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Print ISSN: 1793-9623
Online ISSN: 1793-9615

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International Journal of Modeling, Simulation, and Scientific Computing

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Chenglong Ge, Yuanchang Zhu, and Yanqiang Di, *Int. J. Model. Simul. Sci. Comput.*
https://doi.org/10.1142/S1793962318500095

Equipment remaining useful life prediction oriented symbiotic simulation driven by real-time degradation data

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Received: 10 May 2017
Accepted: 16 August 2017
Published: 14 September 2017

As an emerging simulation technology in the field of system modeling and simulation, the equipment symbiotic simulation has become research emphasis. In the field of equipment maintenance support, the outstanding problem of equipment remaining useful life (RUL) prediction is analyzed, i.e., the stable model parameters without self-evolution ability, which has become the primary factor that hinders self-adaptive prediction of equipment RUL. Combined with parallel systems theory, the equipment RUL prediction oriented symbiotic simulation framework is proposed on the basis of modeling analysis and Wiener state space model (SSM) is taken as the basic simulation model in the framework. Driven by the dynamic injected equipment degradation observation data, the model parameters are updated online by using expectation maximum (EM) algorithm and the data assimilation between simulation outputs and observation data is executed by using Kalman filter, so as to realize dynamic evolution of the simulation model. The simulation model evolution which makes the simulation outputs close to equipment real degradation state provides high fidelity model and data for predicting equipment RUL accurately. The framework is verified by the performance degradation data of a bearing. The simulation results show that the symbiotic simulation method can accurately simulate the equipment performance degradation process and the self-adaptive prediction of equipment RUL is realized on the basis of improving prediction accuracy, proving the feasibility and effectiveness of symbiotic simulation method.

Keywords: Symbiotic simulation; model evolution; remaining useful life; data assimilation; parameter estimation