Industrial Internship Report on

"Predict the number of remaining operational cycles before the failure of Turbofan Engine"

Prepared by

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Executive Summary
This report provides details of the Industrial Internship provided by upskill Campus and The IoT Academy in collaboration with Industrial Partner UniConverge Technologies Pvt Ltd (UCT). This internship was focused on a project/problem statement provided by UCT. We had to finish the project including the report in 6 weeks' time. My project was **"Predict the number of remaining operational cycles before failure of Turbofan Engine"** Accurate prediction of engine failures enables operators to identify potential issues in advance and take appropriate actions to prevent catastrophic failures or accidents. This enhances the overall safety of the engine and the associated equipment or vehicles that rely on it. It offers benefits such as improved maintenance planning, cost reduction, enhanced safety, increased asset lifespan, and data-driven decision-making. This internship gave me a very good opportunity to get exposure to Industrial problems and design/implement solutions for that. It was an overall great experience to have this internship.

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1   Preface

Through this remote Internship, I learned a lot about Data Science and Artificial Intelligence, Big Data Analytics, Machine Learning. The project I performed was based on Machine Learning in which first I have to analyze the problem and to find the best suited algorithm which can give the best optimized solution.

In this Internship, I learned Impact of Big Data on Business. It is profitable to lean on Big Data to make business decisions. Also depending upon analyzing performance can certainly affect the business model. It helps to make critical business decisions based on facts and trades. Big Data Hadoop and technologies like cloud-based analytics proved to be essential elements. AI and ML blended with big data technologies help to analyze massive amounts of data. It empowers predictive analytics to make predictions about behaviors. Also I learned the difference between Data Scientists and Data Analysts. The pros and cons of being the Data Scientist and Data Analyst.

The difference between AI and Data Science and the difference between AI and Machine Learning was also another learning from this Internship. In this internship curriculum the introduction about statistics and machine learning is also there. Also to enter in the field of Data Science and Machine Learning which skills are really needed I learned.

The machine Introduction and various skills required to become a machine learning engineer I got to know in this Internship. The optimization techniques while developing a machine learning project is also another learning from these 6 weeks of Internship.

The need of Relevant Internship In Career Development:

Internships are valuable experiences that contribute significantly to career development. Here are some key points highlighting their importance:

1. Real-World Exposure: Internships provide hands-on experience in a professional setting, giving you a taste of what your career might entail.

2. Skill Development: You can learn and refine practical skills that are directly applicable to your field of interest.

3. Networking: Internships allow you to build a network of professionals in your industry, which can be beneficial for future job opportunities.

4. Resume Enhancement: Having relevant internships on your resume showcases your practical experience and makes you stand out to potential employers.

5. Industry Insights: Internships provide insights into the industry's workings, helping you understand trends, challenges, and opportunities.

6. Mentorship: Many internships offer mentorship opportunities, allowing you to learn from experienced professionals.

7. Confidence Building: Successfully completing internships boosts your confidence and helps you feel more prepared for a full-time role.

8. Preparation for Job Interviews: Internship experiences provide valuable examples to discuss in job interviews, showcasing your capabilities.

In conclusion, internships are essential for gaining real-world experience, developing skills, building a network, and preparing for a successful career in your chosen field.


Brief about project/problem statement on which I worked:

The problem statement involves developing a predictive model to estimate the number of operational cycles remaining before the failure of turbofan engines. This requires analyzing historical data, engine sensor readings, and other relevant parameters to create a model that can forecast engine health and remaining useful life. The goal is to improve maintenance planning, reduce downtime, and enhance operational efficiency by providing advanced warning of engine failures.

The Internship Opportunity at UniConverge Technologies in the field of Data Science and Machine Learning was Substantial. It involves overall learning of Data Science and Machine Learning. The Internship period was for 6 weeks. From 1st week to 6th week the relevant topics to Data Science and machine Learning were assigned on internship portal. There were different blogs related to Data Science, Big data analytics, Machine learning, AI written by the Upskill campus and IOT academy I read. That were useful for the thorough understanding of Data Science and Machine Learning. In 6th week of whole Internship, blogs and information related to career development in machine learning, data analysts and data scientist, pros and cons of becoming data scientist and data analysts. Also how much a data engineer earns were provided on internship portal. Overall Information about how to choose a career in Data related field like data engineer and other roles were gained through this internship

Another part of the Internship was to work on a real-world problem statement. There were different types of problem statements were given by the UCT. We had to choose one problem on which we had to find the optimized solution by developing a machine learning model which can give an accurate prediction.

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The Internship Program was planned as follow:
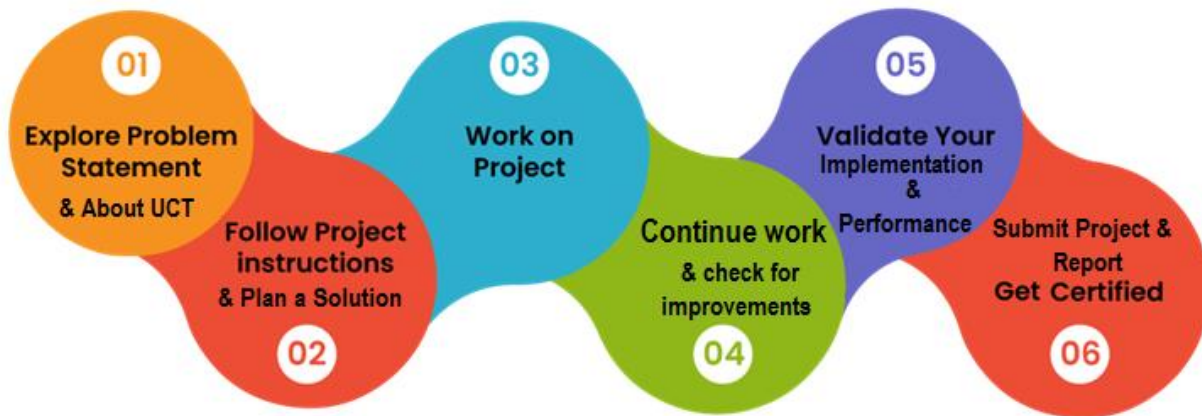
Learning and overall experience:

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My sincere thanks to CEO and Founder of UniConverge Technologies Mr. Kaushlendra Singh Sisodiya for guiding us about the Internship and Introducing about the company and also the faculty assigned to guide us who were solving our each and every query. Also thankful to the faculties and respected guests who invest their time for taking the session organized in overall internship and guide us about different concepts like Resume preparation and related to job opportunity.

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2 Introduction

2.1 About UniConverge Technologies Pvt Ltd

A company established in 2013 and working in Digital Transformation domain and providing Industrial solutions with prime focus on sustainability and RoI.

For developing its products and solutions it is leveraging various **Cutting Edge Technologies e.g. Internet of Things (IoT), Cyber Security, Cloud computing (AWS, Azure), Machine Learning, Communication Technologies (4G/5G/LoRaWAN), Java Full Stack, Python, Front end** etc.

## i. UCT IoT Platform (**uct Insight**)

UCT Insight is an IOT platform designed for quick deployment of IOT applications on the same time providing valuable "insight" for your process/business. It has been built in Java for backend and ReactJS for Front end. It has support for MySQL and various NoSql Databases.

- It enables device connectivity via industry standard IoT protocols - MQTT, CoAP, HTTP, Modbus TCP, OPC UA

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- It supports both cloud and on-premises deployments.

It has features to
• Build Your own dashboard
• Analytics and Reporting
• Alert and Notification
• Integration with third party application(Power BI, SAP, ERP)
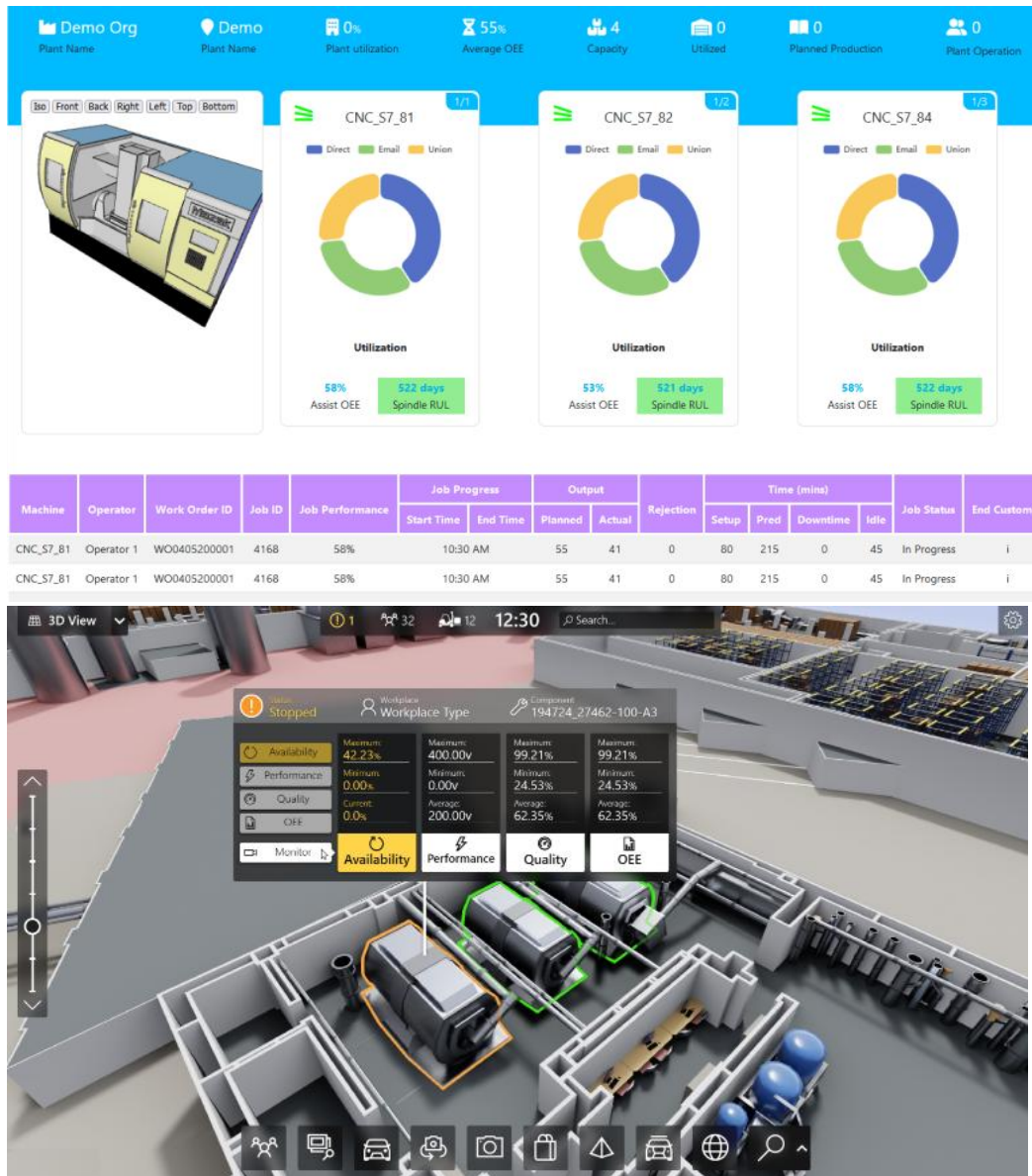• Rule Engine

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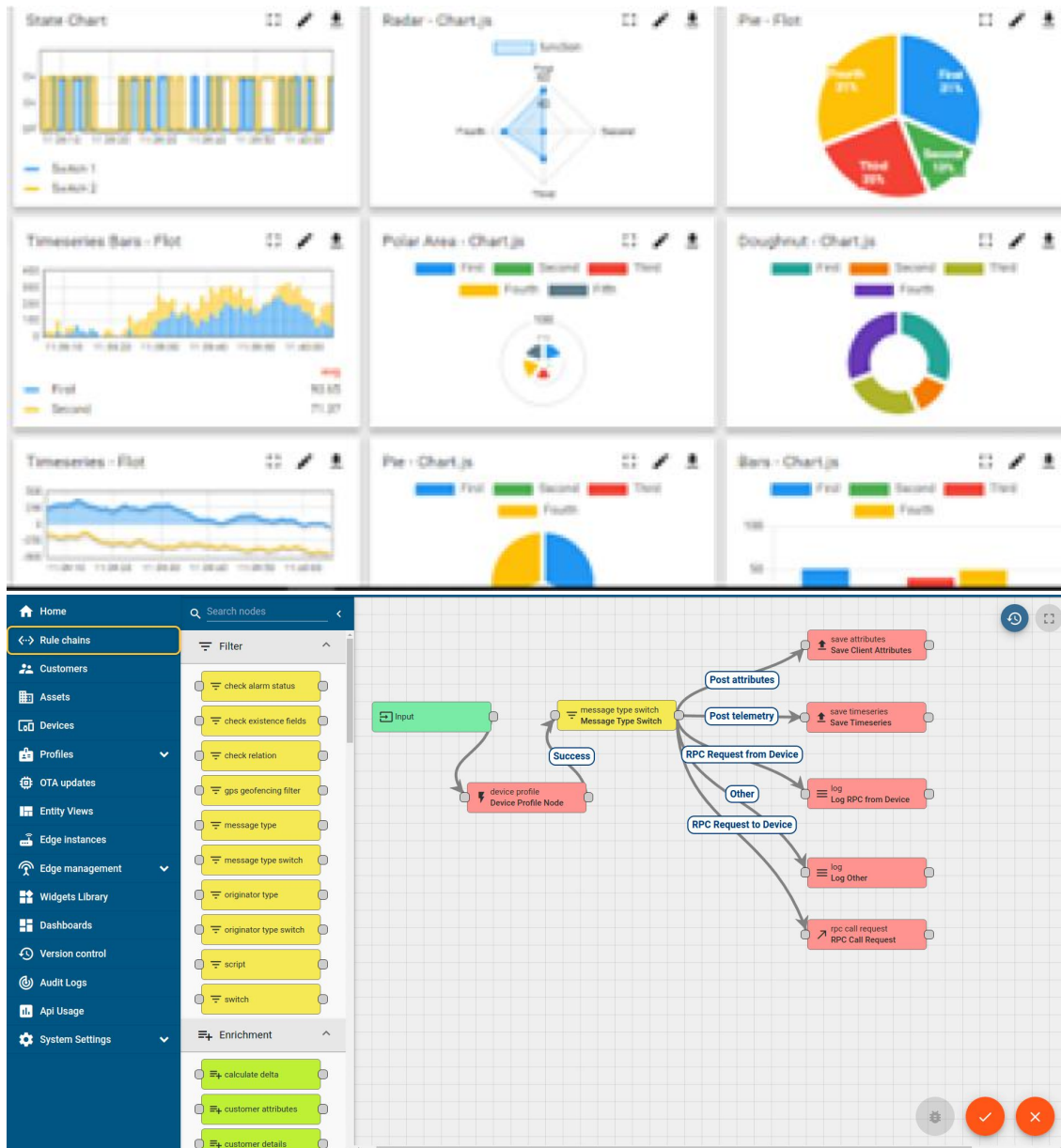
ii.   Smart Factory Platform (FACTORY WATCH)

Factory watch is a platform for smart factory needs.

It provides Users/ Factory

- with a scalable solution for their Production and asset monitoring

- OEE and predictive maintenance solution scaling up to digital twin for your assets.

- to unleased the true potential of the data that their machines are generating and helps to identify the KPIs and also improve them.

- A modular architecture that allows users to choose the service that they what to start and then can scale to more complex solutions as per their demands.

Its unique SaaS model helps users to save time, cost and money.

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Machine	Operator	Work Order ID	Job ID	Job Performance	Job Progress		Output		Rejection	Time (mins)				Job Status	End Customer
					Start Time	End Time	Planned	Actual		Setup	Pred	Downtime	Idle		
CNC_S7_81	Operator 1	WO0405200001	4168	58%	10:30 AM		55	41	0	80	215	0	45	In Progress	i
CNC_S7_81	Operator 1	WO0405200001	4168	58%	10:30 AM		55	41	0	80	215	0	45	In Progress	i

iii. **LoRaWAN** based Solution

UCT is one of the early adopters of LoRAWAN technology and providing solution in Agritech, Smart cities, Industrial Monitoring, Smart Street Light, Smart Water/ Gas/ Electricity metering solutions etc.

iv. Predictive Maintenance

UCT is providing Industrial Machine health monitoring and Predictive maintenance solution leveraging Embedded system, Industrial IoT and Machine Learning Technologies by finding Remaining useful life time of various Machines used in production process.
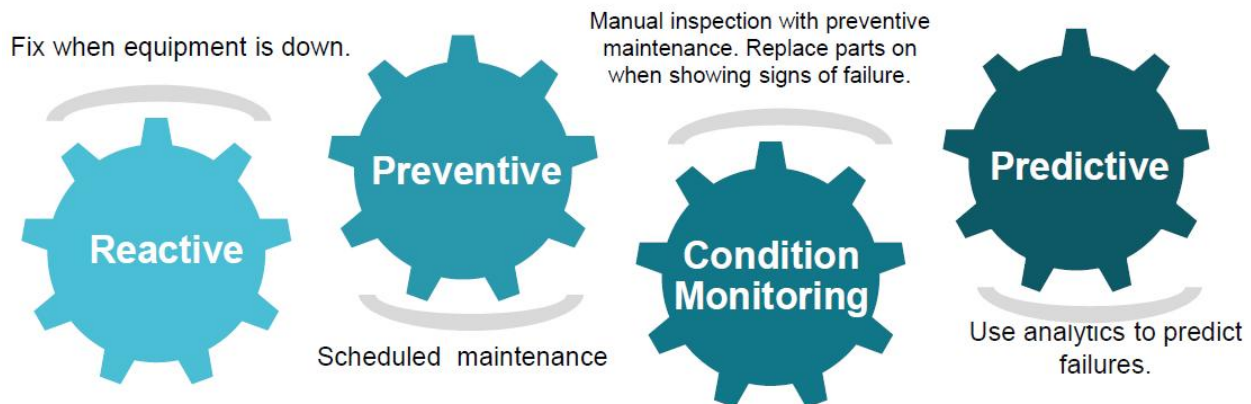
2.1 About upskill Campus (USC)

upskill Campus along with The IoT Academy and in association with Uniconverge technologies has facilitated the smooth execution of the complete internship process.

USC is a career development platform that delivers **personalized executive coaching** in a more affordable, scalable and measurable way.
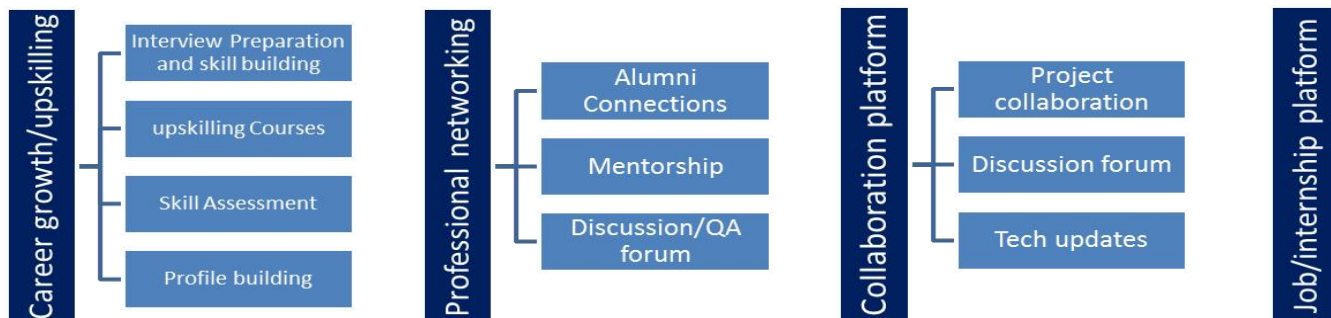
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Seeing need of upskilling in self paced manner along-with additional support services e.g. Internship, projects, interaction with Industry experts, Career growth Services

upSkill Campus aiming to upskill 1 million learners next 5 year

HYPERLINK "https://www.upskillcampus.com/"
https://www.upskillcampus.c

Career growth/upskilling		Professional networking		Collaboration platform		Job/internship platform
Interview Preparation and skill building		Alumni Connections		Project collaboration		
upskilling Courses		Mentorship		Discussion forum		
Skill Assessment		Discussion/QA forum		Tech updates		
Profile building						

2.2 The IoT Academy

The IoT academy is EdTech Division of UCT that is running long executive certification programs in collaboration with EICT Academy, IITK, IITR and IITG in multiple domains.

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2.3 Objectives of this Internship program

The objective for this internship program was to

☛ get practical experience of working in the industry.

☛ to solve real world problems.

☛ to have improved job prospects.

☛ to have Improved understanding of our field and its applications.

☛ to have Personal growth like better communication and problem solving.

2.4 Reference

[1]   GeeksforGeeks Official Website for Machine learning and Algorithms

[2]   Damage Propagation Modeling for Aircraft

   Engine Run-to-Failure Simulation Research Paper.

[3]   E-book Introducing Data Science - Machine Learning

2.5 Glossary

Terms	Acronym
Data Science	DS
Machine Learning	ML

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3. Problem Statement

The Problem Statement is "Predict the number of remaining operational cycles before the failure of turbofan engine."

The objective of this project is to develop a machine learning model to predict the remaining useful life of aircraft turbofan engines. The Remaining Useful Life (RUL) is the amount of cycles an engine has left before it needs maintenance. The Overall Project was based on the real world problem faced by aircraft engine when certain period of time it started to fail while working so its important to predict the remaining operational cycles of turbofan engine of an aircraft.

4. Existing and Proposed solution.

After doing research for a certain period of time, I got some sample solution for the given problem statement. The solution was giving the accurate result but accuracy was less which can be improved more. The one solution I found on internet in which the Random Forests Algorithm was using for predicting the number of remaining operational cycles(RUL). which was using the supervised learning algorithm. The entire solution was correct but by using other techniques of machine learning which are advanced the proposed model can be optimized and can give the accurate prediction.

The proposed solution I found is to change the algorithm applied in previous solution of machine learning. So I applied CNN algorithm over Random Forests which improved the accuracy of machine learning model develop for the problem statement.

4.1 Code submission (Github link) - https://github.com/Anjalihiwale

4.2 Report submission (Github link) : https://github.com/Anjalihiwale

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3   Proposed Design/ Model

a. Flowchart for the Machine Learning problem
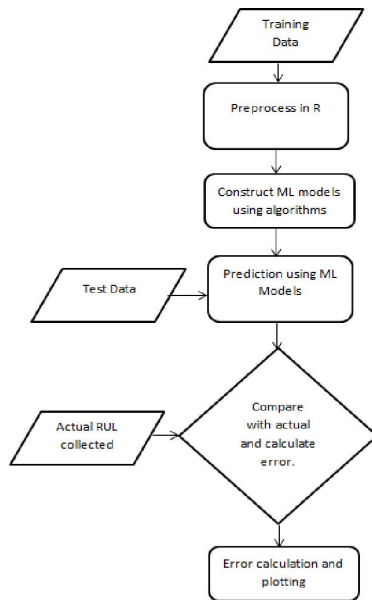
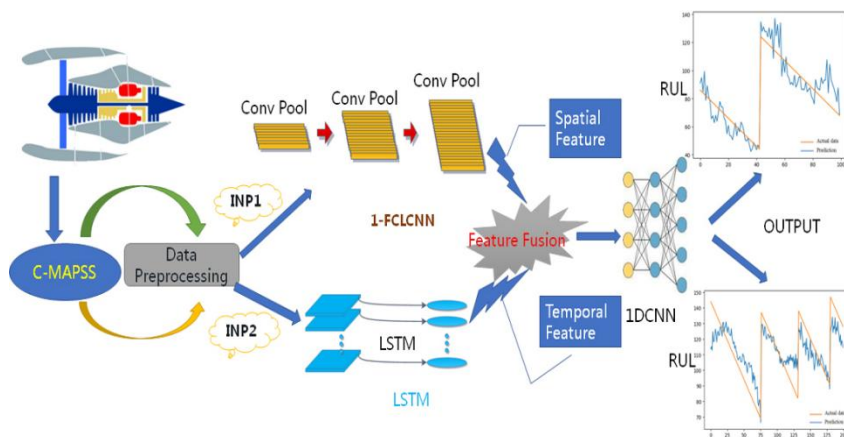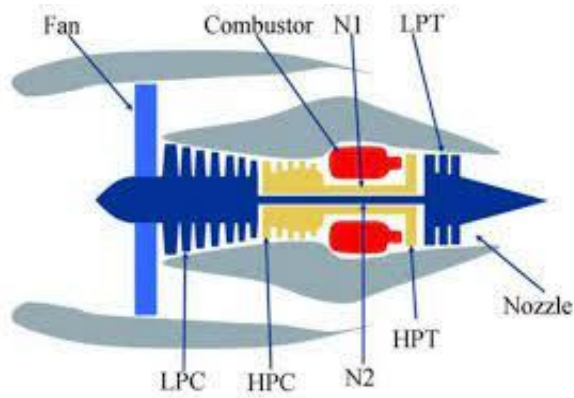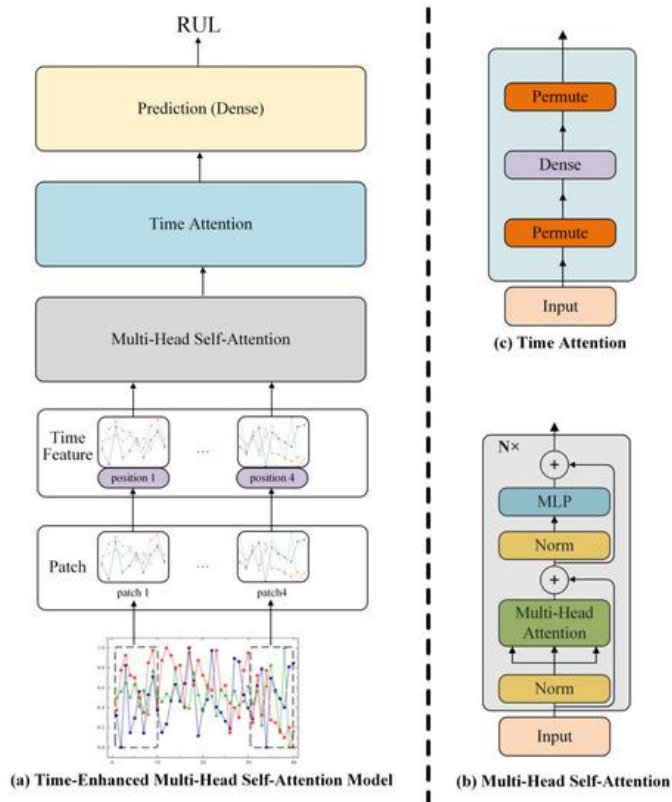## 3.1 High Level Diagram (if applicable)

Figure 1: HIGH LEVEL DIAGRAM OF THE SYSTEM

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3.2 Low Level Diagram (if applicable)

3.3 Interfaces (if applicable)

(a) Time-Enhanced Multi-Head Self-Attention Model

(b) Multi-Head Self-Attention

(c) Time Attention
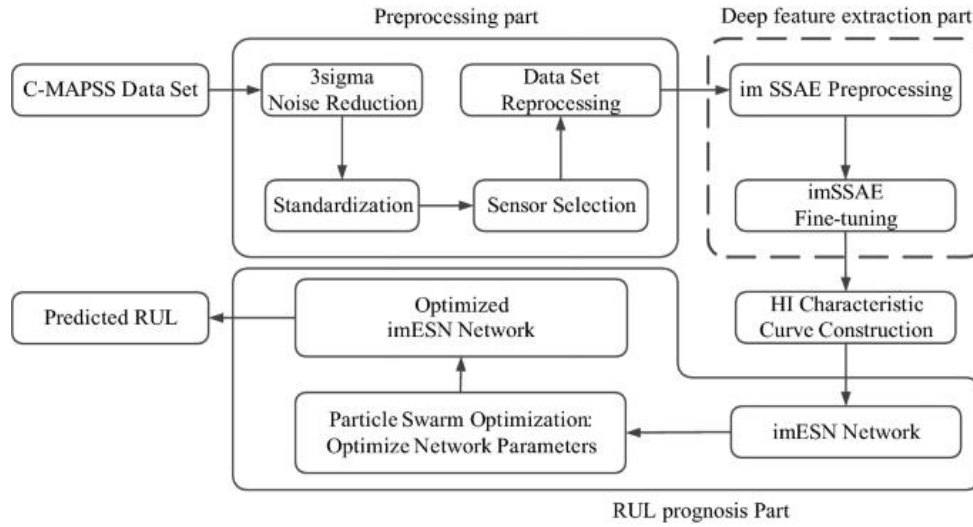
4 Performance Test

4.1 Test Plan/ Test Cases

Identifying Operating Regime

The FD002 and FD004 sub-dataset has 6 operating conditions, which can be determined by operating setting columns. However, the range of operating settings is not specified in the data set. So, 6 different operating regimes can be identified by clustering as shown in the figure. While doing normalization of FD002 and F004 data, it is advisable to do it operating regime wise.

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4.2 Test Procedure

4.3 Performance Outcome

FD001 Test Engine Unit-24

FD004 Test Engine Unit-32

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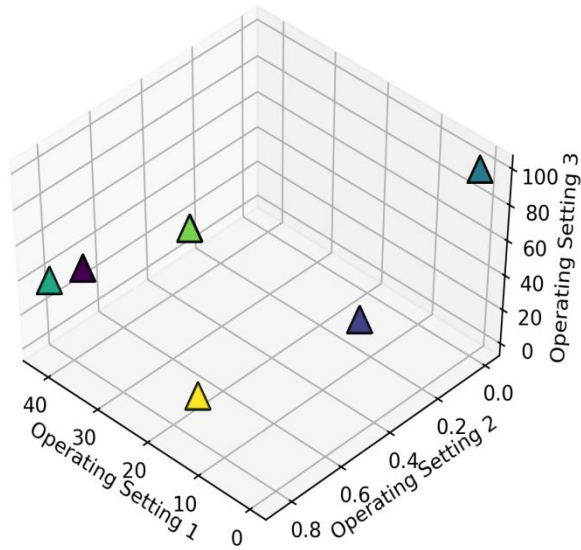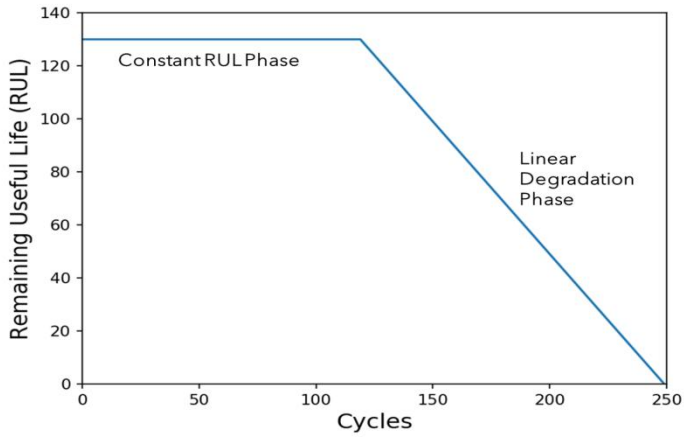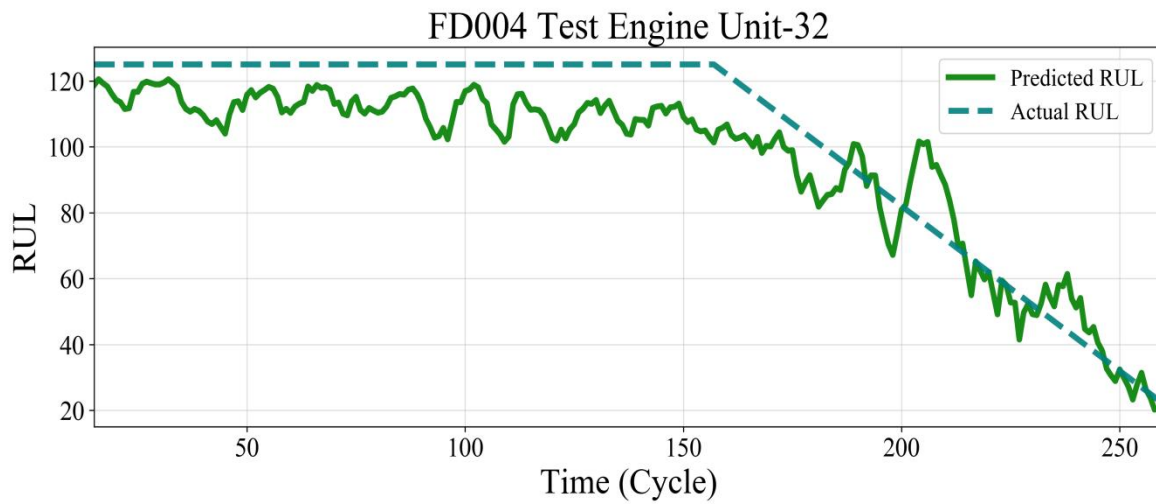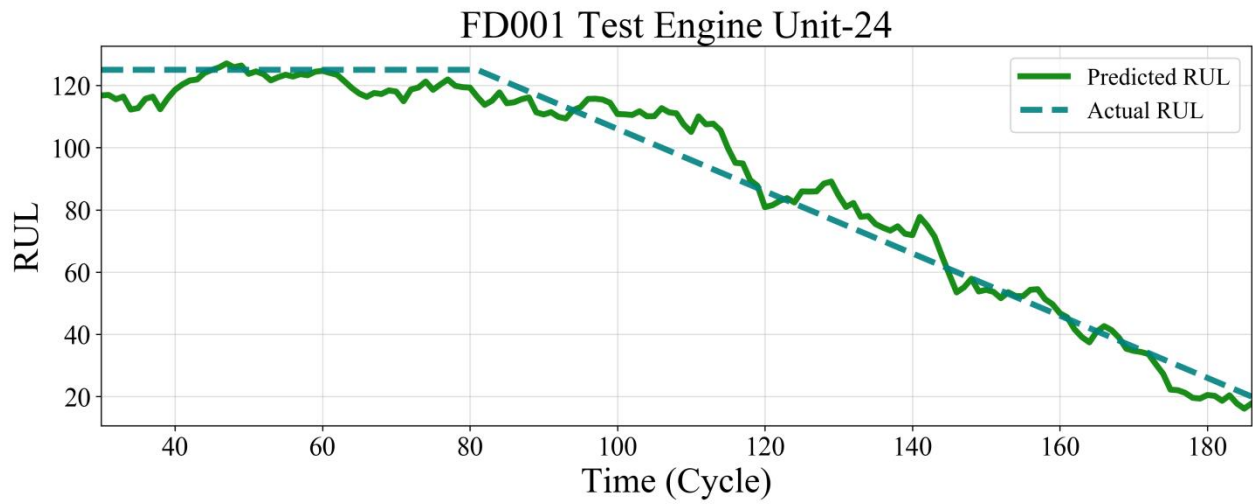
5   My Learnings:

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6 Future work scope

"Enhance Model Robustness: Investigate methods to make the predictive model more robust by addressing variations in operating conditions and environmental factors."

"Incorporate Sensor Fusion: Explore the integration of data from multiple sensors to improve prediction accuracy by capturing a broader range of engine behavior."

"Long-Term Trend Analysis: Develop algorithms to identify and predict long-term trends in engine degradation, allowing for proactive maintenance scheduling."

"Anomaly Detection: Implement anomaly detection techniques to identify sudden and unexpected deviations from normal operating behavior, enabling early warning systems."

"Leverage Unsupervised Learning: Investigate unsupervised learning methods to uncover hidden patterns in sensor data that might impact engine health."

"Multimodal Data Integration: Combine textual, image, and time-series data sources to create a comprehensive model for predicting engine failures."

"Transfer Learning: Explore the potential of transfer learning by pre-training models on related engine datasets and fine-tuning for specific engine types."

"Online Learning: Develop an online learning system that can continuously update the predictive model as new data becomes available, ensuring real-time accuracy."

"Uncertainty Quantification: Integrate techniques to quantify prediction uncertainty, allowing operators to make informed decisions based on risk assessment."

"Maintenance Strategy Optimization: Use the predictive model's insights to optimize maintenance schedules, reducing downtime and maximizing engine utilization."

"Failure Root Cause Analysis: Investigate methods to provide insights into the underlying causes of engine failures, aiding in design and manufacturing improvements."

"Automated Feature Engineering: Implement automated feature engineering techniques to identify the most relevant features from raw sensor data, improving model performance."

"Hybrid Models: Combine machine learning with physics-based models to enhance prediction accuracy by leveraging domain knowledge."

"Human-Machine Collaboration: Develop an interactive dashboard that allows engineers to validate model predictions and contribute their domain expertise."

"Adaptive Model Updating: Implement an adaptive learning framework that adjusts the model's parameters over time based on evolving operational conditions."

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