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USING ANFIS FOR MAINTENANCE PLANNING OF TEXTILE MACHINES

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Abstract: *Considering the complexity of the wear of textile machines, a mathematical modeling of this phenomenon is not available in the existing literature. Based on the advantages of both fuzzy logic and neural networks, a neuro-fuzzy approach seems to be well suited for the prediction of the maintenance activities of textile machines. Therefore, the Adaptive Neuro Fuzzy Inference System (ANFIS) was proposed in this study to plan the maintenance activities of textile machines. The research was performed on the PEGASUS sewing machine at a working speed of 3100 stitches/minute. The sewing material used in the experiments was cotton, while NM 80 sewing needles were employed. The vibrations along the OZ axis and level of noise of the PEGASUS sewing machine were measured with appropriate devices. The ANFIS of the Matlab® software was used to plan the maintenance of textile machines. The amplitude of vibration and level of noise of the needles were used as inputs in the ANFIS system. The output of the ANFIS system was the time to replacement of the needles. The performance of the developed ANFIS system was expressed through the RMSE and MAPE measures. Considering their values, it may be pointed out that the ANFIS prediction system demonstrates good performance.*

Key words: *wear, vibration, noise, ANFIS, replacement*

1. INTRODUCTION

Considering the complexity of the wear of textile machines, a mathematical modeling of this phenomenon is not available in the existing literature [1]. Within this framework, fuzzy logic was employed in the previous studies of the authors for the maintenance modeling of textile machines [1, 2, 3]. However, such approach is relatively difficult, since fuzzy logic does not have learning capabilities. On the other hand, neural networks have such capabilities. Therefore, a neuro-fuzzy approach seems to be well suited for the prediction of the maintenance activities of textile machines. Considering its applicability [4], the Adaptive Neuro Fuzzy Inference System (ANFIS) developed by Jang [5] was proposed in this study for planning the maintenance activities of textile machines.

2. MATERIALS AND METHODS

The research was performed on the PEGASUS sewing machine, at a working speed of 3100 stitches/minute. The sewing material used in the experiments was cotton, while NM 80 sewing needles were employed. The experimental stand used in this study is shown in Figure 1. The Top Lab-GBDT-L device was employed for the measurement of the vibrations along the OZ axis. The level of noise was measured with the Center 322 sonometer.

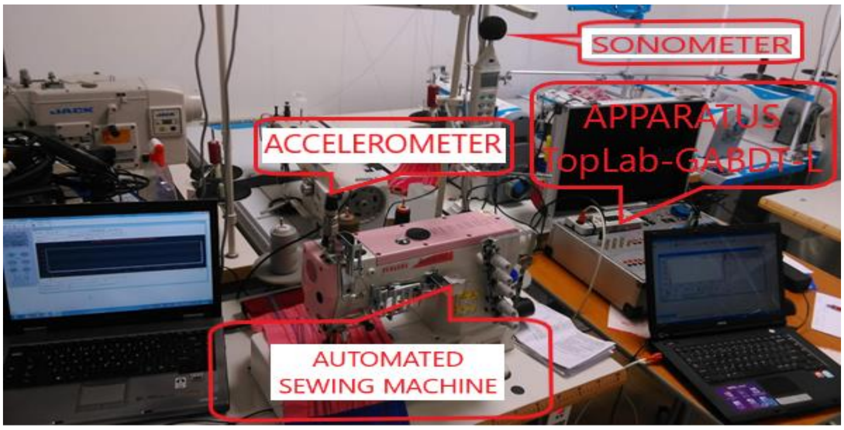
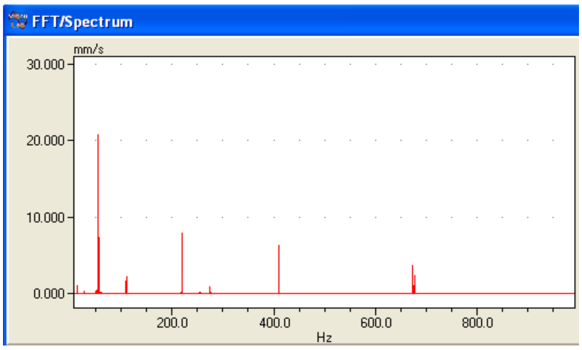
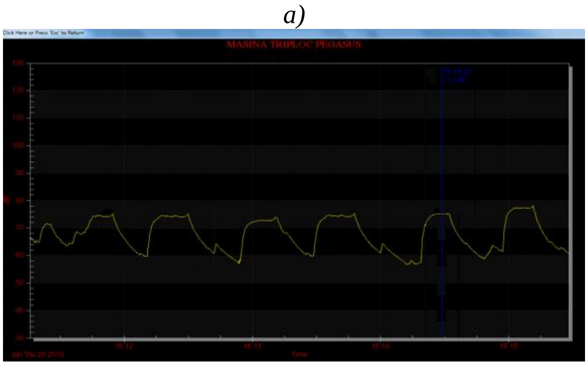


***Fig. 1**: The experimental stand*

The measurement of vibration and noise of a needle are presented in Figure 2.



a)



b)

***Fig. 2:** The measurement of a) amplitude of vibrations and b) level of noise of a needle*

The ANFIS of the Matlab® software was used for the maintenance planning of textile machines.

3. RESULTS

Two inputs were used in the ANFIS system: the amplitude of vibration AV [mm/s] and level of noise LN [db]. The output of the system was the time to replacement of the needles TR [minutes]. The structure of the ANFIS system is depicted in Figure 3.

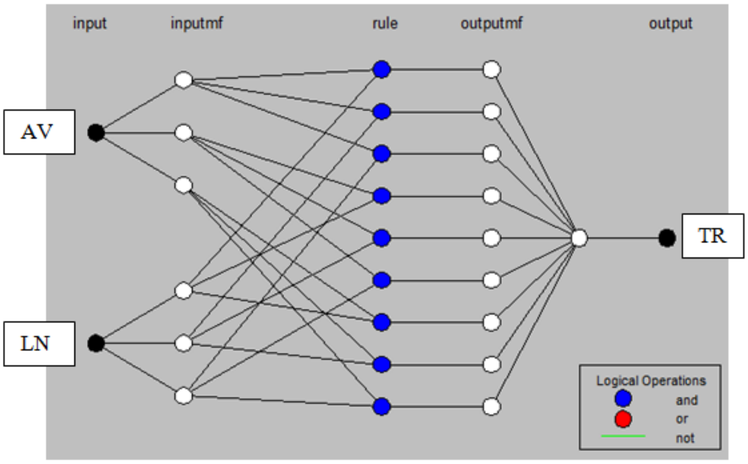


Fig. 3: *The ANFIS system*

A number of 40 experiments were carried out, which were randomly divided into two groups. The first group of data obtained from 32 experiments (80%) was used for training the ANFIS system. The second group of data obtained from 8 experiments (20 %) was employed to check the system. The grid partition was employed to generate the fuzzy inference system based on the first-order Sugeno model for all the eight membership functions implemented in ANFIS. The best results were obtained for the gauss2mf membership function. The training error for this membership function was 0.55203 (Figure 4).

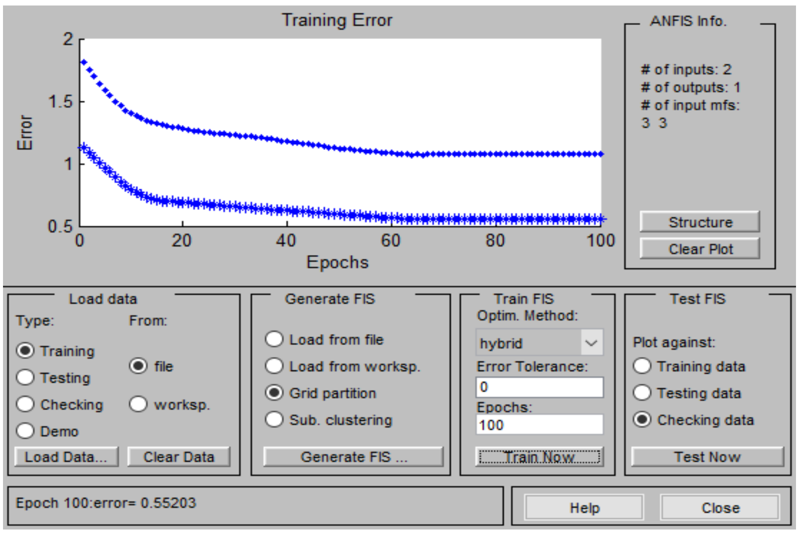


Fig. 4: *The training error*

The performance of the developed ANFIS system was expressed through the RMSE and MAPE measures [6]:

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\mathrm{TR}_{p_i} - \mathrm{TR}_{m_i}\right)^2} \tag{1}$$

and

$$\mathrm{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{\mathrm{TR}_{m_i} - \mathrm{TR}_{p_i}}{\mathrm{TR}_{m_i}}\right| \tag{2}$$

where TR_{p_i} and TR_{p_i} are the predicted and measured value of the TR and $i = \overline{1,8}$. The value of RMSE was 1.0564, while the value of MAPE was 5.84%. Based on [7], we may point out that the ANFIS prediction system demonstrates good performance.

5. CONCLUSIONS

In this study, an ANFIS approach was employed for planning the maintenance activities of textile machines. The amplitude of vibration and level of noise of the needles were used as inputs in the ANFIS system. The output of the ANFIS system was the time to replacement of the needles. The performance of the developed ANFIS system was expressed by the RMSE and MAPE measures.

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