Investigating Novel Approaches to Overcome Data Deficiency in Prognostics and Health Management

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Research Objective

Performance of prognostics requires large amount of run-to-fail data, which is however not easy due to the high cost or inability to run until failure under real operation. This is overcome by exploiting two resources in terms of data: 1) accelerated life data at laboratory 2) real data with suspension at field. In this study, a new algorithm is developed that combines these two data sources for better prognostics.
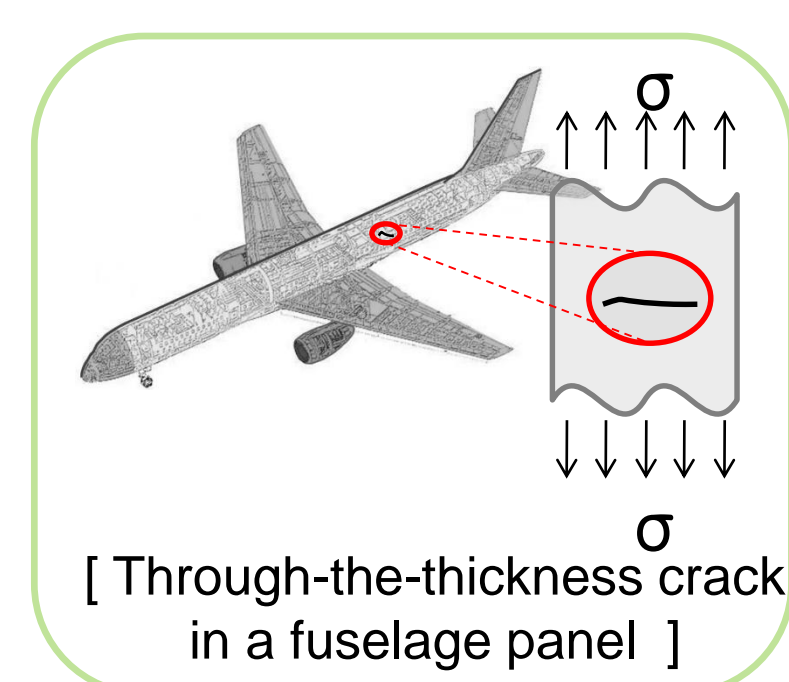
Expected Contributions

- ALT data with several high loads is transformed into those under normal loading condition.
- Suspension data that does not reach threshold will be utilized to make accurate prognostics.
- Several data sets under different loadings and unknown loadings can be mapped into current normal loading condition.
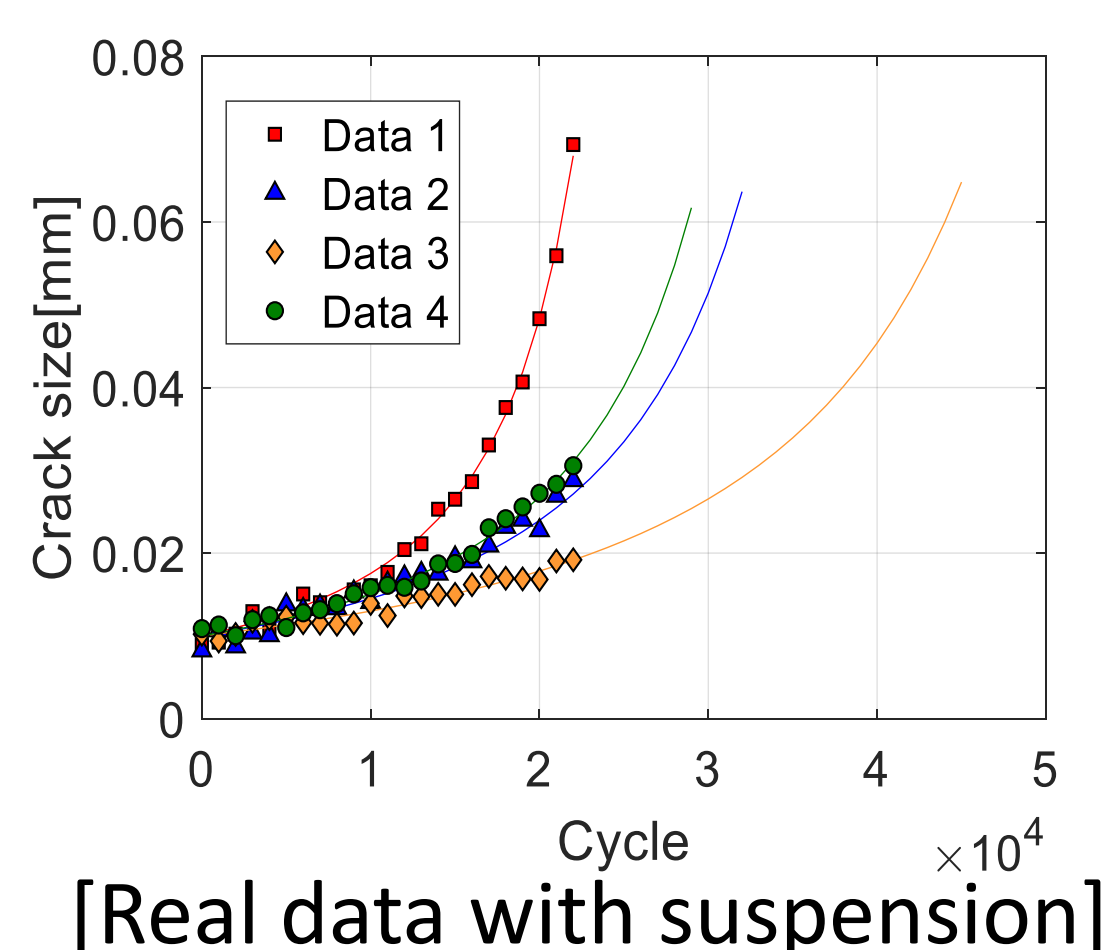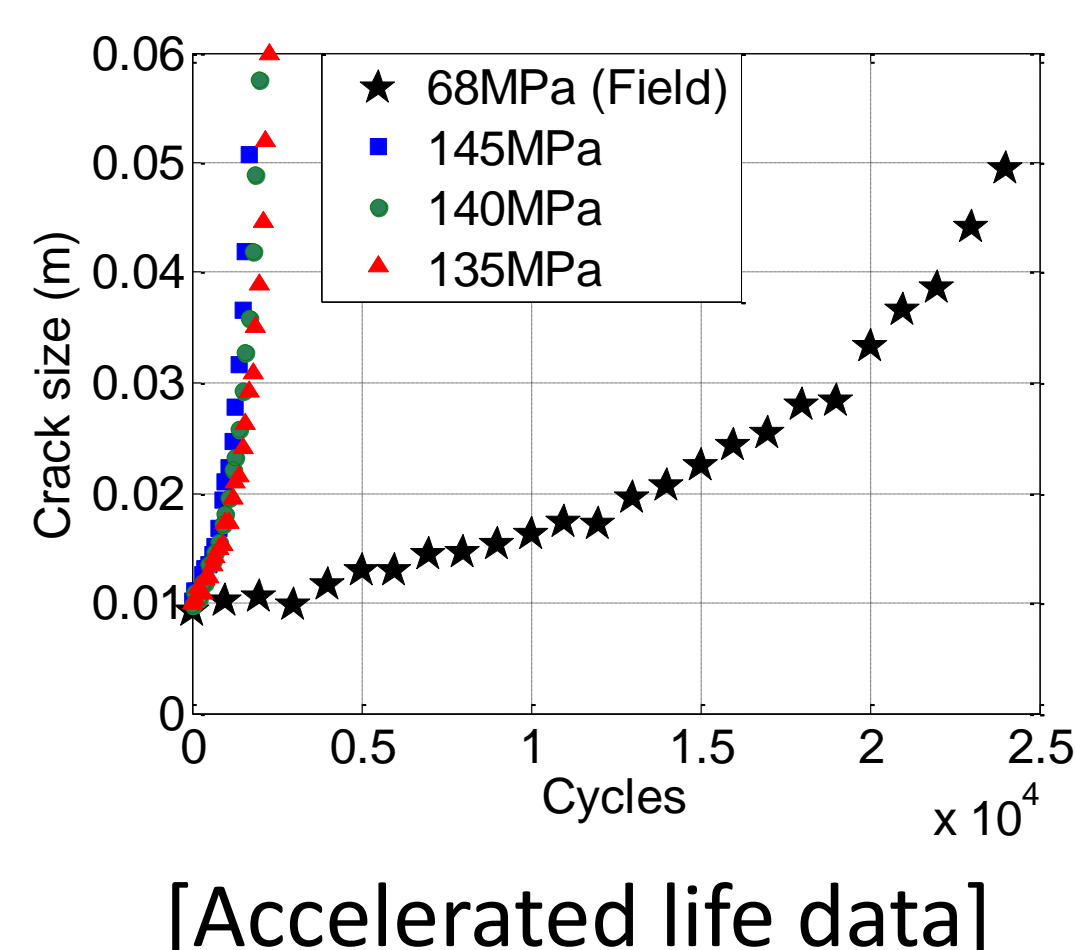
State of Research

Authors have developed algorithm that utilizes ALT data for prognosis under field loading condition, using the crack growth problem. The approach, however, requires both loading information (ALT & field), which is not easy to acquire in practice.

[with accelerated test data]

Next Steps

- A new approach is proposed that transforms the data even under unknown loading conditions will be developed, based on the method of mapping matrix with similarity.
- The method will be validated by the crack growth problem.

Research Details

Crack growth example

- Performance of prognostics depends on large amount of data.
- There are two resources in terms of data
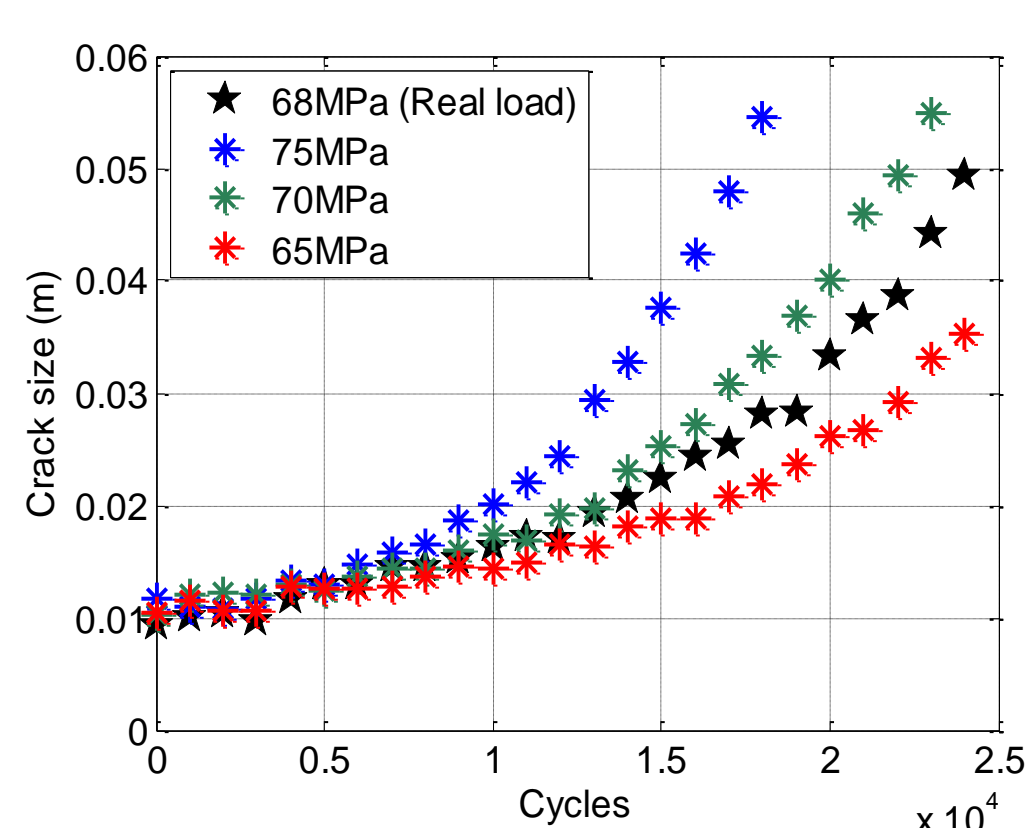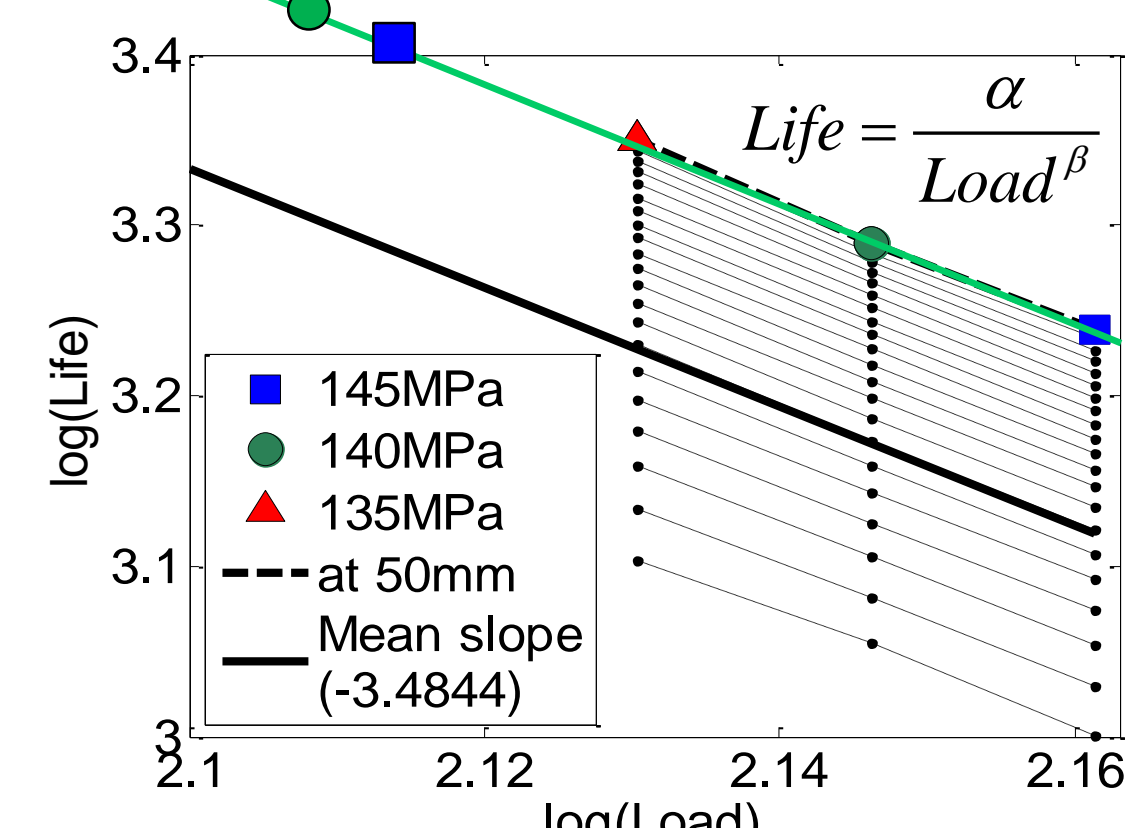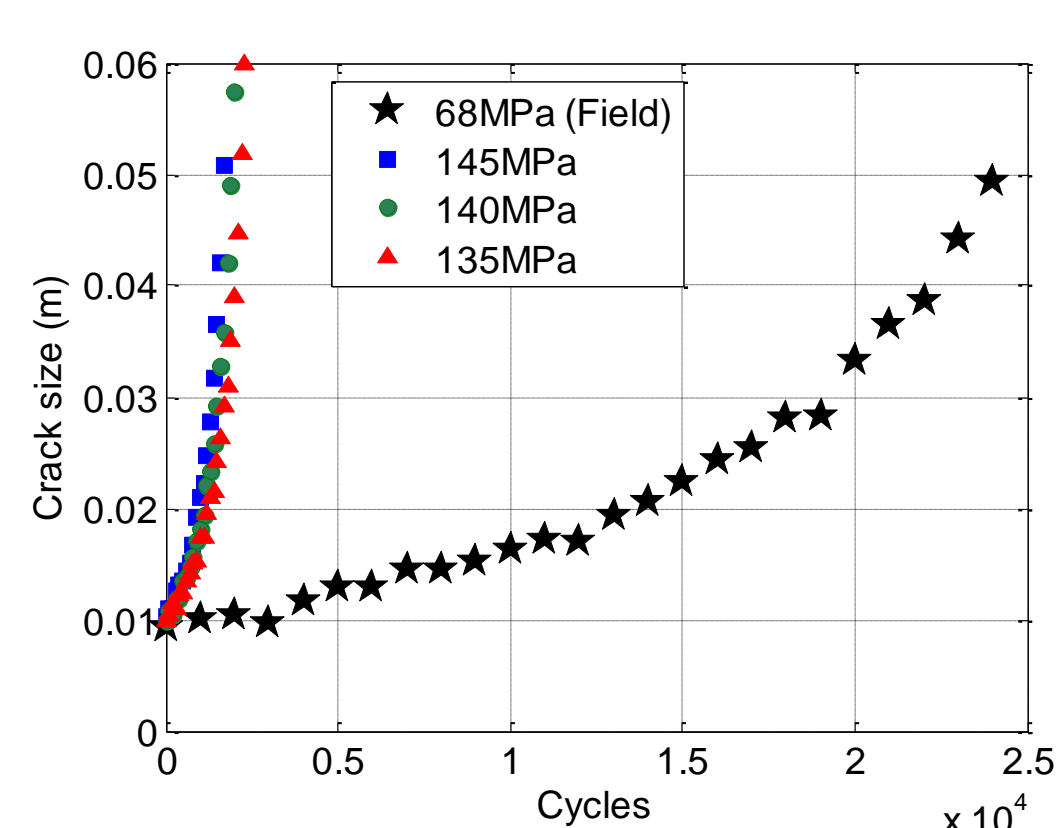 1) accelerated life data
  2) real data with suspension at field

[Through-the-thickness crack in a fuselage panel]

$$\frac{da}{dN} = C(\Delta K)^m, \ \Delta K = \Delta\sigma\sqrt{\pi a}$$

[Accelerated life data]

[Real data with suspension]

Utilizing accelerated life test data

- Inverse power model is employed to transform the ALT data to field measured data
- ANN (Artificial Neural Network) is trained with mapped data.

$$Life = \frac{\alpha}{Load^\beta}$$

[Accelerated data & field data]

[Inverse power model]
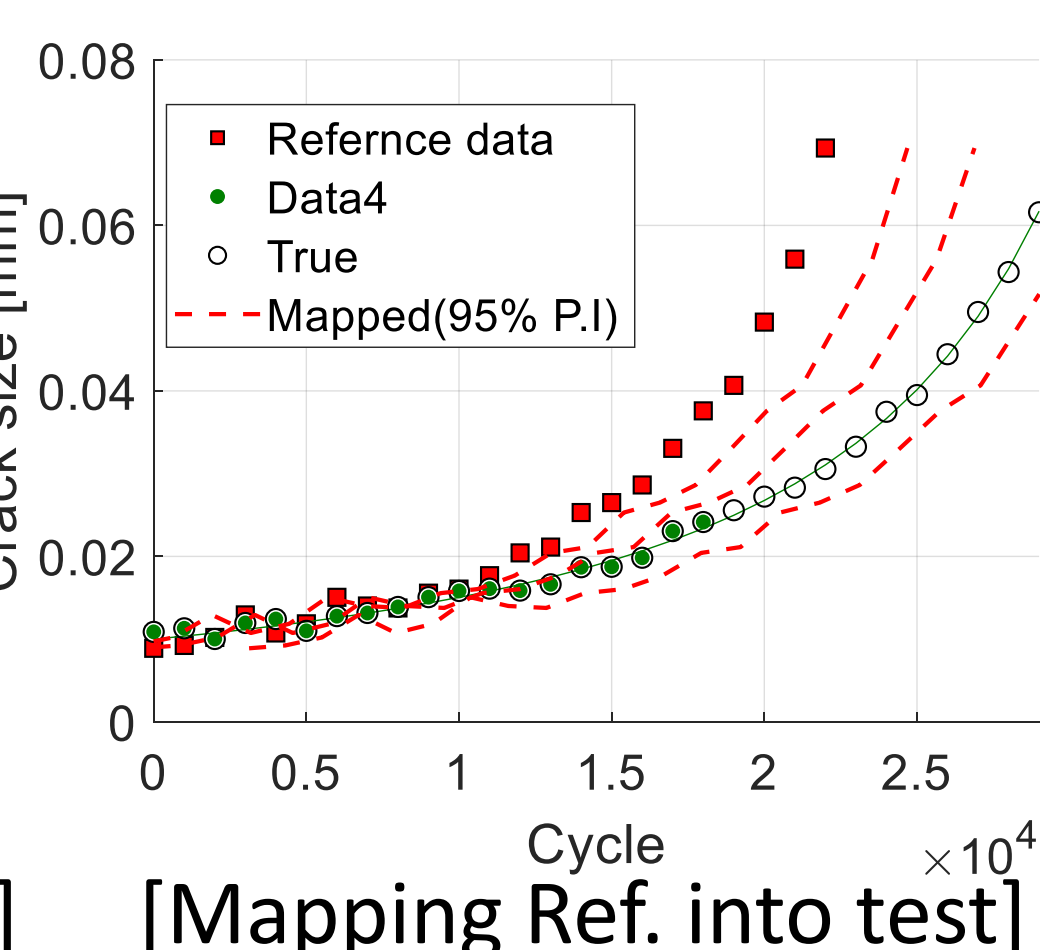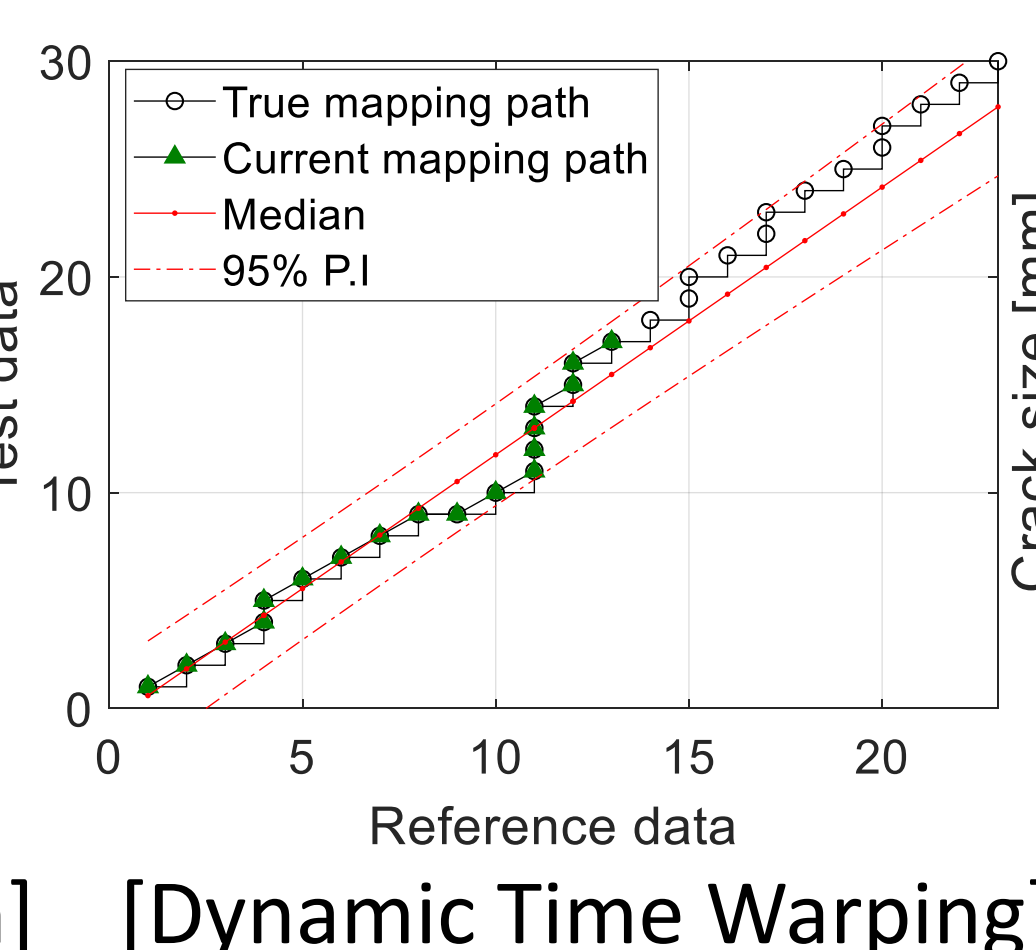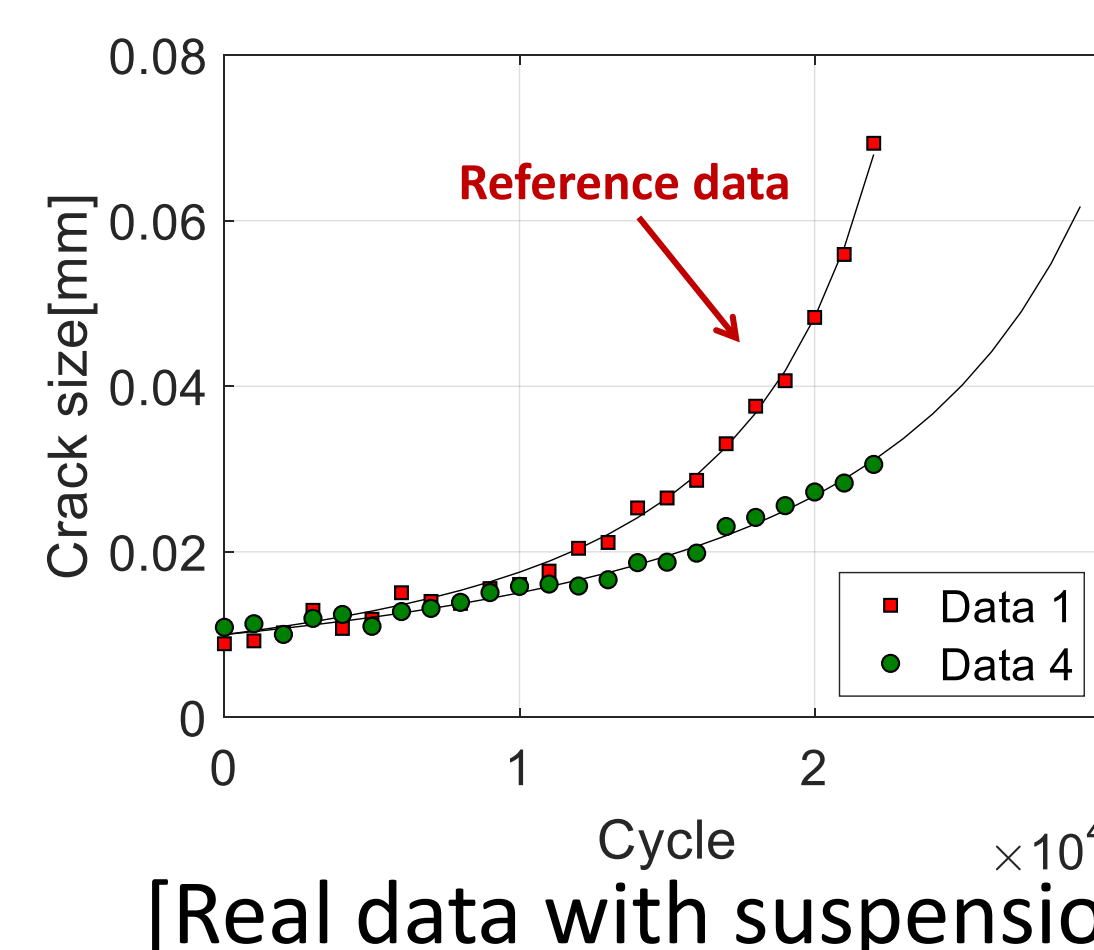
[Mapping into field loads]

Utilizing suspension data at field operation

- Suspension data which shows the highest degradation is considered as reference data.
- Dynamic time warping is applied to measure similarity between reference data and current operation data.
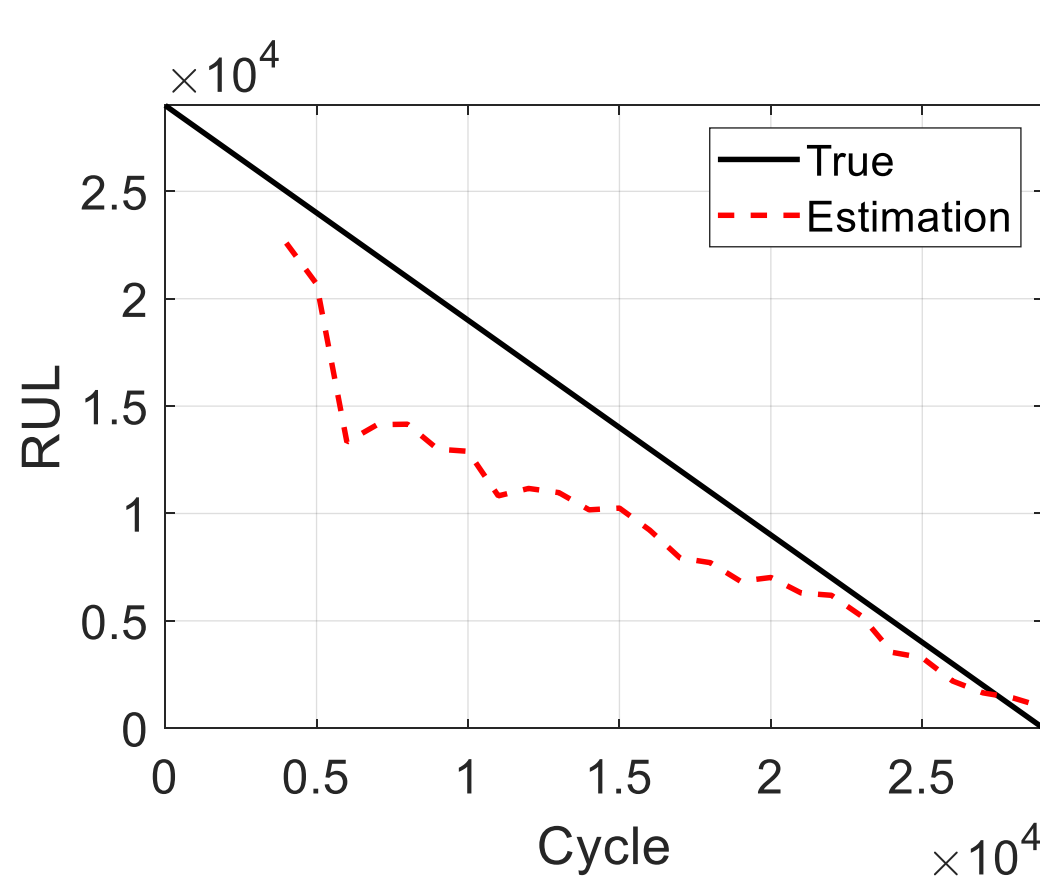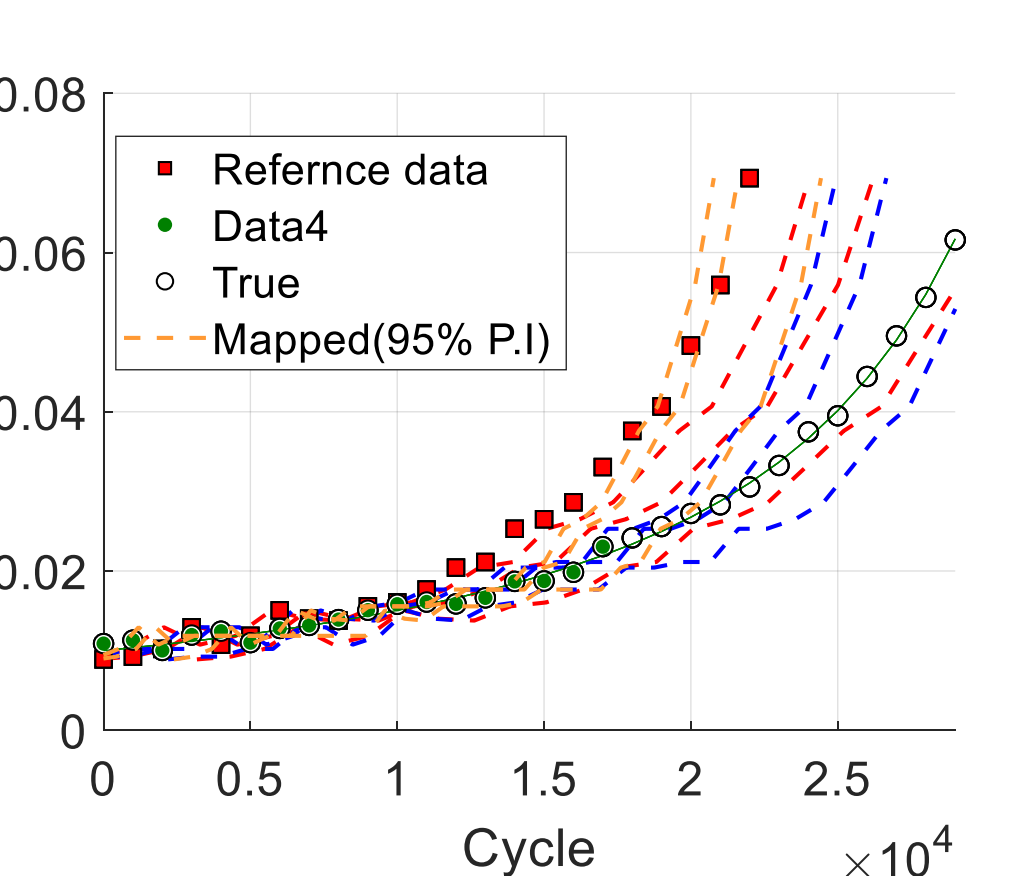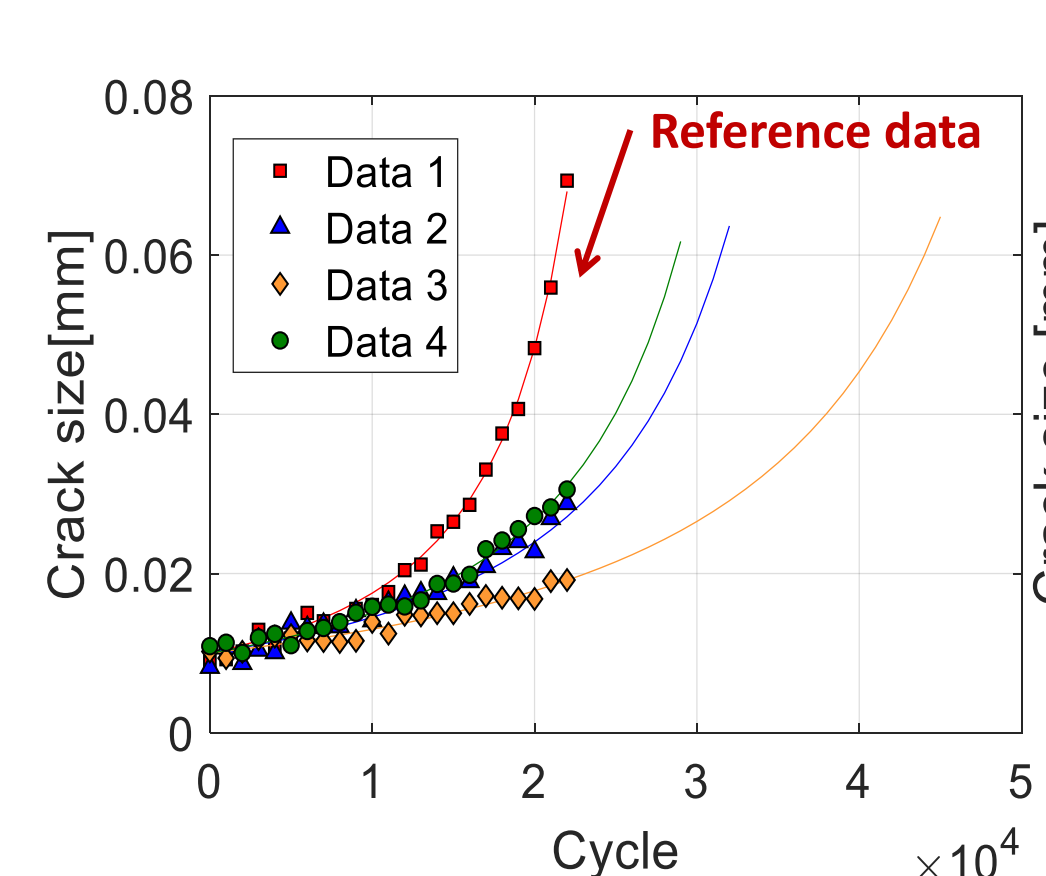

[Real data with suspension]

[Dynamic Time Warping]

[Mapping Ref. into test]

Utilizing all possible suspension data

- By using DTW based mapping, suspension data provide training data set for training ANN model.

[Real data with suspension]

[Mapping into Sus. data]

[RUL prediction result]

Acknowledgments and References

D. An, N. H. Kim, J. H. Choi, "Practical use of accelerated test data for the prognostics methods", Annual Conference of the PHM, New Orleans, LA, Oct. 2013, pp. 14-17, 2013.
P. Senin, "Dynamic time warping algorithm review," Information and Computer Science Department University of Hawaii at Manoa Honolulu, 2008.