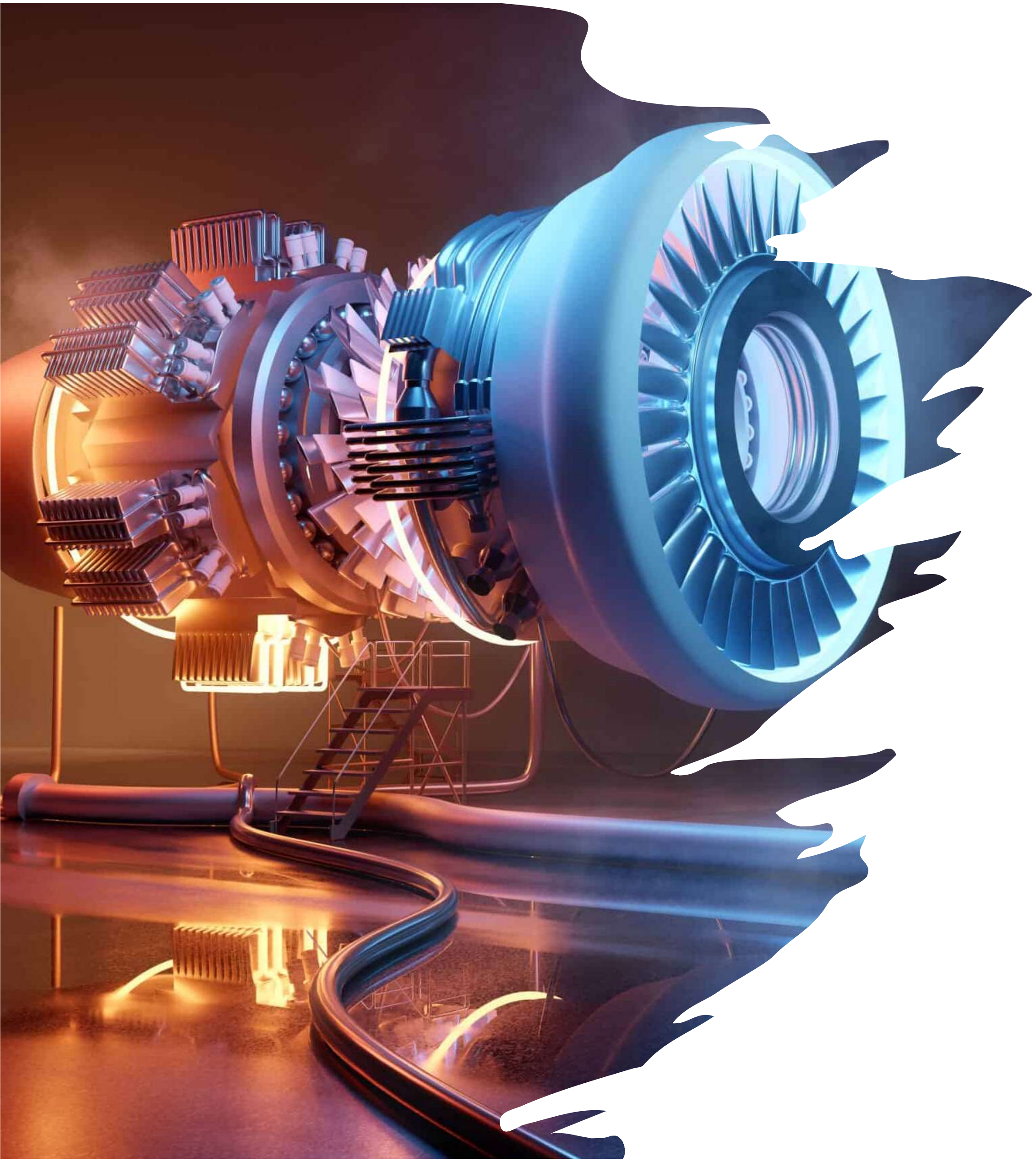


भारतीय प्रौद्योगिकी संस्थान जम्मू
INDIAN INSTITUTE OF TECHNOLOGY JAMMU
विद्याधनं सर्वधन प्रधानम्

Deep Learning : Project 3

Aviation Engine Failure Prediction Deep Learning Model

Project submitted to

Dr. Vinit Jakhetiya

Head of Department | Computer Science & Engineering

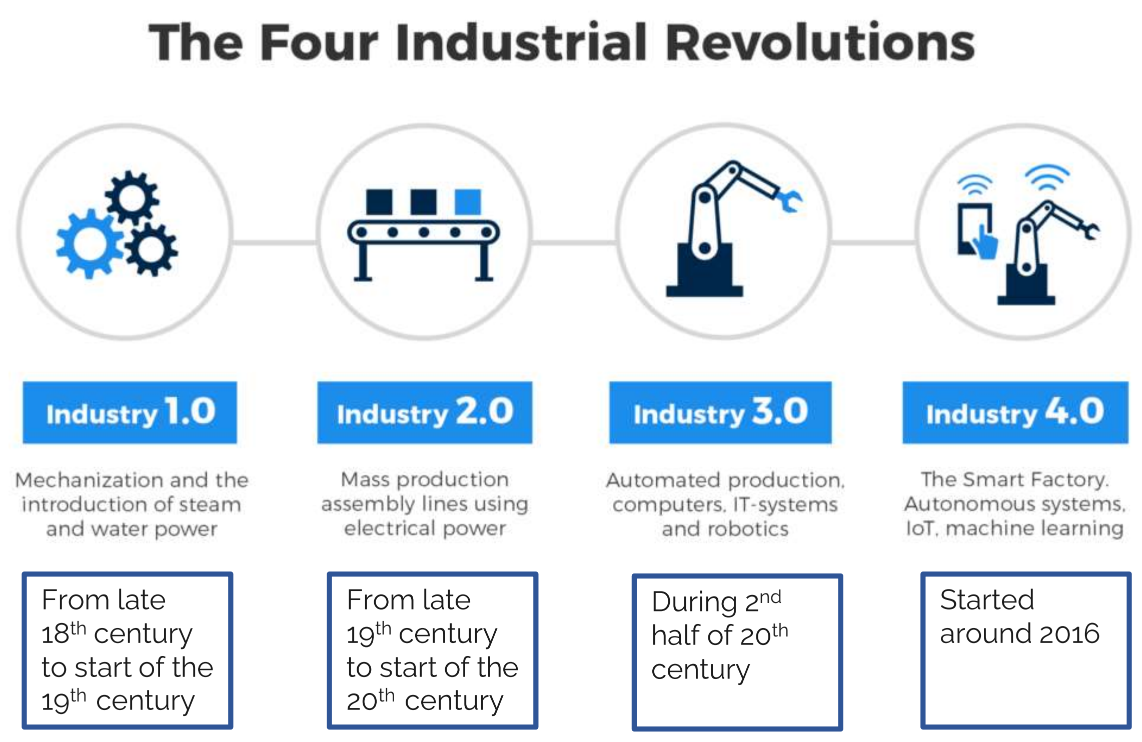
INDIAN INSTITUTE OF TECHNOLOGY, JAMMU, INDIA

Project Team:
Kumari Anjali
Hitesh Humane
Narayanan V
M.Tech(AI & ML) 2022-24

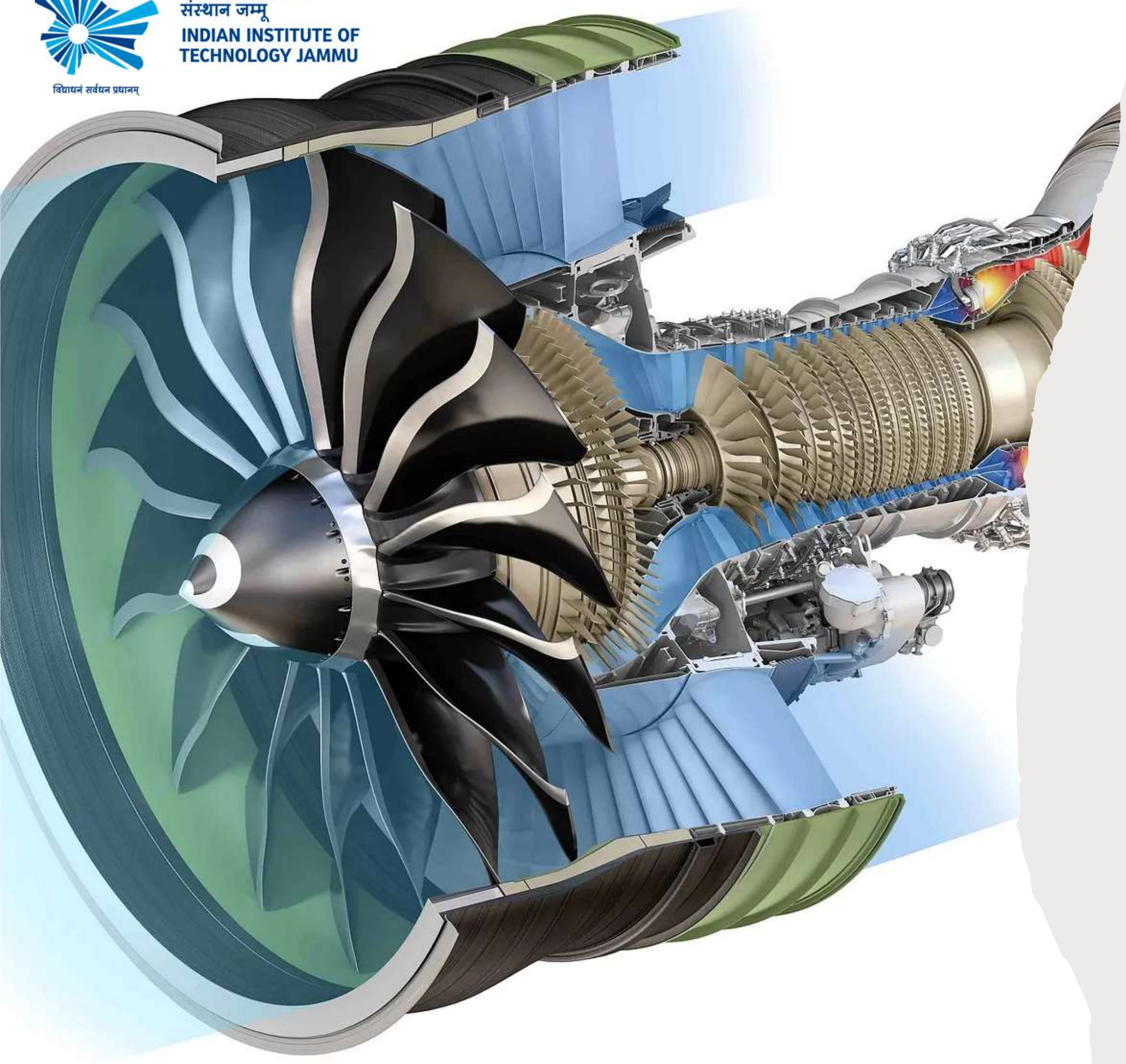
भारतीय प्रौद्योगिकी संस्थान जम्मू
INDIAN INSTITUTE OF TECHNOLOGY JAMMU

Aviation Engine RUL Prediction Model

- Industry 4.0:
- Artificial Intelligence (AI) revolutionized industries by introducing smarter, more efficient methodologies for solving complex problems.
- In aviation maintenance, AI, particularly through Deep Learning, plays a pivotal role.
- Deep Learning, which involves neural networks with many layers, uses a specific type called Long Short-Term Memory (LSTM) to analyse sequential data over time.
- LSTMs possess the remarkable ability to remember patterns over prolonged periods, making them exceptionally suitable for time-series data, such as the consistent monitoring of aircraft engine performance metrics.



भारतीय प्रौद्योगिकी संस्थान जम्मू
INDIAN INSTITUTE OF TECHNOLOGY JAMMU
विद्याधनं सर्वधन प्रधानम्



Goal, Analysis, Modelling & Application

Goal:
To predict the Remaining Useful Life (RUL) of Aviation/Turbo Engine.

Analysis:
Exploratory Data Analysis (EDA),
Feature Engineering

Modelling:
Used LSTM models for direct RUL prediction.

Evaluation:
For classification, employ accuracy, precision, recall.
Use MAE (Mean Absolute Error) for regression.
Evaluate regression models using the coefficient of determination (R^2).

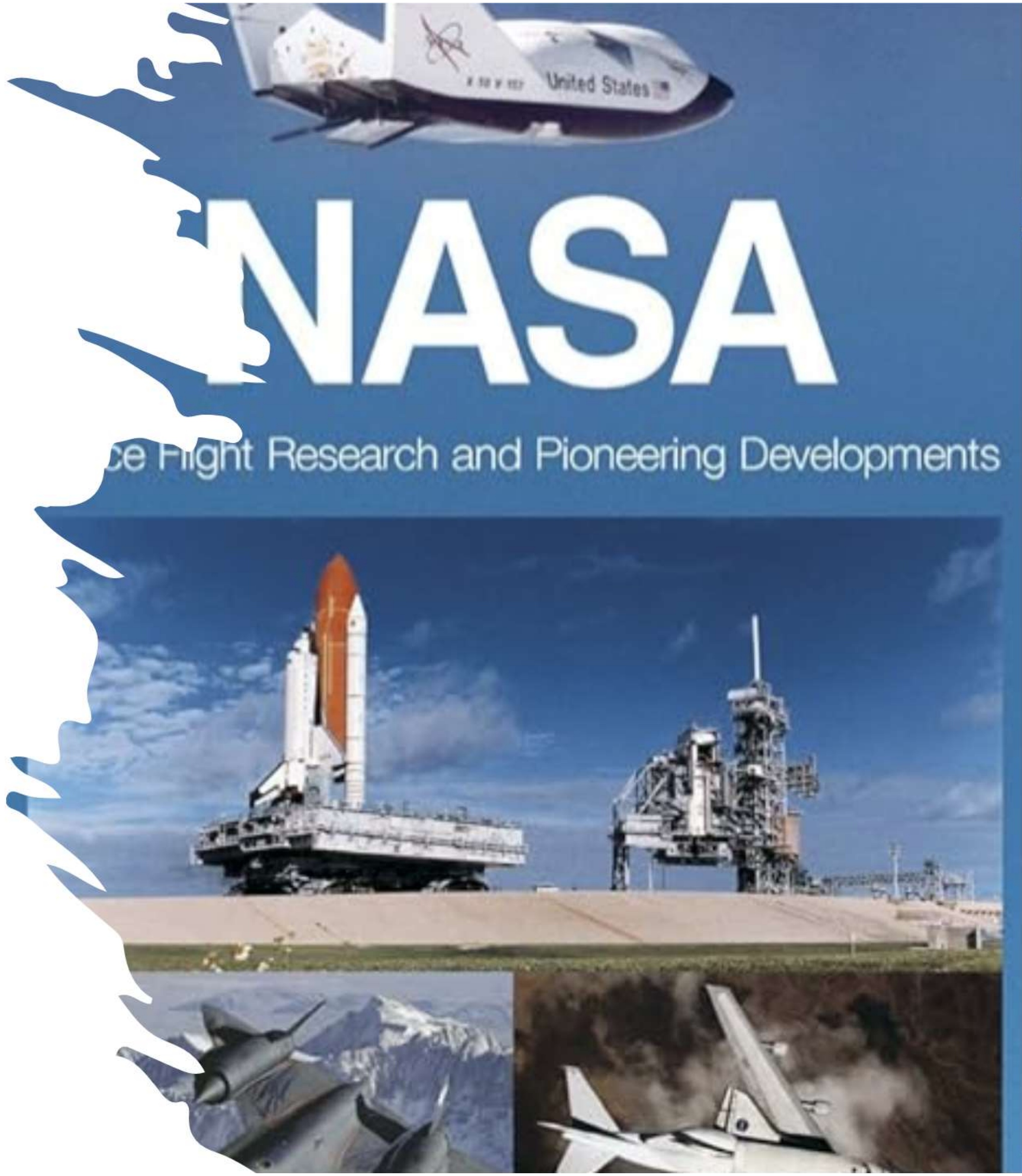
Implementation:
LSTM Networks
CNNs
Traditional Models

Application:
Benefits for aerospace companies, airlines, and maintenance organizations include:
Predictive Maintenance: Proactive scheduling reduces downtime.
Safety: Ensure servicing or replacement before critical failures.
Cost Efficiency: Optimize resource usage and avoid unnecessary maintenance.

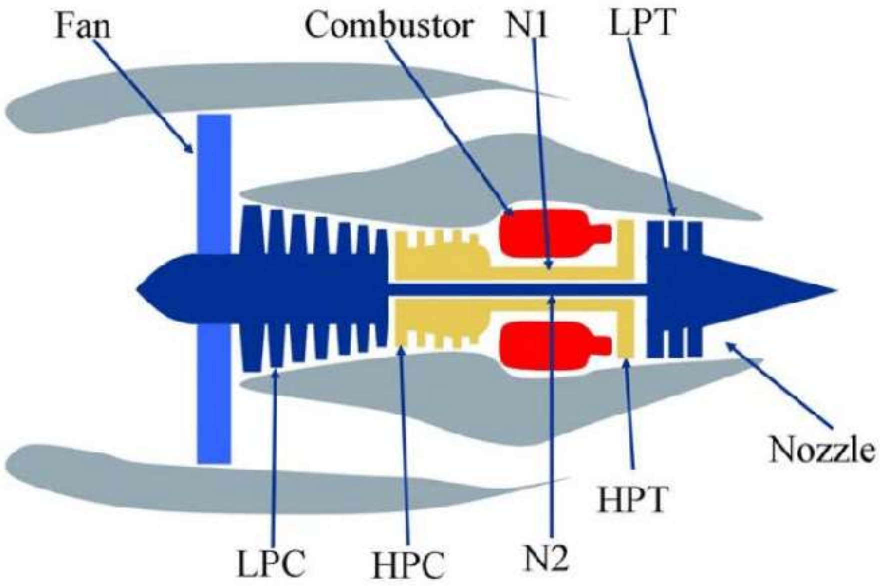
भारतीय प्रौद्योगिकी संस्थान जम्मू
INDIAN INSTITUTE OF TECHNOLOGY JAMMU
विद्याधनं सर्वधन प्रधानम्

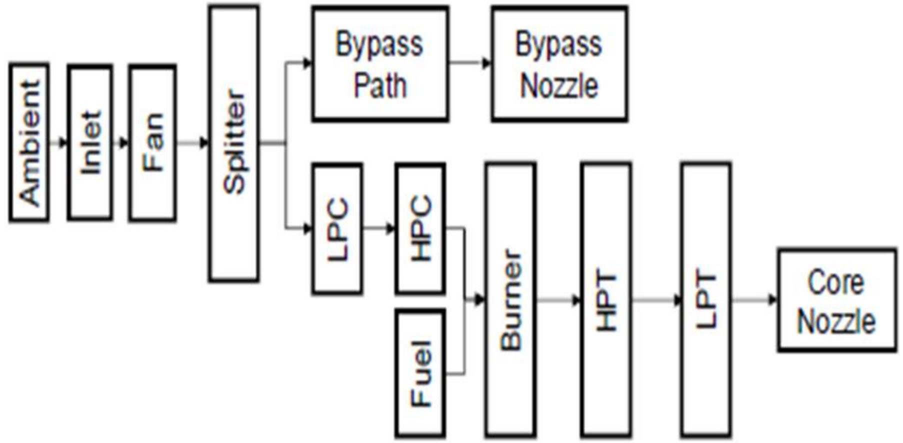
Data Source & Data Details

- **Data Source:** NASA Prognostics Data Repository. The data set is provided by the NASA Ames Prognostics Centre of Excellence (PCoE).
- **Data Link** : https://www.nasa.gov/intelligent-systems-division/discovery-and-systems-health/pcoe/pcoe-data-set-repository/
- **Name of Data :** C-MAPSS dataset (Commercial Modular Aero-Propulsion System Simulation).
- **Application:** Commonly used for developing and validating predictive maintenance algorithms.
- **Data Features:**
  Time-Series: Each series represents a different engine run-to-failure simulation.
  Operational Settings: Includes throttle settings.
- **Sensor Measurements:** The data set includes time-series measurements of various pressures, temperatures, and rotating equipment speeds that for the jet engine.



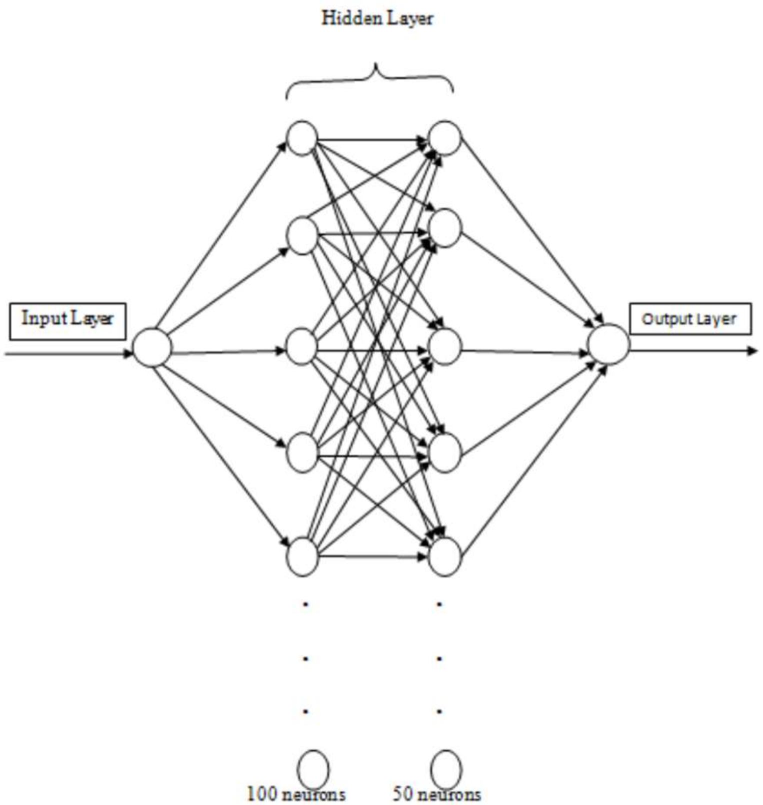
Data capture mechanism in latest Aircraft Engine





Above left figure: shows the main elements of the engine model
Right figure: The flow chart shows how various subroutines are assembled in the simulation, a layout showing various modules and their connections as modelled in the simulation

भारतीय प्रौद्योगिकी संस्थान जम्मू
INDIAN INSTITUTE OF TECHNOLOGY JAMMU
विद्याधनं सर्वधन प्रधानम्



LSTM neural network diagram for Deep Learning Model

Our Deep Learning Model

In this project, our primary focus is to detect the faults in the aircraft engine using LSTM deep learning model.

1. INPUT DATA

- Downloaded from Repository of NASA with 21 individual sensor value as discussed earlier.

2. DATA PRE-PROCESSING

- Data wrangling for unused, redundant and null values
- Rescaling using Min-Max scaler

3. MODEL TRAINING AND TESTING

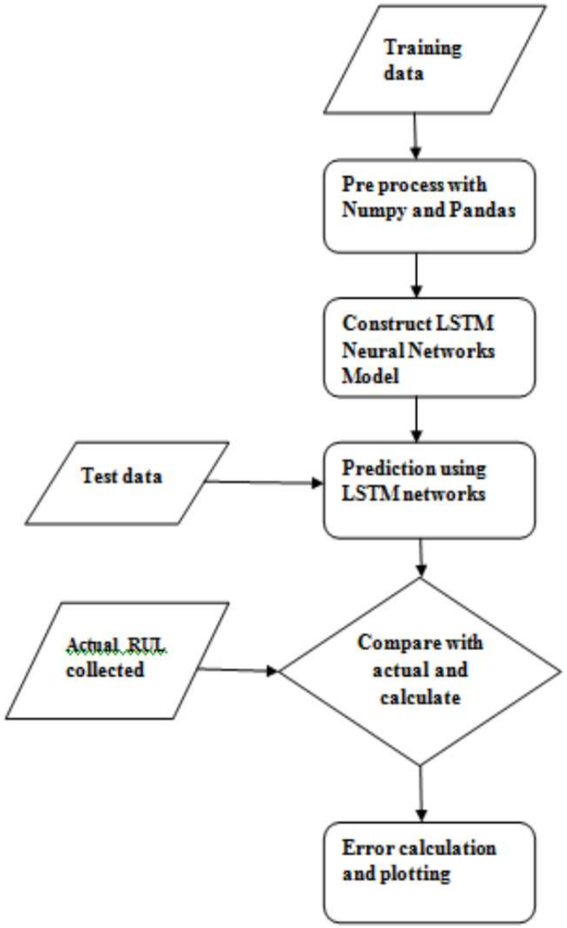
- Used LSTM first layer of 100 units followed by another LSTM layer with 50 units.
- Dropout has been applied after each LSTM layer to control overfitting.
- Final layer is a Dense output layer with single unit.

5. OUTPUT

- Accuracy measured:
    - Accuracy & Loss performance
    - Mean Absolute Error (MAE) and
    - Rsquared (R^2) error.

भारतीय प्रौद्योगिकी संस्थान जम्मू
INDIAN INSTITUTE OF TECHNOLOGY JAMMU
विद्याधनं सर्वधन प्रधानम्

Model Flow Chart



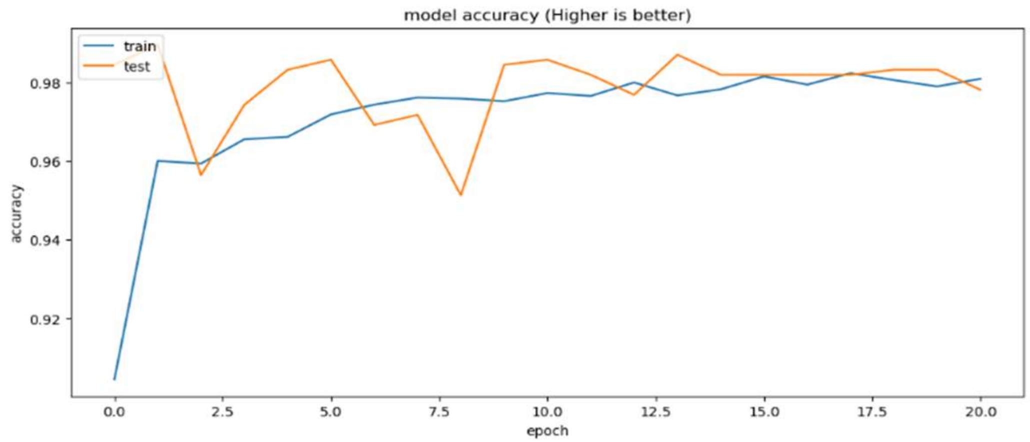
Classification (LSTM) :

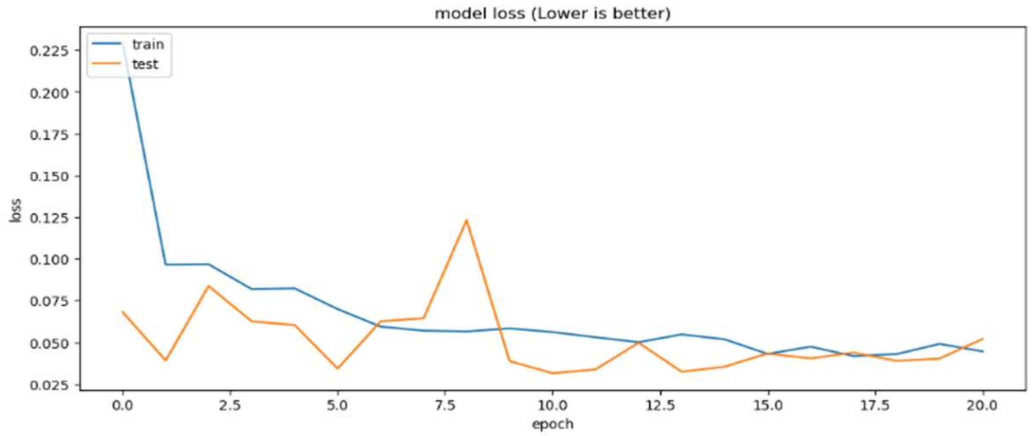
Accuracy: 0.97812
precision : 0.9181
recall : 0.9767

Confusion matrix :

[[12261 270]

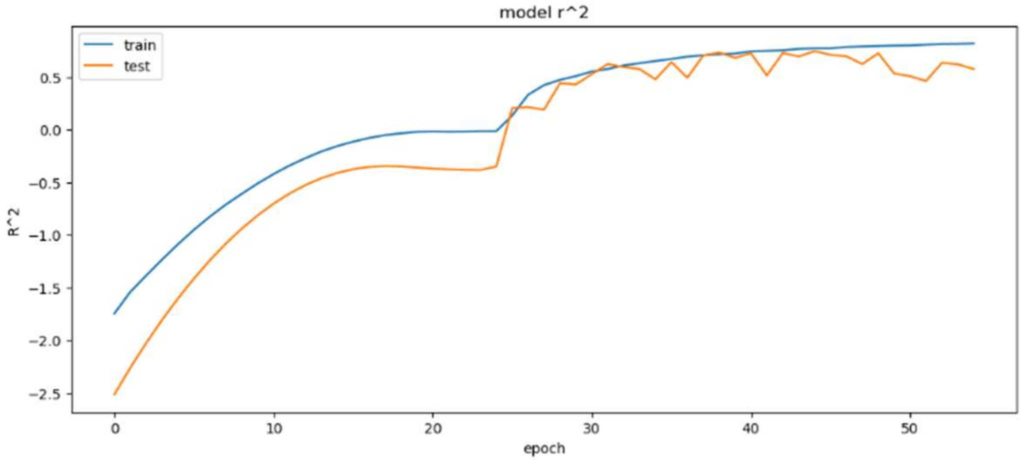
[72 3028]]

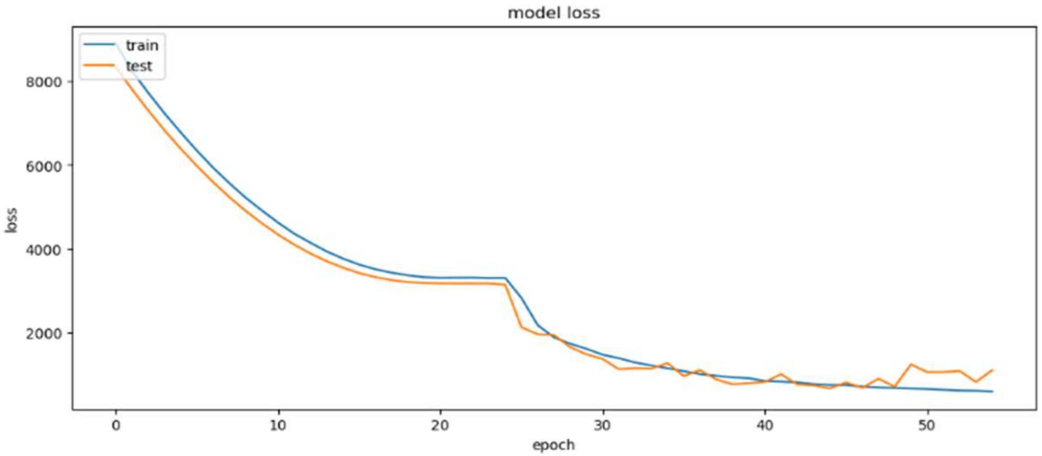


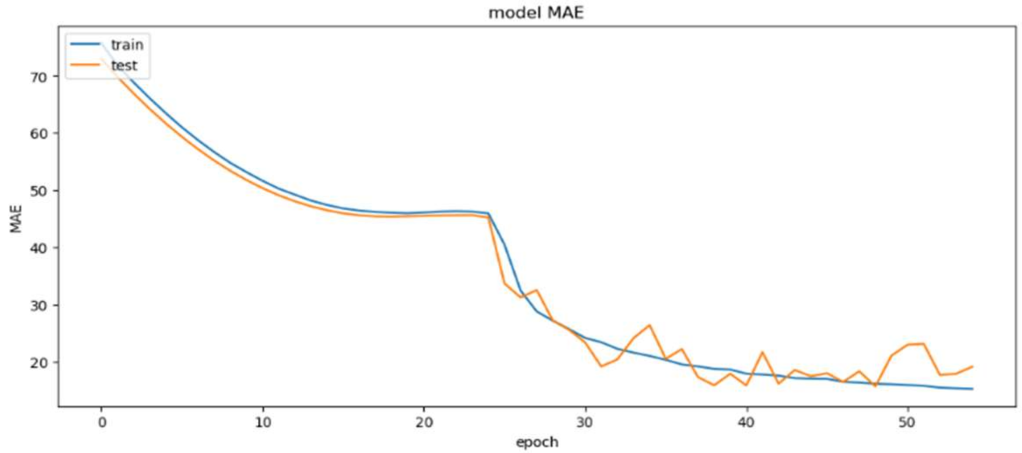


Regression:

MAE: 13.8566
R^2: 0.8091

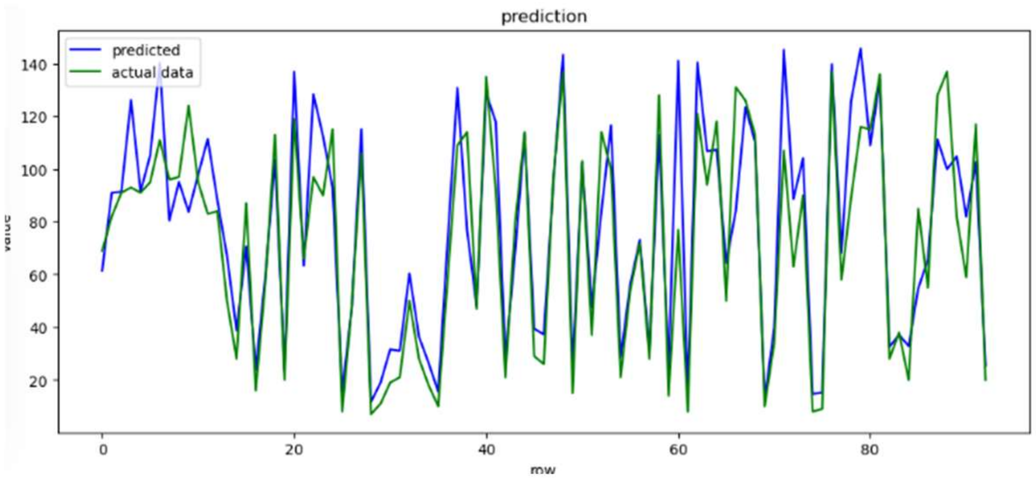


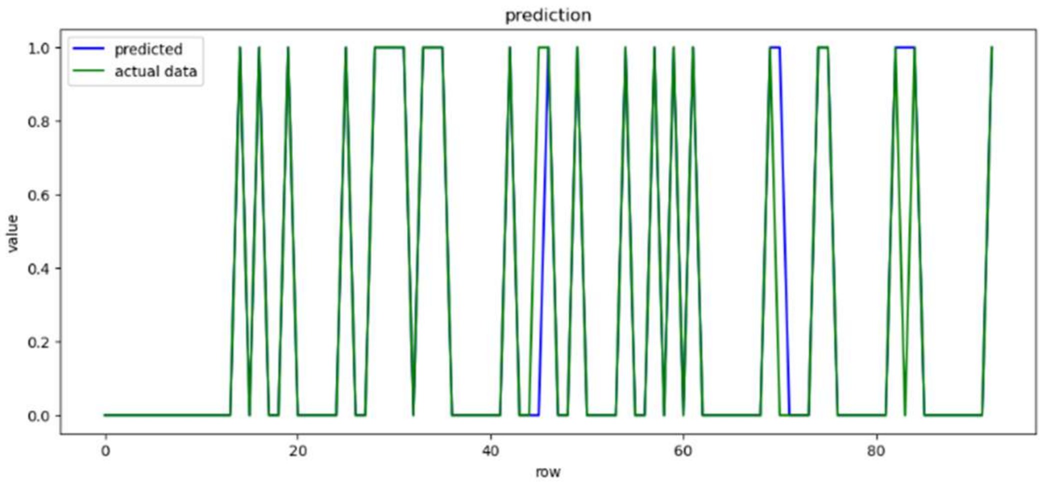




Regression Vs Classification (LSTM):

Predicted vs Actual:





Conclusion & Future Work

- LSTM model performs very well and gets a lower MAE and R^2 value
- The experimental results clearly show that our deep learning model can accurately predict the remaining useful life (RUL) of aircraft engines.

Future Work and Considerations for improvement might include:

- Feature Engineering: Revisiting the features, perhaps some additional features might be informative, or some existing features might need to be transformed or removed.
- Model Complexity: The architecture might be too complex or too simple for the problem. We might need to adjust the number of layers, units, or both.
- Other Model Types: While LSTM is a powerful model for sequence data, it might be worth exploring other architectures or even simpler models to establish a baseline performance.
- Training Strategy: Adjusting batch sizes, epochs, or using different optimizers and learning rates.
- Data Augmentation: Using techniques to artificially increase the size of our training dataset.

भारतीय प्रौद्योगिकी संस्थान जम्मू

INDIAN INSTITUTE OF TECHNOLOGY JAMMU

विद्याधनं सर्वधन प्रधानम्

Thank You !!!