IE3100R Systems Design Project AY2022/23 | Department of Industrial Systems Engineering and Management (ISEM)

PREDICTIVE MAINTENANCE OF MACHINE PARTS FOR OVERALL TOOL HEALTH

NUS Supervisor: A/Prof Napat Rujeerapaiboon

Team Members (Group 13 - Micron 2): Luu Phan Duc Thinh | Joshua Sim | Lin Yaohua | Tan Jin Song

Company Information

Micron Semiconductor Asia is a semiconductor company that specializes in developing and manufacturing memory and storage products commonly used in computers, data centres, as well as the automotive and healthcare industries. Micron produces a rich portfolio of highly efficient DRAM, NAND, and NOR memory storage products. Their Singapore plants focus on NAND products.

We were working with the Data Science department. The goal of the department is to use data science methods to increase overall productivity and cost optimisation.

Problem Description

Current tool maintenance is based on a fixed schedule. There are signs of degradation of machine parts but are not change out promptly leading to unplanned downtime.

Predictive Maintenance (PdM) of machine tool parts has to be conducted to identify information that can predict the useful lifespan and trigger pre-emptive replacement or delay the change if the part can last longer than currently planned.

Our group was assigned 2 machine tools that make up our 2 use cases. Analysis had to be conducted to determine the variables affecting Remaining Useful Life (RUL).

Problem Impacts

- Lead to unplanned downtime due to tool part replacement
- Lead to unnecessary opportunity costs due to early replacement
- Lead to deviation from the optimal performance of the machine

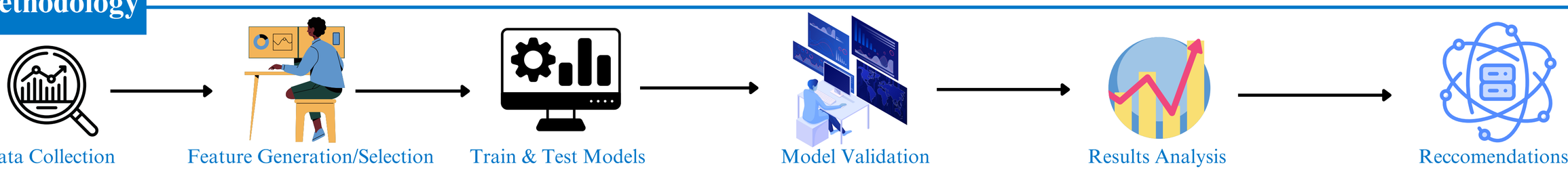
Objectives

To develop predictive models for both use cases by using machine learning and data analysis to maximize the useful lifespan for the machine tool parts, and recommend an optimal useful lifespan for each of the 2 sets of machine tools assigned.

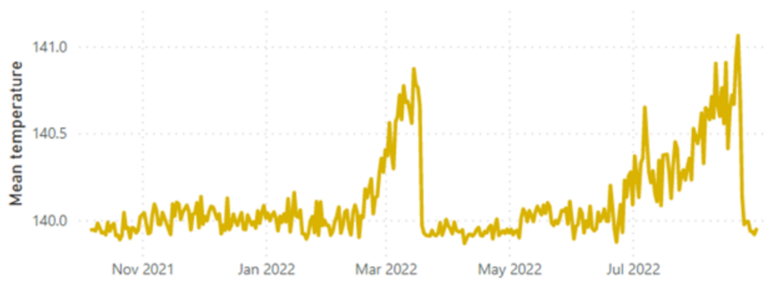
Key Skillsets

1. Programming - Python language that enables:
   a. Data Analysis - Data cleaning, feature engineering, data visualization.
   b. Machine Learning - Comparison of different techniques using different metrics.
2. Project Management - Liaising with stakeholders with different needs.

Methodology



Data Pre-Processing (Use Case 1)



^ Cyclical trend where temperature fluctuations increased across period of 5-6 months and decreases at the end of cycle - corresponds to the filter change periods.

Data Formatting:

- Data quality assessment
- Removed outliers and missing data from datasets, replaced with mean
- Data aggregation over a 24-hour period

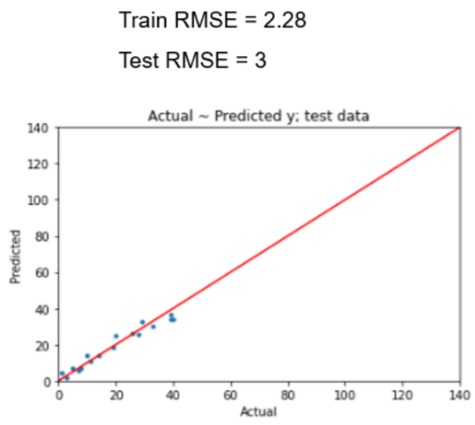
Feature Scaling:

- Predictors are scaled with min-max scaler to reduce any biasness

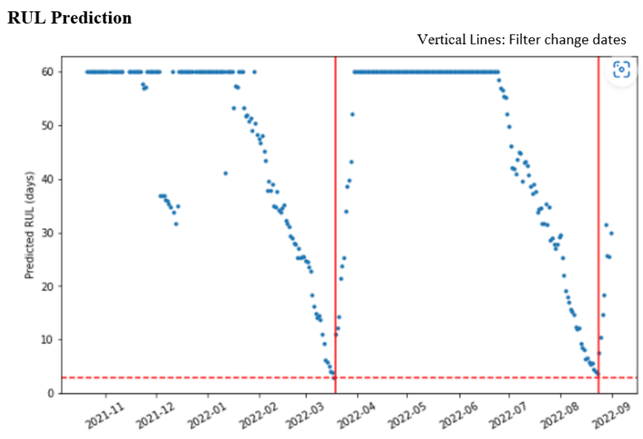
Feature Selection/Generation:

- Sieve out important features for prediction
- Generated new variables for model exploration
- Identify relationships between selected features using PowerBI

Prediction Model (Use Case 1)

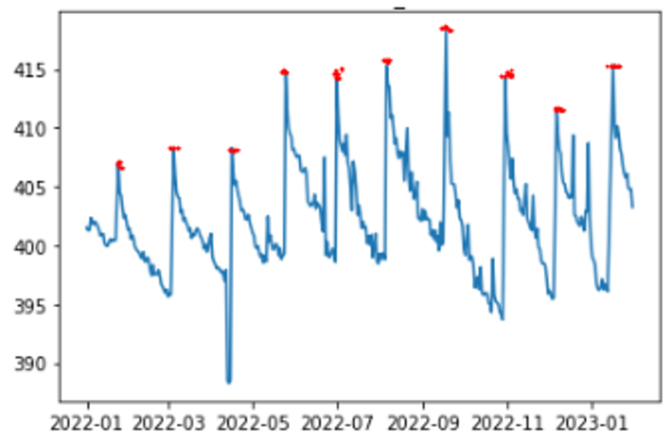


Developed and trained Random Forest Classifier prediction model to acceptable level of accuracy.

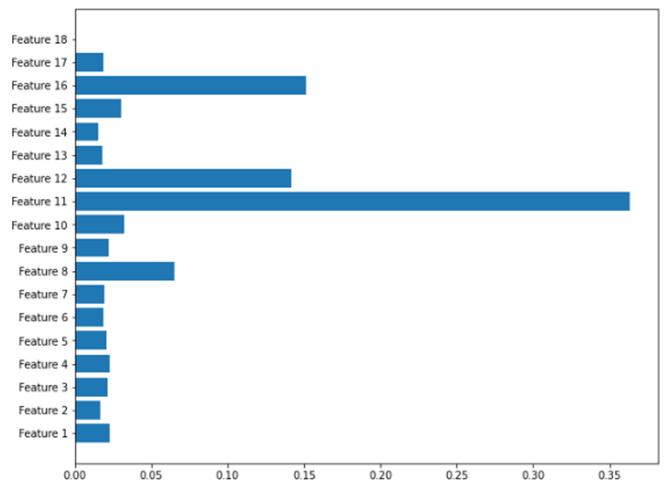


Prediction model validated - corresponds to RUL behavior within a cycle

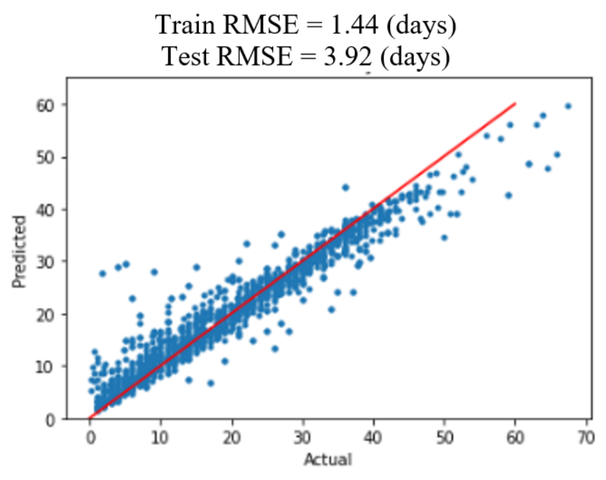
Use Case 2



Cyclical trend where the red dots signify the maintenance dates



Feature Selection for 18 sensors, determined that Features 8, 11, 12 & 16 are the most significant for prediction modelling



Developed and trained Random Forest Regressor prediction model to acceptable level of accuracy

Recommendations

- Delay the replacement change period of the tool part in Use Case 1 by 2 months which is the threshold for healthy temperature fluctuations.
- Continue monitoring the temperature daily using prediction algorithm, prompting T+3 days in advance for the filter change.
- Prompt T+4 days in advance for the tool part change in Use Case 2.

Benefits

- Reduction in downtime of machine tools resulting in increased machine availability.
- Reduction of unnecessary machine part replacements.
- Increased fabrication machine performance and efficiency.
- Saves maintenance costs and opportunity costs for replacement for company.

Future Directions

- Constant monitoring of 2 use cases has to be conducted to further improve model.
- More prediction can be made if other tool parts have failure data.
- Prediction model still to be developed for Use Case 2 (in the coming weeks).
- PdM can be applied across other use cases provided further datasets are given.