LITERATURE SURVEY ON MACHINE LEARNING-BASED PREDICTIVE ANALYTICS FOR AIRCRAFT ENGINE

Sl. No:	Title, Author, Name of the Journal & Year	Concept	Disadvantages	Future Work
1	**Title:** Machine Learning-Based Predictive Analytics for Aircraft Engine Conceptual Design **Author:** Michael T. Tong **Year:** 2020	• Supervised machine-learning algorithms for regression and classification were employed to study patterns in an existing, open-source database of production and research turbofan engines, and resulting in predictive analytics for use in predicting performance of new turbofan designs. • The predictive analytics were trained and deployed in Keras, an open-source neural networks application program interface (API) written in Python, with Google's TensorFlow (an open source library for numerical computation) serving as the backend engine. The promising results of the predictive analytics show that machine-learning techniques merit further exploration for application in aircraft engine conceptual design.	• To further improve the accuracy (and reduce the uncertainty) of TSFC prediction extended Database is needed • limitation of publicly available engine data	• The TSFC predictive analytics has an average accuracy of 98.3 percent, with 3.5 percent uncertainty. The engine core-size predictive analytics has an overall accuracy of 100 percent, with 4.3 percent uncertainty. Overall, both predictive analytics show remarkable prediction accuracy. • To further improve the accuracy (and reduce the uncertainty) of TSFC prediction, the database needs to be expanded. However, the limitation of publicly available engine data is a challenge to overcome.
2	**Title:** Failure Prediction of Aircraft Equipment Using Machine Learning with a Hybrid Data Preparation Method **Author:** Kadir Celikmih, Onur Inan , and Harun Uguz **Year:** 2020	• Performance of the hybrid data preparation model on the maintenance dataset of the equipment is evaluated by Multilayer Perceptron (MLP) as Artificial Neural network (ANN), Support Vector Regression (SVR), and Linear Regression (LR) as machine learning algorithms. Moreover, performance criteria such as the Correlation Coefficient (CC), Mean Absolute Error (MAE), and Root Mean Square Error (RMSE) are used to evaluate the models.	• In aviation, the use of maintenance data is highly critical in the analysis of reliability and maintenance costs. • The main target of predictive maintenance is to predict equipment failures and; to analyze the reliability and maintainability of a complex repairable system.	• This study could function as a guide for using hybrid data preparation methods in machine learning algorithms and data mining.
3	**Title:** Implementation of a Predictive Maintenance Method based on Deep Learning for Aviation **Author:** Lovejinder Singh **Year:** 2021	• This article explains the development of a Predictive Maintenance Deep Learning methodology based on Big Data for Aviation.	• A huge amount of data does not mean successful results. Moreover, it can generate more noise which interferes with optimal	• The Performance of the classifiers with this data is promising especially considering that there was the incomplete and noisy data. With better data, such as data coming from the Health and Usage

			predictions. It is necessary to carefully choose the input data. • Sometimes, it is difficult to understand the correlation of the input with the output, since it is an "invisible" process, where the user cannot see the logic followed by the algorithm.	Monitoring System (HUMS), it is possible to improve this performance and even try to predict internal failures of the aircraft engine
4	**Title:** Data-Driven Prediction of Unscheduled Maintenance Replacements in a Fleet of Commercial Aircrafts **Author:** Gianluca Nicchiott and Julien Rüegg **Year:** 2018	• Data-driven based prognostic uses pattern recognition and machine learning techniques to train historic data. • In a further step a subspace technique, borrowed from image processing domain and named Eigenface, allows to produce the signatures of the different types of maintenance actions and a template matching algorithm determines among the prognostics alert candidates the component to be replaced.	• Test results over 4 years of flights of a fleet of commercial airplanes have been presented and in 8 cases over 9 selected a precision above 50% has been achieved.	• In order to further improve the performances in terms of recall, time analysis of the alert sequences (Tschirpke & Salfner, 2008) is under investigation.
5	**Title:** A rare failure detection model for aircraft predictive maintenance using a deep hybrid learning approach **Author:** Maren David Dangut Ian K. Jennions Steve King Zakwan Skaf **Year:** 2022	• To develop a data driven model to predict probable failures that could cause interruption	• It was an unclear whether employing a bidirectional strategy to train imbalanced time series data would increase modal performance because there may not be enough definite temporal context.	• In future AE-CNN BGRU architecture will be studied further by translating time data into graphical representation utilising recurrence plot, other aircraft data can also be imported into ACMS to improve training
6	**Topic:** Predictive Maintenance for Aircraft Engine Using Machine Learning: Trends and Challenges **Author:** F A Adryan1, K W Sastra1 **Year:** 2021	• This provides the literature survey for recent research which trends and challenges on PdM of aircraft engine using ML that compared the research from international and Indonesia. Result of this work shows that ML method, Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) are the best method to calculate PdM with more than 99% on rate accuracy, and low	• They have limitation that cannot deal with irregular time-series data because in the aviation industry the record data in regular form of time series	• There are some possibilities for the future work, they are including the combination of ML method with itself or other method, tunning hyperparameter to optimize the computation process, and implemented the result and calculation on real-data as premier source, because most of research conducted to artificial data

		level of Indonesia institution research which focused on PdM on aircraft engine using ML		
7	**Topic:** Analysis of Aeronautical Engines Based on Machine Learning **Author:** Enrique López Droguett **Year:** 2021	• With the advance of DL techniques, its success on PHM and the continuous growth of data measured by sensors in planes, the motivation of this thesis is to predict the fuel consumption of a planes, which is related to its efficiency. To accomplish the prediction a machine learning (ML) model is used for forecasting and then used as an anomaly detector between predicted and true fuel consumption data.	• The limitations of ignoring specific behaviour of internal parts of the engine. • The inclusion of other useful features on the model would provide more consistency to the predictions. It's important to mention that some features were excluded because their use was not beneficial to the prediction.	• Other ideas for future future work include use of different architectures for the model selected, such as gated recurring units (GRU) [17] or attention models [4], which have had great success in other areas of ML. • Other options not considering specialized software include the use of a neural network (NN) to extract information from raw data and then train a second NN with the extracted features.
8	**Topic:** Machine-Learning-Based Condition Assessment of Gas Turbines **Author:** Martí de Castro-Cros *, Manel Velasco and Cecilio Angulo **Year:** 2021	This article explains that the combination of the available information captured through the collectors and the ML techniques shows promising results in increasing the accuracy, robustness, precision, and generalisation of industrial gas turbine equipment.	• The number of simultaneous events that can be detected is still a challenging task. • Another important issue to tackle is the online performance. Most of the methods proposed are able to properly detect anomalies and system performance deviation by analysing data either when the failure has occurred or in simulation software. Further research is needed to integrate all this information in real time, as well as to have a proper recommendation action system.	• Future research line remains, and important challenges need to be faced. Treating uncertainties, enhancing the model's robustness, and reducing the computational time of complex methods must be the focus for the next generation of algorithms.