Chapter 17
Prediction of Remaining Useful Life of Batteries Using Machine Learning Models

Jaouad Boudnaya
https://orcid.org/0000-0003-3224-2410
Moulay Ismail University, Morocco

Hicham Laacha
https://orcid.org/0009-0000-7489-2177
Moulay Ismail University, Morocco

Mohamed Qerras
Moulay Ismail University, Morocco

Abdelhak Mkhida
Moulay Ismail University, Morocco

ABSTRACT

Predictive maintenance is a maintenance strategy based on monitoring the state of components to predict the date of future failure. The objective is to take the appropriate measures to avoid the consequences of this failure. For this reason, the authors determine the remaining useful life (RUL) which is the remaining time before the appearance of the failure on the component. It is an important approach that allows the prediction of aging mechanisms likely to lead components to failure. In this chapter, a new methodology for predicting the remaining useful life of components is proposed using a data-driven prognosis approach with the integration of machine learning. This approach is illustrated in a battery case study to predict the remaining useful life.

DOI: 10.4018/979-8-3693-0497-6.ch017

1 INTRODUCTION

The prediction of the Remaining Useful Life (RUL) of a system is a significant challenge nowadays. It involves understanding, modelling, and forecasting aging mechanisms that may lead to failure.

In the literature, several prognostic approaches exist, and each approach is based on different models. These approaches can be classified according to their application and complexity (Pauline, 2009). Among these methods, it is worth mentioning prognosis based on the use of component failure history data and/or operational usage profile data, which has been employed to monitor the health of a gas turbine alternator (Roemer et al., 2009).

The paper (Tsui et al., 2015) reviews Prognostics and Health Management (PHM) as a crucial framework for enhancing system reliability and competitiveness in the global market. It highlights data-driven approaches and real-world examples to illustrate PHM's applications in practice.

The paper (Sharma et al., 2023) highlights the environmental impact of vehicular emissions and stresses the role of machine learning for accurate estimation of Remaining Usable Life (RUL) in electric vehicles, addressing challenges in lithium-ion battery degradation.

Fault diagnosis has also received considerable attention in the artificial intelligence community (Schwabacher et al., 2007). Frameworks that illustrate the use of artificial intelligence algorithms have been discussed in the literature under the name model-based approach (Schwabacher et al., 2007). Finally, the data-driven approach has been integrated into avionics maintenance architecture (Ghelam et al., 2006). However, some of these models have limitations. They are often restricted to one or two stress factors without incorporating the interactions that may exist among them.

This article presents a novel methodology for predicting the Remaining Useful Life (RUL) of components by using a data-driven prognostic approach with the integration of machine learning. A case study is conducted on batteries to illustrate this approach.

The proposed document is structured as follows: Section 2 introduces maintenance concepts. Section 3 presents the notion of Prognostics and Health Management. Then, Section 4 contains a methodology for predicting the Remaining Useful Life (RUL). Subsequently, Sections 5 and 6 are dedicated to the presentation of machine learning. Part 7 illustrates our case study on battery RUL prediction with results and discussions. Finally, Section 8 concludes the article.

2 CONCEPTS OF MAINTENANCE

Maintenance is an essential step in the lifecycle of any complex system. According to AFNOR's definition, maintenance aims to keep or restore an asset to a specified condition so that it can provide a given service (AFNOR, 2001). There are two main categories of maintenance: corrective maintenance and preventive maintenance.

The first strategy generally incurs additional costs (Lee et al., 2006) and significant system unavailability (Palem, 2013), and it can pose safety issues. Preventive maintenance reduces the risk of unexpected failures and downtime, but it can result in high costs as some components are replaced while still in a slightly degraded operational state (Lee et al., 2006; Le, 2016).

To address these drawbacks, a new form of maintenance has emerged: predictive maintenance (Palem, 2013). It involves regular monitoring of the system's components (Bartelds et al., 2004), which enables the assessment of their proper functioning. Consequently, it becomes possible to predict the occurrence

Related Content