SMARTINTERNZ EXTERNSHIP PROGRAM

“PREDICTIVE MAINTENANCE OF ENGINES”

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CONTENT OUTLINE

1. Overview

Predictive maintenance is used to determine the useful life of an engine is proposed. As the engine is very low fault-tolerant, which means a tiny error or failure leads to huge catastrophes, precise and real-time observation of the engine condition is compulsory. Deep learning is utilized in learning the behaviour of the engine in historical information and gathering data to predict the accurate time that the system will fail. This project presents a predictive maintenance solution of engines and contains Data Pre-Processing, Model Building, Application Building, and Model Deployment in Web Application.

2. Purpose

The main goal of this project is to predict the most precise failure time so that the maintenance service is there right before it happens. Which is why it helps avoid accidents and as the maintenance is scheduled in advance according to needs, it avoids unnecessary maintenance. In other words, it predicts the breakdown of the system in the future based on historical data.

3. Problem and Proposed Solution

The problems we are trying to solve as the accomplishment of this project are unnecessary upholding and the foresight of the accurate time of the system breakdown.

This project tries to estimate when the failure will occur depending on the collected data predefined predictive algorithms, so then the maintenance is scheduled based on these estimates. This particular project is done by Pre-Processing the data, Analysing the pre-processed data, training the machine with pre-processed data using an appropriate machine learning algorithm, saving the model and its dependencies, and lastly building a Web application using flask that integrates with the built model. This approach based on past data is the one we used to build this project.

4. Advantages and Disadvantages

- ## Advantages

1. Reduces Spending

   Predictive Maintenance helps save a lot of money as it provides with the opportunity to only do maintenance while needed. This reduces long-term maintenance spending and reduces the time spent on performing maintenance tasks. This reduces the overtime hours of employees and saves money.

2. Decreases Downtime

   Downtime caused by a failure of the equipment is often long and expensive. When an engine runs until it breaks down, the cost of repairing is often higher than making small repairs in advance or before it breaks down.

3. Increases lifecycle

   When an engine is carefully repaired using predictive maintenance, it serves a lot more before being replaced. The increase in the lifecycle of the equipment significantly lowers the long-term cost of the motors. Replacing equipment also requires significant downtime, so by increasing the lifespan of equipment, downtime and its associated expenses are also reduced.

4. Improves product quality

   In the manufacturing field, predictive maintenance can improve product quality. Because when the machines are not working properly, there is a higher chance of getting defects.

- ## Disadvantages

1. Requires skillful Data Interpretation

   The skill of data collection and interpretation is needed which a lot of people do not have. A skilled person is needed to manage when to do maintenance and so on. It requires both the knowledge of the engine itself and predictive maintenance usage. It may be required that companies need to provide a special training for the predictive maintenance to be effective.

5. Applications

The predictive maintenance of engines can be used in diverse industries. The major areas where the predictive maintenance techniques used are: motor circuit analysis, acoustics, infrared or thermal imaging tests (thermography), vibration analysis and oil analysis.

- Thermographic analysis and infrared analysis:

Thermographic analysis can also be applied to several types of equipment to detect wear, rusting delaminations, and disconnections that might go unnoticed to the naked eye.

Applications: electrical connections and systems, heating systems, fluid analysis, discharge patterns, roof maintenance.

- Motor circuit analysis:

Motor circuit analysis implements a technique known as electric signature analysis (ESA), to find abnormality in electric engines. Furthermore, analyzing the circuit and its units, it evaluates the voltage and current entering the engine. It's compatible with both, AC and DC motors and can be used while the motor is running.

Applications: insulation, gears, shaft and rotor alignment, scan for short-circuits, assess engine degradation.

- Oil analysis:

The main purpose is to test the viscosity while applying this oil analysis, the amount of water and the presence of other materials, including metals, to determine the wear of the equipment.

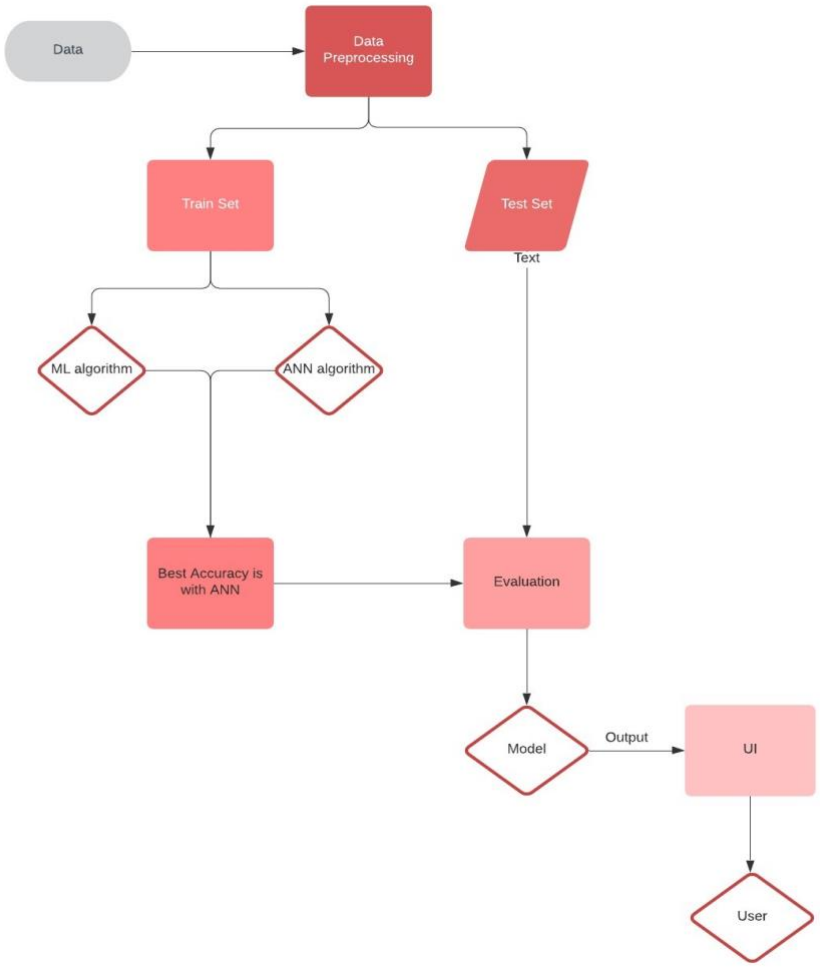
Applications: gears, turbines, evaluate engines, transmissions, hydraulic and electro-hydraulic systems, lubricant levels

- Acoustic analysis:

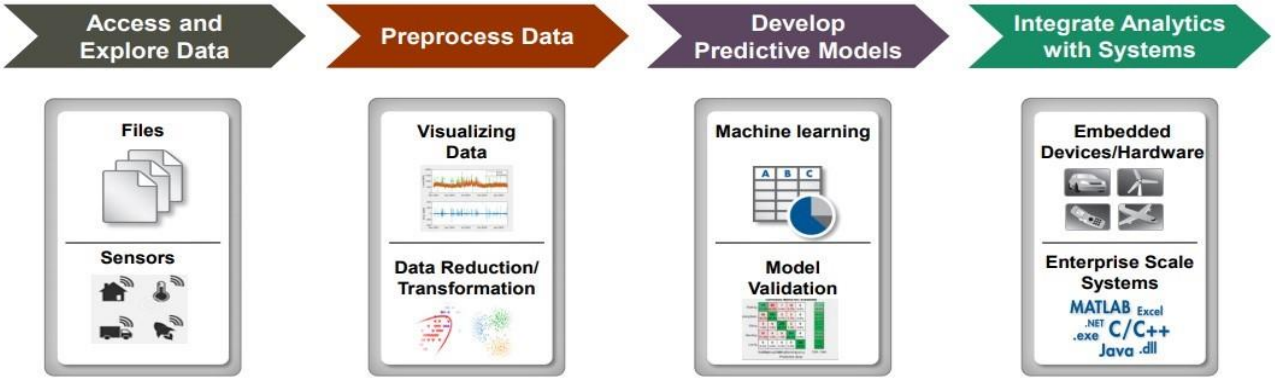
We're know that sound waves are our allies. Acoustic analysis is a technique used to detect problems in the material's technical performance, pinpoint the source of the problem, and perform "checkups" on the equipment's overall health. How? By detecting changes in sound frequencies.

Applications: pipes and plumbing, condensers, vacuum systems, fans, air compressors

6. Diagrammatic Overview of the Project



7. Flow chart



8. Libraries imported for the Project

One of the most popular languages for ML (machine learning) and DL (deep learning) is python. The main reason why python is popular programming language for ML and DL is the availability of libraries and open-source tools, making it perfect environment to build your project. Possibly the next reason is the broad set of libraries. Probably for each problem existing in everyday life there is a solution.

- TensorFlow

One of the best open-source libraries to work with ML in python is TensorFlow. This library was offered by Google, making it easy to build your own model to beginners as well as professionals. Using TensorFlow you can train and test your model. The core areas where TensorFlow is most useful are:

- Abstraction capabilities
- Effortless collaboration of codes and ideas
- Image, text, speech recognition
- Natural language processing
- Handling deep learning network

- Keras

The ideal open-source python's library to work with neural networks is Keras. The library was designed by one of the Google engineers which was initially designed for ONEIROS. (Open-Ended Neuro Electronic Intelligent Robot Operating System) Soon the Keras was available within the TensorFlow library. Keras tools and block to create neural network are:

- Dropout
- Objectives
- Neural layers
- Activation and cost function
- Pooling
- Batch normalization

- NumPy

The NumPy library is handling with multi-dimensional data and complex mathematical functions which are operates on data. Python's NumPy library offers us speedy computation of complicated set of problems in matter of seconds and executes these functions in arrays. The common functions to use in NumPy are:

- Random simulations
- Support for n-dimensional arrays
- Basic linear algebra and statistical operations
- Sorting and selecting capabilities
- Discrete Fourier transformations
- Shape manipulation

- Pandas

Pandas is data analyses library of python which was built on top of numpy library. It is mainly used in data manipulation and analyses. Pandas is used to prepare dataset to train and test. Some of the features of pandas are:

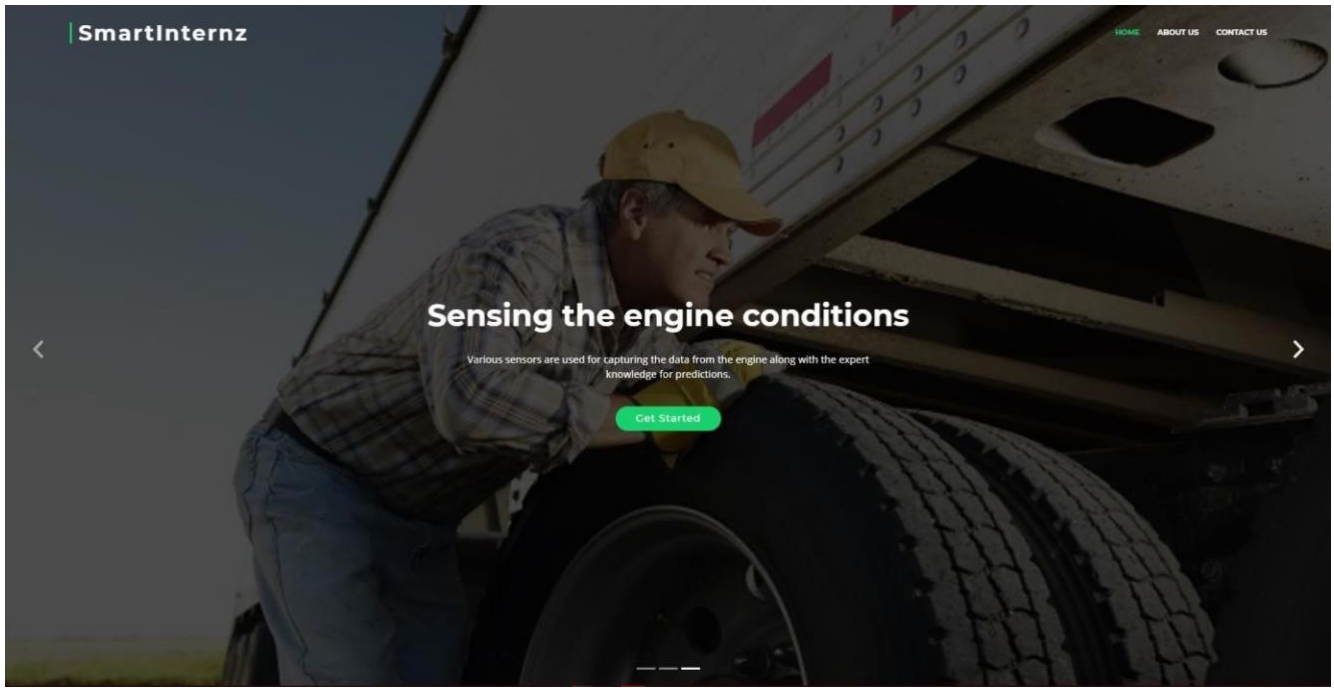
- Merging and joining dataset
- Handling with missing values and data alignment
- Dataset reshaping and pivoting
- Data filtration options
- Various indexing options such as Hierarchical axis indexing, Fancy indexing

- **Scikit-learn (sklearn)**

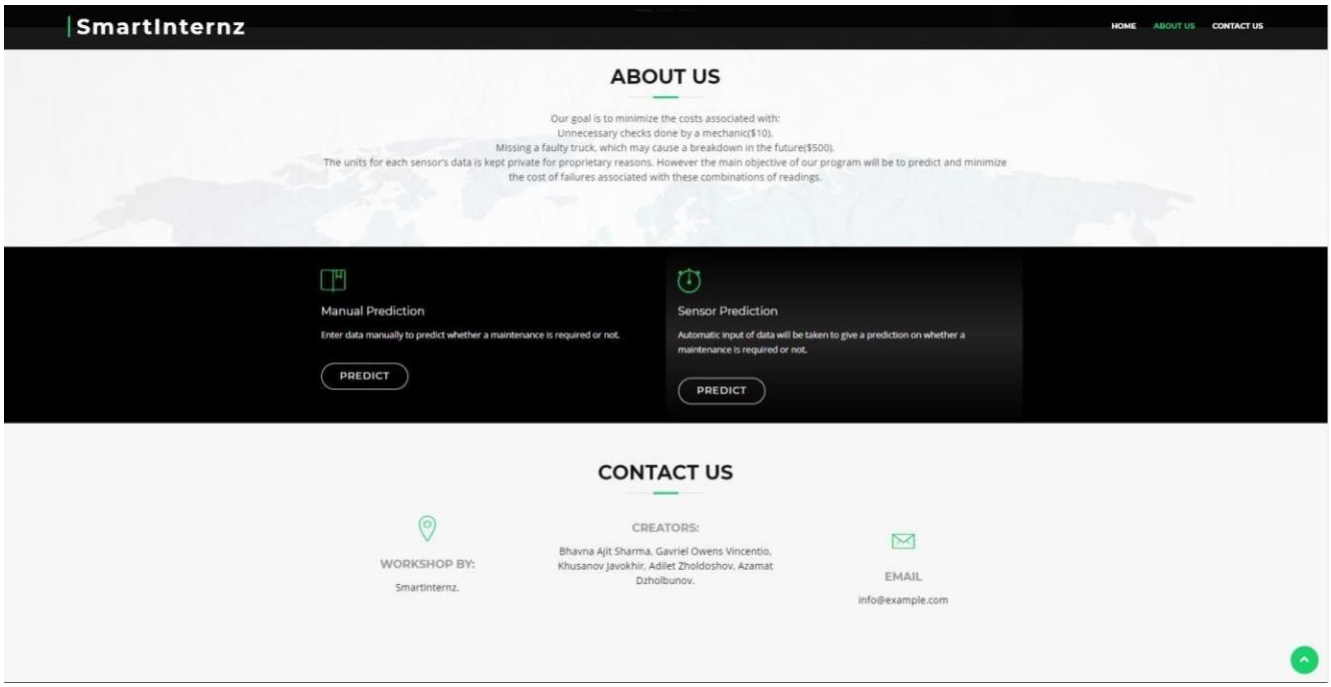
The scikit-learn is one of the most actively used libraries in python for machine learning. The useful feature of scikit-learn library is easily integrating with other machine learning libraries such as NumPy, Pandas. This library mainly focused on data modelling and not with Scikit-learn have some various algorithms:

- Regression
- Classification
- Clustering
- Model selection
- Preprocessing
- Dimensionality reduction

9. Result

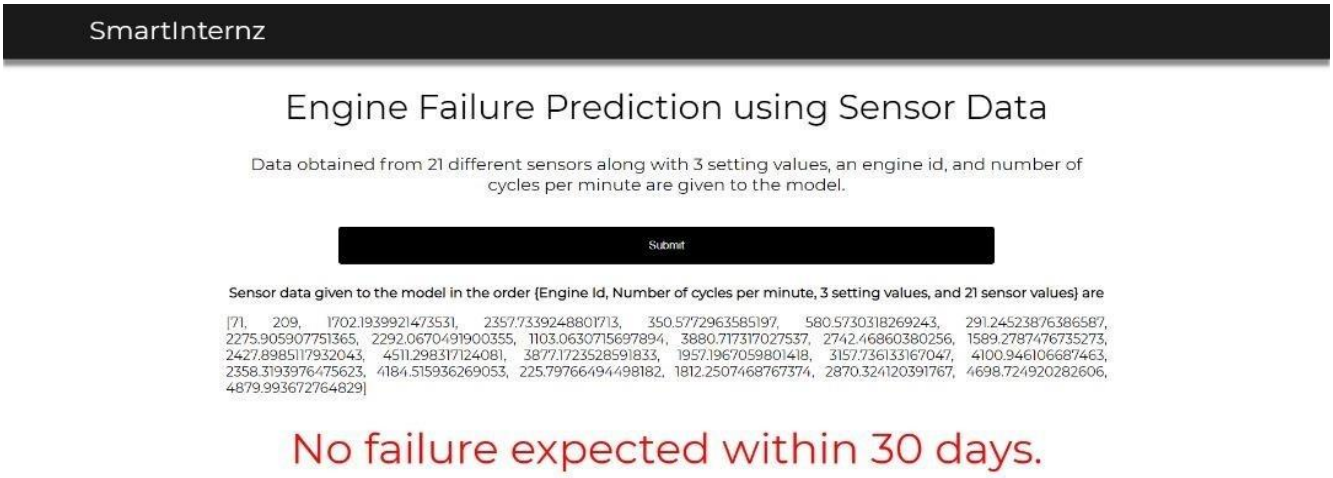


The picture above shows the final HTML result of the project. The picture below shows that there are two options to choose from, namely the manual prediction and the sensor prediction. In manual option, the user is asked to enter the data manually to predict the maintenance. For the sensor prediction, user does not enter data, but it will be input automatically by sensors.

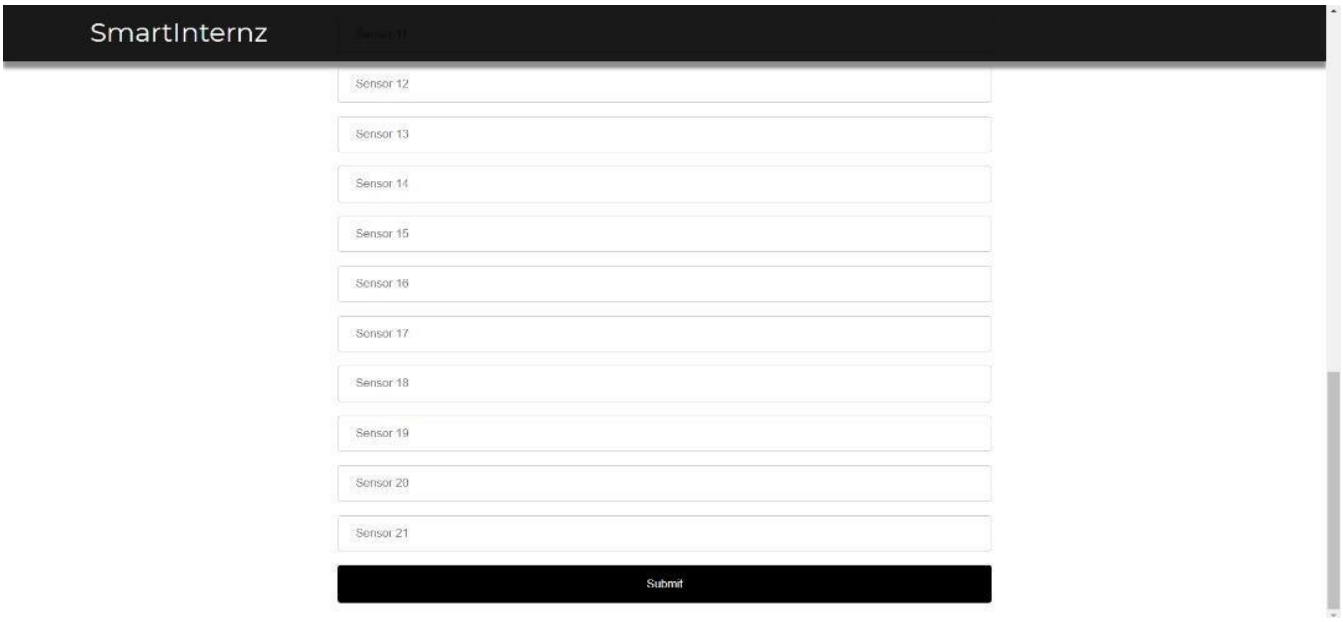


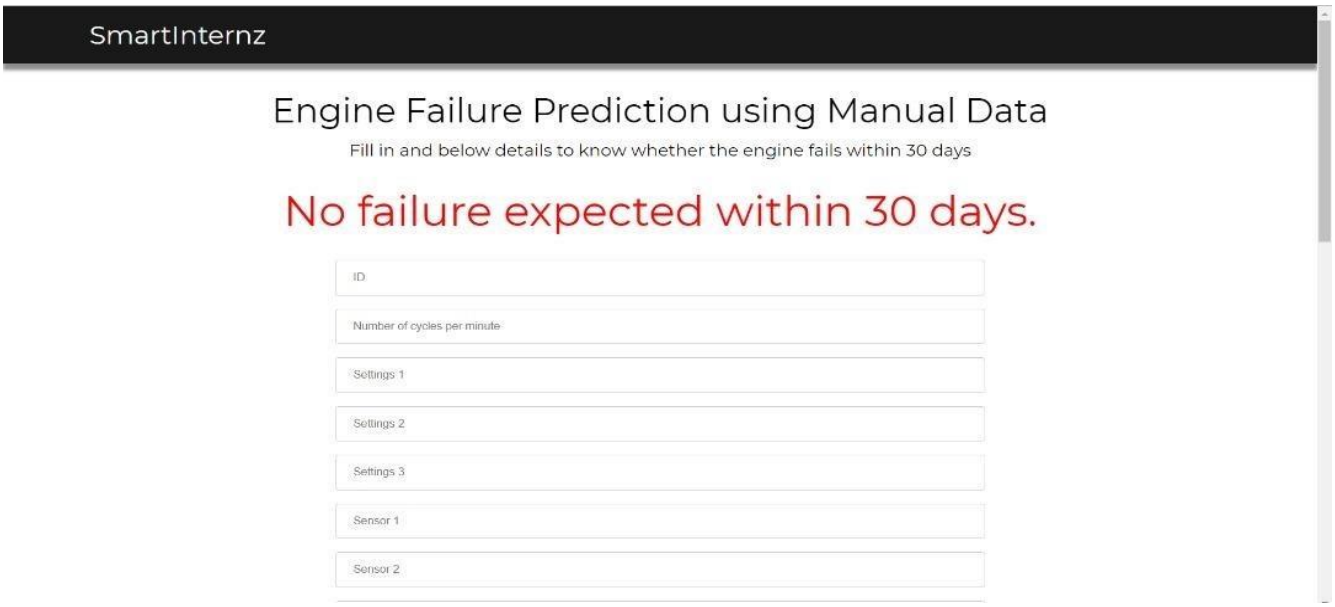
Here are two examples of manual and sensor predictions:

The picture below is a prediction using sensor data.



The pictures below are an example of a manual prediction.





10. Future Scope

To make improvements in Predicting the more precise time of failure, the requirements are collecting more data, adding more features, and include some other environmental factors that might affect the life of an engine.

11. Conclusion

The predictive maintenance of an engines is used to monitor future failures in an engine. Regularly maintaining the overall condition of engines to avoid future accidents and identifying the root causes of issues. This will be implemented by predictive models and sensor data by deploying to the equipment and to the cloud. In order to solve particular problem, we used supervised learning of machine learning and build application which will the estimate the probability of failure until it crashes based on collection of previous data. This model has benefits as well as drawbacks.

The benefits of this model are: reduces expenses, decreases downtime, increases the lifecycle of the engines and increases the overall product's quality. Probably it is one of the drawbacks is that this project requires skillful data interpretation. This model can be applied to diverse fields. Such as: motor circuit analysis, acoustics, infrared or thermal imaging tests (thermography), vibration analysis and oil analysis. There are several programming languages to accomplish this project but obviously the most developer-friendly machine learning and deep learning programming language is python which has variety of libraries catering to your each and every use case, project.

Among the most used libraries of python are NumPy, Pandas, TensorFlow, sklearn and keras. By accomplishing this task, we will help to prevent engine crash by predicting it is maintenance. In future, perhaps, it becomes industrial breakthrough.

12. References

Websites:

- https://scikit-learn.org/stable/
- https://yajasd.github.io/2018/06/04/Predicting-Engine-Failure/
- https://www.sciencedirect.com/science/article/pii/S0951832018307506
- https://ti.arc.nasa.gov/tech/dash/groups/pcoe/prognosticdatarepository/#turbofan

Papers:

- **Damage Propagation Modeling for Aircraft Engine Run-to-Failure Simulation**