Analysis of Process Data for Remote Health Prediction in Distributed Automation Systems

Source

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Related works
Introducing iFA

- **To fit into different industries' requirements, CPA comes with different equipment drivers**.
- The internet and the cloud are connected by CPA's communication module.
- The AMCoT framework can also **incorporate the AVM, IPM, IYM, and other services in the cloud to be intelligent cloud services for global customers to fulfill their requirements**.
- **iFA system platform not only help to improve manufacturing productivity but enhance product quality while avoiding unscheduled downs and cutting down the tool maintenance costs**.

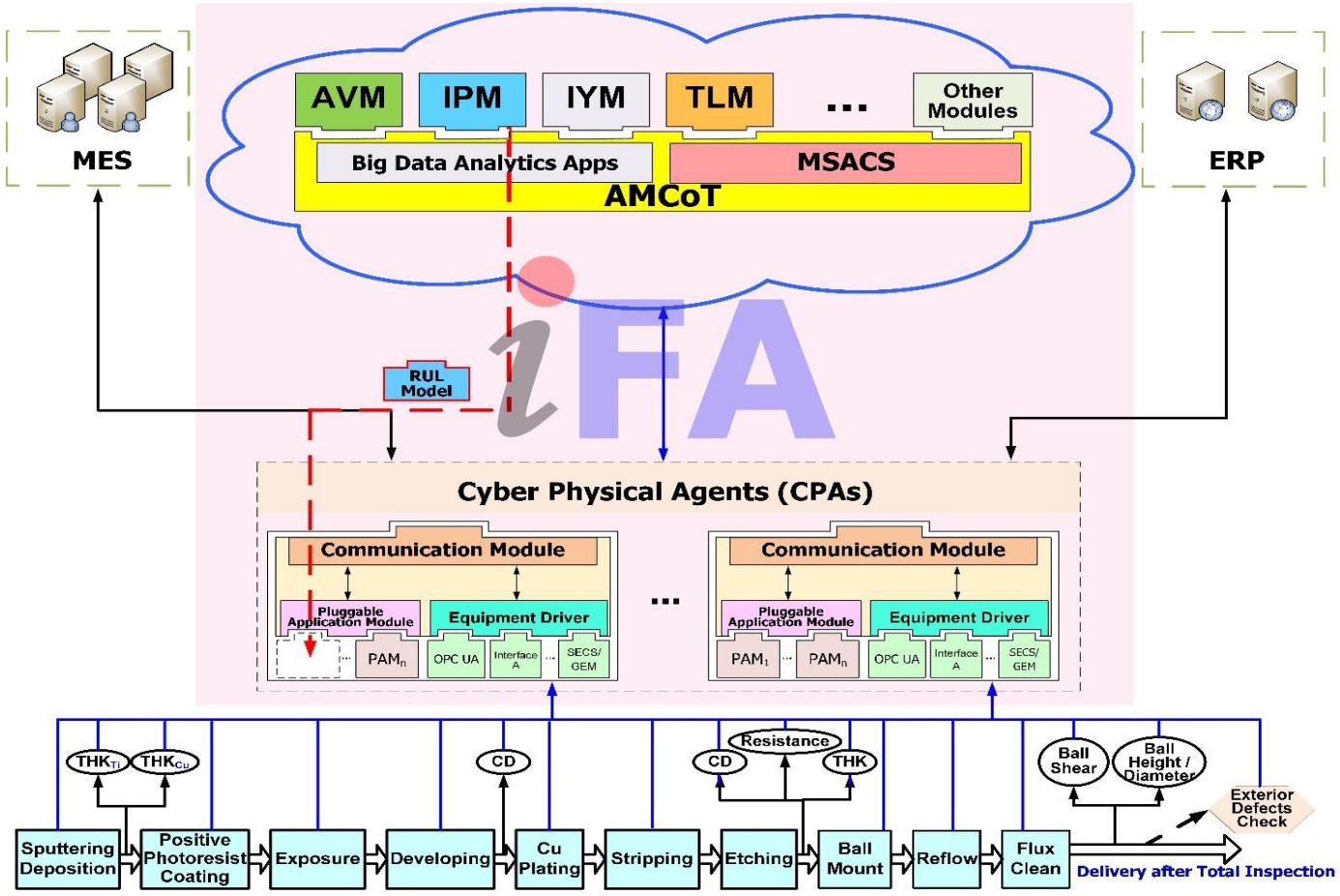

Fig. 1 Cloud-based iFA system platform

Related works
Introducing IPM

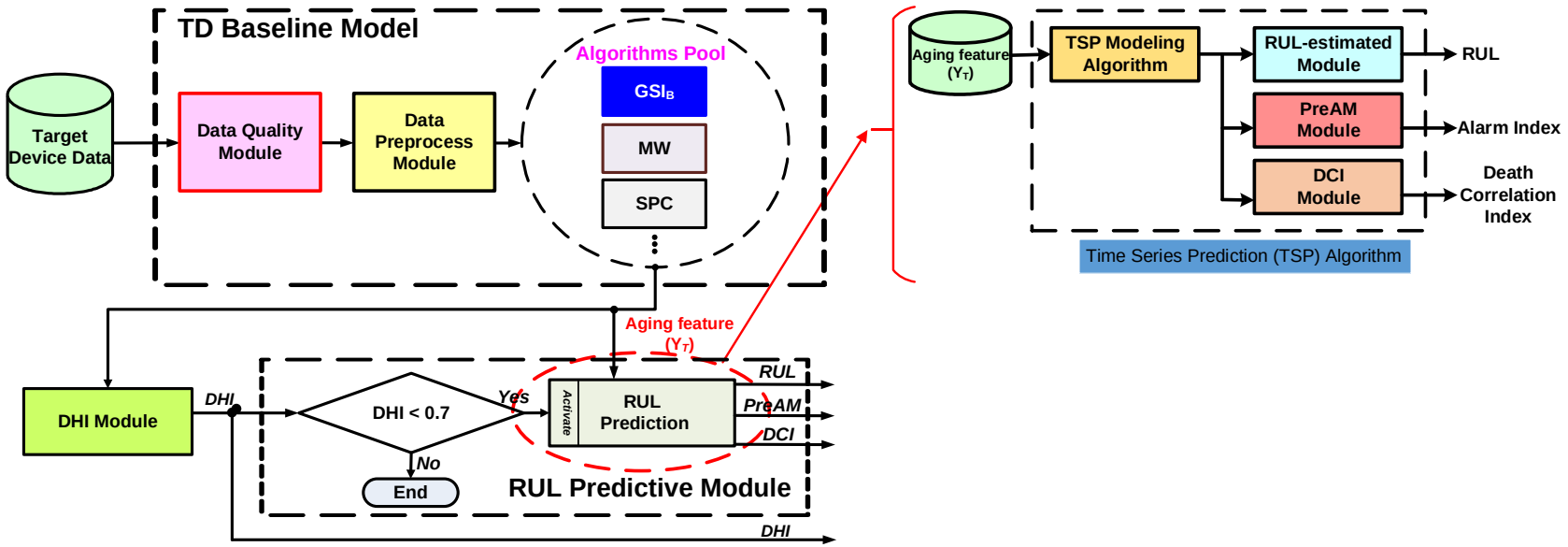

Fig. 2. Advanced baseline predictive maintenance scheme

- The IPM system adopts the **Advanced Baseline Predictive Maintenance Scheme (ABPM)** as the algorithm.
- The ABPM Scheme is comprised of Data Quality Module, Data Preprocess Module, Algorithms Pool, Device Health Index (DHI) and RUL Prediction Module.

- **In the ABPM Scheme, the algorithm in RUL Prediction Module is the Time Series Prediction (TSP) Algorithm**.

Operational Scenario of The Proposed Architecture

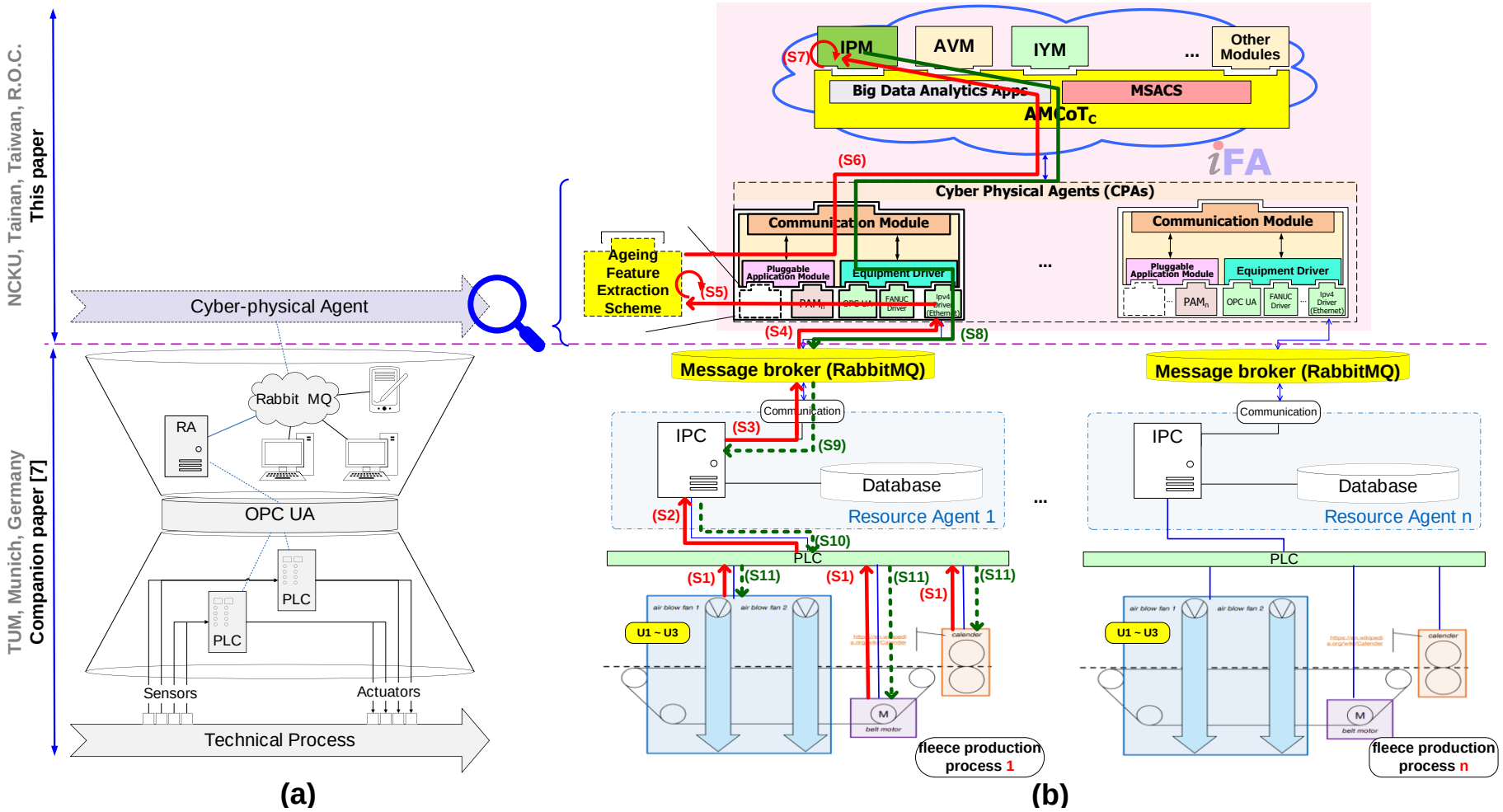

Fig. 3. Operational scenario of the proposed architecture. The control hierarchy is visualized based on the automation diabolo as shown in Fig.3 (a) [15]. An extended version of the diabolo can be found in [7].

Operational Scenario of The Proposed Architecture

Ageing Feature Extraction Scheme

- The goals of data preprocessing are to eliminate the noise imbedded in the signal and extract key-feature-related information. Common data preprocessing consists of three steps: segmentation, cleaning, and feature generation. **However, the correlation between the extracted aging features and tool failure records should also be considered in the aging feature extraction aiming for predictive maintenance**.
- **In view of this, AFES is proposed in this paper to solve the above-mentioned problems as shown in Fig. 4 and illustrated below.**

- **Step 1. Data Segmentation: data segmentation extracts the meaningful data intervals from the original data in consideration of physical meaning.**
- **Step 2. Data Cleaning: Data cleaning attempts to cancel the noise in signal and improve the S/N ratio to prepare for post-processing.**

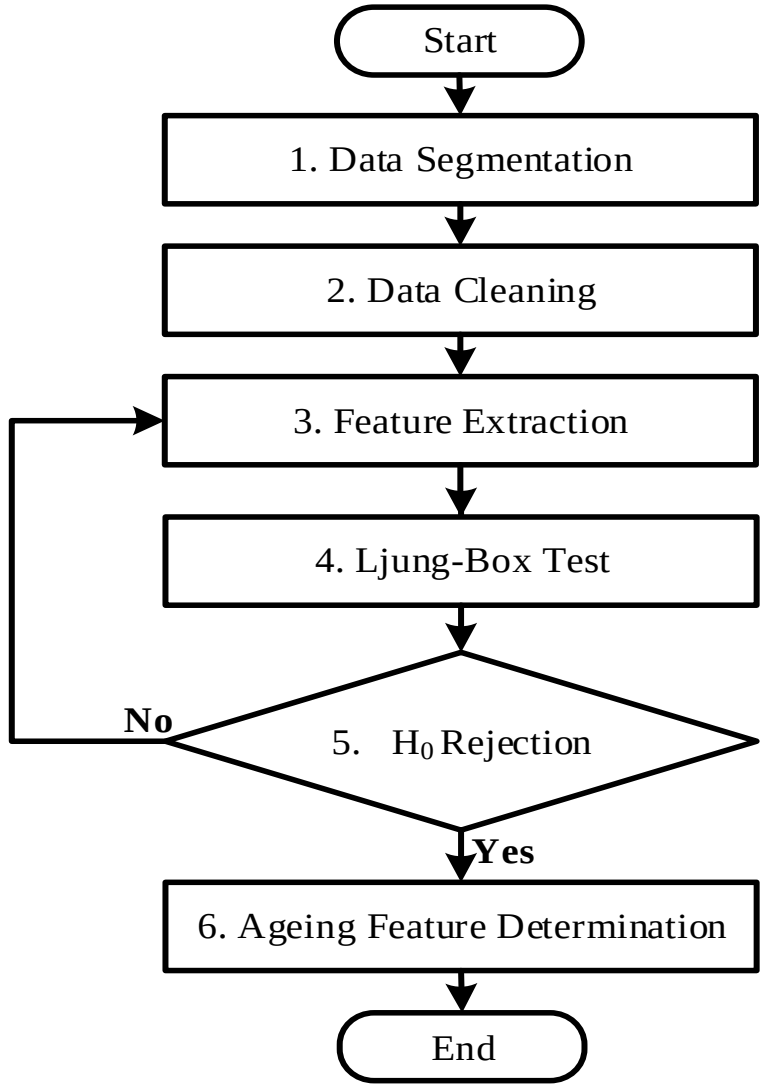

Fig. 4. Flowchart of ageing feature extraction scheme

Operational Scenario of The Proposed Architecture

Ageing Feature Extraction Scheme (continue)

- **Step 3. Feature Extraction: Feature extraction is the process to generate a smaller linear or nonlinear combination set to represent the original high-dimensional data set.**
- **Step 4. Ljung-Box Test: This step checks if there is correlation between the extracted feature set in Step 3 and the tool failure records.**

$$r_i = \frac{\sum_j^n (F_{ij} - \bar{F}_i)(Y_j - \bar{Y})}{\sqrt{\sum_j^n (F_{ij} - \bar{F}_i)^2}\sqrt{\sum_j^n (Y_j - \bar{Y})^2}} \quad (1)$$

where

F_{ij} : j[th] sample of the i[th] feature value,
$\bar{F}_i$: mean of the i[th] feature value,
Y_j : j[th] sample of the failure records,
$\bar{Y}$: mean of the failure records.
with $i = 1, 2, \ldots, p$,
$j = 1, 2, \ldots, n$.

$$H_0: \rho_1 = \rho_2 = \ldots = \rho_n = 0 \quad (2)$$

$$H_a: \rho_j \neq 0, \text{where } j = 1, 2, \ldots, n. \quad (3)$$

- **Step 5. H_0 Rejection: If H_0 is rejected, go to Step 6; otherwise, go back to Step 3 to re-extract the features.**
- **Step 6. Aging Feature Determination.**

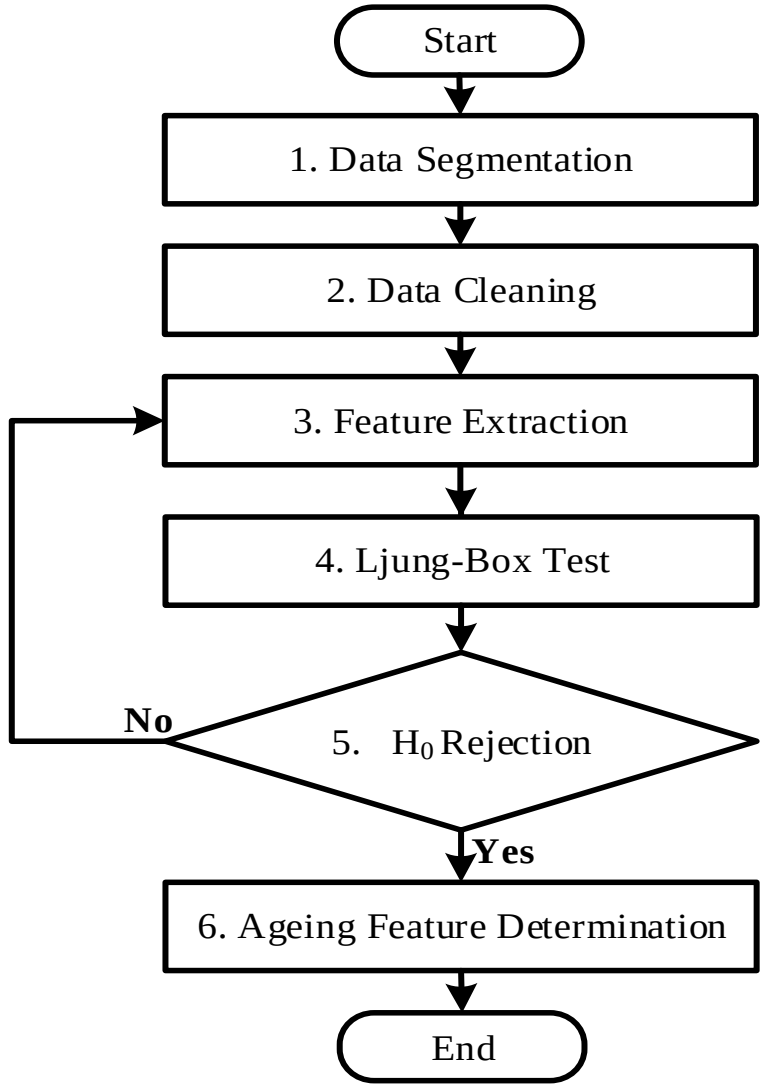

Fig. 4. Flowchart of ageing feature extraction scheme

Illustrative Example

Operational Scenario of the Proposed Architecture for Fleece Production

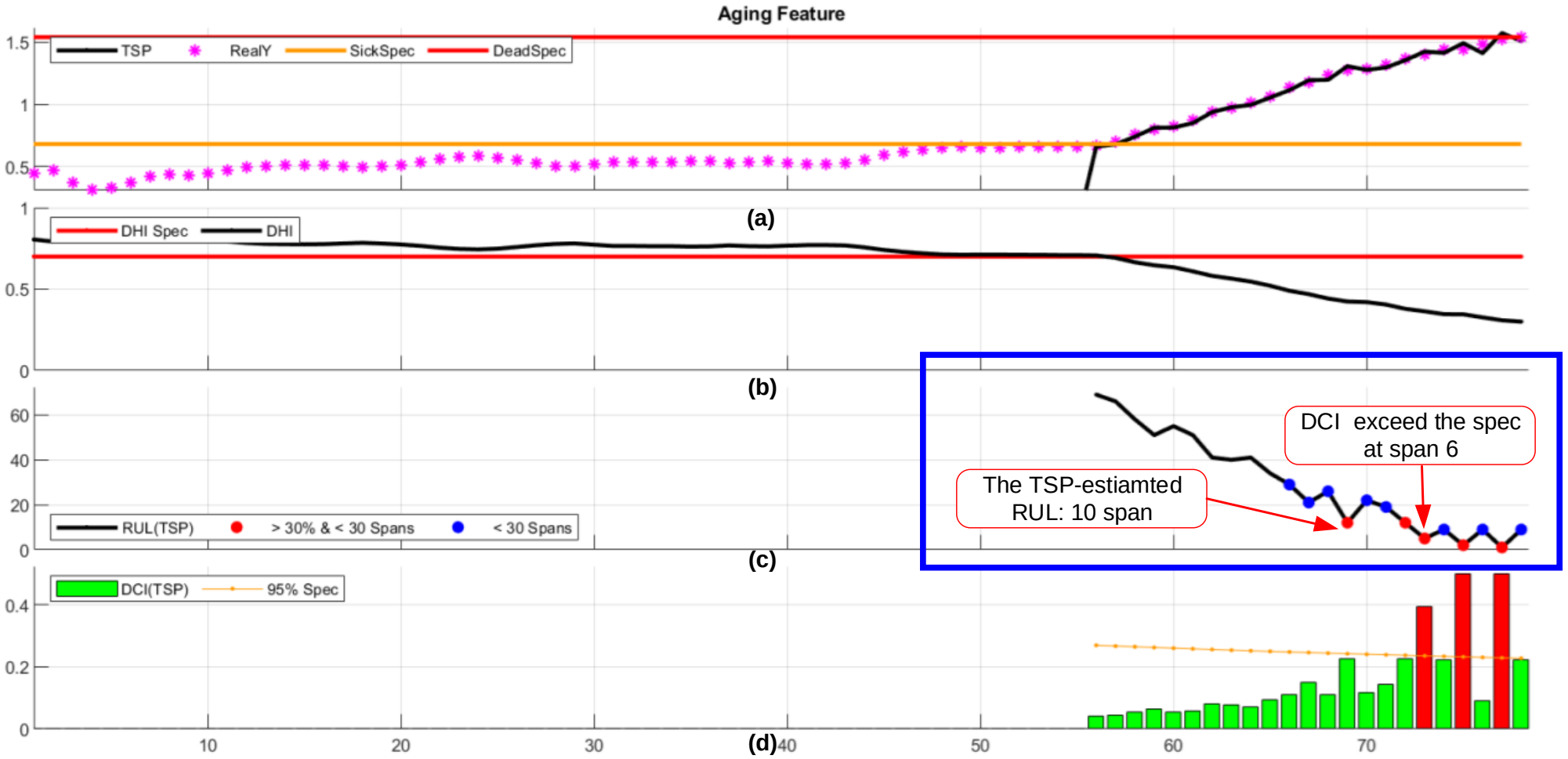

Fig 7. TSP result of Unit 1 Fan