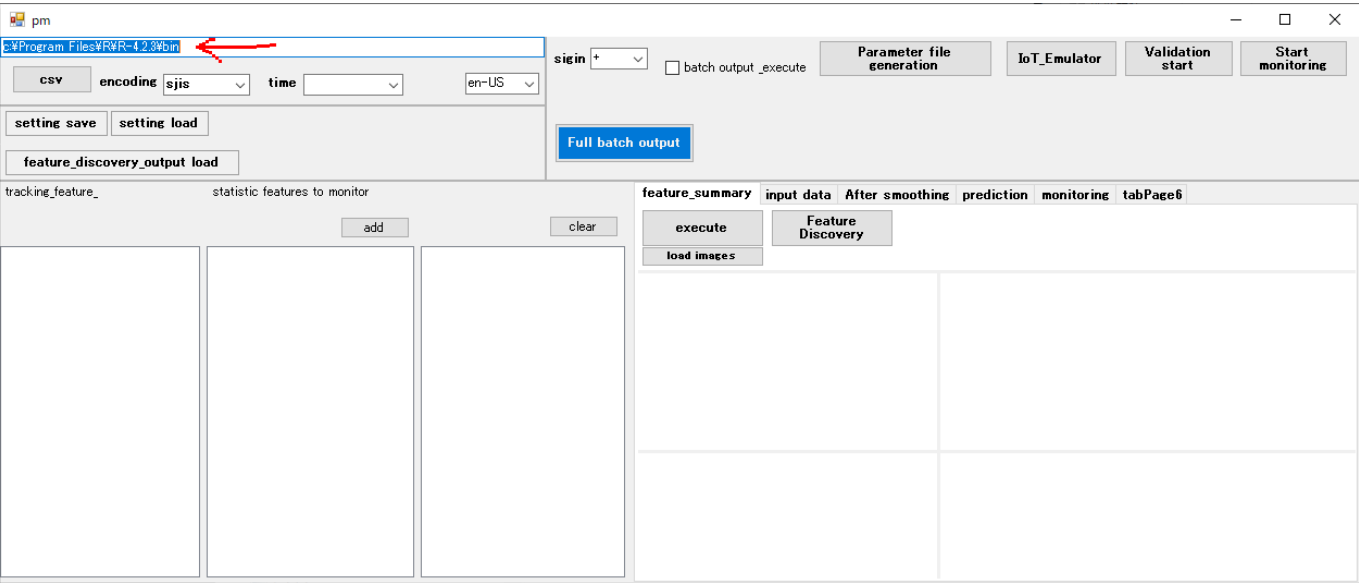


pm.bat

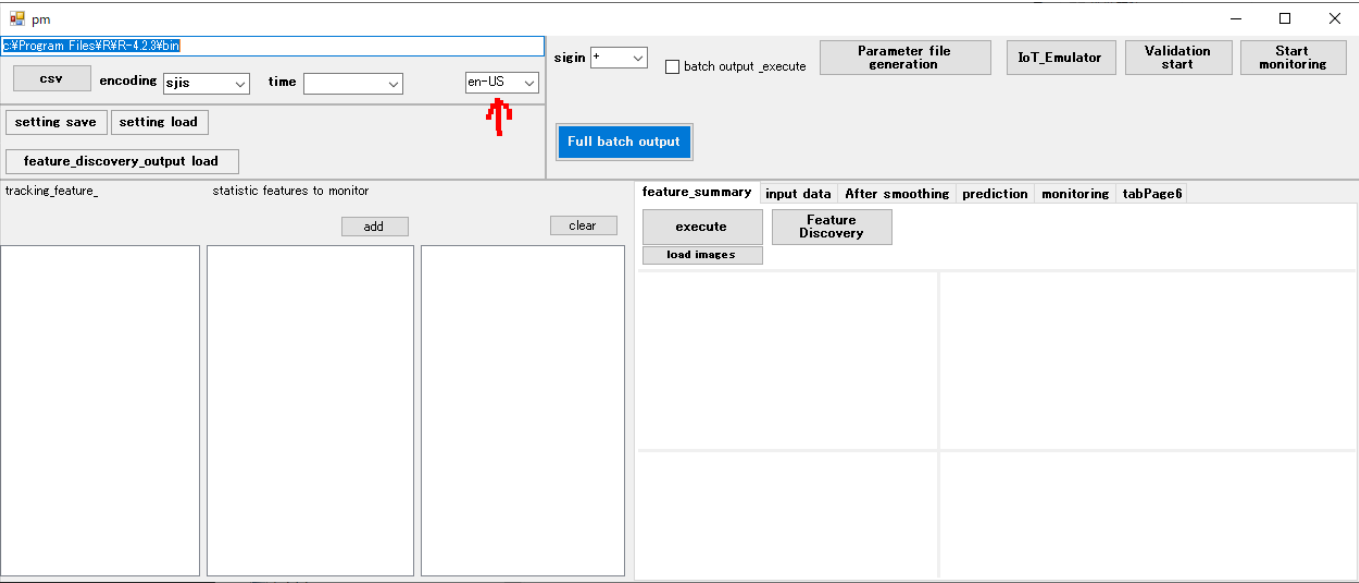
Set the installation location for R



This only needs to be done once.

Language Settings

You can choose between Japanese or English. After setting, restart to apply the specified language.



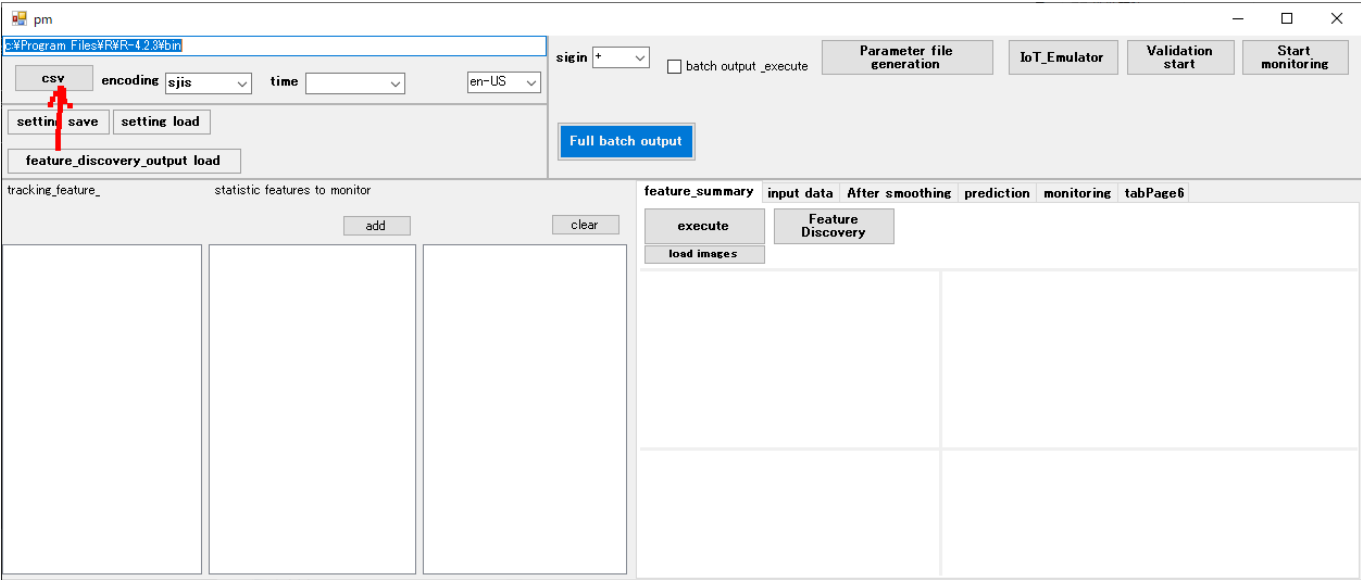
File encoding settings

Currently, it is fixed to UTF-8, and all input CSV files are automatically converted to UTF-8. Also, all output files are output in UTF-8.

Importing CSV Data

CSV data can be either accumulated data from periodic saving or consolidated CSV files. One or multiple files are acceptable. Place these CSV files under an appropriately named folder. Use the "CSV" button to access the

folder and select the first CSV file.

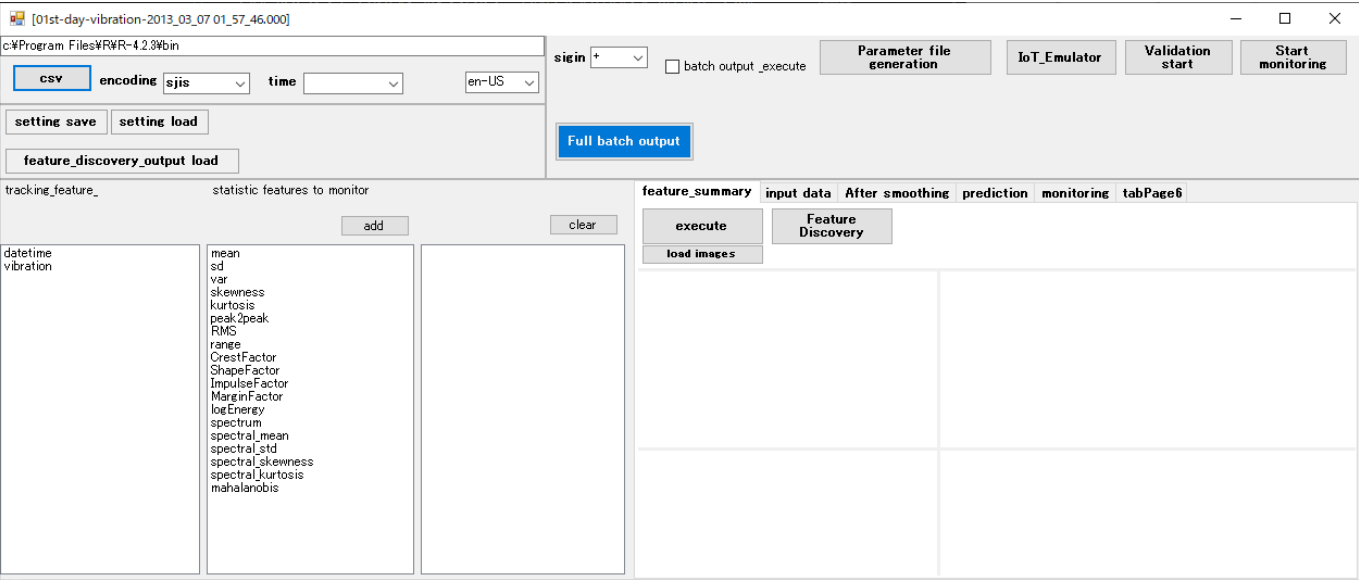


Select the first CSV file.

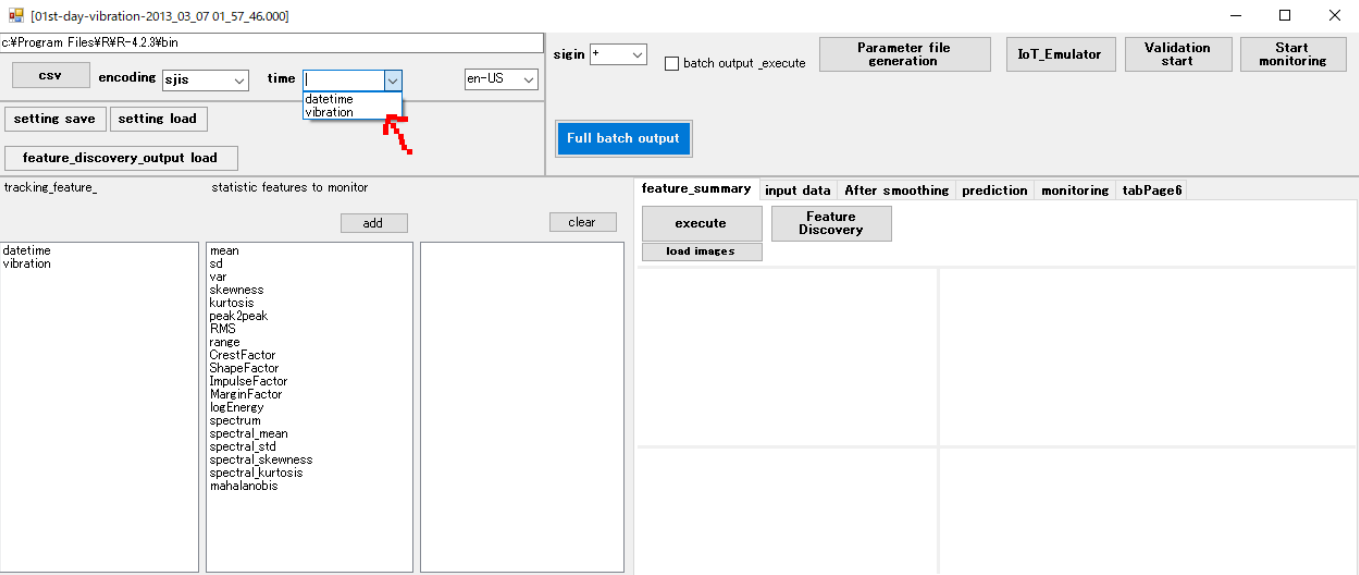
| | | | | |
|--|--|-----------------|-----------------------|-----------|
| | 01st-day-vibration-2013_03_07 01_57_46.... | 2024/03/28 6:51 | Microsoft Excel CS... | 20,788 KB |
| | 02nd-day-vibration-2013_03_08 01_57_46.... | 2024/03/28 6:51 | Microsoft Excel CS... | 20,795 KB |
| | 03rd-day-vibration-2013_03_09 01_57_46.... | 2024/03/28 6:51 | Microsoft Excel CS... | 20,799 KB |
| | 04th-day-vibration-2013_03_10 01_57_46.... | 2024/03/28 6:52 | Microsoft Excel CS... | 20,799 KB |
| | 05th-day-vibration-2013_03_11 01_57_46.... | 2024/03/28 6:52 | Microsoft Excel CS... | 20,798 KB |
| | 06th-day-vibration-2013_03_12 01_57_46.... | 2024/03/28 6:52 | Microsoft Excel CS... | 20,790 KB |
| | 07th-day-vibration-2013_03_13 01_57_46.... | 2024/03/28 6:52 | Microsoft Excel CS... | 20,798 KB |
| | 08th-day-vibration-2013_03_14 01_57_46.... | 2024/03/28 6:52 | Microsoft Excel CS... | 20,792 KB |
| | 09th-day-vibration-2013_03_15 01_57_46.... | 2024/03/28 6:52 | Microsoft Excel CS... | 20,798 KB |
| | 10th-day-vibration-2013_03_16 01_57_46.... | 2024/03/28 6:53 | Microsoft Excel CS... | 20,795 KB |
| | 11th-day-vibration-2013_03_17 01_57_46.... | 2024/03/28 6:53 | Microsoft Excel CS... | 20,798 KB |
| | 12th-day-vibration-2013_03_18 01_57_46.... | 2024/03/28 6:53 | Microsoft Excel CS... | 20,801 KB |
| | 13th-day-vibration-2013_03_19 01_57_46.... | 2024/03/28 6:53 | Microsoft Excel CS... | 20,798 KB |
| | 14th-day-vibration-2013_03_20 01_57_46.... | 2024/03/28 6:53 | Microsoft Excel CS... | 20,785 KB |
| | 15th-day-vibration-2013_03_21 01_57_46.... | 2024/03/28 6:54 | Microsoft Excel CS... | 20,802 KB |
| | 16th-day-vibration-2013_03_22 01_57_46.... | 2024/03/28 6:54 | Microsoft Excel CS... | 20,800 KB |

Timestamp Parameter Settings

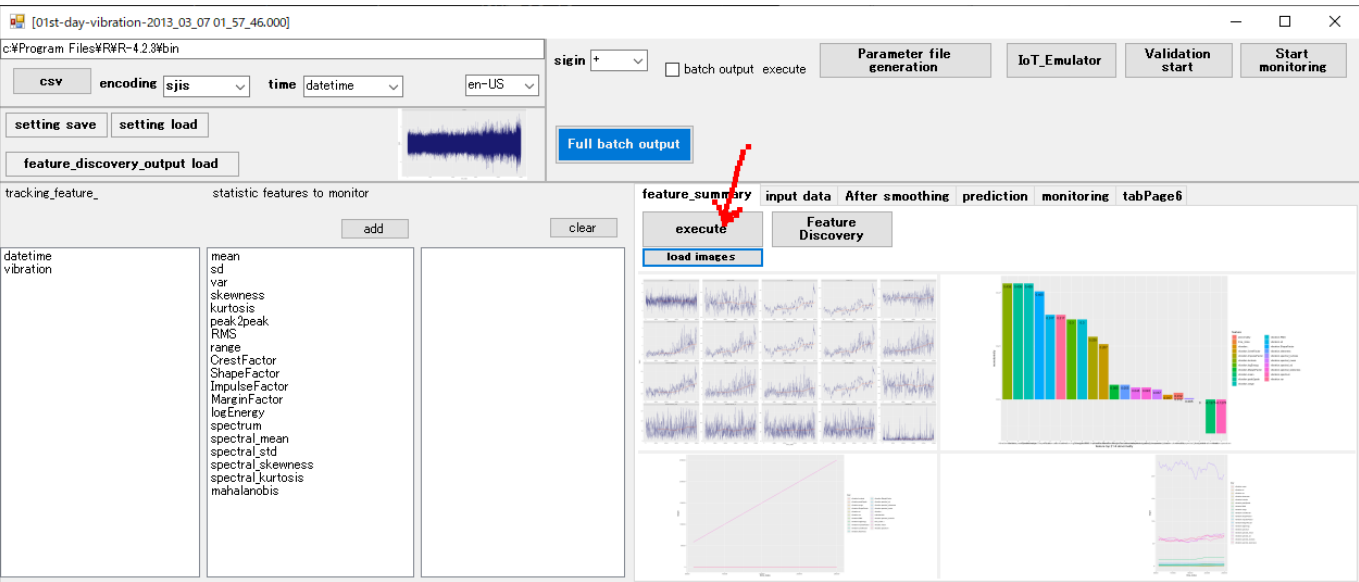
When CSV data is loaded, each item and a list of investigable features are automatically set.



First, select and specify the item representing the timestamp.



Summary of Features



xxxx_feature_summary_visualization.bat ("xxxx" is determined from the name of the imported CSV file.)

Generates a batch for visualizing the summary of features for each data item.

batch output & execute If the checkbox is ON, batch generation and execution are performed. This process takes time as it is done for all items.

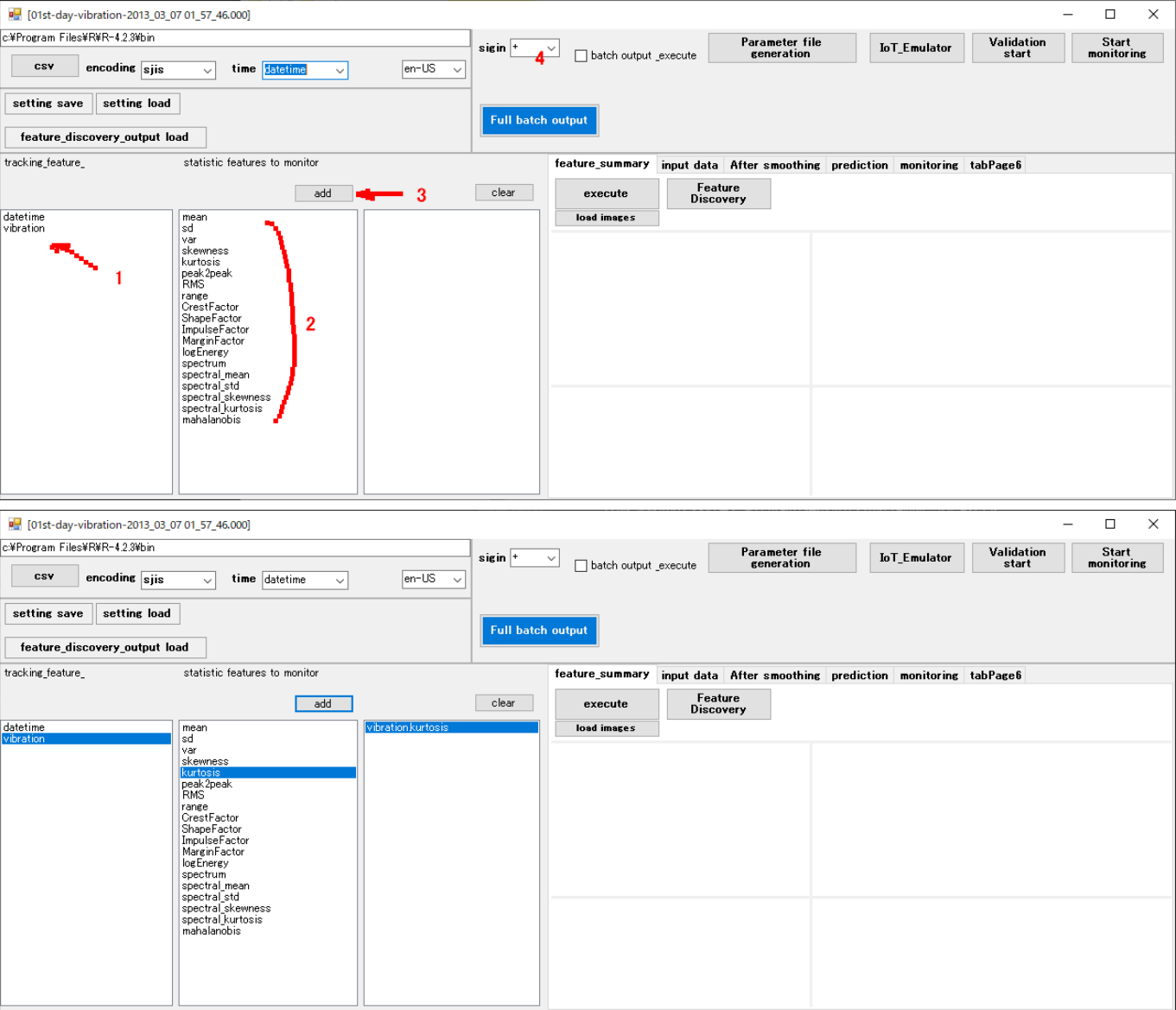
Parameter Settings for Estimating Remaining Useful Life (RUL)

You can set parameters either manually or semi-automatically. You can also adjust specific parameters manually after semi-automatic setting.

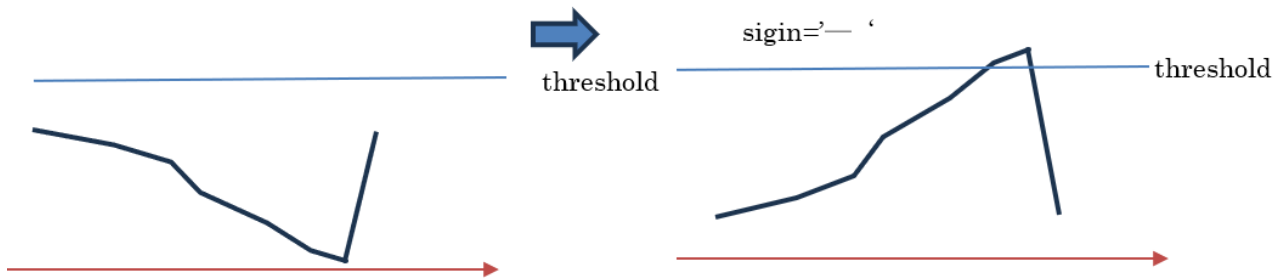
Various Settings

Feature Selection

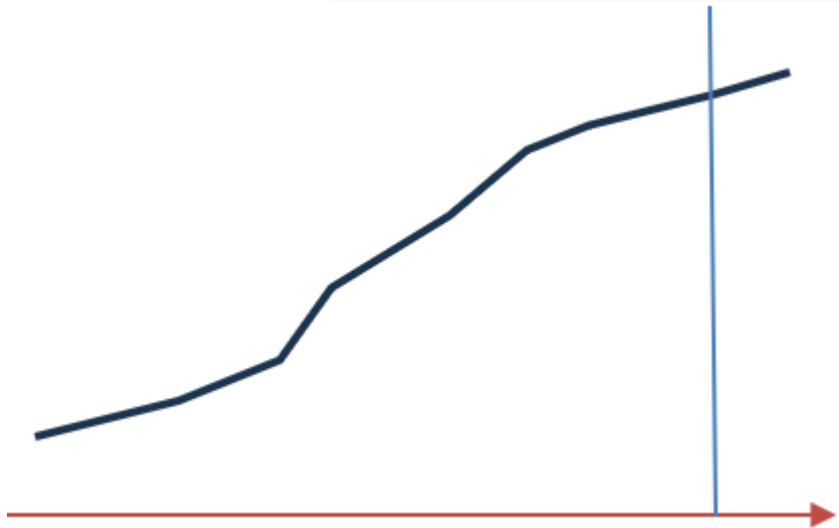
No setup is required for semi-automatic configuration. Select the items and features for tracking RUL and press the **add** button.



- **sign** Specify whether to reverse the sign of the feature.

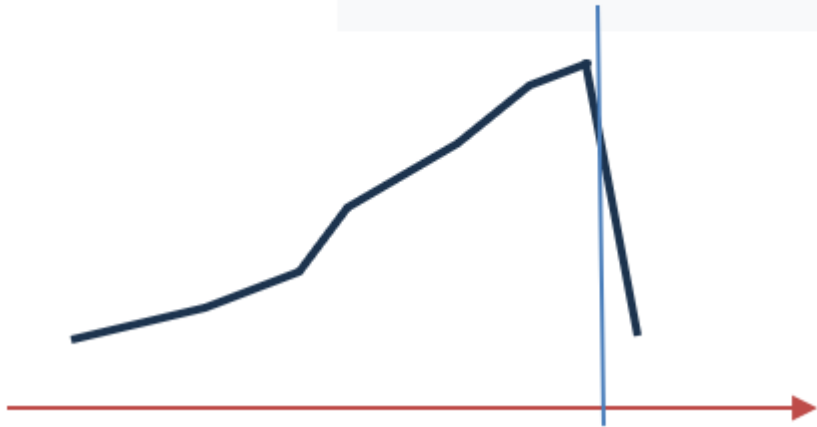


Features need to increase over time to exceed the threshold as the lifespan decreases.



If this feature represents RUL, it will likely show a sharp drop after maintenance, making it critical for decision-making.

maintenance



Two items and features must be set for tracking RUL. Additional settings will not be tracked.

The screenshot shows the 'prediction' tab of the software interface. The 'tracking_feature_' list on the left contains 'datetime' and 'vibration'. The 'feature_summary' section on the right has 'max_prediction_length' set to 800 and 'forecast_time_unit' set to 'day'. The 'prediction model' section has 'use_arma' selected. The 'failure_time_init' is set to '1000*max_prediction_length*unit_of_record'.

Also, **sign** and other parameters are shared. The second listed feature is tracked as reference data. In the later **Forecast Execution (Validation)** step, thresholds will be adjusted automatically.

Input Data Settings

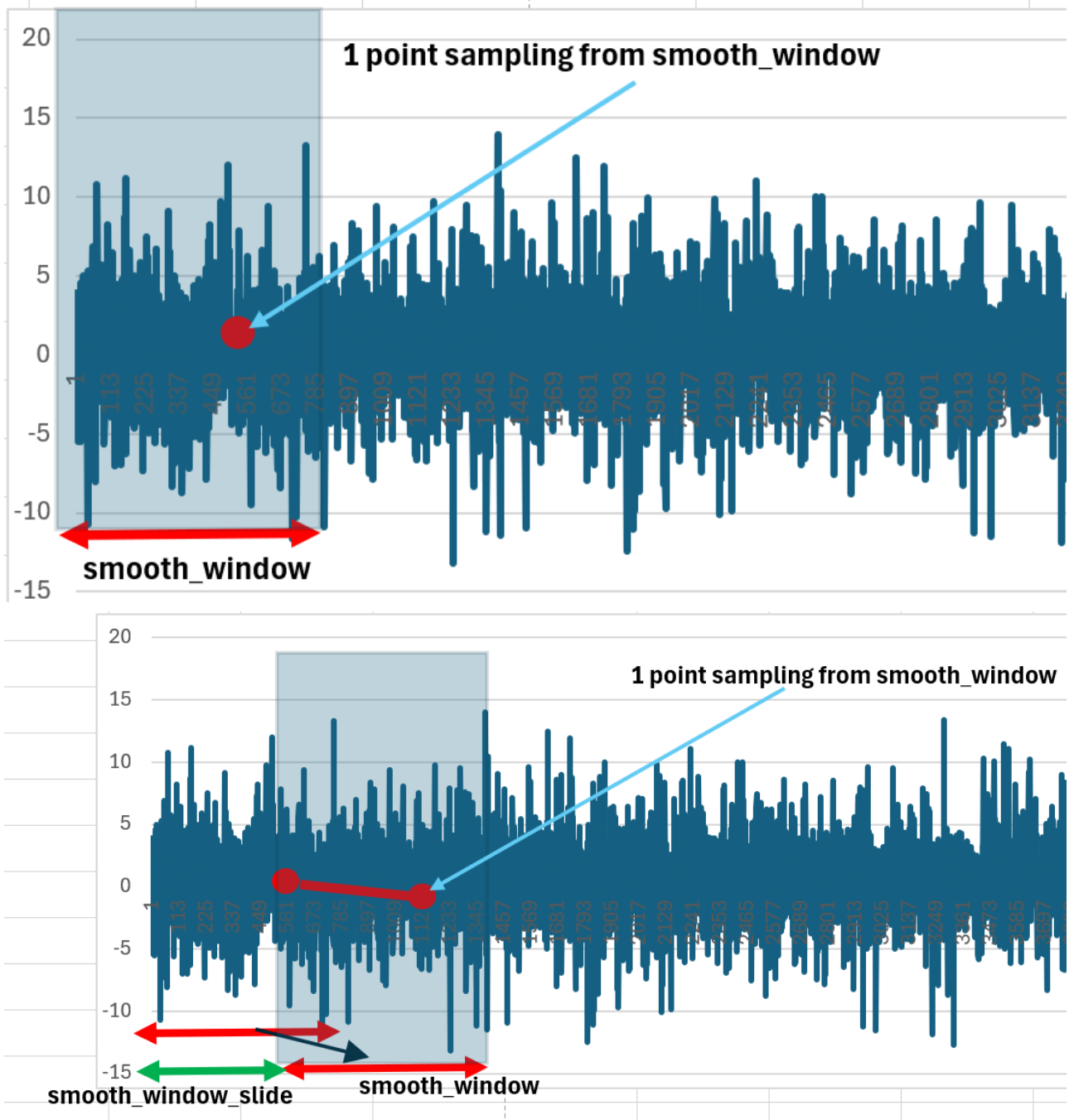
Specify the time unit of the data, the approximate amount of observational data generated each time, the amount used for training, and the maximum amount to retain, including historical data. If the maximum retention is exceeded, the oldest data is automatically deleted.

The screenshot shows the 'input data' tab of the software interface. The 'unit_of_time' is set to 'sec', 'unit_of_record' is '(1/585936)*60*60*24', 'one_input' is '24*60*60', 'max_train_span' is '11*30*24*60*60', and 'max_retained_length' is '3*30*24*60*60'. The 'smooth_window' and 'smooth_window_slide' settings are highlighted with a red box.

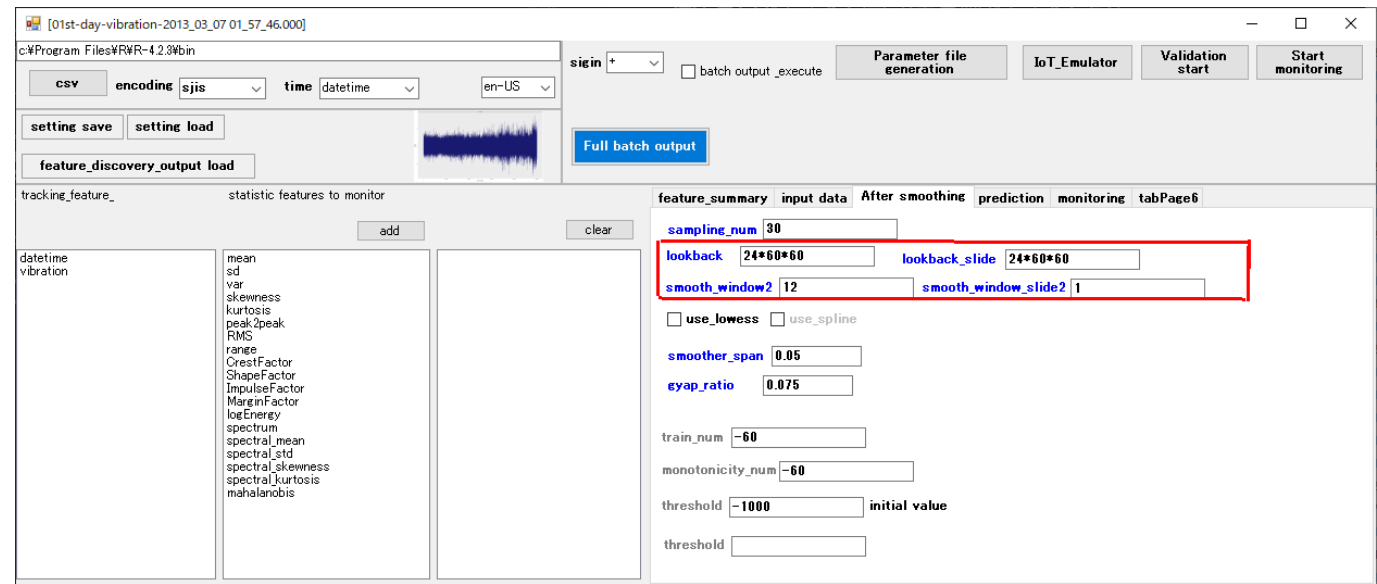
The parts highlighted in red can be set automatically. Typically, this parameter is fine at 0. If the input data is huge, sampling can be done based on **smooth_window** and **smooth_window_slide** settings.

- **unit_of_time** Time unit of the data.
- **unit_of_record** Time interval between rows.
- **one_input** Amount of CSV data provided each time. This is the row count of CSV files provided during operation. CSV files are automatically split based on this setting and generated in the files folder. These files are copied to the Untreated folder, processed one file at a time, and moved from Untreated to the Processed folder during operation.

- **max_train_span** Amount used for training (needed for threshold estimation and Mahalanobis distance calculation). If data accumulation exceeds this amount, threshold estimation stops, and the Mahalanobis distance model is generated using data up to this point.
- **max_retained_length** Maximum retention of historical data. Set it significantly larger than max_train_span.
- **smooth_window** Specifies the window size for sampling input data.
- **smooth_window_slide** Specifies the movement of the sampling window for input data.

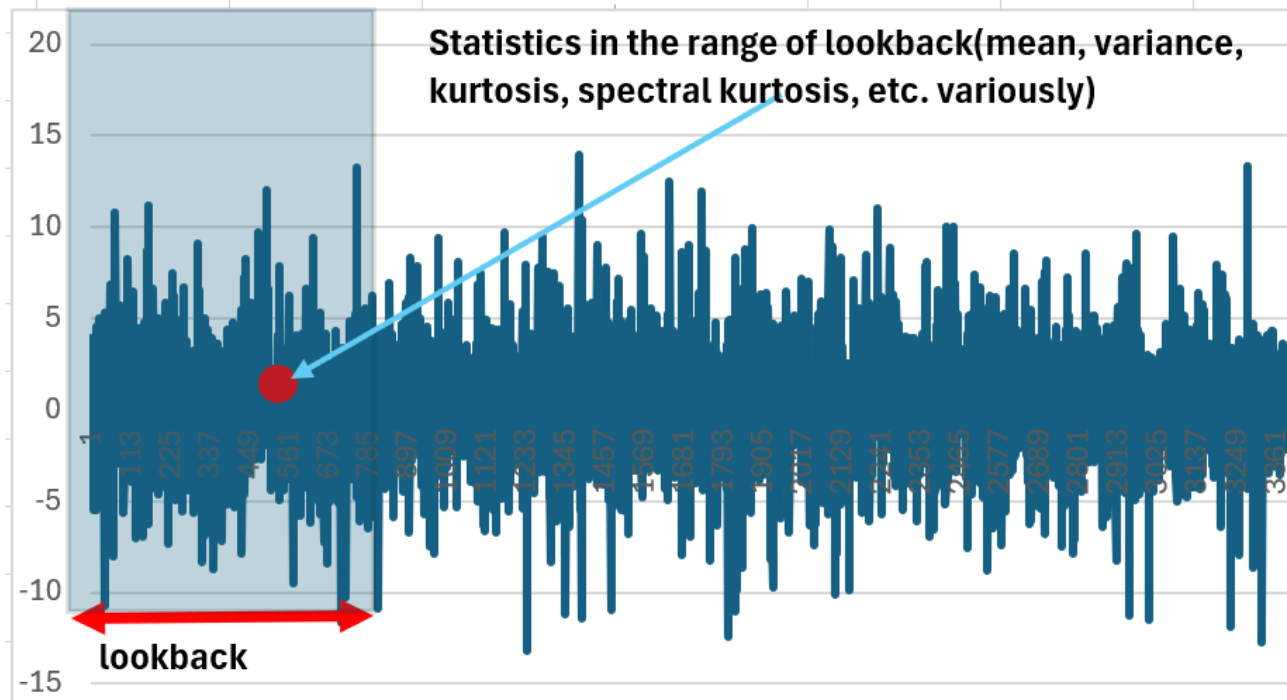


Feature Tracking Settings

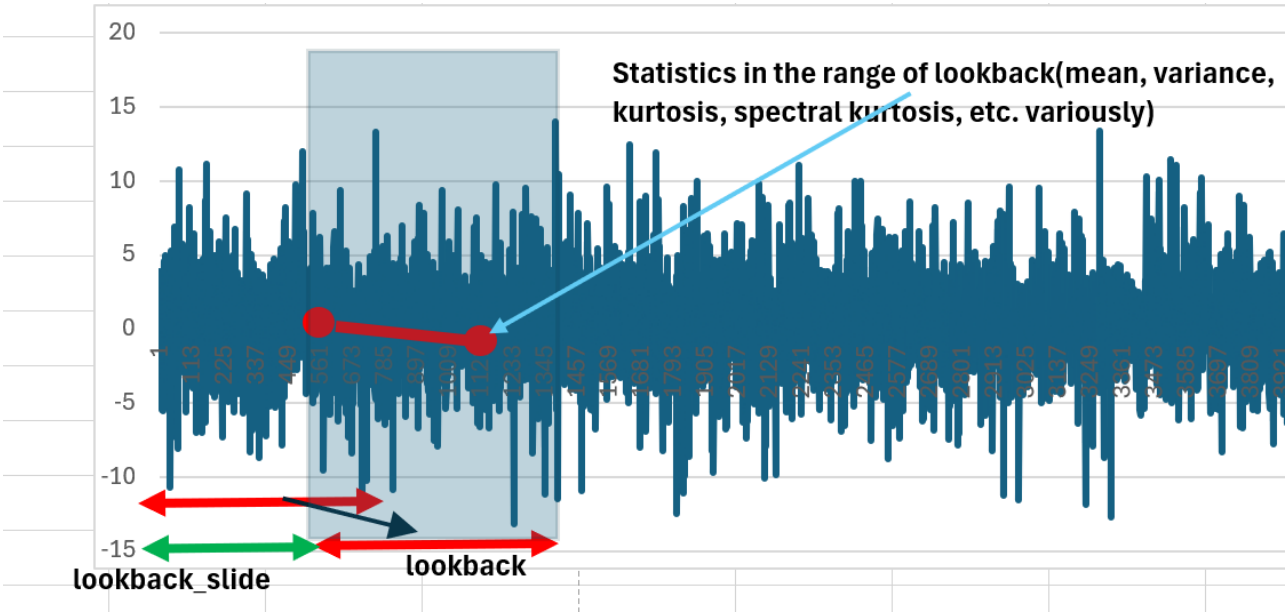


The parts highlighted in red can be set automatically.

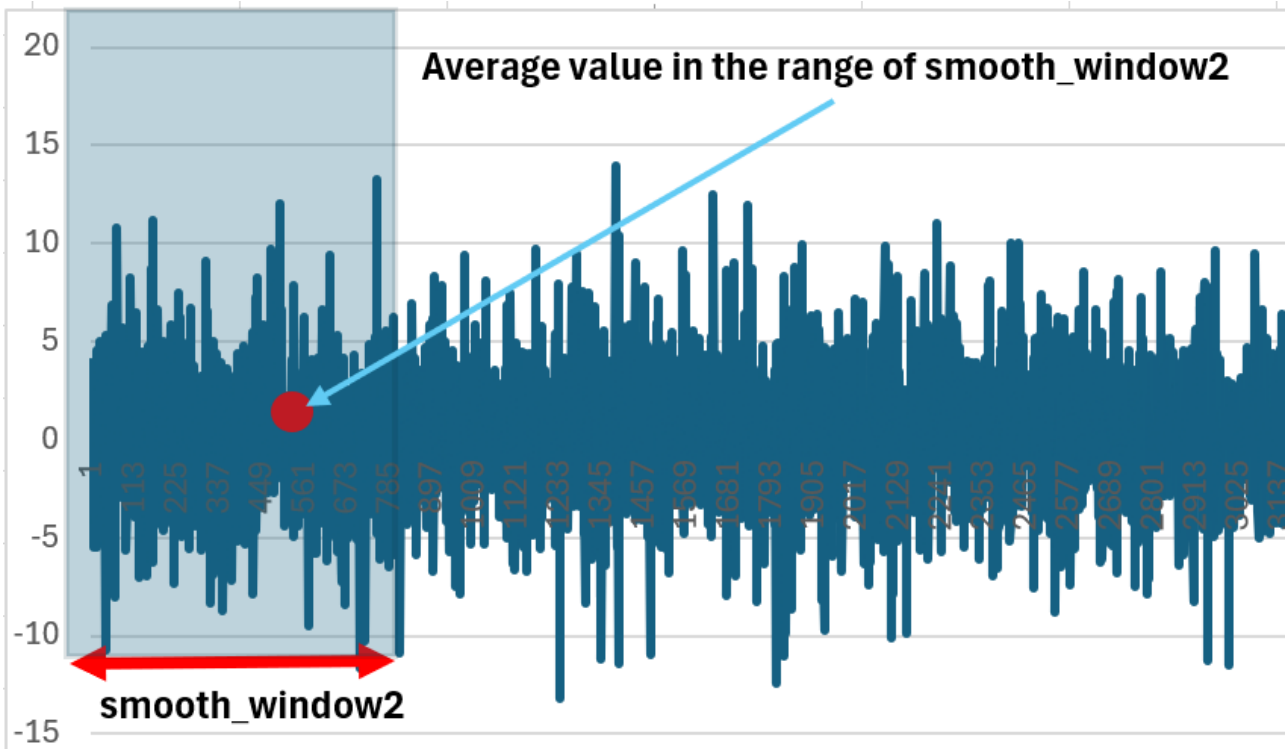
- **sampling_num** Specify the number of samples to fit when creating a prediction line without referencing all historical data.
- **lookback** Specify the window size for creating statistical feature data from input data.



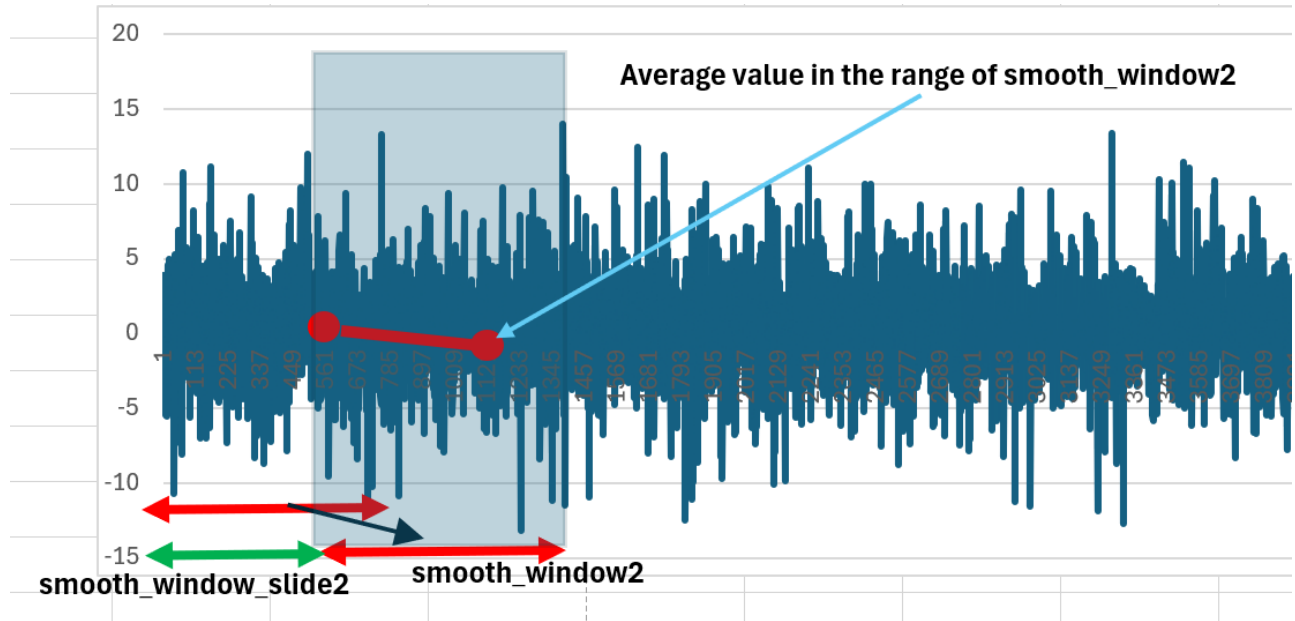
- **lookback_slide** Specify the window movement amount for creating statistical feature data from input data.



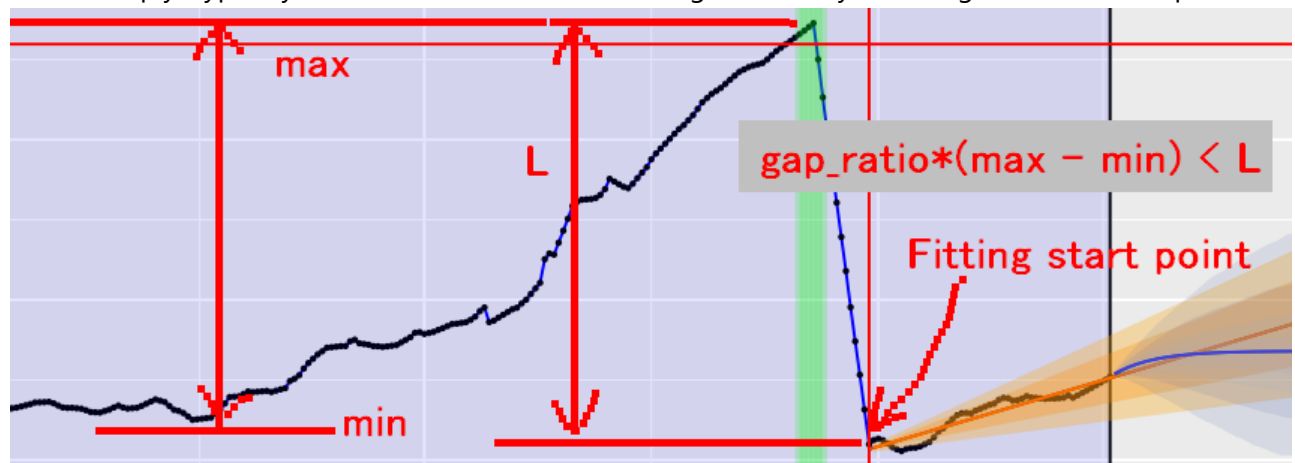
- **smooth_window2** Specify the window size for smoothing features.



- **smooth_window_slide2** Specify the movement of the smoothing window for features.

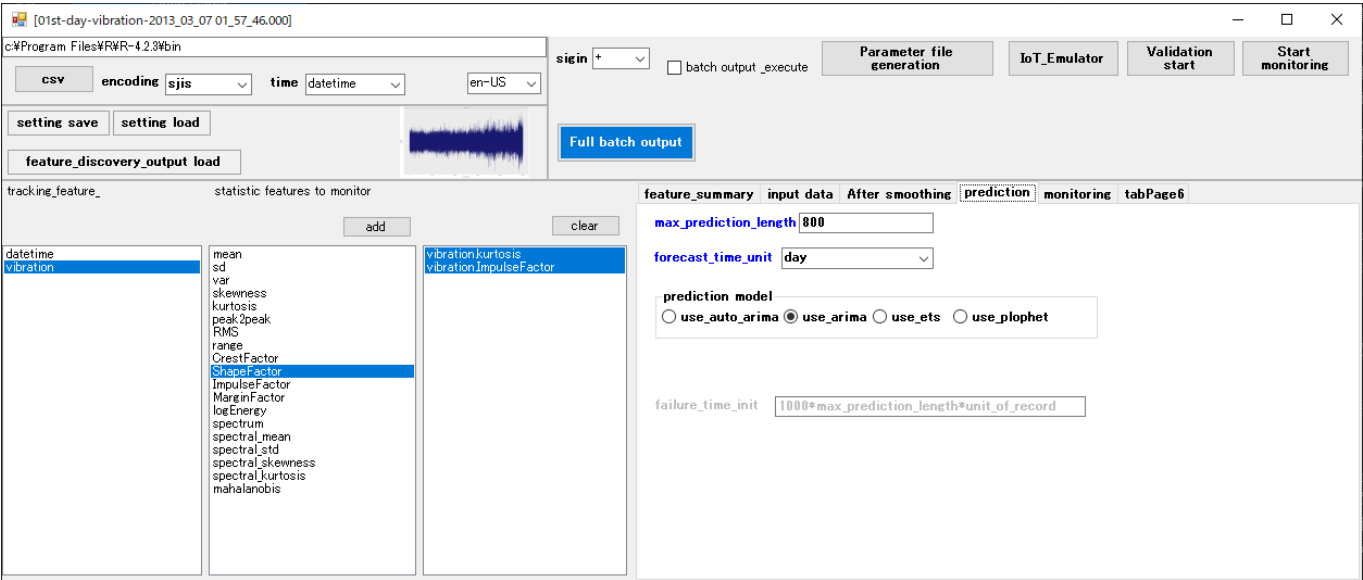


- **smoother_span** Smooth the point sequence before fitting the input data. Smaller values retain the original fluctuations; larger values make it smoother.
- **gap_ratio** Reset the fitting start point to the position of a sudden change when input data trends rise or fall sharply. Typically, after maintenance, trends change drastically, so fitting starts from this point.

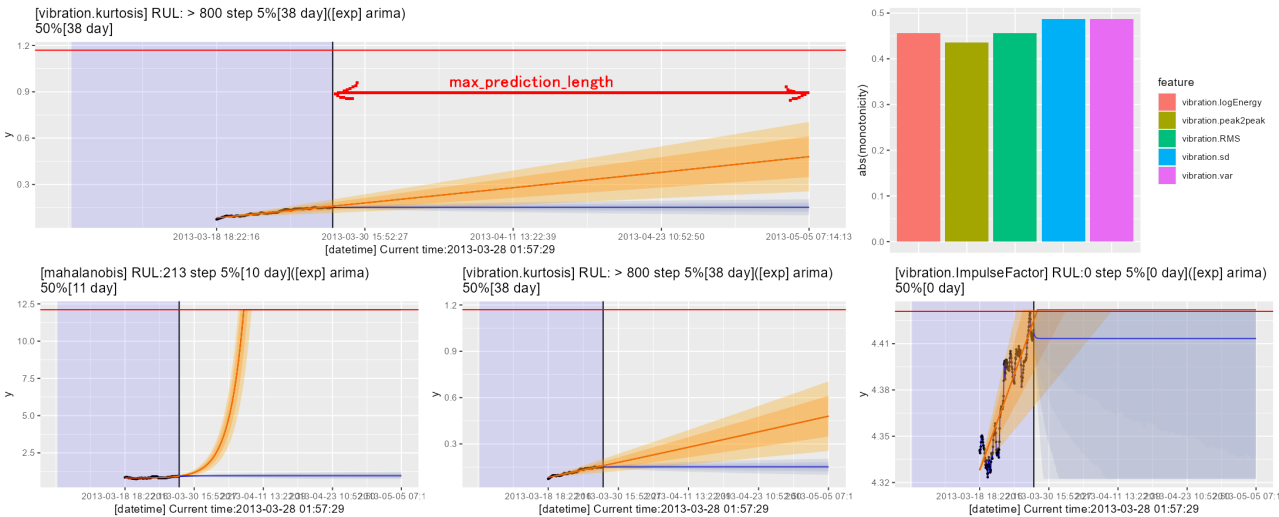


- **train_num** Specify the amount of past data used to create a prediction line. Negative values use all past data. Positive values truncate past data and use only the specified number of points to create the prediction line.
- **monotonicity_num** Specify the amount of past data used for monotonicity checks. Negative values use all past data, while positive values truncate past data and use only the specified number of points.
- **threshold initial value** Automatically adjust the threshold until the total input data exceeds **max_train_span**.
- **threshold** Specify a value as the threshold if automatic adjustment is not performed. This only applies to the first listed feature.

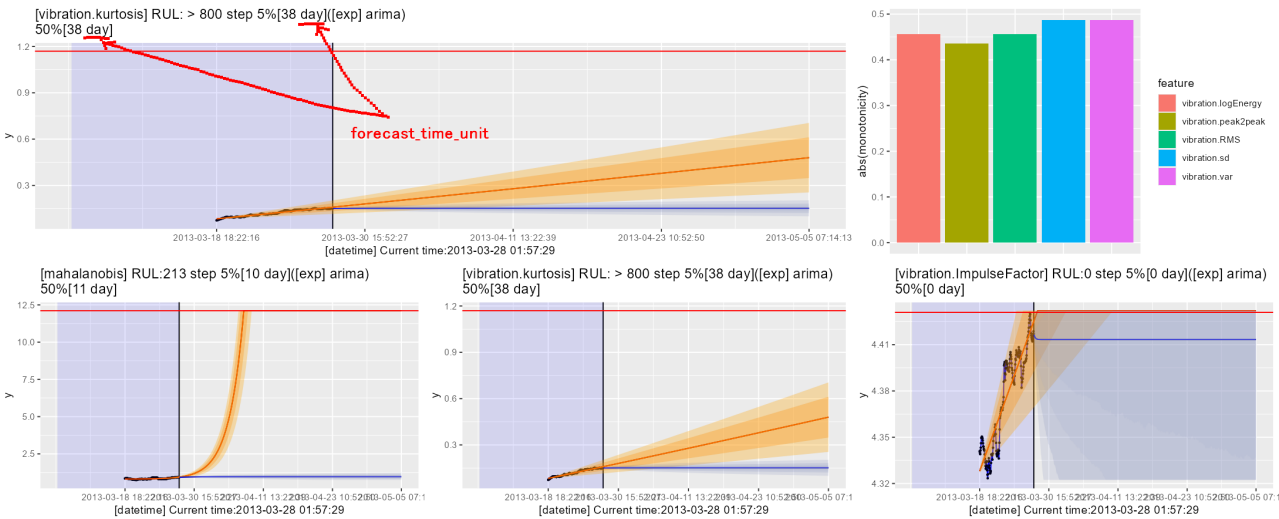
Prediction Conditions Settings



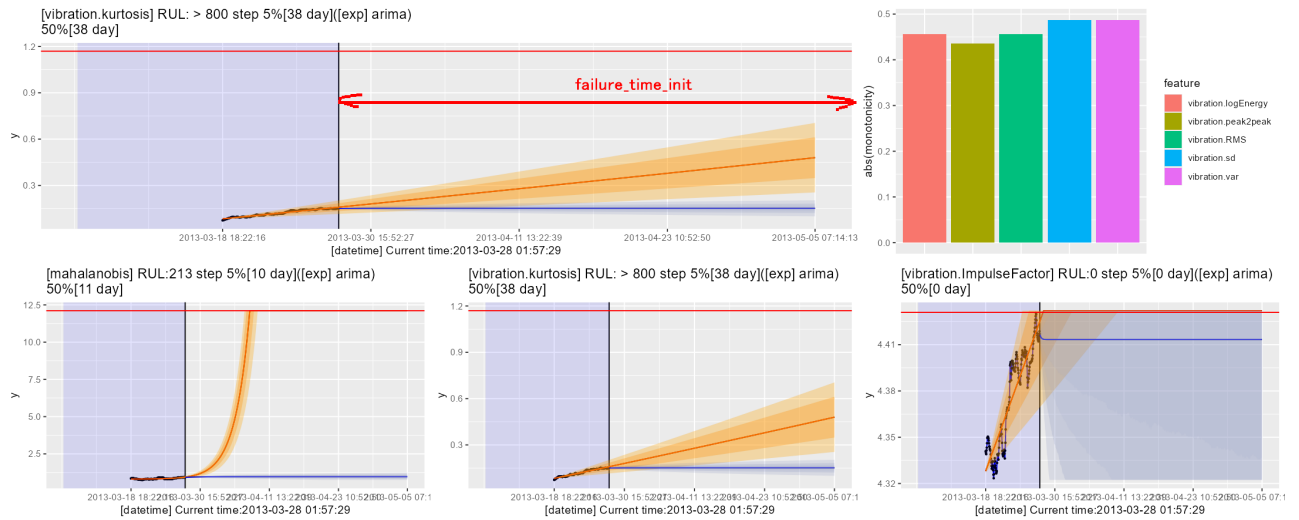
- **max_prediction_length** Specify the number of future points to predict from the last observed point.



- **forecast_time_unit** Specify the time unit for displaying the predicted results.



- **failure_time_init** If the number of maximum prediction points until the threshold is exceeded is surpassed, it is judged that the threshold will not be exceeded even infinitely.



Batch Generation

[01st-day-vibration-2013_03_07_01_57_46.000]

c:\Program Files\FWR-4.2.3\bin

csv encoding sjis time datetime en-US

setting save setting load

feature_discovery_output load

tracking_feature_ statistic features to monitor

add clear

datetime vibration

mean sd var skewness kurtosis peak2peak RMS range CrestFactor ShapeFactor ImpulseFactor MarginFactor logEnergy spectrum spectral_mean spectral_std spectral_skewness spectral_kurtosis mahalanobis

vibration.kurtosis vibration.ImpulseFactor

sign + batch output _execute

Parameter file generation 1

IoT_Emulator 2

Validation start 3

Start monitoring 4

Full batch output

feature_summary input data After smoothing prediction monitoring tabPage6

max_prediction_length 800

forecast_time_unit day

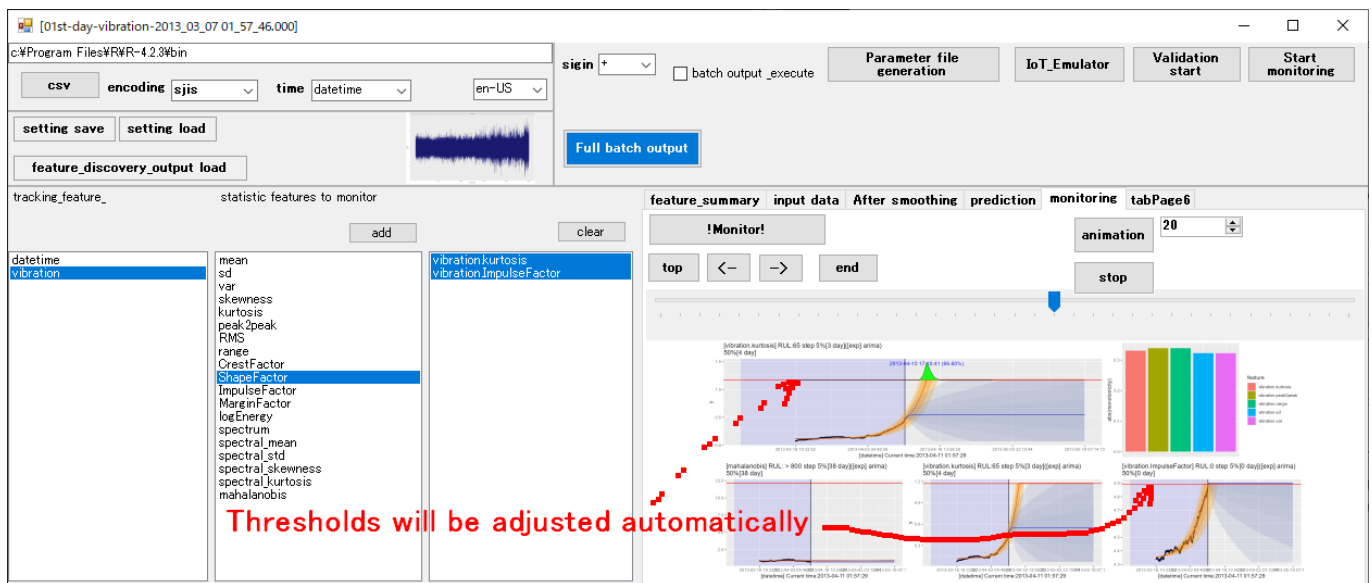
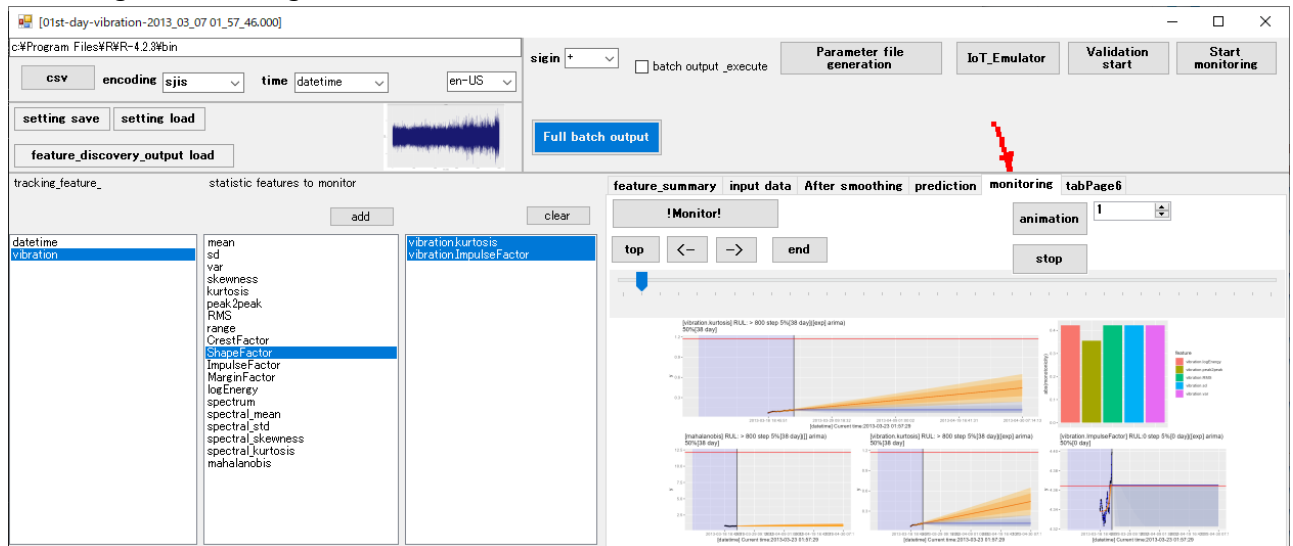
prediction model

☐ use_auto_arima ☒ use_arima ☐ use_ets ☐ use_plophet

failure_time_init 1000*max_prediction_length*unit_of_record

- [1] Generate Parameter File xxxx_parameters.r ("xxxx" is determined from the name of the imported CSV file.)
- [2] Generate Data Emulation Batch xxxx_IoT_Emulator.bat ("xxxx" is determined from the name of the imported CSV file.) Emulates transfer to the folder (**work\Untreated**) for processing CSV files.
- [3] Perform Prediction (Validation) xxxx_test.bat ("xxxx" is determined from the name of the imported CSV file.) Execute the batch and open the **monitoring** tab to visualize the prediction simulation

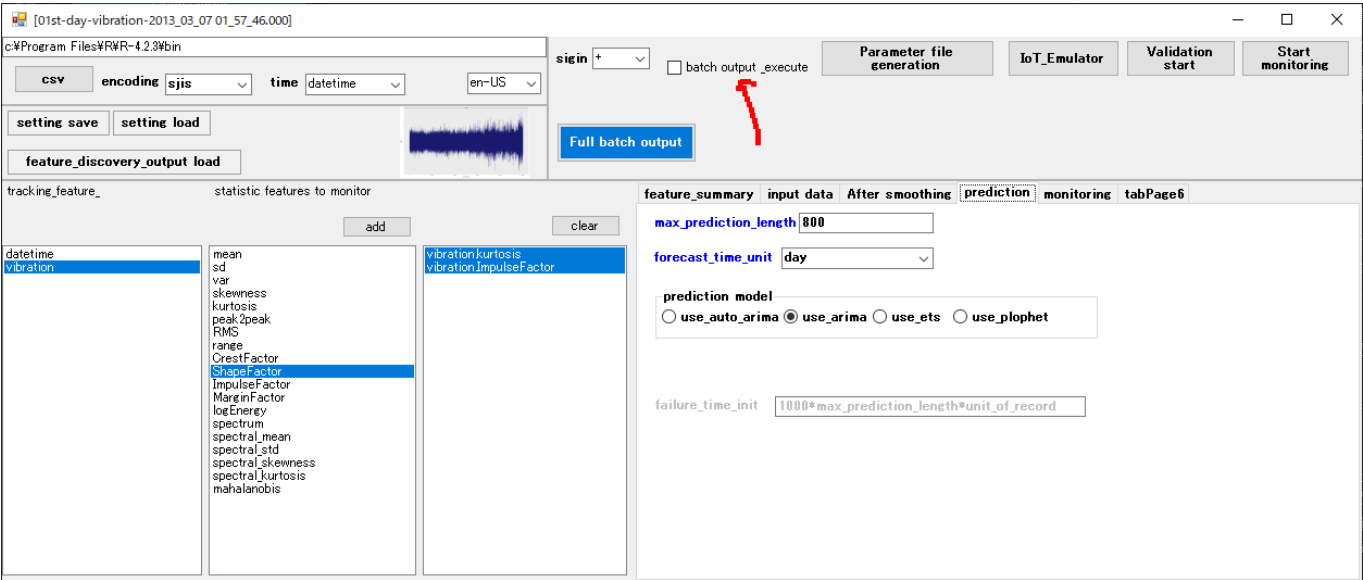
according to the settings.



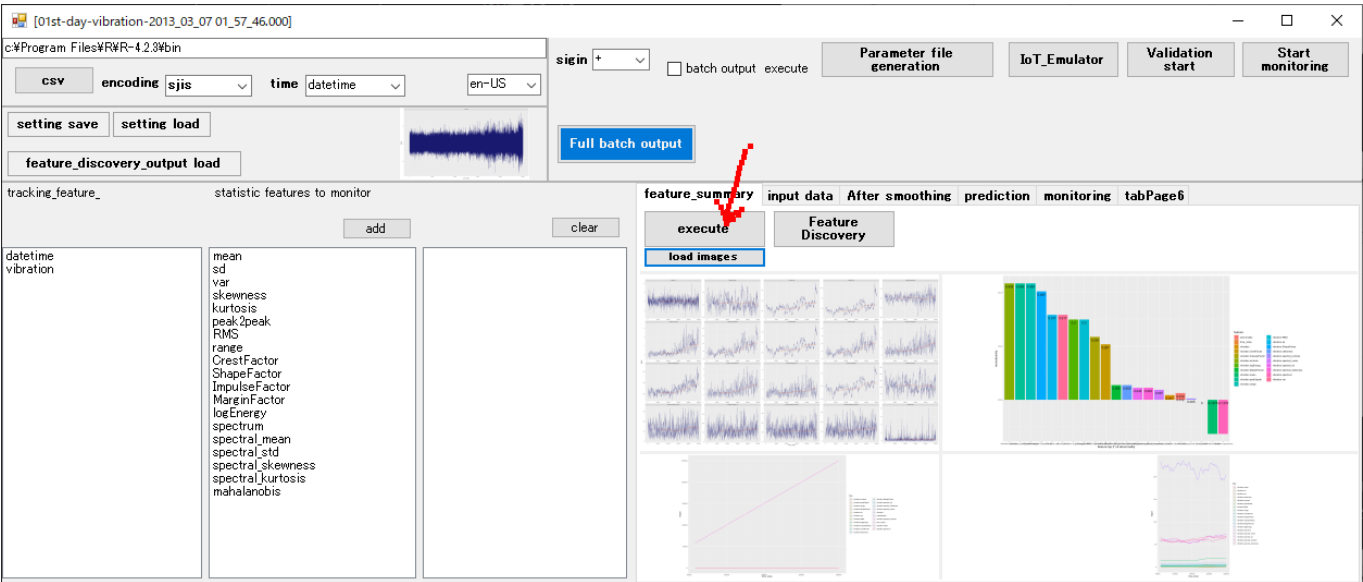
Appropriate thresholds are set during this execution. **Batches must be executed in the order 1, 2, 3.** During this validation execution, parameters are adjusted, and a file "**work/xxxx_feature_param.csv**" is generated and recorded.

- [4] Execute Operation xxxx_execute.bat ("xxxx" is determined from the name of the imported CSV file.) Generate a batch for actual operation. Once operation starts, the folder (**work\Untreated**) for processing CSV files is periodically accessed, and files are processed if present. Files are split and processed according to the **one_input** setting. The **Full batch output** button allows batch output of all files at once. However, even if the **batch output & execute** checkbox is ON, the batch is not executed.

Batch Execution

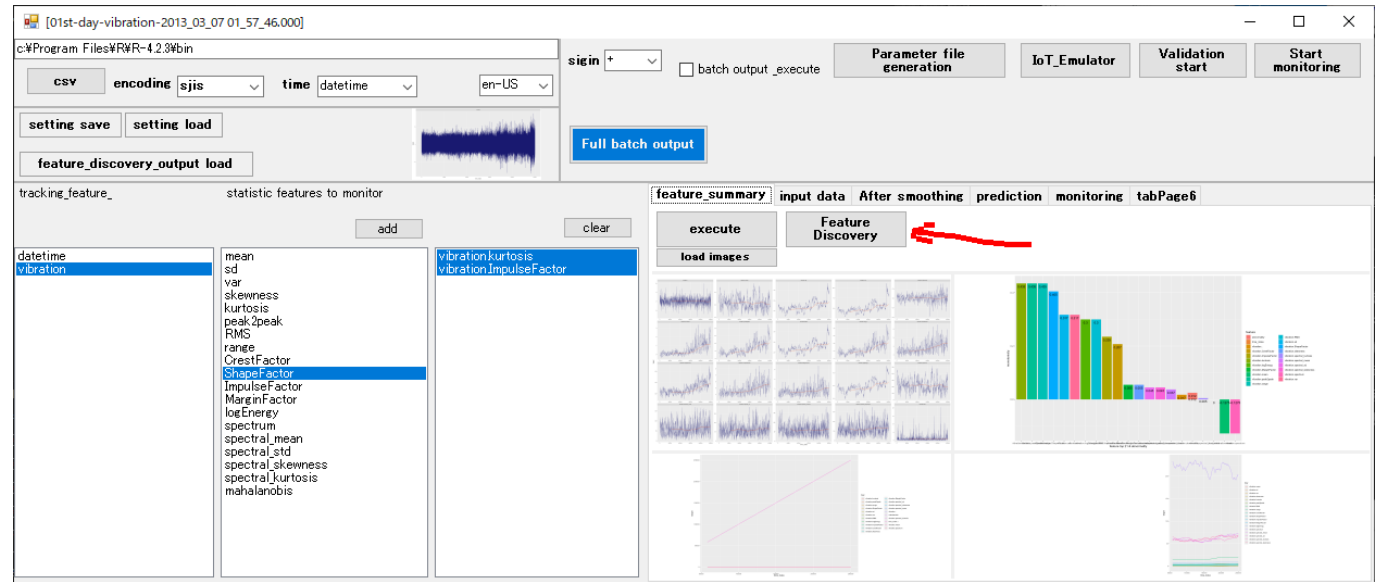


If the **batch output & execute** checkbox is ON, batch generation and execution are performed. After batch generation, individual batches can also be executed from the command prompt. The batch files are output, and they can be executed from the command prompt. Regardless of the method, **Batch Generation** steps 1 and 2 must be executed beforehand. Additionally, if **Feature Summary**



is checked, batch generation and execution are performed if the **batch output & execute** checkbox is ON.

Parameter Auto-Discovery (Semi-Automatic Parameter Setting)

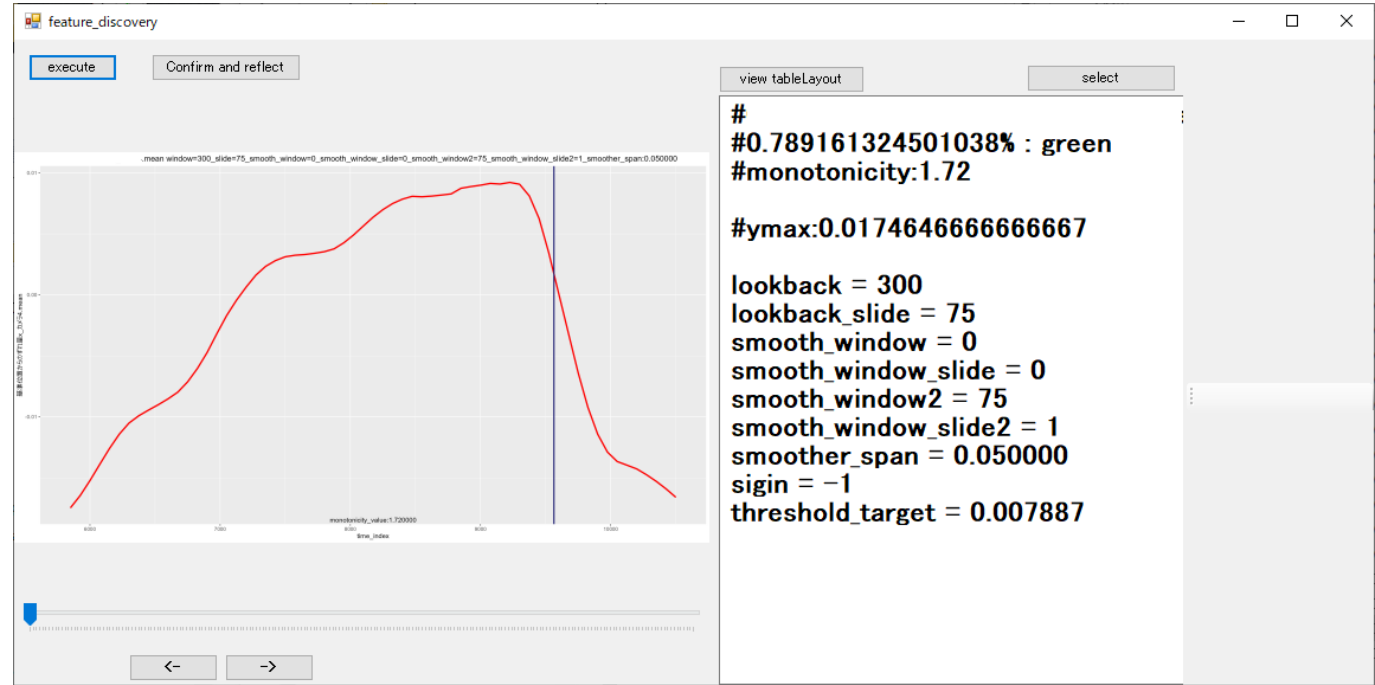


xxxx_feature_discovery.bat ("xxxx" is determined from the name of the imported CSV file.) Generate a batch for parameter auto-discovery. If the **batch output & execute** checkbox is ON, batch generation and execution are performed. This batch starts parameter auto-discovery when executed. The **Timestamp Parameter Settings** step must be completed in advance.

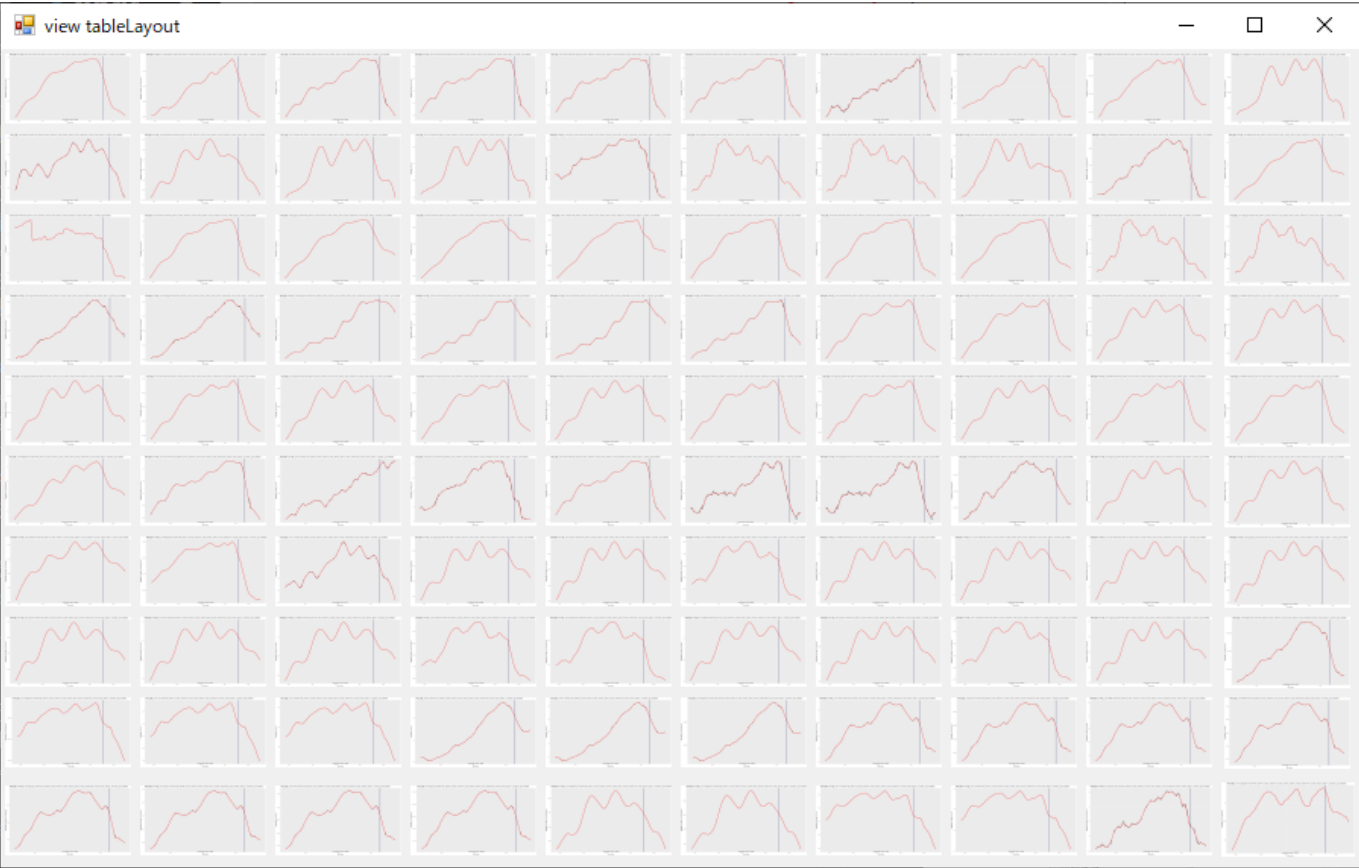
The parameters explored include **smooth_window**, **smooth_window_slide**, **lookback**, **lookback_slide**, **smooth_window2**, **smooth_window_slide2**, **threshold**, and **sign**.

During this exploration, all files in the folder specified during **Importing CSV Data** are combined, and the entire observation period is targeted for exploration.

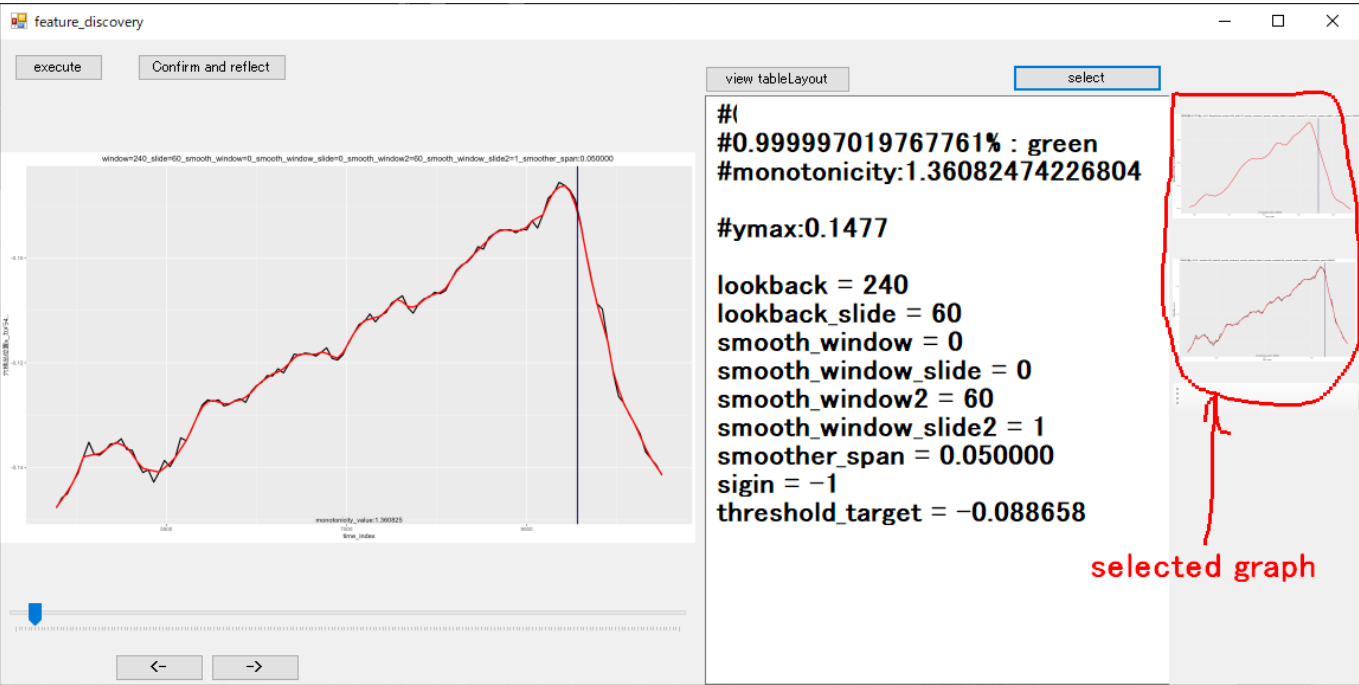
When batch execution ends, the most suitable parameter settings and feature graphs are displayed.



Press the **view tableLayout** button to display all candidate feature graphs deemed suitable.



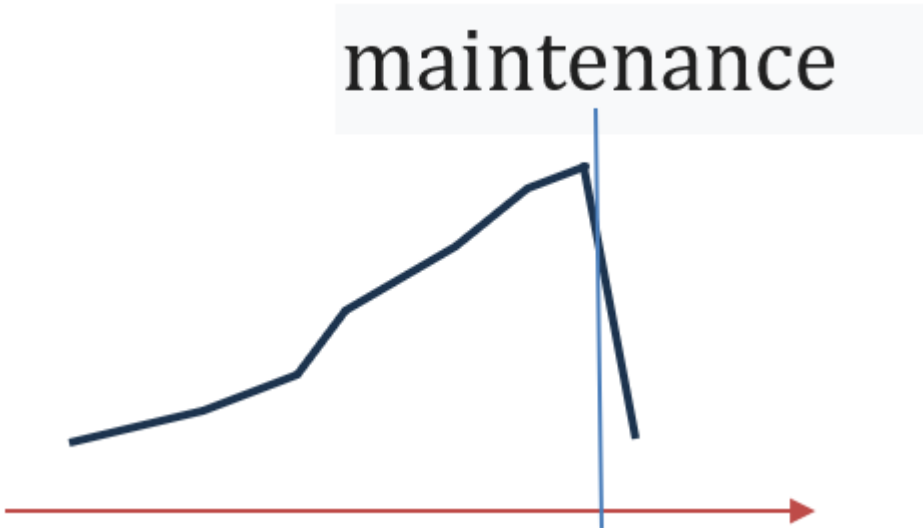
From this list, select appropriate feature graphs or use the trackbar to display suitable feature graphs and confirm the selection with the **select** button. Up to two features can be selected.



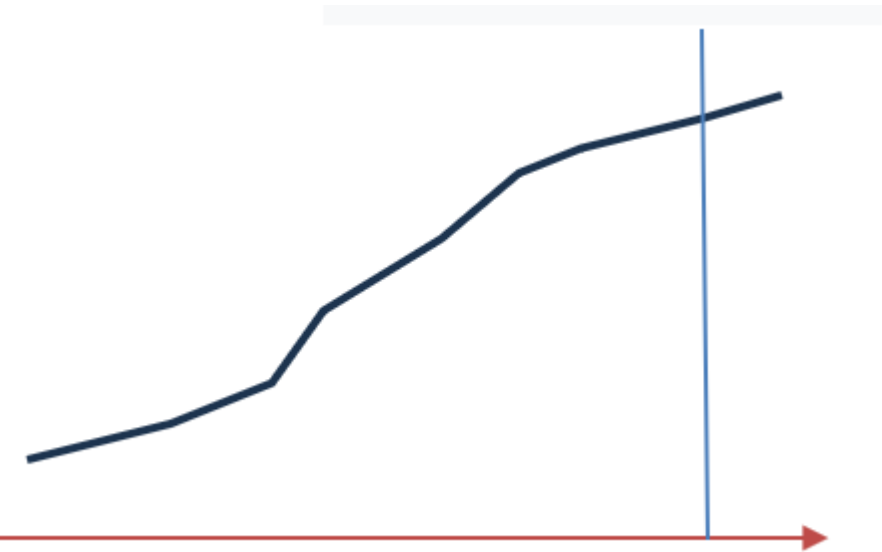
Double-click a selected graph to deselect it. For tracking RUL, the topmost selected graph is used as the primary feature, while the second graph is used as a supplemental feature. Be sure to select two features.

About Selecting Features and CSV Data Items

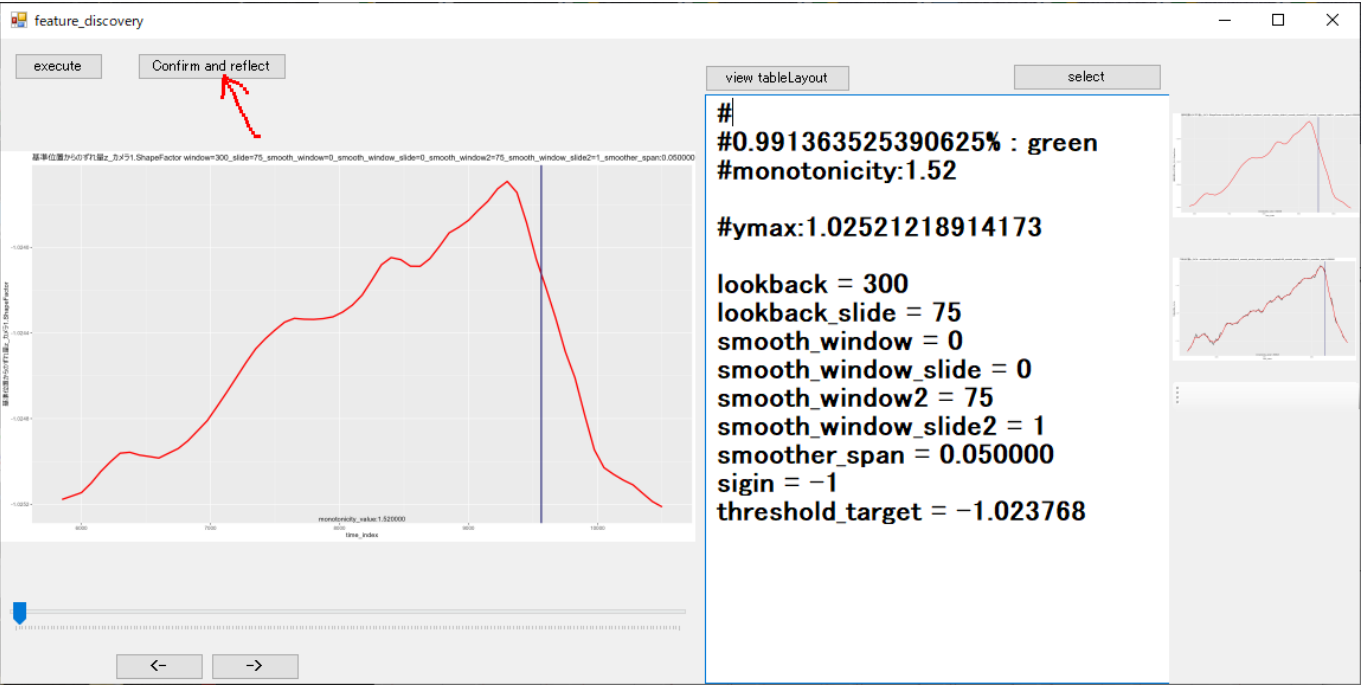
Features for tracking RUL must have an upward trend and exhibit a rapid decrease after maintenance.



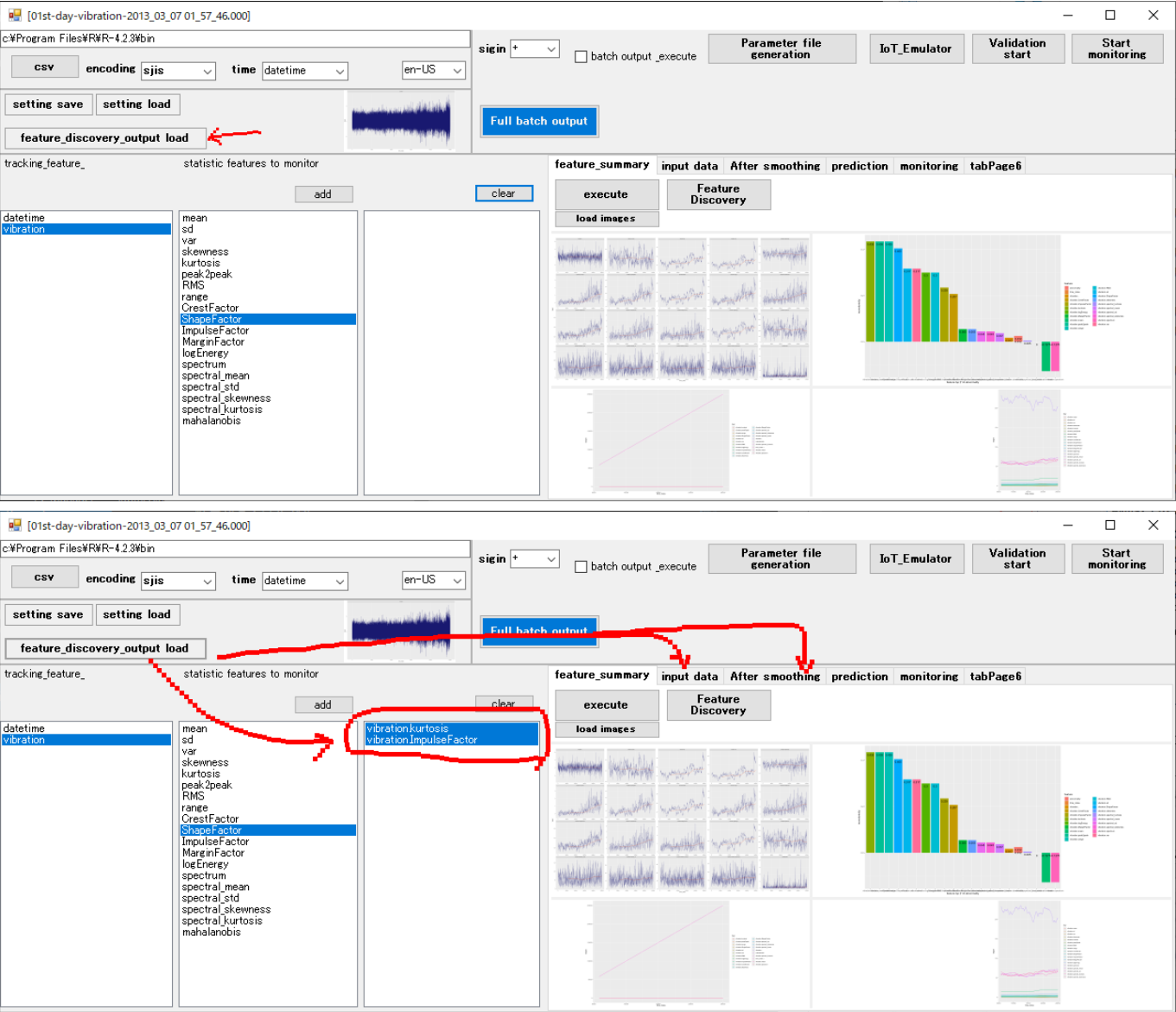
The entire observation period is targeted, but if a column named **maintenance** (with a value of 1 during maintenance periods) exists, the data from the start to the next maintenance and the subsequent maintenance position are extracted to check if they meet the tendencies of features tracking RUL. If no **maintenance** column exists, the data is assumed to start at the beginning and end just before the termination point as if maintenance was performed there. The tendency to meet RUL tracking feature cr...



Confirm with the **confirm and reflect** button.



Next, press the **feature_discovery_output load** button to set all the parameters and selected features from exploration and selection.



Operation Execution

Using the parameter settings generated in **Forecast Execution (Validation)**

"work/xxxx_feature_param.csv", RUL is tracked during operation. Once started, the folder **(work\Untreated)** for processing CSV files is periodically accessed, and files are processed if present.