Machine vision based monitoring system for milling using ANFIS

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Abstract

The surface roughness of machined work pieces are the important discussion since the fitness of the product mainly related to the roughness of the machined surface. In our research work deals with the rough monitoring by machine vision technique on the machined surface. Here, the machined surface images are captured by vision system. A novel adaptive neuro fuzzy inference system (ANFIS) model is used to correlate the prediction values with experimental value of the input and the response parameters in the end milling operation. The ANFIS results shows error while extraction of image values feed as ANFIS training process. Correlation accuracy encouraging us for suitable monitoring technique of the proposed ANFIS model with image extraction technique with image processing method and it is very suitable for online monitoring in the automated production industries.

Keyword. Milling, machine vision, Non contact, surface roughness; ANFIS

1. Intriduction

In the modern manufacturing era, end milling process is essential one as well as regularly utilizing for machining of the metal. Recently, manufacturing components quality as main concern in the competitive industrial sectors and needed to online monitoring methods [1]. The work piece surface roughness could be measured through two ways such as contact as well as non-contact methods. In the method of contact sensor probe has touch on the machined surface lead to form scratches on it. In order to avoid physical touch during measurement the on line image processing technique as well as machine vision methods are introducing in this research work [2].

In computerized manufacturing scenario, computer machine vision method is a main play role for fast monitoring [3]. The regular research has been followed through computer machine vision method into the modern manufacturing sector., The non-contact online monitoring methods very suitable for machined surface roughness measurement without affecting the already machined surface.[4].

Recent day’s machine vision based techniques eliminated disadvantages of the conventional probe measuring methods. Galante et al stated that the vision approach
in the process of turning for prediction [5]. Benardos used taquchi's optimization design method for prediction in the process of face milling [6]. Lee constructed a model to measure the roughness through online monitoring for the operation of turning [7].

In our research work we used neuro fuzzy logic for correlating actual as well as predicted roughness values on the work piece with various condition of machining.

In our research work firstly explain machined surface image extraction and then ANFIS method has been introduced. After that shows the ANFIS prediction results for the different machining conditions with the results of the correlating values with the percentage error. Finally our research work take part of result as well as discussion with model output and conclude the work for possible experimental approaches with accurate dimensions for optimizing the machining time on end milling process.

2. Measurement of roughness of the work piece

In 1960 the image processing method was introducing especially for the investigation of space for generating graph of earth. Now a day, it improved for computer aided manufacturing as well as all sector of developed industrial area for monitoring by machine vision [8]. The purpose of vision technique for online monitoring investigated through the literature [9]. Bradly [10] developed a novel online measurement and monitoring model for roughness through image processing method.

In our research work, image and vision method has been used for predicting roughness of the surface in end milling as shown in Figure 1. First sources of light has been focus on job next image of the machined surface has been accrued through vision system then directed to work station with personal computer through frame grabber. WE use a Surf coder for measuring the machined surface roughness of work material with the dimension of 8 mm long and the speed is 0.5 mm/s. The mean of arithmetic roughness of the machined surface $R_a$ has been measured through the formulae below:

$$R_a = \frac{1}{n} \sum_{i=1}^{n} |y_i|$$

Where $y_i$ is the height of roughness from its mean

$n$ is the experimental date number

$G_a$ is the average gray value of the image of work piece machined surface.
Figure 1. Rapid I of Computer vision model

V: 28 m/min V: 28
m/min
F: 0.002 mm/rev F: 0.0466
mm/rev.
D: 0.6 mm D: 0.8
mm
R: 0.6371 µm R: 0.8517 µm

Figure 2. Captured work piece Images

The expression of the gray value in arithmetic average is shown in equation 2:

\[
G_a = \frac{1}{n} \sum_{i=1}^{n} |G_i|
\]  
(2)

Where \(G_i\) is the average gray value of the image of the surface

3. ANFIS Model for surface rough

Problem has been generating through fuzzy rules with membership function. These difficulties are overcome with ANFIS through explicit adaptive knowledge of fuzzy with implicit learning capacity of neural networks [11]. The Artificial neural network (ANN) gives experts neurons to generate fuzzy control if then rules including membership for obtaining suitable formulations methods [12].

The advantages of both traditionally fuzzy expert and the neural networks combined with the practice of computer to obtain computational performance by layer of hidden neurons as well as the learning capacity. The model structure of ANFIS is shown in Figure 3.

Figure 3: Model structure of ANFIS

4. Experimental discussion

The practical status of CNC milling process is shown in Figure 4

Figure 4: The practical status of CNC milling process
Experimental Results

Table 1: End milling process experiment values

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>V m/min</th>
<th>F mm/rev</th>
<th>D mm</th>
<th>Ga</th>
<th>Ra microns</th>
</tr>
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<tr>
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<td>0.6</td>
<td>0.6607</td>
<td>0.6371</td>
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<td>0.2359</td>
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<tr>
<td>3</td>
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<td>0.6</td>
<td>0.7592</td>
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<tr>
<td>4</td>
<td>38</td>
<td>0.002</td>
<td>0.8</td>
<td>0.9069</td>
<td>0.4431</td>
</tr>
<tr>
<td>5</td>
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</tr>
<tr>
<td>6</td>
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<td>0.0466</td>
<td>0.6</td>
<td>0.6744</td>
<td>0.6503</td>
</tr>
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<td>0.8</td>
<td>0.8694</td>
<td>0.5837</td>
</tr>
<tr>
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<td>0.587</td>
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<td>0.6</td>
<td>0.8097</td>
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<td>0.3157</td>
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<td>0.0466</td>
<td>1.0</td>
<td>0.7754</td>
<td>0.286</td>
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</table>

The experimental values are tabulated in Table 1. 27 experiments through different milling conditions have been obtained to train the ANFIS for monitoring roughness of the work piece surface. The experimental values were tabulated in Table 1.

5. Prediction of Machined surface

Input data Normalisation

Normalization technique has been utilized for obtaining test values from -1 to +1. The normalization process mainly used for training the parameter values uniformly as well as to meet equal gap to the training parameters to increase performance of ANFIS method at the same time reducing
the computation time. Figure 5 shows the ANFIS training.

For training ANFIS first proper topology has been chosen through trial-error method. Then various topologies have been tried and 4-4-1 topology network has been selected for training the ANFIS. Figure 5 shows the created ANFIS.

Finally, trained ANFIS has been simulated through new input for testing to predict roughness of the machined surface.

**Input data for validation**

Five new sets of data have been taken to validate proposed ANFIS model. Table 2 shows the values for input as well as output variables. The % of error in the predicted as well as experimental value have been obtained through following formula.

\[
\% \text{ of Error} = \frac{\text{Predicted Value} - \text{Experimental value}}{\text{Experimental value}} \times 100
\]

The output of the validation is shown in Figure 6.

**Figure 5: ANFIS training**

**Table 2: Validation between predicted with experimental values**

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>V m/m in</th>
<th>F mm/rev</th>
<th>D mm</th>
<th>Ga</th>
<th>Ra in microns</th>
<th>Error %</th>
</tr>
</thead>
<tbody>
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<td>0.854</td>
<td>4</td>
<td>0.2632</td>
<td>0.2599</td>
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</tbody>
</table>

Average Absolute Error = 4.997 %

**Figure 6: Output of the validation by ANFIS**
6. Result and discussion

Proposed model has been developed through ANFIS. With twenty seven various machining parameters are as shown in Table 1 used to predict the roughness of the machined surface in the end milling. The validation of the predicted values with experimental values is shown in Figure 7.

![Comparison Chart](image)

**Figure 7: Validation of experimental with ANFIS predicted data**

The mean error of percentage of the proposed model with ANFIS is **4.997% and accuracy is 95.003%**.

7. Conclusion

The results shows that an on line measuring as well as monitoring method by machine vision method for investigating machined surface of the roughness of work piece by ANFIS. Through this results this proposed ANFIS model as well as image processing technique is best suited for monitoring methods. The outputs of experiment are comparing through results of the proposed method shows the proposed model could be produced very accurate result.

REFERENCES


