Prediction of diameter error in one-setup machining test by using machine learning algorithms

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ABSTRACT

To efficiently collect data for training machine learning (ML) algorithms in predicting diameter error for process planning optimization, a one-setup milling test with 27 cylinders on a workpiece implements a full factorial experiment of three factors, each with three levels. The factors are cutting parameters: width of cut, cutting speed, and feedrate. Results show that, among those three factors, cutting speed is the main contributor with the standardized effect of up to 57 to the diameter error, followed by the feedrate (standardized effect of 43). Three ML algorithms are tested to predict the diameter error: Polynomial, XGboost (eXtreme Gradient Boosting) and AdaBoost (Adaptive Boosting). Besides three cutting parameters, positions of each cylinder and the desired initial diameter are also considered as features. Taking Polynomial as a base line, and using a 5-fold cross-validation method, the mean and standard deviation of R-squared of each ML algorithm are compared. It shows that both regressors perform better than the base line (average R-squared=0.7522), the average R-squared of XGboost (0.9126) is slightly higher than the one of AdaBoost, which is 0.9015. Moreover, the standard deviation of R-squared for XGboost(0.0483) is smaller than the one of AdaBoost (0.0569), which shows a more robust performance for XGboost. By applying AdaBoost or XGBoost, more than 90% of the diameter error is explained by the six inputs (positions of each cylinder in x and y on the test workpiece, three cutting parameters and the desired initial diameter).

Keywords: machine learning, diameter error, cutting parameters