**ENGINE CONDITION**

**TREND MONITORING**

*Predicting the probability of failure of an Aircraft Engine*

By

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**INTRODUCTION**

This report will be of interest for Pilots, Aircraft Engine Manufacturers, Data Scientists and Researchers. This report provides an overview of how Machine Learning algorithms can help predict the probability of failure of aircraft engines. This process is called Engine Condition Trend Monitoring.

* 1. **Background**

Faststream Technologies is a vanguard of technology solutions, specializing in Product & System Engineering, IoT, Big Data, Security, and Application Development with a global footprint across North America, EMEA, and APAC. With over 200+ clients, Faststream Technologies enables Digital Transformation for enterprises by delivering a flawless customer experience, business competence, and deep insights through an integrated set of disruptive technologies and expertise. We are passionate about delivering well-organized, inventive and world-class hardware and software solutions, with a focus on Healthcare, Aerospace, Semiconductors, Automotive, Consumer Electronics, Home Automation, Telecommunications, Security, Retail, and E-Commerce.

Faststream Technologies works at the juncture of business and technology, assisting clients with advancing their product and business performance through sustainable information technology solutions. Faststream Technologies drives innovation to help clients advance their product design, business processes, and application development. Our engineering team’s deep expertise in transforming design specs into marketable hardware products — through ASIC design services that include RTL design, design verification and physical design for digital and analogue/mixed-signal semiconductors — is a key differentiator to our suite of application development capabilities.

For today’s challenges like embedded processor SoC specifications, Faststream Technologies delivers all of the required firmware/embedded software, positioning us as the turnkey ‘concept-to-product’ design company. The team is led by a group of focused senior executives and Technologists who complement each other with significant industry experience in building turnkey solutions. Many of our technologists have multiple patents to their credit in the areas of Analog/Mixed-Signal Design, IoT and embedded systems.

* 1. **Engine Condition Trend Monitoring**

Engine Condition Trend Monitoring (ECTM) is defined as using engine operational data to find symptoms of damage, deterioration or excessive wear. Essentially, it’s a technique to continuously monitor the health of engines. By tracking a known set of parameters like altitude, noise from the fan blade, exhaust gas temperature of turbine, fuel flow of turbine, low pressure fan speed, high pressure rotor speed, mechanical problems in the engine, oil leaks, fuel pump etc., operators are able to predict needed maintenance before a failure occurs. This doesn’t stop the initial problem from happening but is a great tool to predict a failure before anything catastrophic occurs.

Although flight crews are able to notice big or sudden changes to performance, ECTM will identify subtle changes over a period of time that a flight crew won’t. Every flight, the aircraft is in different environmental conditions that may not give a clear picture of performance to the flight crews. ECTM will calculate the information provided, correct it for standard day conditions and predict when the engine might fail.

Properly trained, humans can manually do the analysis, but the risk for error is great. Computers and software is used to identify and interpret trends and aircraft operator is notified of any anomalies that need to be addressed.

* 1. **Machine Learning**

Machine Learning is the science (and art) of programming computers so they can learn from data. For example, your spam filter is a Machine Learning program that can learn to flag spam given examples of spam emails (e.g., flagged by users) and examples of regular (non-spam) emails. The examples that the system uses to learn are called the training set. Each training example is called a training instance (or sample). In this case, the task T is to flag spam for new emails, the experience E is the training data, and the performance measure P needs to be defined; for example, you can use the ratio of correctly classified emails. This particular performance measure is called accuracy and it is often used in classification tasks.

***Supervised Learning***

Machine Learning systems can be classified according to the amount and type of supervision they get during training. There are four major categories: supervised learning, unsupervised learning, semi-supervised learning, and Reinforcement Learning. In supervised learning, the training data you feed to the algorithm includes the desired solutions, called labels.

***Unsupervised learning***

It is the machine learning task of inferring a function that describes the structure of "unlabelled" data (i.e. data that has not been classified or categorized). Since the examples given to the learning algorithm are unlabelled, there is no straightforward way to evaluate the accuracy of the structure that is produced by the algorithm—one feature that distinguishes unsupervised learning from supervised learning and reinforcement learning

* 1. **Objectives**

The goal of the project is to validate Engine Condition Trend Monitoring’s performance across three Machine Learning Regression Algorithms – Multiple Linear Regression, Decision Tree and Random Forest.

* 1. **Dependencies and Tools**

1. Python – a general-purpose interpreted, interactive, object-oriented, and high-level programming language
2. Anaconda – a free and open source distribution of the Python and R programming languages for data science and machine learning related applications, that aims to simplify package management and deployment
3. Numpy – the fundamental package for scientific computing with Python.
4. Scipy - a Python-based ecosystem of open-source software for mathematics, science, and engineering
5. Pandas - pandas is an open source, BSD-licensed library providing high-performance, easy-to-use data structures and data analysis tools for the Python programming language.
6. Matplotlib – a Python 2D plotting library which produces publication quality figures in a variety of hardcopy formats and interactive environments across platforms
7. Sci-kit learn – a free software machine learning library for the Python programming language.

**ASSUMPTIONS**

Since there was no data avai