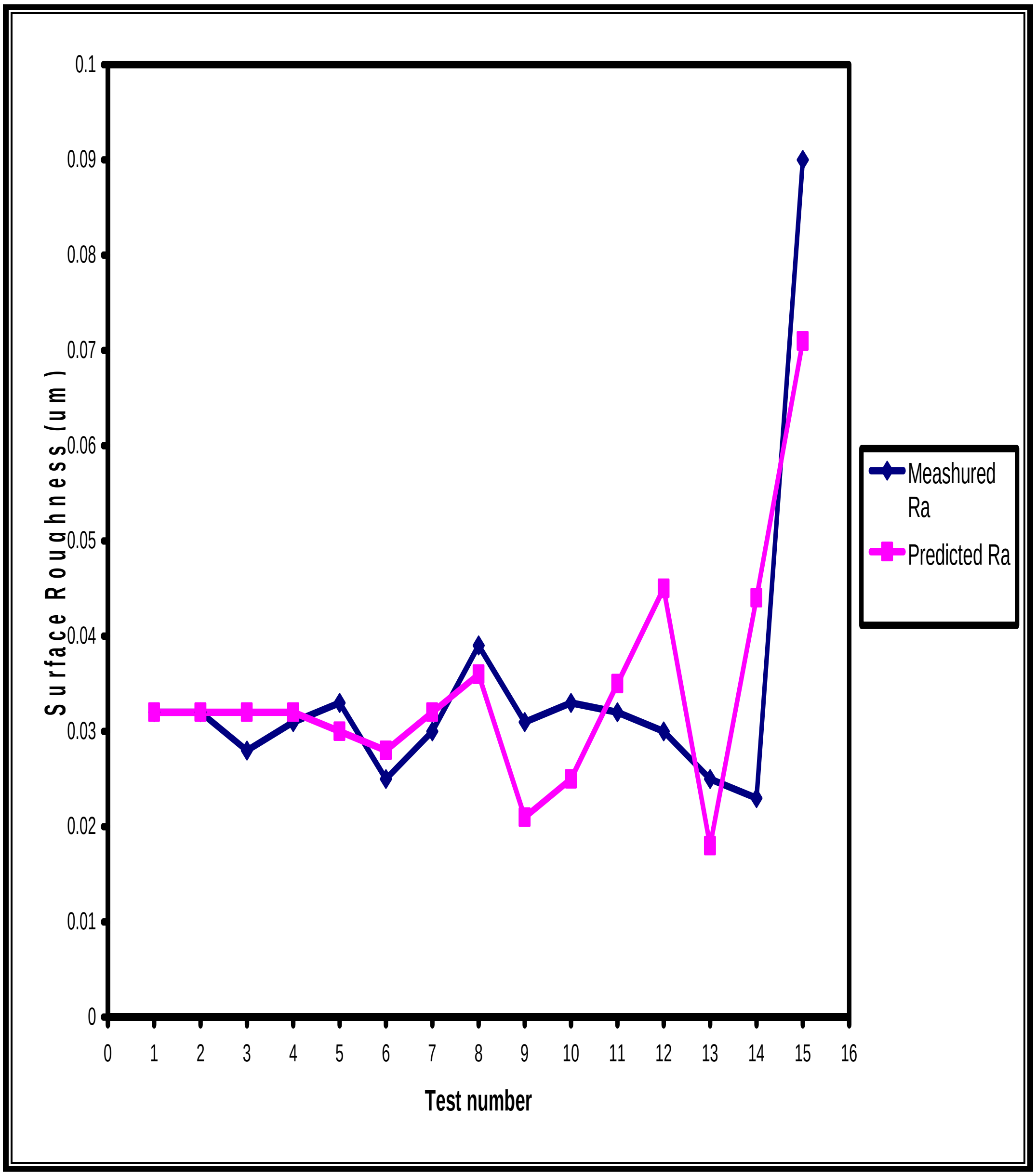

Figure (2): The diagram of the measured and predicted surface roughness for the experimental data using the commercial statistical package (SPSS)