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Editorial: Editor's challenge in digital manufacturing - digital transformation of manufacturing through industrial metaverse: opportunities and challenges for industry 5.0

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Editorial on the Research Topic
Editor's challenge in digital manufacturing - digital transformation of manufacturing through industrial metaverse: opportunities and challenges for industry 5.0

With Industry 5.0 comes the next wave of industrialization, integrating advanced technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), Digital Twins (DTs), Extended Reality (XR), and Blockchain. The pillars of Industry 5.0 are human-centricity, sustainability and resilience (Figure 1). Through the technologies and frameworks of Industrial Metaverse, manufacturing systems undergo digital transformation to obtain new possibilities for optimization of production, systems, and services, with the aid of enhanced collaboration capabilities. Benefits of digital transformation include reduced waste sizes, increased throughput, and more effective workforce training, among others. However, digital transformation also poses several challenges for manufacturers, including but not limited to security, compatibility, and costs involved with initial transformation and further utilization of digital technologies.

The purpose of this Research Topic is to examine opportunities and challenges presented by Industry 5.0 during the digital transformation of manufacturing through Industrial Metaverse. The Research Topic explores current and future digital developments in manufacturing systems to provide useful insights to manufacturers aiming to transform their systems and stay ahead of the curve.

Rahamaddula et al. suggested that, while large enterprises have already begun their digital transformation, Small and Medium Enterprises (SMEs) are often left behind. This is a major issue according to the authors, as SMEs form a large percentage of the manufacturing capability of many countries, and losing the benefits associated with digitalization and smart manufacturing can impose significant costs. The main challenge identified in this case was uncertainty and the cost-benefit balance of digital transformation for SMEs. A readiness assessment tool was proposed which utilizes several

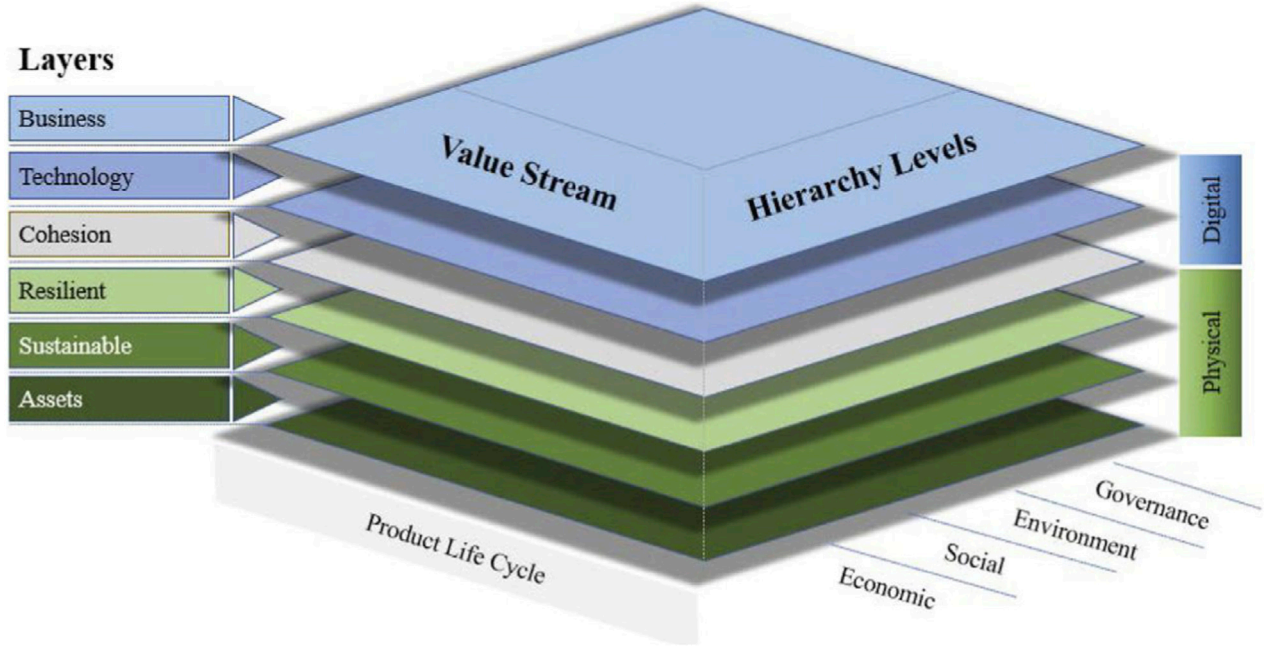

FIGURE 1
RAMI 5.0 (Aheleroff et al.).

factors recognized by experts that contribute to the readiness level of an SME, which was applied to practical use cases.

Magas et al. highlighted collaboration as the main challenge of digital transformation, regarding data transfer between different domains. While robust system mapping that uses ontologies could solve this problem, it proved to be a significant challenge, especially with inexperienced practitioners. The technologies of Industrial Metaverse and their interoperability can be used to establish platforms of ontology standards, creating collaborative tools that can support ontology framework application, enhance system resilience and ensure smooth cross-domain operations throughout the unique life cycle of every domain. As such, digital transformation provides an opportunity for understanding extended and complex systems.

Mourtzis and Aheleroff et al. focused instead on the opportunities inherent in digital transformation. Overcoming the challenge of increasing complexity caused by market demands, leading to the transition from Mass Customization to Mass Personalization, requires leveraging the capabilities of digital technologies. Aheleroff et al. suggested that Industry 5.0 cooperates with the previous concept of Industry 4.0, utilizing enhanced versions of existing technologies which can enhance system sustainability and resilience when they are operated around the pillar of human-centricity Figure 1. Specifically, the collaboration of humans with advanced technologies adds significant value by enabling the utilization of the scalability offered by Industry 4.0 while maintaining high flexibility in production and quality in products. Mourtzis, on the other hand, discussed the possibilities provided by Digital Twins for Human-Machine Interaction (HMI). Traditional systems undergoing digital transformation to become Cyber-Physical Systems (CPSs) often proves a challenge in maintaining a human-in-the-loop approach. Industrial Metaverse platforms offer the solution to this challenge by immersing humans into CPS operations, facilitating greater system understanding and collaboration, streamlining communications, and promoting system adaptability, and thus sustainability and resilience. Even so, significant challenges were discovered when delving deeper into digital transformation, including security, privacy, financial stability, standardization, and regulation.

Summarising, this Research Topic showcased several opportunities for digital transformation and Industrial Metaverse to promote Industry 5.0 goals, such as resilience and sustainability. These opportunities rely heavily on the immense potential of advanced digital technologies for data transfer, optimization, and collaboration. However, such powerful tools proved understandably challenging to use, mostly due to their cost, complexity, and the uncertainty of their impact. Future directions for this Research Topic include the generalization of readiness assessment and digital system mapping tools, standardization to facilitate collaboration, and the exploration of novel application possibilities for system performance optimization.

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