國立勤益科技大學
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碩士論文

# 基於混合式田口基因演算法與倒傳遞類神經網路應用於銑床主軸熱變形研究

# Study on Thermal Deformation of Milling Machine Spindle Based on Hybrid Taguchi Genetic Algorithm and Back Propagation Neural Network

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# 摘要

由於科技快速且朝無人化發展，在精密工業產業裡能夠快速且長時間生產零件，但因快速和長時間的加工導致機台溫度上升，機台受熱誤差影響使加工零件精度下降。熱誤差中以主軸受熱所產生的誤差為主，但在實際加工時主軸位移的量測是困難且昂貴，因此，為解決熱誤差對於加工精度的影響，本研究提出三個部分建立主軸熱誤差模型，第一部分為蒐集主軸長時間運轉的主軸溫升及位移資料，以及資料蒐集的環境與業界實際加工條件相同，目的為提高產業與學界之間的連結性。第二部分為倒傳遞類神經網路訓練參數的設定沒有固定的依據，訓練參數設定還須依照資料特性調整最合適的參數，為減少尋找最佳參數的時間與提升模型的預測精度，本研究採用擁有強大全局搜索能力的混合式田口基因演算法來尋找最佳參數，以模型預測與實際值誤差作為優化目標，並且使用 K 折交叉驗證確保同樣參數下訓練出的模型結果客觀，才能有效調整參數。第三部分則為使用最佳化網路參數訓練倒傳遞類神經網路，建立具有強建性及穩定性的主軸熱誤差模型。

實驗結果顯示，蒐集主軸運轉時的溫度與位移資料，經由混合式田口基因演算法尋找類神經網路訓練參數，解決過去使用試誤法調整類神經網路參數耗時及繁瑣的過程，且相較使用基因演算法尋找類神經網路訓練參數，提升 75 % 的效率。使用最佳訓練參數建立模型，模型預測與實際均方根誤差皆在 6 μm 內，驗證了模型具有很高強建性及穩定性。

**關鍵字**：倒傳遞類神經網路訓練參數最佳化、主軸熱變形、混合式田口基因演算法、K 折交叉驗證、主軸熱誤差模型

# Abstract

Due to the rapid and unmanned development of science and technology, workpiece can be produced quickly and for a long time in the precision industry. However, the rapid and long-time processing, the temperature of the machine increases, and the Thermal error of the machine reduces the accuracy of the processed workpiece. The thermal error is mainly caused by the Thermal of the spindle, but it is difficult and expensive to measure the displacement of the spindle during the actual processing. Therefore, in order to solve the influence of thermal error on the processing precision, this study proposes three parts to establish the thermal error model of the spindle. The first part is to collect the spindle temperature rise and displacement data of the spindle for a long time, and the data collection environment is the same as the actual processing conditions of the industry, and the purpose is to improve the connectivity between the industry and the academic world. In the second part, because there is no fixed basis for the parameter setting of the back propagation neural network, the most appropriate parameters should be adjusted by trial and error method according to the data characteristics. In order to reduce the time to find the best parameters and improve the prediction accuracy of the model, this study uses the hybrid Taguchi genetic algorithm with strong overall search ability to find the best parameters, using the model prediction and the actual error of the value is taken as the optimization objective, and k-fold cross-validation is used to ensure that the

model results under the same parameters are the same, so as to effectively adjust the parameters. In the third part, the back propagation neural network is trained by using the optimized network parameters, and the spindle thermal error model with the robustness and stability is established.

The experimental results show that collecting temperature and displacement data during spindle operation, searching for neural network training parameters through a hybrid Taguchi genetic algorithm, solving the time-consuming and tedious process of adjusting neural network parameters using trial and error in the past, and compared with the use of The genetic algorithm looks for neural network training parameters and improves efficiency by 75%. The best training parameters are used to build the model. The model prediction and the actual rms error are both within 6, which verifies that the model has a robustness and stability.

**Keyword**：Optimization of training parameters of Back Propagation Neural Network、Spindle thermal deformation、Hybrid Taguchi Genetic Algorithm、K-fold cross validation、Spindle thermal error model