Intelligent digital twin system design in semiconductor manufacturing

Collecting data about processes and performance has been a core area of interest for most businesses. Various technological advancements have improved this process through several new tools, methods, and approaches which have been introduced to this field. In the Semiconductor industry, a massive volume of ingested data is being generated from the lifecycles of different products. In contrast, gathering data in real time from platforms such as the Internet of Things (IoT) has brought a number of challenges, for instance; the structured, semi-structured and unstructured data generated from the manufacturing process, bottlenecks when designing large analytical tools, and a need for high capacity storage to save and organize the collected data.

The introduction of the concepts of Industry 4.0 and IoT have widely contributed to improving the manufacturing stages. In the future, this will allow us to implement newer emerging technologies such as Smart Manufacturing and Digital Twin technologies (DT). A DT aims to achieve a high level of visualization throughout an integration between Big Data, the Virtual environment and the physical system. Besides that, the quality and accessibility of massive data via real-time streams will make Digital Twin systems even more beneficial to increase productivity and provide higher quality devices. It also aims to introduce more intelligent systems which integrate different technologies to allow more effective data gathering, analysis, and decision-making.

This paper highlights aspects of a work-in-progress design for an intelligent system which involves the design of a DT system within the Semiconductor manufacturing area. A design for a robust communication system is also proposed to provide a high level of convergence and synchronization between the developed DT and the physical manufacturing plant. On this basis, this paper explains a new approach that is going to help an international semiconductor manufacturing company to automate and digitize their physical production process. Furthermore, this project aims to design a high-level application that allows engineers to enhance their product design, planning, manufacturing, and incorporate Predictive Maintenance.

The scope of this project is to overcome the heterogeneity problem in acquiring data that is collected from the semiconductor manufacturing process and to design a synchronising, high convergence, and complex digital replica for the physical production line. Another goal is to develop a data-streaming system to ingest nearly real-time data from the production equipment and feed it into the designed DT system. Furthermore, the designed DT platform will include a streaming Machine Learning pipeline to predict possible failure within devices and relay them in real-time to the decision-makers at the company. Thus, as a result, all maintenance procedures will be planned well in advance to avoid any sudden interruptions during the production process. Also, this project will be developed on a distinguished Gaming Engine (Unity) to develop efficient and realistic visualisations, and utilise Real-Time Rendering tools to achieve a number of effects typically implemented in gaming. Such effects include the optimisation of Level of Distance (LOD) to visualise complex assets, texturing and Engine Dynamics to incorporate a higher level of realism and allow users be more immersed in the designed environment. Animations and fly-through rendering in real-time will also be used to allow easy interaction, reviews, and view changes in the virtual environment which are not usually found in traditional visualization methods.