ICPHM23 Data Challenge on Industrial Systems' Health Monitoring using Vibration Signal Analysis

Introduction

Industrial systems are prone to defects and failures, which may lead to various undesirable consequences. Industrial practitioners and managers, therefore, are motivated to leverage real-time system monitoring techniques to mitigate the risk of failures, reduce machinery downtime, and have optimum productivity by performing efficient maintenance strategies.

Vibration signals are widely used for fault detection in industrial/manufacturing machinery and are the focus of the ICPHM23 data challenge. ICPHM23 aims to encourage research on developing machine learning (ML)-based models for analyzing vibration signals for industrial systems' health monitoring.

Initial Dataset

- The initial dataset will be released on 27th Feb., 2023.
- The dataset includes vibration signals of normal and four different types of fault conditions and their corresponding ground-truth labels for two different operational conditions.
- Vibration signals have been divided into smaller segments using window size of 200 data points to reduce the computational time.
- Vibration signals are available in three directions (x, y, z). Participants are free to use either one direction or any combination of them.
- Papers results should be written based on the model's performance trained and tested on the initial dataset over a five-fold cross-validation approach. The same model should be used for both operational conditions.

Final Test Set

- The final test set (without the ground-truth labels) will be released on 25th March. 2023.
- Participants need to submit their model's predicted labels on the final test set for both operational conditions in a ".csv" file.

Submission Guidelines

Participants submit their codes in the Python environment. Each team needs to submit a ".zip" package including:

- A ".csv" file containing the predicted labels for the test set.
- A ".pdf" file for the report. The report should follow the PHM paper template or report template.
- A folder including all codes to execute the model and a ".pdf" file providing a brief and straightforward explanation to the technical committee on how to use the code and run the model. Please submit your work by email to ***farnoosh.naderkhani@ieee.org***.

We encourage participants use the Piazza platform which is an online gathering place where students can ask any question and doubts, answer, and explore under the guidance of our data challenge organizers. Please register via https://piazza.com/icphm2023/other/31

Teams

Teams can be comprised of students and professionals from one or multiple organizations. There is no restriction on team size. You can register your team's entry via EDAS: https://edas.info/newPaper.php?c=30293

Teams should respect the following criteria:

- Full in person or virtual registration at the PHM 2023 Conference is needed by all team members.
- Participants need to submit either a full-length paper or a report. If you decided to submit a full paper report, and present your work at the conference, after review process, all presented papers that meet IEEE quality standards will be submitted to IEEE Xplore for publication. You can find a sample template for both report and full paper on the conference webpage.
- Presentation of the results and the methodology at the conference. Presentations can be either in-person or virtual.

If a team's behavior is inconsistent with fair and open competitions, the organizers reserve the right to modify these rules and disqualify that team.

Prize

The winning team will be awarded 1000 $. The second team will be awarded 500 $, and the third team will be awarded 300 $. Additionally, each of the top three teams will be offered one free registration per team for the next year conference. Please note that if additional sponsorship funding is secured, the prize money for the competition could be increased.

Tentative Schedule

Competition Open:	27th Feb., 2023
Initial data will be released:	27th Feb., 2023
Teams' author information registration on ICPHM23 data challenge in EDAS:	10th March., 2023
Test data will be released:	25th March., 2023
Results Submission:	31th March., 2023
Finalist Teams Announced:	12th Apr., 2023
Registration at Conference:	14th Apr., 2023

Link to Data

You can access the data set via the link below:

https://drive.google.com/drive/folders/1fdpMztoH1kCBx9G8lKDLPMAXShKqm412?usp=sharing

Organizing Committee and Jury Members

Dr. Farnoosh Naderkhani, Assistant Professor at Concordia University, Program Chair of ICPHM 2023.

Dr. Janet Lin, Professor at Mälardalen University, Sweden and Luleå University of Technology, Sweden.

Paper Review Chair of ICPHM 2023.

Dr. Haizhou Chen, Researcher at Luleå University of Technology, Sweden.

Mr. San Giliyana, Industrial Doctoral at Mälardalen Industrial Technology Center (MITC), Sweden.

Mrs. Nastaran Enshaei, PhD Candidate at Concordia University, Local Arrangement Vice Chair of ICPHM 2023.

Mr. Soroush Shahsafi, PhD student at at Concordia University, Virtual Session and Publicity chair of ICPHM

2023.

Mrs. Mehrnaz Mirzaei, Master of Science Student at Concordia University.

Data Sponsor

For ICPHM2023, MDU/MITC provide experiment data for the competition from a test rig consists of a driving motor, two-stage planetary gearbox, two-stage parallel gearbox and magnetic brake.

❖ **Mälardalen University (MDU)**

MDU has campuses in Eskilstuna and Västerås, Sweden. Around 20 000 students study courses and programmes in Design and Communication, Economics, Healthcare, Education, Engineering, Chamber Music, and Opera. At MDU research is carried out in many disciplinary domains to solve problems in society, whereby research in Future Energy and Embedded Systems is internationally prominent.

❖ **Mälardalen Industrial Technology Center (MITC)**

MITC in Sweden builds on collaboration between the manufacturing industry and academia. Results are created where different competences, capabilities and technologies meet, and since 2011 MITC has been generating results through building needs-driven co-operation for SMEs development, training, research, and technical projects together with our industrial partners. The testbed from MITC includes IoT- platform, IoT sensors for maintenance data collection, AR for maintenance instructions and remote maintenance, a new generation of Computerized Maintenance Management System (CMMS), communication and data collection through the communication standard Open Platform Communications-Unified Architecture (OPC-UA), data visualization, data analysis using AI, and Application Programming Interface (API) for system integration.

Dataset Description

The test rig consists of a driving motor, two-stage planetary gearbox, two-stage parallel gearbox and magnetic brake as shown in *Figure 1*. The experiment just focuses on the planetary gearbox, and the detailed parameters are described in Table *1*. The test rig is driven by an alternative current motor, and its rotating speed ranges from 0 to 6000 revolution per minute (rpm), which is adjusted by a speed transducer. The torque is applied to the output shaft of the parallel gearboxes by the magnetic brake. Due to the heavy alternative stress and impact, sun gear teeth on the second stage of the planetary gearbox are more likely to suffer damages in practical application, and thus four common sun gear faults, i.e. surface wear, chipped, crack and tooth missing, are created as shown in Figure *2*. The vibration signals are acquired by the portable data acquisition system of National Instruments (NI), of which the acquisition card is NI PXI-4498. The acceleration sensor is 356A01 manufactured by PCB Piezotronics, which is mounted on the second stage of the planetary gearbox to acquire the vibration signals. The vibration signals for this data challenge have been acquired under two different operating conditions, as represented in Table *2*. Each vibration signal is recorded in three directions (x, y, z), for a period of five minutes, and with a sampling frequency of 10 kHz. The examples of time-domain signal acquired in different operating conditions are displayed in Figure *3* and Figure *4*.

Table 1. Specifications of planetary gearbox

Parameters	First stage			Second stage		
	Sun gear	Planet gear	Ring gear	Sun gear	Planet gear	Ring gear
Teeth number	20	40	100	28	36	100
Gear number	1	3	1	1	4	1
Reduction ratio	6:1			32:7		

Table 2: The operational condition for two experiments

	Motor speed (rpm)	Load (Nm)
Exp. 1	1500	10
Exp. 2	2700	25

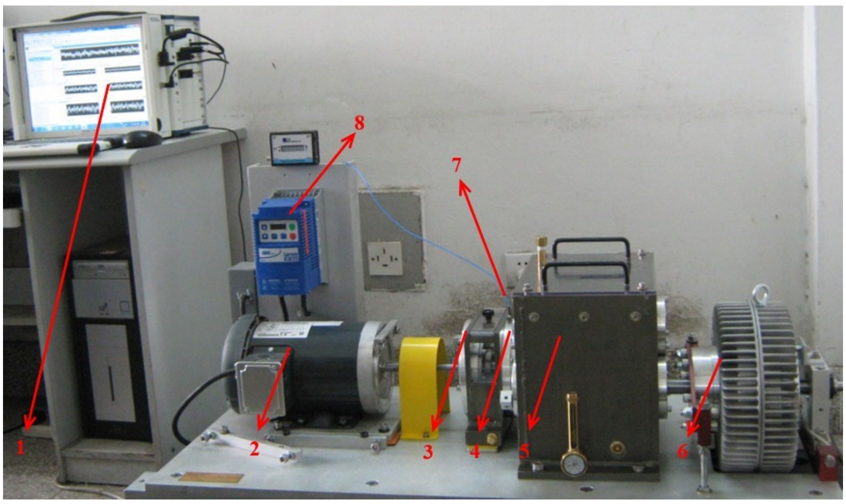

Figure 1. Test rig. 1-Portable data acquisition system, 2-Motor, 3-First stage of planetary gearbox, 4-Second stage of planetary gearbox, 5-Parallel gearbox, 6-Magnetic brake, 7-Acceleration sensor, 8-Speed transducer

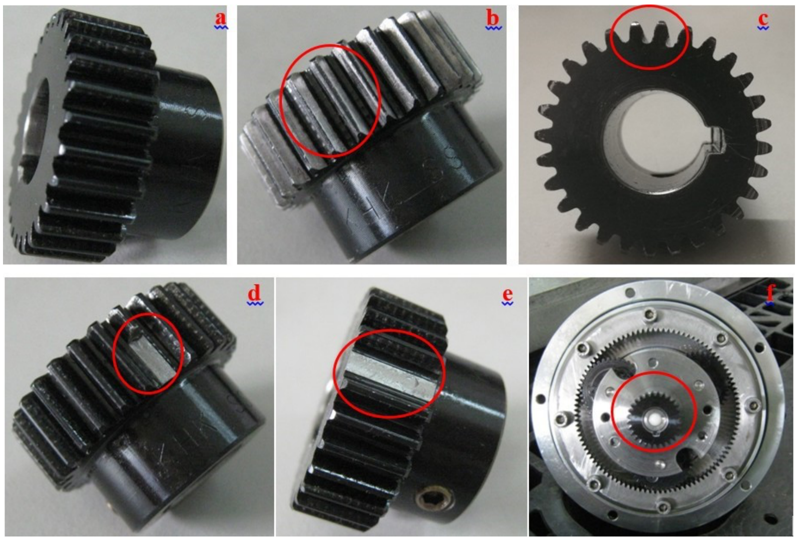

Figure 2. Pictures of the measured sun gear. a-normal, b-surface wear, c-crack, d-chipped, e-tooth missing, f-the measured sun gear

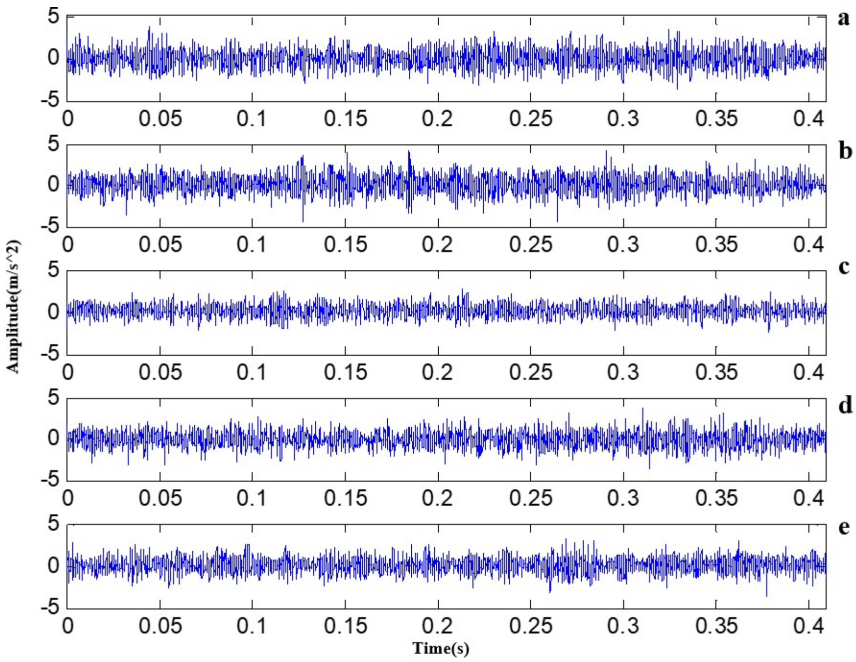

Figure 3. Time domain vibration signals under operational condition of 1500-rpm motor speed and 10Nm load. (a) normal, (b) surface wear, (c) crack, (d) chipped, (e) tooth missing

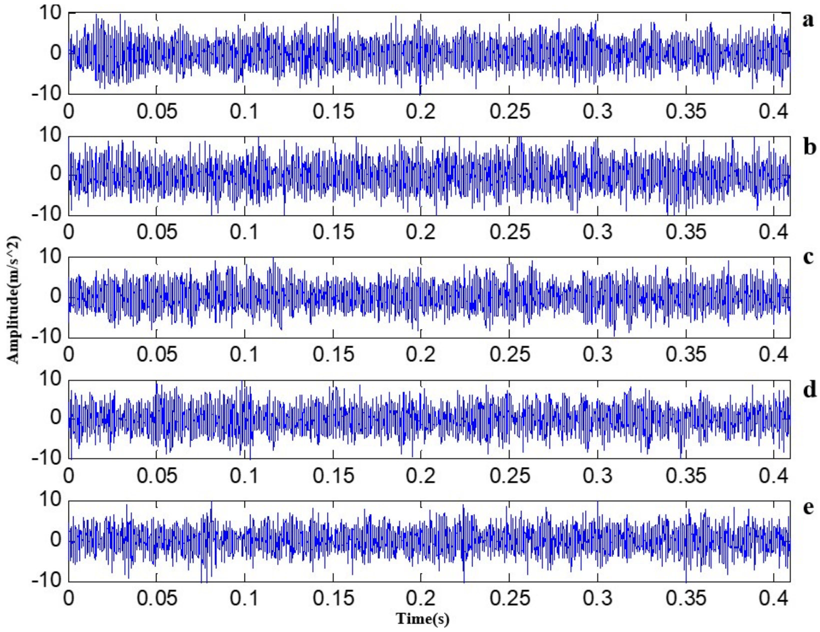

Figure 4. Time domain vibration signals under operational condition of 2700-rpm motor speed and 25Nm load. (a) normal, (b) surface wear, (c) crack, (d) chipped, (e) tooth missing