Micron AI Challenge

Registration Due Date: Apr 30, 2025

Submission Due Date: Jun 15, 2025

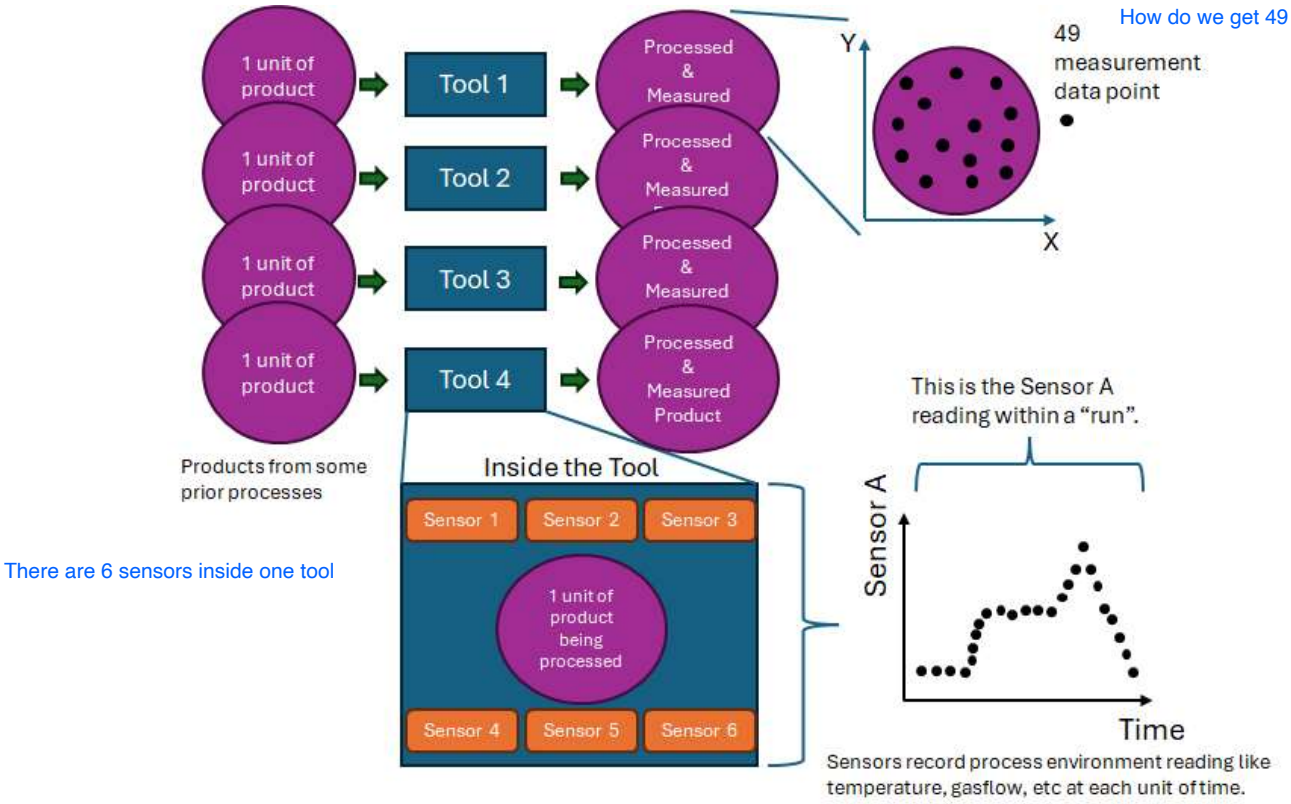
Signals to Quality: Unlocking Insights from Process Data

Introduction

In semiconductor manufacturing, complex process steps and toolings are involved. In this data challenge, we are particularly interested in one of the critical process steps. Various tools are involved in this step, and multiple sensors capture the signals during the process. At the end of each run, a wafer level measurement is collected which records the output value at each location of the product (indexed by the *x,y* coordinates). Due to equipment variations and process dynamics, the resulting measurements can exhibit non-uniformity across different locations. Accurately predicting both the **average measurement** and its **variability** is essential for optimizing manufacturing processes.

On top of the complex relations between tool setup, process signals, and the output, the tools degrade over time, and have varying lifetimes. As a result, the performance of the tools fluctuates over time. It is of interest to account for the tool degradation in the output prediction. It is noted that certain hardwares inside the tools can be replaced, and their lifetime will be reset after replacement. An illustration of the data structure and relation is shown in Figure 1.

How do we get 49 data points?



There are 6 sensors inside one tool

Figure 1. Illustration of the process data and quality data

Data

Data comes from a processing step from a semiconductor manufacturer. Participants will receive two datasets capturing process conditions and measured values:

1. **Process Data (run_data.parquet)**

This dataset contains **time-series in-situ sensor readings** recorded during each manufacturing run. The input data are organized in the following format. Essentially, the inputs record time series of various sensors associated with tools during the process runs. The age of the tools is recorded as "ConsumableLife" to consider the impact of tool degradation over the performance.

Input data schema

Column Name	Data Format	Description
ToolId	String	UUID for the tool where the unit of product has been processed in.
ConsumableLife	Numeric	The consumable life of the tool since last count reset.
RunId	String	Each unit of product is processed in a tool for a specific time. This span of activity of process is called a "run". RunId is the UUID for the specific run.
RunStartTime	DateTime	The start date time of the specific run
RunEndTime	DateTime	The end date time of the specific run
Recipe	String	Recipe UUID. The specific way that a unit of product processed is called a "recipe".
ProcessStep	String	A unit of product passes through a few processes. This column is to indicate which process the run and sensor data belong to.
TimeStamp	Numeric	Accumulative time stamp when the sensor data is collected, counting from start of the run.
StepId	Numeric	Within a recipe or a process, there are multiple steps. The number is chronologically accumulative from one step to another.
SensorName	String	Name of the sensor
SensorValue	Numeric	Value of the sensor at the point of data collection.

A sample data is shown below.

Input data sample

The information of the sensors that are used

ToolId	ConsumableLife	RunId	RunStartTime	RunEndTime	Recipe	ProcessStep	TimeStamp	StepId	SensorName	SensorValue
Tool A	23.5	EIWOFHWOFUEW	3/7/2025 15:34	3/7/2025 16:34	REYUIHEWUHFEOW	Process Step A	0	1	Sensor A	324.5
Tool A	23.5	EIWOFHWOFUEW	3/7/2025 15:34	3/7/2025 16:34	REYUIHEWUHFEOW	Process Step A	0.016689847	1	Sensor B	0.2

Tool A	23.5	EIWOFHWOFUEW	3/7/2025 15:34	3/7/2025 16:34	REYUIHEWUHFEOW	Process Step A	0.033379694	1	Sensor A	325.5
Tool B	203.5	EIWOFHWOFUER	3/8/2025 14:34	3/8/2025 15:34	REYUIHEWUHFEOW	Process Step A	0	1	Sensor A	314.5
Tool B	203.5	EIWOFHWOFUER	3/8/2025 14:34	3/8/2025 15:34	REYUIHEWUHFEOW	Process Step A	0.016689847	1	Sensor B	1.2
Tool B	203.5	EIWOFHWOFUER	3/8/2025 14:34	3/8/2025 15:34	REYUIHEWUHFEOW	Process Step A	0.033379694	1	Sensor A	315.5

2. **Measurement Data (measurement_data.parquet)**

This dataset provides **point-level measurements** across the manufactured product surface. Each Run ID record corresponds to 49 measurement points located at consistent locations of the product surface, whose Run ID can be used to link back to the process data. The data format and examples are shown below.

Output data schema

Column Name	Data Format	Description
X	Numeric	X-direction coordinate of the measurement on the product
Y	Numeric	Y-direction coordinate of the measurement on the product
Measurement	Numeric	Measurement value
RunId	String	Each unit of product is processed in a tool for a specific time. This span of activity of process is called a "run". RunId is the UUID for the specific run.

Group by RunId, each group should have 49 datapoints

Output data sample

X	Y	Measurement	run_id
104.7738693	47.48743719	10.09654695	EIWOFHWOFUEW
-139.4472362	-55.02512563	10.13458545	EIWOFHWOFUEW
41.45728643	-143.9698492	10.13446887	EIWOFHWOFUEW

The tools themselves will degrade overtime -> first predict the tools?

Objective

The primary objective of the data challenge is to develop a predictive model that utilizes the given signal data and tool usage data in each run to predict the output quality. The model should account for the variations in tool performance across different lifetimes and the impact of hardware changes.

A successful model will be evaluated based on its accuracy in predicting the point-level measurement outcome of the product. The accuracy will be evaluated on a separate set of test data provided by the competition committee based on the RMSE of all the point-level data in the test dataset. The model should demonstrate high precision and robustness in handling the time series data and the inherent variability in tool performance.

Submission Details

Team of up to 3 participants may participate in this challenge. The submission deadline is June 15, 2025. The submission should consist of a report along with the source code used to generate figures and tables in the report. The report should be limited to 25 pages, excluding references. It should clearly highlight your methodology, assumptions, preprocessing steps, and implementation details. The prediction outcome on the test dataset should also be submitted. Please put all predicted measurement values on the test data in a **single CSV file** following the data format of the output data. Participants can use any coding language to solve the problem.

Submission will be evaluated by a panel of judges based on (i) the accuracy of the methods; (ii) the suitability and innovation of the used methodology, (ii) the insights derived from the model, and (iii) the clarity, technical correctness and completeness of the report and the presentation. Finalists will present their solutions live at the ICQSR conference workshop on June 30 in Singapore. The first place and runner up of the competition will be then announced and recognized at the conference. A cash prize or an equivalent award will be granted.

The competition judges consist of experts from academic and industry. All submissions should contain a single zip file named "Micron_AI_Teamname.zip" and emailed to the organizers Chen Nan isecn@nus.edu.sg by June 15 2025, Singapore time.

Registration

If you are interested in participating in the data challenge, please register your interest here by Apr 30 2025. The link to the data will be sent to registered participants.
Registration link: https://forms.office.com/r/HuySLnDuVa