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### Title

## Diagnosis and Prognosis of Structural Damage Growth with Parameter Sharing in Fleet Maintenance Digital Twins

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### Abstract

Digital-twin-based structural diagnosis and prognosis are essential for enhancing the structural integrity and economy of aeronautic structures [1]. However, most research focuses on individual structures, creating a digital twin to represent damage growth while accounting for multiple uncertainties [2]. Little attention has been paid to multiple similar structures at the fleet level. Individuals within a fleet often share characteristics that enable grouping according to a specific purpose. Considering similarities within a fleet can improve the efficiency of digital twin-based diagnosis and prognosis.

In this study, we consider two categories of uncertain parameters in individual digital twins within a fleet: fleet-shared and standalone. Fleet-shared parameters have the same or very similar true values among individuals in a fleet, while standalone parameters vary due to manufacturing or environmental factors. Our main contribution is the addition of a sharing step in the particle filter, allowing the distributions of fleet-shared parameters to be shared among different individuals. To maintain correlation among states and parameters, we use Gaussian copula functions [3] to measure and recover correlation before and after sharing.

Preliminary validation using several hypothesized specimens with simple crack growth processes illustrates our proposed approach. Results show improved accuracy in parameter calibration, leading to improved diagnosis and prognosis. Further validation on complex structures with complicated damage growth mechanisms is left as future work by the authors.

### References

- [1] E.J. Tuegel, A.R. Ingraffea, T.G. Eason, S.M. Spottswood, Reengineering Aircraft Structural Life Prediction Using a Digital Twin, *International Journal of Aerospace Engineering*. 2011 (2011) 154798. <https://doi.org/10.1155/2011/154798>.
- [2] C. Li, S. Mahadevan, Y. Ling, S. Choze, L. Wang, Dynamic Bayesian Network for Aircraft Wing Health Monitoring Digital Twin, *AIAA Journal*. 55 (2017) 930–941. <https://doi.org/10.2514/1.J055201>.
- [3] C. Genest, J. Nešlehová, A Primer on Copulas for Count Data, *ASTIN Bulletin: The Journal of the IAA*. 37 (2007) 475–515. <https://doi.org/10.1017/S0515036100014963>.