An electronic circuit Prognostic method based on improved particle filter

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1. Introduction

As a result of intense global competition, companies are considering novel approaches to enhance the operational efficiency of their products. For some products, high in-service reliability can be a means to ensure customer satisfaction. For other products, increased warranties, or at least reduced warranty costs, and a reduction in liability due to product failures, are incentives for manufacturers to improve field reliability and operational availability. Electronics are integral to the functionality of most systems today, and their reliability is often critical for system reliability. Interest has been growing in monitoring the ongoing health of electronics products, whether they be components, systems, or systems-of-systems, to provide advance warning of failure and assist in administration and logistics. Here, health is defined as the extent of degradation or deviation from an expected normal condition. Prognostics is the prediction of the future state of health based on current and historical health conditions.

2. Background

The particle filter is considered by many as the state-of-the-art tool for model-based or hybrid prognostics. Indeed, it allows using a Bayesian formulation of a problem. Both physical models and data can be incorporated to the framework and the formulation thanks to a state vector enables linking the state of the system to numerous inputs. The classification of the approach into model-based or hybrid prognostics is still debated. Indeed, a model is needed to perform state of health estimation but data are also continuously used to update the parameters of the model and the state estimation.

3. Why using particle filter for prognostics?

The main point of this section to keep in mind is that the particle filter is not suitable to perform prognostics but only SoH estimation. Starting from this conclusion, it becomes easier to define why it should be included in a prognostics and what its role is.

As a component of a prognostics scheme, it is expected from the particle filter to give precise SoH estimates based on the current data. This implies taking into account the aging of the system, its behaviors as well as rare and sudden events such as changes in the mission profiles, maintenance interventions, uncontrolled rejuvenation phenomena or unpredictable/sudden failures.

For this purpose, we take advantage of (1) its possibility to fuse multiple measurement sources in a logical manner, (2) its ability to deal with nonlinear non-stationary and/or non-Gaussian processes, (3) its ability to take into account the stochasticity of the process, (4) the possibility to perform parameter and state estimations simultaneously, (5) the probabilistic form of the output and finally (6) its computational efficiency with respect to other MC methods.

However, by integrating this tool in the prognostics scheme, we have to face with its drawbacks. The use of particle filters requires a precise initialization and assumes that the degradation dynamics and the observation equation are exactly known. Also, it might be used without the respect of the first-order HMM hypothesis. It should not be forgotten that the classical choice of the importance density as may not always be appropriate, that the choices of parametrization can be complicated. Adding to that, the algorithm can be time-consuming so it is necessary to know exactly what the maximum delay expected to obtain results is. Finally, the aspects of uncertainty representation, quantification and management can be tricky. We will see later that we have to precisely define what kind of uncertainty can be handled by particle filters.

References

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