Digital Twin: An Autonomous System on Public Utility of Chemical Fiber Factory

Jerry Chen
Department of Mechanical Engineering, Yuan Ze University, Taoyuan 32003, Taiwan
s1088701@mail.yzu.edu.com

Rick Chang
Far Eastern Fibertech Company, Ltd., Taoyuan 32853, Taiwan
rick.chang@fefc.com.tw

Jiann-Shing Shieh*
Department of Mechanical Engineering, Yuan Ze University, Taoyuan 32003, Taiwan
jsshieh@saturn.yzu.edu.com

1 Introduction

Digital twin is a virtual representation of the physical entity. The physical entity and its virtual counterpart are linked by data. This allows the user to explore much more potential information of the physical environment with computational techniques for minimum costs [1]. Application of digital twin involves real-time monitoring, simulation, prediction, optimization, etc. The data driven model is the core of this approach; an accurate depiction of the physical world enables the virtual part to meet the application requirements. Also, in order to maintain the accuracy of model, the digital twin has to be governed by a system structure to deal with the uncertainty. This research proposes an architecture of autonomous system and its application on public utility to build a digital twin for chemical fiber factory.

2 Development of an autonomous system

An autonomous system consists of layers of function from bottom to top. The layers are actuator and sensor, process, model, critic, fault detection, and specification as shown in Figure 1.

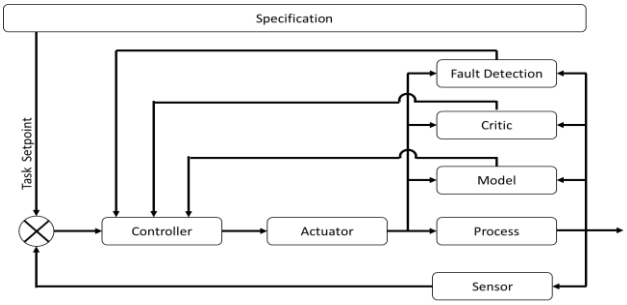

Figure 1: The structure of an autonomous system

The actuator and sensor layer are where the data originated from the physical environment. The process layer provides the mechanism that define the correlation and causation among the datasets. The model layer is the virtual representation formulated by numerical method and artificial intelligence via high performance computing (HPC). The critic layer is responsible to initiate a model re-train process and warning if the prediction of the model deviates from the real-world data readings. The fault detection is indispensable for diagnosing system malfunctions. Finally, the specification layer governs the entire system including the subsystems [2].

3 Data flow

The data flow coming from sensor and actuator could be obtained and stored in a general pattern shown in Figure 2. For embedded sensor that works with the microprocessor, the data package could be transmitted over Message Queuing Telemetry Transport (MQTT) protocol. With a MQTT subscriber on Node-RED, the data can be displayed in real-time and also stored in database for historical data inspection and model training.

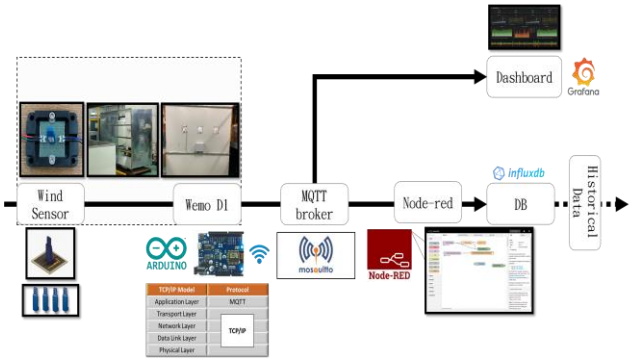

Figure 2: Data flow

4 Summary

Building digital twin requires heavy computations and multiple layers of function especially for applications in manufacturing. With HPC system [3] and on-premise servers, it provides not only the ultimate protection from cybersecurity threats but also the administration over hardware and software configuration for building an entirely autonomous system in industry process.

REFERENCES

[1] M. Grieves, 2014. Digital twin: manufacturing excellence through virtual factory replication.
[2] Chen, J., Abbod, M., Shieh, J.S., 2019. Integrations between autonomous systems and modern computing techniques: a mini review. Sensors, 19(18).
[3] Ohmura, T., Shimomura, Y., Egawa, R., Takizawa, H., 2023. Toward building a digital twin of job scheduling and power management on an HPC system. Job Scheduling Strategies for Parallel Processing.