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Metaverse and eXtended uniVerse (XV): Opportunities and Challenges for Consumer Technologies

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■ **XV (eXtENDED META/UNI/VERSE)**, also known as “Mersivity”, “Vironmentalism”, “Social XR”, “Physical metaverse”, etc., combines XR (eXtended Reality), XI (eXtended Intelligence), XB (eXtended Being, including Digital Twin), XE (eXtended Economy), and XS (eXtended Society) into a vision that covers a generally agreed metaverse scope while extending the impacts to include physical and social implications. XV is the next evolution at the nexus of three axes: the (1) physical; (2) virtual; and (3) social worlds.

Consumer technologies are regarded today as not just a key element to foster the success of XV, but as a

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fundamental cornerstone for its widespread adoption. One of the essential factors is accessibility of platforms, and ease of use and ergonomics of immersive devices. There are many other challenges set by the wide range of involved technologies, required, e.g., to let millions of users interact in the same shared XV space synchronously. It will also be necessary to define open XV standards to support a whole ecosystem of experiences, with a multitude of use cases coexisting in a single XV possibly made of diverse, interoperable instances. Consumer technologies are also asked to provide tools for coping with the emerging issues brought by XV in the physical, virtual, and social domains, concerning, among others, the physical environment, data privacy, security, trust, authentication, law, ethics, etc. These issues are addressed by the 10

articles selected for this Special Section.

Two articles open the Special Section framing the context of XV. “eXtended meta-uni-omni-Verse (XV): Introduction, Taxonomy, and State-of-the-Art”, by *S. Mann et al.*, introduces previous related literature, novel concepts, terminology, and classification of *realities*. Next, the work “Dyadic-XV: A Taxonomy of Digital Beings” by *C. L. Gittens* extends the previous classification by providing a taxonomy that considers the perspective of digital beings (e.g., ensomadroids and pragmatatars).

The technical challenges of building the XV are pointed out by *J. Shin et al.* in the work “Evaluating Metaverse Platforms: Status, Direction, and Challenges”, which also proposes a six-factors framework to evaluate metaverse platforms. Current implementations of social VR platforms are further analyzed in “Exploring Avatar Experiences in Social VR: A Comprehensive Analysis of User Reviews” by *J. Dong et al.*, whose insights will be valuable for designers of these platforms, especially regarding the personalization of the avatar experience. A framework focused on the technical aspects of communication in shared virtual worlds is proposed by *C. Cortes et al.* in the work “Understanding Latency and QoE in Social XR”. The authors demonstrate how the framework can be used to identify the possible latency sources in various social XR use cases and their implications on the quality of the user experience.

Two articles explore the implication of the metaverse on a key application scenario represented by healthcare. In particular, the work “The Metaverse for Cognitive Health: A Paradigm Shift” by *S. P. Ramu et al.* elaborates on various scenarios in which doctors can exploit this new paradigm, and provides future research directions to drill the potential of the metaverse for cognitive health. The work “Digital Healthcare in the Metaverse: Insights into Privacy and Security” by *M. Letafati et al.*, in turn, analyzes potential issues and implications in terms of privacy and security.

Another perspective is provided in the work “Explainable AI and Blockchain for Metaverse: A Security and Privacy Perspective” by *P. Kumar et al.*, whose focus is on enabling technologies, i.e., explainable AI and Blockchain; the work is accompanied by a use case that demonstrates the benefits of the proposed architecture and provides future research directions in building a futuristic Consumer Internet of Things-inspired metaverse.

The Special Section is concluded by two articles

which are expected to envision and inspire future researchers. The work “INTERBEING: On the Symbiosis Between INTERNET and HUMAN BEING” by *M. Maier et al.* conceives a unifying design of virtual, embodied, intelligent cross-reality environments, ranging from a stigmergic Society 5.0 to the so-called Interbeings, based on the symbiosis between Inter(net) and (human) beings; the work lays the foundation for creating a future virtual society that benefits from the convergence of digital evolution and biology to wholesome tap into the reality-virtuality continuum. Finally, the work “A Fusion Model: Toward a Virtual, Physical, and Cognitive Integration and Its Principles” by *H. L. Zhang et al.* proposes a so-called Fusion Universe model, in which the virtual, physical, and cognitive worlds are merged; the underlying principles for integrating such a model are presented, together with investigating the implications regarding the design of immersive and interactive experiences with the aim to enable the compatibility of the model with the physical universe.

The Guest Editors express their gratitude to the Authors for their outstanding contribution, to the Reviewers for their invaluable effort, and to the Editor in Chief for having offered the opportunity to organize this Special Section, which will hopefully contribute at making this incredible domain evolve further.

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