LITERATURE SURVEY

MACHINE LEARNING-BASED PREDICTIVE   ANALYTICS FOR AIRCRAFT ENGINE

1)Machine Learning-Based Predictive Analytics for Aircraft Engine Conceptual Design(Michael T. Tong)
Description: Big data and artificial intelligence/machine learning are transforming the global business environment. Data is now the most valuable asset for enterprises in every industry. Companies are using data-driven insights for competitive advantage. With that, the adoption of machine learning-based data analytics is rapidly taking hold across various industries, producing autonomous systems that support human decision-making. This work explored the application of machine learning to aircraft engine conceptual design. 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. Specifically, the author developed machine learning-based analytics to predict cruise thrust specific fuel consumption (TSFC) and core sizes of high-efficiency turbofan engines, using engine design parameters as the input. 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.

2) Predictive Maintenance and Performance Optimisation in Aircrafts using Data Analytics(Shakthi Weerasinghe, Supunmali Ahangama.) IEEE 2018
Description: Airline industry has provided a significantly conventional, faster and reliable mode of transportation for passengers and freight over the decades in which the industry has been in service despite the pressure being applied especially in maintaining operational affordability. The study critically reviews the techniques and tools, infrastructure and general application architecture for discussing the applicability of data analytics based on both batch processing and real time stream data in general aviation for health monitoring and predictive analysis in order to predict maintenance and optimize the performance of aircrafts. In this respect, the study further evaluates the significant capability in addressing contemporary problems which are uniquely addressed by data analytics system.

3) Applications of deep learning in big data analytics for aircraft complex system anomaly detection:(Shungang Ning, Jianzhong Sun , Cui Liu and Yang Yi)(SAGE 2021)
Description: Big data analytics with deep learning approach have attracted increasing attention in transportation engineering, involving operations, maintenance, and safety. In commercial aviation sectors, operational, and maintenance data produced on modern aircraft is

increasing exponentially, and predictive analysis of these data is an exciting and promising field in aviation maintenance, which has a potential to revolutionize aerospace maintenance industry. This study illustrates the stateof-the-art applications of deep learning in big data analytics for predictive maintenance and a real-world case study for commercial aircraft. A Long Short-Term Memory network based Auto-Encoders (LSTM-AE) is proposed for complex aircraft system fault detection and classification, which makes use of the raw time-series data from heterogeneous sensors. The proposed method uses nominal time-series samples corresponding to healthy behavior of the system to learn a reconstruction model based on LSTM-AE framework. Then the system health index (HI) and fault feature vectors are derived from the reconstruction error matrix for fault detection and classification. The proposed method is demonstrated on a real-world data set from a commercial aircraft fleet. The typical PCV faults as well as the 390 F sensor and 450 F sensor faults due to sense line air leakage are successfully detected and distinguished based on the extracted features. The case study results show that the computed HI can effectively characterize the health state of the aircraft system and different fault types can be identified with high confidence, which is helpful for line fault troubleshooting.

4) A Generic and Scalable Pipeline for Large-Scale Analytics of Continuous Aircraft Engine Data: (Florent Forest, Jérôme Lacaille, Mustapha Lebbah and Hanene Azzag)
Description:A major application of data analytics for aircraft engine manufacturers is engine health monitoring, which consists in improving availability and operation of engines by leveraging operational data and past events. Traditional tools can no longer handle the increasing volume and velocity of data collected on modern aircraft. We propose a generic and scalable pipeline for large-scale analytics of operational data from a recent type of aircraft engine, oriented towards health monitoring applications. Based on Hadoop and Spark, our approach enables domain experts to scale their algorithms and extract features from tens of thousands of flights stored on a cluster. All computations are performed using the Spark framework, however custom functions and algorithms can be integrated without knowledge of distributed programming. Unsupervised learning algorithms are integrated for clustering and dimensionality reduction of the flight features, in order to allow efficient visualization and interpretation through a dedicated web application. The use case guiding our work is a methodology for engine fleet monitoring with a self-organizing map. Finally, this pipeline is meant to be end-to-end, fully customizable and ready for use in an industrial setting.

5)Predictive Aircraft Engine Maintenance(Vikas Chhikara)
Description: For maintenance decisions and selecting a suitable operation for a machine, it's necessary to analyze the remaining useful life of the machine accurately. Machine learning techniques for RUL are usually focused as they are faster and easy to use. The existing models for RUL prediction are a single path or based on a top down approach. For increasing the accuracy and to achieve promising results this report proposes a methodology that combines the Convolutional neural networks (CNN) and Long short-term memory in order to predict the

useful life of the machine. A different approach than existing models for this report CNN and LSTM model is actually combined rather than just using CNN for extracting features. But as for input single timestamp is used that can further lead to the same batch padding which could affect the model's prediction. The proposed methodology is used to overcome these issues by sliding the time one step size. For this report turbofan engine degradation data by NASA is used for training, testing, and validation of the RUL Model. By comparing the model using different Models like simple LSTM and transfer learning using the same dataset. With comparison, it will be easy to examine the performance of the proposed approach.

6)Approach And Landing Aircraft on-boardParameters Estimation with LSTM Networks (Author –Gabriel Jarry).
Description: This paper addresses the problem of estimating aircraft on-board parameters using ground surveillance available
Parameters. The proposed methodology consists in trainingsupervised Neural Networks with Flight Data Records to
estimate target parameters. This paper investigates the
learning process upon three case study parameters: the fuel
flow rate, the flap configuration, and the landing gear position.Particular attention is directed to the generalization
to different aircraft types and airport approaches. From the Traffic Management point of view, these additional parameters enable a better understanding and awareness of aircraft behaviors. Theseestimations can be used to evaluate and enhance the air traffic management system performance

7)Aircraft Engine Reliability Analysis Using Machine Learning Algorithms(Author – Deepnkar Singh)
 Description: In the aviation industry, the reliability analysis of aircraft
engines is essential for ensuring the smooth functioning of
each component of an aircraft engine. The reliability analysis
s also important to predict their scheduled maintenance event
and the Remaining Useful Life (RUL) of engine parts.Existingapproaches for engine reliability are based on
numerical methods, which do not predict RUL accurately. Hence, a more accurate model is required for predicting maintenance events. The reliability of an aircraft engine can be measured using readings of different sensors. In this work, the performances of different machine learning algorithms are studied, and finally, a better algorithm is suggested for peredictingRUL. Additionally, a classification approach is proposed to classify the health state of an engine. The experimental results show that the XGBoost gives the best prediction accuracy in terms of root mean square error. The proposed LightGBM-based classifier further enhances the
maintenance prediction based on the health state of the aircraftengine. Thus, the proposed analysis shows that and LightGBM is a better choice for predicting the RUL, and for classifying the health state of the aircraft engine.