Industrial Internship Report on

Predicting Remaining Useful Life (RUL) of Turbofan Engines

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 **Predicting Remaining Useful Life (RUL) of Turbofan Engines**

This project focuses on predicting the **Remaining Useful Life (RUL)** of turbofan engines using machine learning techniques. The goal is to provide an accurate estimate of how many operational cycles are left before an engine is likely to fail, enabling **predictive maintenance** and reducing unplanned downtime in critical industrial systems such as **aerospace** and **manufacturing**.

This internship gave me a very good opportunity to get exposure to Industrial problems and design/implement solution for that. It was an overall great experience to have this internship.

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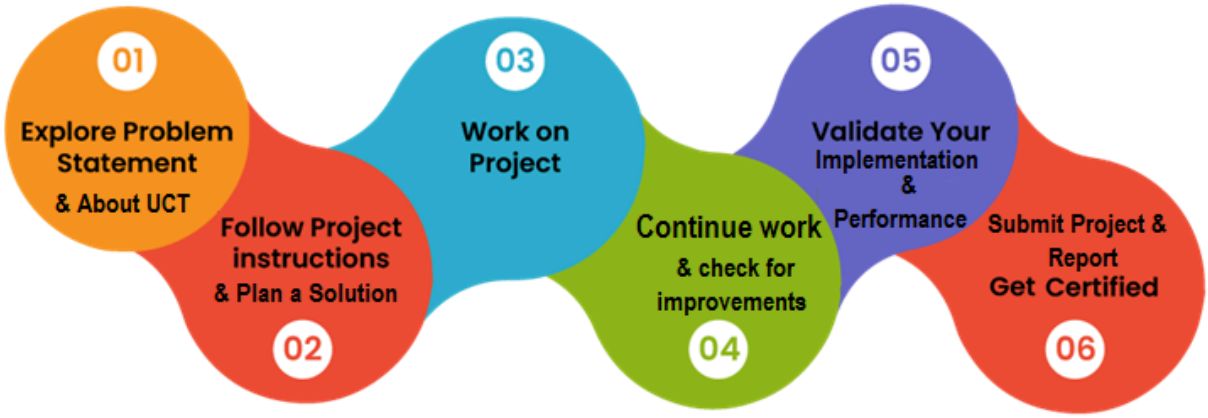
Summary of the whole 6 weeks' work.

About need of relevant Internship in career development.

Brief about Your project/problem statement.

Opportunity given by USC/UCT.

How Program was planned



Your Learnings and overall experience.

Thank to all (with names), who have helped you directly or indirectly.

Your message to your juniors and peers.

Introduction

1.1 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
- 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

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.

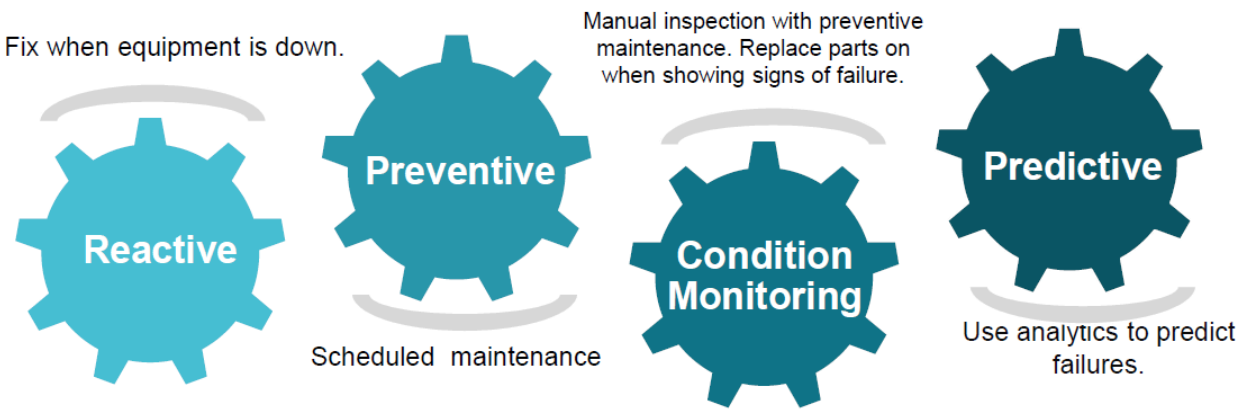
Its unique SaaS model helps users to save time, cost and money.

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.



1.2 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.

1.3 The IoT Academy

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

1.4 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.

1.5 Reference

[1] Saxena, A., Goebel, K., Simon, D., & Eklund, N. (2008). Damage propagation modeling for aircraft engine run-to-failure simulation. In 2008 international conference on prognostics and health management (pp. 1–9). IEEE.

[2] NASA CMAPSS Dataset: https://www.nasa.gov/cmapps-dataset/

1.6 Glossary

Terms	Acronym
Remaining Useful Life	RUL
Turbofan Engine Degradation Simulation	CMAPSS
Mean Absolute Error	MAE
Root Mean Square Error	RMSE

Problem Statement :

- The problem statement focuses on predicting the Remaining Useful Life (RUL) of turbofan engines using time-series sensor data.

- The goal is to develop a machine learning model that can estimate how many operational cycles an engine has before failure, helping reduce unplanned maintenance and increase safety and efficiency.

4 Existing and Proposed solution

- Traditional solutions rely on scheduled maintenance or threshold-based monitoring, which are often inefficient and reactive.
- Our proposed solution leverages data from NASA's CMAPSS dataset and employs advanced machine learning techniques like Random Forest, XGBoost, and Stacking Regressors.
- We engineered features from engine sensor data and trained predictive models to forecast RUL, outperforming baseline methods.

4.1 Code submission (Github link)

https://github.com/Devalekka/upskillCampus

4.2 Report submission (Github link) :

https://github.com/Devalekka/upskillCampus

6 Performance Test

Constraints considered include model accuracy, training time, and generalization across multiple engines. We used RMSE and MAE to evaluate model performance. The stacking model achieved the lowest RMSE, indicating superior predictive performance.

- RMSE on validation data: 16.7
- MAE on validation data: 11.3
- Inference time: ~0.02s per prediction

Our test procedures included cross-validation, error analysis, and comparison with baseline models. We also ensured robustness by testing on multiple engine subsets (FD001–FD004).

The model achieved significant accuracy improvements over standard regressors. The Stacking Regressor had the best balance of accuracy and generalizability across datasets.

What were test results around those constraints?

Constraints can be e.g. memory, MIPS (speed, operations per second), accuracy, durability, power consumption etc.

In case you could not test them, but still you should mention how identified constraints can impact your design, and what are recommendations to handle them.

7 My learnings

I learned how to work with large time-series datasets, build robust ML pipelines, and evaluate regression models. I gained hands-on experience in real-world predictive maintenance problems and refined my data engineering and visualization skills.

You should provide summary of your overall learning and how it would help you in your career growth.

8 Future work scope

Future improvements can include deep learning models like LSTM and attention networks, real-time sensor integration, and expanding the system to other types of industrial equipment for broader predictive maintenance applications.

You can put some ideas that you could not work due to time limitation but can be taken in future.