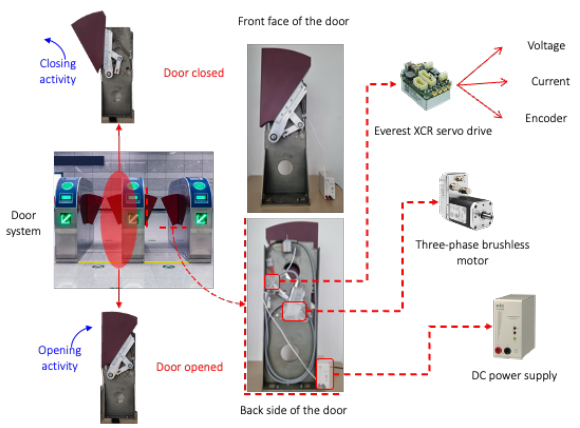
Introduction

In this section, a test bench for the Prognostics of Industrial Machines for System Safety and Integrated Safety (PIMSSIS) is presented. It is used for the development of prognostic algorithms for the estimation of the remaining useful life (RUL) and for the integration of algorithms for health management in the field of system security.

This test bench is a type of rotating machine (servomotor) used in a subway ticket validation door. A general overview of the different parts of the test bench is shown in Figure 1.



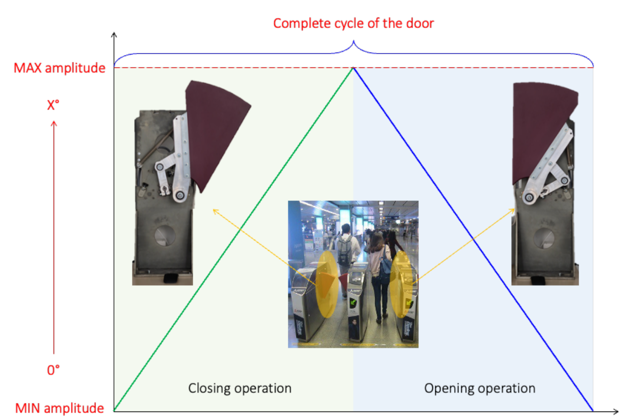


Figure 1: Overall view of the test bench.   Figure 2: Illustration of closing and opening activities.

Specifically, the test bench comprises a three-phase brushless motor and a control board. The three-phase brushless motor supplied by Crouzet Motors Industry (France) is used to move the shaft of the door from position 1 (open) to position 2 (closed), i.e. for the closing activity, and reversely from position 2 to position 1 for the opening operation, as shown in Figure 2.

The movement activities of the door are carried out by the controller developed by INGENIA industry (Spain) called EVEREST XCR, which includes several microcontrollers. The XCR controller is used to set the target position of the door and to monitor and collect the data from the installed hall sensors. It can also embed the monitoring algorithm into one of the built-in microcontrollers to interact with the motor for safety and health management.

The objective of the challenge is the RUL estimation of the degradation of the door position, i.e. the activity of the motor when opening or closing, which is affected by the degradation of the position over time.

The winning teams will be asked to prepare a full manuscript which will be featured in the PHM conference proceedings and a representative will be expected to make an oral presentation at the event. The prize will be awarded at the conference social event.

Datasets and Challenge

Dataset

The dataset is composed of experiments in which the door of the security system performs several opening and closing operations until the door can no longer be opened.
To generate multiple failure scenarios, the XCR controller is used to inject stochastic errors into the closing activity, resulting in a reduction of the maximum position degree over time until failure. In this case, a failure scenario occurs when the closing process can no longer be executed, i.e. when the closing position of the door is less than 10% of the optimal position. For this purpose, a Python script with a baseline degradation equation (see Equation 1) is used to perform this failure simulation and then store the monitoring data from the installed sensors.

$$X_{\max}\left(t_{s_n}\right) = \left[1 - p\left(t_{s_n}\right)\right] \cdot X_{\max}\left(t_{s_{n-1}}\right)$$

$X_{max}\left(t_{s_n}\right)$ and $X_{max}\left(t_{s_{n-1}}\right)$ are the maximal position degrees of the subway door after the n_{th} and the n_{th-1} degradation.
$p\left(t_{s_n}\right)$ is the degradation percentage caused by the nth shock. It is chosen randomly from predefined ranges and reflects the severity of shocks' impact on degradation.
t_{s_n} is the occurrence time of the shocks and it reflects the different degradation rates (degradation speed) of the door.

The variation of these parameters above allows us to generate several failures representing realistic dynamic behavior of the system degradation.

To illustrate, let us assume that the door moves from position 0 to 190 when closing and returns to 0 when opening. Note that these values correspond to the nominal operation of the door. Initially, the Python script randomly generates the time of the first occurrence of a position deterioration, e.g. t_{s_n1}= 4800s from a range of [3600, 7200] s. This time t_{s_n1} represents the moment when an anomaly occurs and causes a reduction in the actual closing position. Here too, the position deterioration $p\left(t_{s_n1}\right)$ is selected randomly from a range [2, 14] % according to a percentage. For example, if $p\left(t_{s_n1}\right)$=5 %, then the closing position changes from 190 to 180.5.
The triggering threshold of position is fixed to 10% of the optimal closing position and it corresponds to the time when we consider the door as failed because under this value the XCR detects that the closing position is too low and consequently cannot move the door anymore.

The failure scenario described above is executed under three different operating conditions multiple times. Each operating condition describes the velocity, acceleration and deceleration in the closing activity. This latter activity allows the collection of dynamic run-to-failure data to test the performance of prognostic algorithms. The overall data set is collected and summarized in Table 1.

In detail, 16 monitoring parameters are collected in .csv files, and each file contains 600 samples of closing or opening activity.. Note that two successive files of closing and opening activities constitute a cycle.

This dataset is part of a single study carried out by Dr. Moncef SOUALHI, Dr. T. P. Khanh NGUYEN and Prof. Kamal MEDJAHER (https://doi.org/10.1016/j.compind.2022.103766). In this study, a first approach with some performance metrics is proposed. It also shows and highlights the practical difficulties in developing PHM algorithms for RUL estimation.

Collected data (.csv files) Description							
Column 1	**Column 2**	**Column 3**	**Column 4**	**Column 5**	**Column 6**	**Column 7**	**Column 8**
Time	POS_REF	POS_FBK	VEL_FBK	VEL_FBK	FBK_DIGHALL	FBK_DIGENC1	DRV_PROT_VBUS
Duration of acquisition	Reference of desired position	Feedback of actual position	Reference of desired velocity	Feedback of actual velocity	Feedback of digital hall	Feedback of digital encoder	Voltage bus level of the driver
Column 9	**Column 10**	**Column 11**	**Column 12**	**Column 13**	**Column 14**	**Column 15**	**Column 16**
MOT_PROT_TEMP	FBK_CUR_A	FBK_CUR_B	FBK_CUR_C	DRV_PROT_TEMP	FBK_VOL_A	FBK_VOL_B	FBK_VOL_C
Temperature of the motor	Feedback current A	Feedback current B	Feedback current C	Temperature of the driver circuitry	Feedback voltage A	Feedback voltage A	Feedback voltage C

Table 1: Synthesis of the different monitoring measurements with referent command data.

Challange

The objectives of this data challenge is to predict when the door system stop working, creating a model able to accurately determine the Remain Useful life (RUL) of the door opening system. The model must be able to predict the RUL **without knowing** the operating condition, simulating the typical scenario of a real system in which the operating is unknown.

The objective of this data set is to predict when the door will cease to function. The main challenge is to propose a technique, a model, a methodology or an approach that can effectively estimate the useful life of the door, despite the variability of the degradation rate, the amplitude of the position at failure and the anomaly occurrence time, with the few existing scenarios.

For this, the teams will have the following experiments for training:

Model training: 48 experiments describing the run to failure of the door closing system are released and used as training and validation datasets. The dataset includes experiments with all operation conditions. For each operating condition, 16 experiments are reported. Table 2 describes the training dataset.

Operating conditions of the PIMSSIS platform				
Velocity	**Acceleration**	**Deceleration**	**Experiments**	**Acquisition parameters**
15	18	18	16 scenarios	Hardware: INGENIA servomotor File extension: .csv Time: 600 samples/file
10	15	15	16 scenarios	
15	18	15	16 scenarios	

Table 2: Synthesis of the different operating conditions of the platform.

For testing the model performance, the following experiments will be used:

Model testing: 18 experiments describing the run-to failure of the door closing system are used as test datasets. The datasets include operating conditions that were available during the training phase. For each operating condition, for testing 6 experiments will be used.

GitHub Repository

For Questions and Answers, Teams are encouraged to leverage the PHME Data Challenge GitHub repository to open issues and discuss them. The repository will be used also to publish updates such as the evaluation metrics, evaluation process, and the Jupyter script used for the evaluation.

Prize

Each of the winning teams will be offered one free registration per team for the conference.

Relevant Dates

Competition Open	Mar 29, 2024
Competition Closed	June 24, 2024, 11:59:59 GMT
Winners Announced	June 27, 2024
PHM Conference Dates	July 03 2024

Teams

Collaboration is encouraged and teams may comprise students and professionals from single or multiple organisations. There is no requirement for team size. Register your team's entry by filling out the form.

The winning teams will be selected and awarded contingent upon:

- Having at least one member of the team register and attend the PHM 2024 Conference.
- Presenting the analysis results and techniques employed at the conference.

The organizers of the competition reserve the right to modify these rules and disqualify any team for any efforts it deems inconsistent with fair and open practices.