Predictive Modeling of Turbofan Engines


METHODOLOGY

• Predict remaining useful life (RUL) of engines
  ○ RUL indicates when a component requires repair or replacement and measures time until failure
  ○ By accurately predicting RUL, Raytheon can proactively schedule maintenance and reduce any costs associated with repairs and unnecessary servicing

DATA

• Four simulated NASA datasets of engine sensors over time
  ○ Multiple multivariate time series
    ◦ 3 operational settings and 21 sensors
    ◦ Include temperature, rotation speed, pressure, etc.
  ○ Calculated RUL using cycle

PREPARING DATA

• Calculated RUL using Cycle
• Standardized

MODEL PERFORMANCE

• Methods used to measure variable importance and understand engine component breakdown or failure indication included:
  ◦ Principal Component Analysis (last 5 cycles and last 120 cycles)
  ◦ Lasso Regression
  ◦ Tree-Based Methods (random forest, gradient boost, and extreme gradient boost)
• The most important engine components across all six techniques were: HPC, LPT, Fuel, and Core Nozzle

ENGINE COMPONENT IMPORTANCE ACCORDING TO NUMBER OF METHODS

<table>
<thead>
<tr>
<th># of Methods</th>
<th>Dataset 1</th>
<th>Dataset 2</th>
<th>Dataset 3</th>
<th>Dataset 4</th>
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</thead>
<tbody>
<tr>
<td>6</td>
<td>HPC, Fuel, Core Nozzle</td>
<td>LPT, Fuel, LPT</td>
<td>HPC, Fuel, Core Nozzle</td>
<td>HPC, LPT</td>
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<td>5</td>
<td>LPT</td>
<td>Fuel</td>
<td>LPT</td>
<td>Bypass Path</td>
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<tr>
<td>4</td>
<td>BYPASS Nozzle</td>
<td>Fan, BYPASS Nozzle</td>
<td>Fan, Inlet, Fan, Fuel</td>
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<td>Inlet, BYPASS Path, LPC, Core Nozzle</td>
<td>BYPASS Nozzle, Core Nozzle</td>
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<tr>
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<td>Fan</td>
<td>Burner</td>
<td>BYPASS Path, LPC, LPC, Burner</td>
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</tbody>
</table>

*HPC: High Pressure Compressor, LPC: Low Pressure Compressor, HPT: High Pressure Turbine, LPT: Low Pressure Turbine

ACKNOWLEDGEMENTS