

Prediction of wheel wear in light rail trains using an improved grey GM(1,1) model

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Background



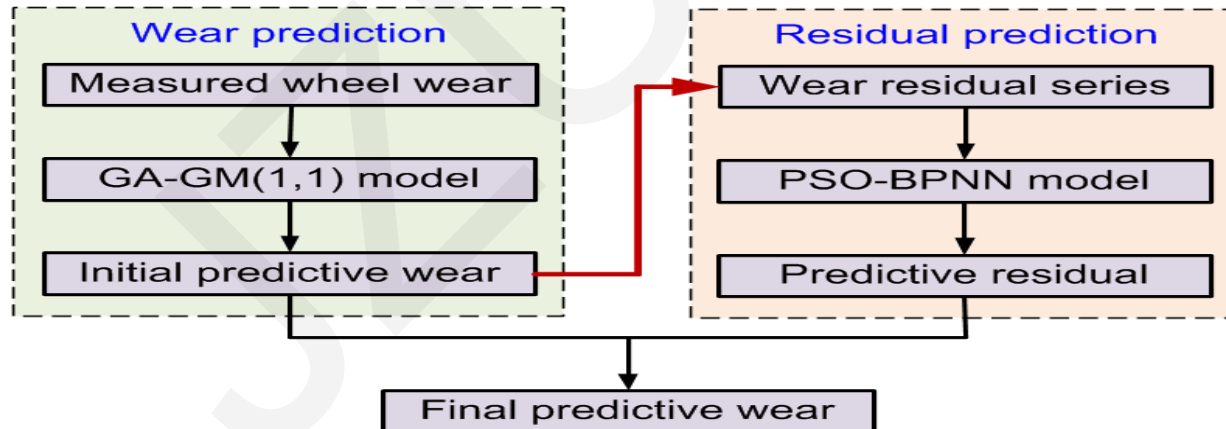
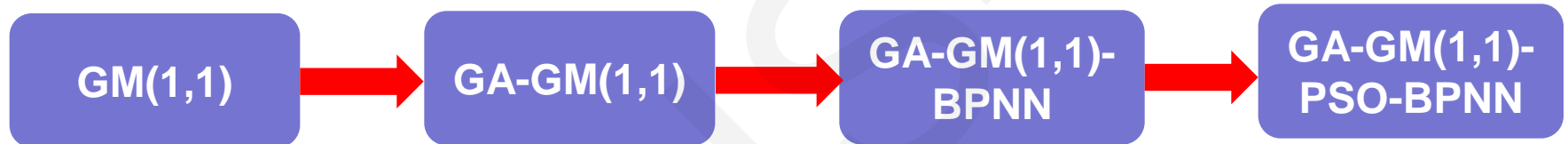
- Accurately prediction of wheel wear of light rail trains in the future is crucial to reduce vehicle operation costs and ensure operation quality.
- The wheel wear is difficult to be predicted due to poor information and small data samples.
- The amount of wheel wear gradually increases with the running mileage.
- The grey future prediction model is supposed to deal with the wheel wear prediction problem effectively.

Method

Background values are optimized by genetic algorithm (GA)

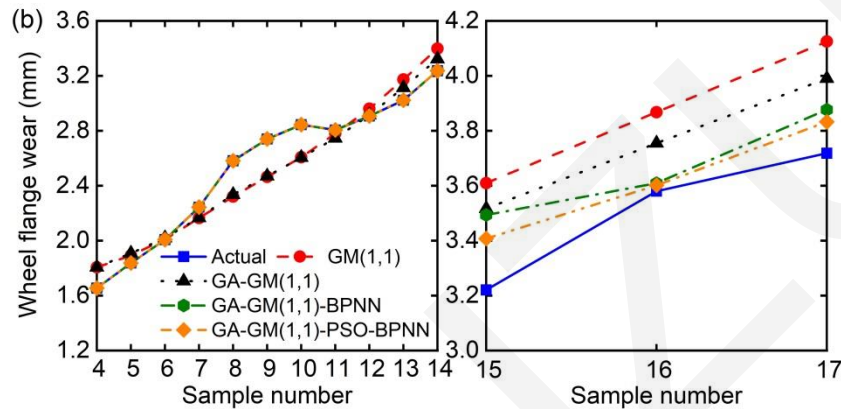
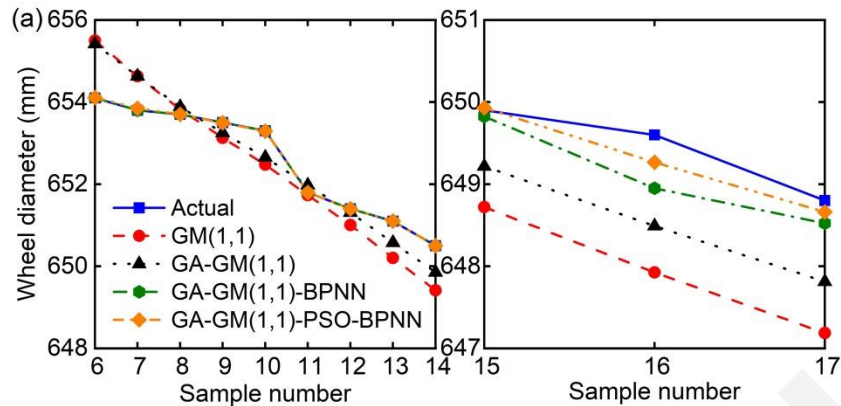
Residual error series of the GA-GM(1,1) model is corrected through back propagation neural network (BPNN)

Weight and bias in BPNN are optimized by particle swarm optimization (PSO) algorithm



Flow chart of the GA-GM(1,1)-PSO-BPNN model for wheel wear prediction

Results



Actual and predictive data curves using different models of wheel diameter (a) and wheel flange wear (b)

- The traditional GM(1,1) model reflected the overall changing trend of the measured wear data series, but could not well track the local variation.
- By correcting the initial predicted residual error series of the GA-GM(1,1) model using the BPNN, the forecasted data were closer to the actual values in each period.
- The GA and PSO algorithms can bring a strong approximation ability to GM(1,1) and BPNN models.
- From highest to lowest, the fitting and prediction performance ranking of the four methods was GA-GM(1,1)-PSO-BPNN > GA-GM(1,1)-BPNN > GA-GM(1,1) > GM(1,1).

Conclusions

- The improved GA-GM(1,1) model lowered both the fitting and prediction errors of the classic GM(1,1) model.
- Combining the advantages of the GA-GM(1,1) model in linear prediction and the BPNN model in stochastic data prediction, the GA-GM(1,1)-BPNN model further upgraded the fitting and prediction performances.
- Benefitting from the contribution of PSO algorithm, the GA-GM(1,1)-PSO-BPNN model showed the most reliable performance with the least errors of the four models.
- The GA-GM(1,1)-PSO-BPNN model overcame the impacts of the nonlinear and random characteristics of the measured data in the case of small samples.