# Decomposition Project

## Goal:

Decompose the signals into faulty and non-faulty components.

$$Y = L + S + E$$

$L$: Low rank component representing the mean of the signal
$S$: Sparse component (anomaly)
$E$: Noise component

## Assumptions:

- The within-period change of the mean signal is smooth;
- The between-periods change of the mean signal is smooth;
- The mean signal possessing low rank characteristics should be nonnegative;
- The sparse anomalous component should be negative.

# Method

- Reformulate the signal into a matrix form where the row represents the time within a day while the column represents the index of a day within a given period.
- Use matrix factorization and B spline basis:

$$Y = UV + B_1 S_a B_2 + E$$

- So, we need to solve this optimization problem:

$$argmin_{U,V,S_a} \left|\left|E\right|\right|_F^2 + \mu_L \left|\left|D_2 U\right|\right|_F^2 + \mu_R \left|\left|D_2' V^T\right|\right|_F^2 + \lambda \left|\left|S_a\right|\right|_1$$

$$St.\ Y = UV + B_1 S_a B_2 + E$$
$$UV \geq 0$$
$$B_1 S_a B_2 \leq 0$$

- $D_1$, and $D_2$ are the second difference matrix.

- The optimization problem can be solved efficiently using block coordinate descent (BCD) method.
- To solve the constrained convex subproblems efficiently, alternating direction method of multipliers (ADMM) is implemented.

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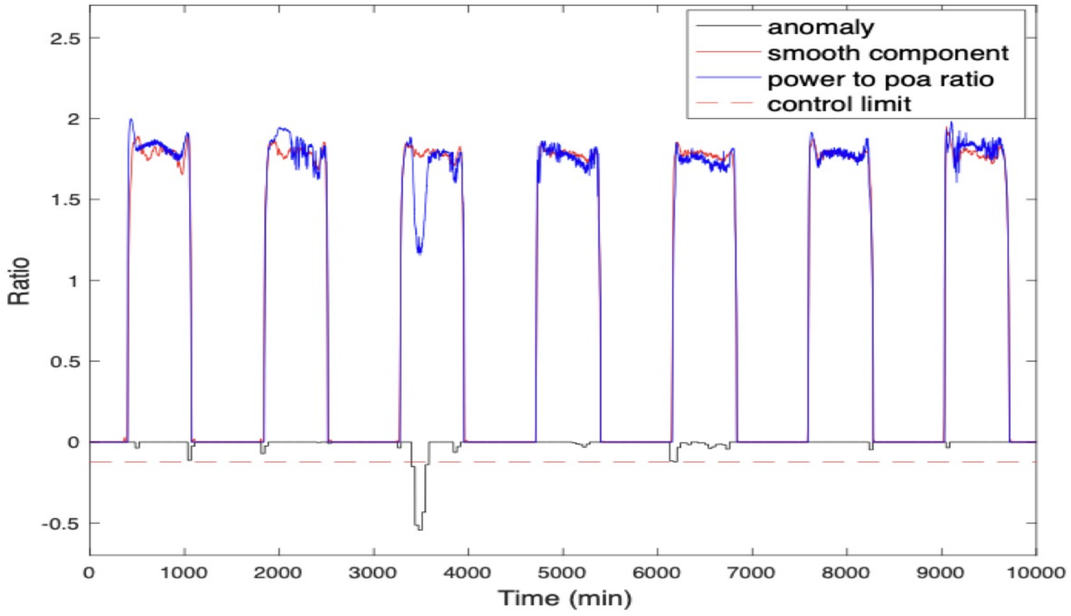
# Results

MEAN AND VARIANCE OF MISS DETECTION RATE

| Duration of Faults (hours) | Percentage of Power Drop | | |
|---|---|---|---|
| | 30% | 50% | 70% |
| 3 | 0.0180 ± 0.00160 | 0.0015 ± 0.00007 | 0.0005 ± 0.00003 |
| 5 | 0.0056 ± 0.00035 | 0.0005 ± 0.00003 | 0 ± 0 |
| 7 | 0.0030 ± 0.00014 | 0 ± 0 | 0 ± 0 |

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# Fault Diagnosis Project

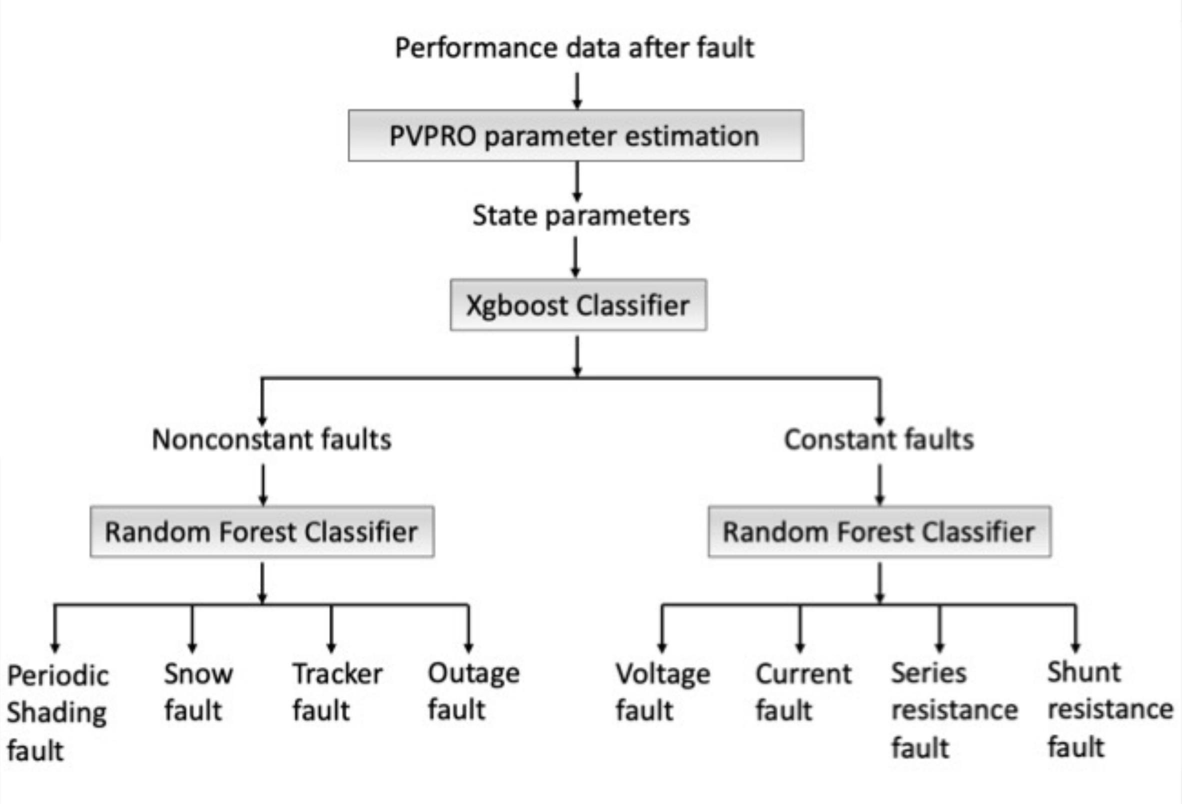
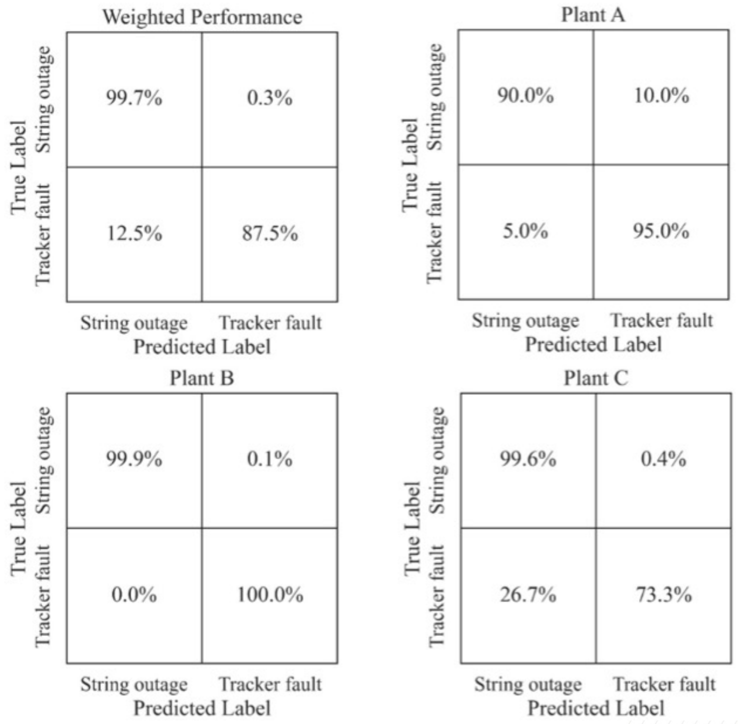



Table 1 Results on the Simulated Dataset

| | Precision | Recall | F1-score | Support |
|---|---|---|---|---|
| Voltage Fault | 0.99 | 0.96 | 0.97 | 20 |
| Current Fault | 0.99 | 0.98 | 0.98 | 20 |
| Series Resistance Fault | 0.90 | 0.87 | 0.88 | 20 |
| Shunt Resistance Fault | 0.91 | 0.96 | 0.93 | 20 |
| Periodic Shading Fault | 0.80 | 0.85 | 0.82 | 20 |
| Snow Fault | 0.92 | 0.89 | 0.90 | 20 |
| Tracker Fault | 0.91 | 0.97 | 0.93 | 20 |
| Outage Fault | 0.78 | 0.68 | 0.72 | 20 |




The classification result for individual site data

# Backup Slide

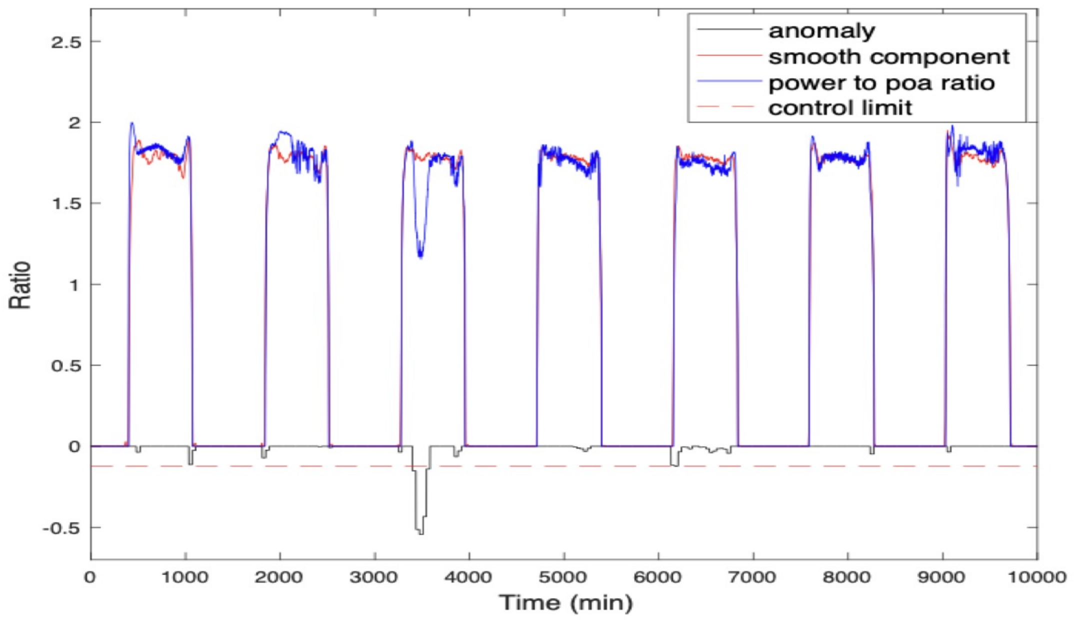
$$argmin_{U,V,S_a} ||E||_F^2 + \mu_L ||D_2 U||_F^2 + \mu_R ||D_2' V^T||_F^2 + \lambda ||S_a||_1$$

$$St.\ Y = UV + B_1 S_a B_2 + E$$
$$UV \geq 0$$
$$B_1 S_a B_2 \leq 0$$

*penalizes the second order difference along the columns of ***U***, which helps to achieve smoothness in the within-period change of the mean signal.

*penalizes the second order difference along the columns of V, which helps to achieve smoothness in the between-periods change of the mean signal.

*The L-1 norm penalty encourages sparsity in the decomposed anomaly component.




An example of fault detection on the power to irradiance ratio signal with the presence of a fault leading to 30% power drop over 3 hours.