Hack the Wind 2018 Challenge

Wind Turbine Fault Prediction

Algorithm Evaluation - Metric

Considering the following operation prices:

Component	Replacement Cost (RP)	Repair Cost (RC)	Inspection Cost (IC)
Gearbox	100 000 €	20 000 €	5 000 €
Generator	60 000 €	15 000 €	5 000 €
Transformer	50 000 €	3 500 €	3 500 €
Hydraulic Group	20 000 €	3 000 €	2 000 €
Generator Bearing	30 000 €	12 500 €	4 500 €

For each component's timeline, we have:

- **Savings associated to "True Positive" predictions**. Here, we avoid a replacement cost, because we can repair the faulty component within the defined time period. The sooner you predict the better.

$$TP_{savings} = \sum_{i=\#TP} \left(Replacement[€] - \left(Repair[€] + (Replacement[€] - Repair[€]) \left(1 - \frac{\Delta t_i}{60}\right)\right)\right)$$

- Your **"False Positive" predictions** will imply accessory **inspection costs**.

$$FP_{cost} = \#FP \times Inspection\ [€]$$

- Your **"False Negative" predictions** will imply **replacement costs**, because you were unable to detect a real failure and the respective faulty component will fail critically and must be replaced.

$$FN_{cost} = \#FN \times Replacement\ [€]$$

The savings of each component will then be calculated by:

$$Savings_{component} = TP_{savings} - FP_{cost} - FN_{cost}$$

Lastly, the Total Prediction Savings are calculated accounting all the 5 components and 5 wind turbines to monitor:

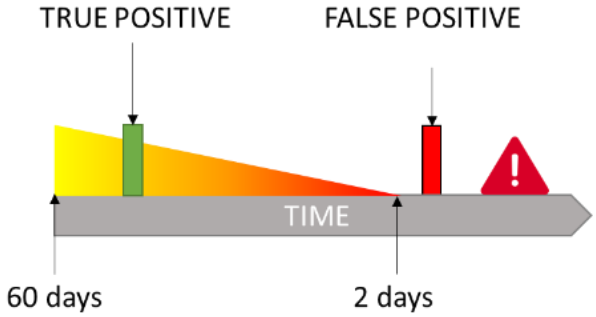
$$Total\ prediction\ savings = \sum_{turbine=1}^{5} \sum_{component=1}^{5} Savings_{component}$$

Algorithm Evaluation - Examples

1. Gearbox savings

For the Gearbox, and using the values in the table above for the associated costs, consider the next group of predictions and the respective timeline containing:

(i) One true positive (TP=1) detected 50 days before the failure (Δt_j = 50);
(ii) One false positive (FP=1); and
(iii) No false negatives(FN=0).



The savings associated to the previous predictions are calculated by

- $TP_{savings} = 100\ k€ - \left(20\ k€ + (100\ k€ - 20\ k€)\left(1 - \frac{50}{60}\right)\right) = 66.7\ k€$
- $FP_{cost} = 1 \times 5\ k€ = 5\ k€$
- $FN_{cost} = 0 \times 100\ k€ = 0€$

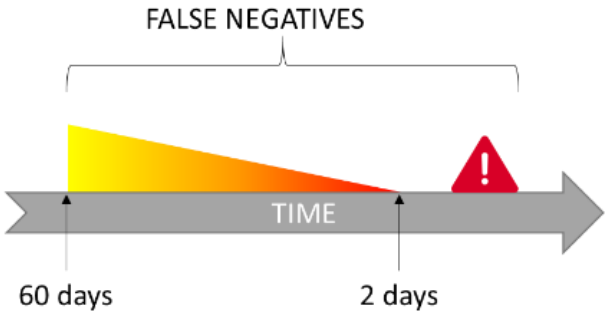
$$Savings_{Gearbox} = 66.7\ k€ - 5\ k€ - 0€ = 61.7\ k€$$

This means that the model's predictions resulted in savings worth 61 700 €.

2. Hydraulic Group savings

For the Hydraulic Group, and using the values in the table above for the associated costs, consider the next group of predictions and the respective timeline containing:

(i) No true positives predicted (TP=0);
(ii) No false positives (FP=0); and
(iii) one false negative (FN=1).



The savings associated to the previous predictions are calculated by

- $TP_{savings} = 0\ €$
- $FP_{cost} = 0\ €$
- $FN_{cost} = 1 \times 20\ k€ = 20\ k€$

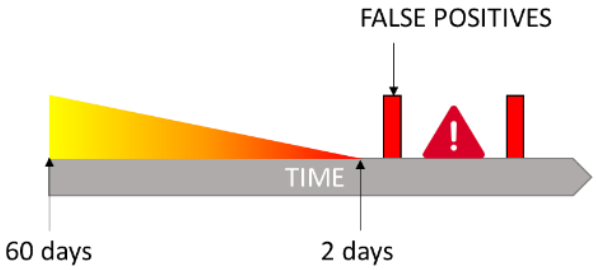
$$Savings_{Hydraulic\ Group} = 0\ € - 0\ € - 20\ k€ = -20\ k€$$

Notice that this is the case where no prediction attempts were made and, consequently, no failures were prevented, making the cost equal to the replacement cost. In this case, there are no savings, only 20 000 € in expenses.

3. Transformer savings

For the Transformer, and using the values in the table above for the associated costs, consider the next group of predictions and the respective timeline containing:

(i) No true positives predicted(TP=0);
(ii) Two false positives (FP=2); and
(iii) One false negative (FN=1).



The savings associated to the previous predictions are calculated by

- $TP_{savings} = 0\ €$
- $FP_{cost} = 2 \times 3{,}5\ k€ = 6\ k€$
- $FN_{cost} = 1 \times 50\ k€ = 50\ k€$

$$Savings_{Transformer} = 0\ € - 50\ k€ - 6\ k€ = -56\ k€$$

Notice that this is the case where there were no successful prediction attempts and, consequently, besides the accessory inspections, it was also necessary to replace the faulty component. Due to this, the savings are negative, meaning there were expenses comprised of replacement and inspection costs in a total of 56 000 €.

4. Final Savings Calculation

The cost per turbine is the result of the following:

Assuming the generator and generator bearing savings to be 50 k€ and -100 k€, the prediction saving for this specific turbine is:

$$Savings_{turbine} = 61.7\ k€ - 20\ k€ - 56\ k€ + 50\ k€ - 100\ k€ = -64.3\ k€$$

For this specific turbine, the prediction savings are negative, meaning the prediction attempts done were not successful.

To know the total prediction savings, the algorithm performs this same evaluation for all the 5 turbines to be analyzed in this challenge.

Grade System - Calculation

There will be a total of six prediction savings:

- The total prediction savings for the overall system; and
- One specific prediction saving for each component analyzed.

To simplify and normalize the evaluation process, each of these prediction savings will be put through an undisclosed sigmoidal activation function which will convert them into a grade between 0 and 20. The sigmoidal activation function* works as follows:

*THIS IS NOT THE REAL FUNCTION TO BE USED