eXtended meta-uni-omni-Verse (XV): Introduction, taxonomy, and state-of-the-art

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eXtended meta-uni-omni-Verse (XV): Introduction, Taxonomy, and State-of-the-Art

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***Abstract*—The term “virtual reality” has been in use since 1938, but the recent explosion of jargon, confusing new terminology, and the hype around a plethora of related “realities” (augmented, mediated, mixed, digital, etc.) have made it necessary to bring some order to these realities. There are also many “grey” areas between and beyond these realities, making it desirable to embrace an overarching vision. Throughout the world, many, including us, have chosen to use the framework of extended reality (XR) as a unifying concept to interpolate between the realities and to eXtrapolate beyond them. Together with XR, there is also XI (extended intelligence) for which the IEEE has convened the Council on eXtended Intelligence (CXI). A related concept is the metaverse, i.e. shared VR, introduced in 1974 as “metavision” and “metaveillance” and recently popularized by industry. In this paper we propose eXtended meta-uni-omni-Verse (XV) as an overarching term, concept, and taxonomy for shared (social) XR across all of the “verses”, including the universe (physical reality, i.e. atoms), the metaverse (virtuality, i.e. bits), the omniverse and multiverse, etc. We also briefly outline the state-of-the-art in the various realities and verses covered by XV. Our main findings highlight the necessity for additional investigation into the potential and worth of XV technologies. This entails improving XV systems through standardization and integration efforts, broadening their uses, developing specialized solutions for those with disabilities and the elderly, and addressing the implications of XV to ensure its accessibility and benefits.**

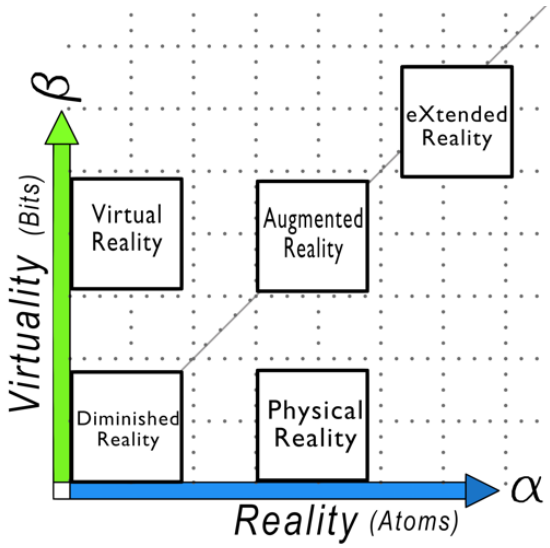

Figure 1. Building blocks of the "realities", set upon the axes of reality, i.e. the universe as made of atoms, α, and the virtual world as made of bits, β.

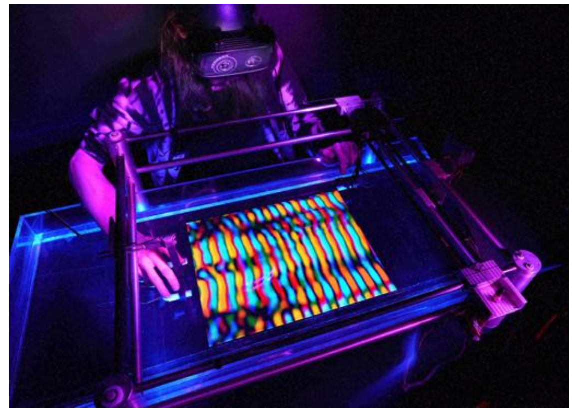

Figure 2. Seeing sonar is an example of eXtended Reality (XR). XR subsumes all the other realities and also goes beyond them [12], [13], [14], [15].

We begin with the realities and verses, encompassing metaverse, universe, multiverse, omniverse, etc.

"Realities"

The term virtual reality was introduced in 1938 [1] and has evolved as more than just a concept, into a technology and whole industry, along with more recent concepts like augmented reality, mixed reality [2], mediated reality [3], [4], [5], [6], [7] and augmediated reality (augmented mediated reality) [8], [9], [10], [11]. The three main building blocks of the realities can be illustrated as in Fig. 1: physical reality, P, virtual reality, V, and augmented reality, A.

Physical reality exists along the α axis, whereas virtual reality (audio, visual, haptic, etc.) exists along the virtuality axis, β. Augmented reality exists along both axes. This defines a set of quadrants — a taxonomy of sorts — where the lower left quadrant refers to a "diminished reality" representing technologies like dark sunglasses, welding glass, earplugs, etc. that deliberately reduce or attenuate (diminish) reality. A goal of eXtended Reality (XR) is to generalize between and beyond all the existing realities, i.e. as an overarching term (X is like a mathematical variable that can represent any of the realities, R), and as a blending or extension to the whole set of all possible realities.

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An example of XR is an eyeglass that allows us to extend vision to see in the ultraviolet, infrared, etc., as well as see radio waves and sound waves, including underwater sound waves (sonar), as shown in Fig 2.

"Verses"

The work shown in Fig 2 is an example of what is known as "metavision" and "metaveillance" (the sensing of sensors and the sensing of their capacity to sense), a concept that dates back to 1974 [16], illustrated in Fig 3, which is often regarded as the origin of the metaverse [17]. In this work, light sources are waved around in a dark room, so a large number of people can see, in real-time, the otherwise invisible metaveillance flux of a surveillance camera, due to video feedback from a wireless receiver connected to a powerful amplifier driving a light bulb. By using different kinds of very sensitive lock-in amplifiers, a variety of virtual phenomena were shared wirelessly across several spaces in which multiple participants shared the same "reality" and participated meaningfully in that reality, including for example gamification (shared-reality video games) [13] that combined traditional photography with real-time video.

Recently, there has been a great deal of interest in the metaverse, as well as various other verses such as the omniverse and multiverse, and their interplay with reality (the universe) [18], [19], [20], [21].

The metaverse is a persistent, networked, con-

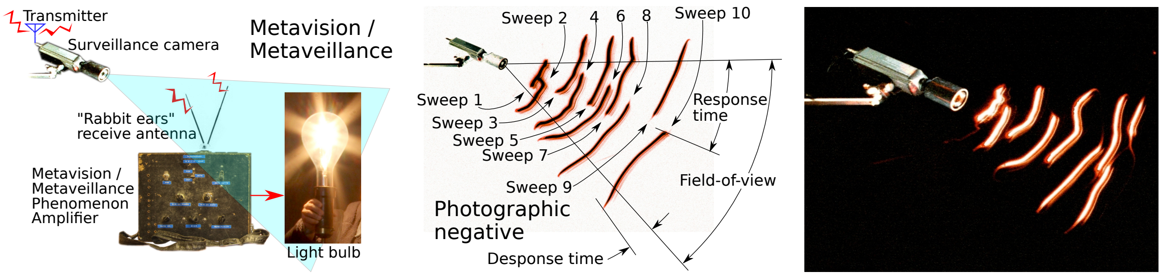

Figure 3. Metavision and Metaveillance [16], the sensing of sensors and their capacity to sense. Here we see a surveillance camera with an extended-reality "bug sweeper" consisting of a television receiver driving a light bulb. By way of video feedback, this results in an overlay of the camera's capacity to sense. The overlay can be seen by large numbers of observers without the need for special eyewear. This and related work on Metavision / Metaveillance is often regarded as the origins of the metaverse [17].

nected, and shared virtual reality. The multiverse is a collection of various separate shared virtual realities (like the metaverse but not universal across all of them). The omniverse is the union of these various realities, i.e. the union of the metaverse and the multiverse [18], [19], [20], [21]. Moreover, "omniverse" is the term used by nVIDIA to refer to its metaverse platform.

When we examine what is now happening with the "verses", we can see a parallel with what happened with the realities, namely that there is a great deal of unnecessary confusion. There is also a need to interpolate between the various verses as well as extrapolate beyond them. This same need that was met by XR for the realities can be now be met by XV for the verses.

Therefore, three main contributions of this paper, in contrast to recent surveys focusing on metaverse definitions [22] and relevant technologies [23], are as follows:

1) Introduction of XV as an overarching term, concept, and three-dimensional taxonomy for shared (social) XR across all of the "verses";
2) Proposal of XV for shared, social, collaborative XR as extension into a third, sociality dimension;
3) Summary of state-of-the-art and future directions in the realities and verses in XV, with examples.

XV

We propose XV for shared, social, collaborative XR, i.e. to take the space of all realities in and beyond the α-β plane and extend them into a third, sociality dimension, as illustrated in Fig 4 and Fig. 5.

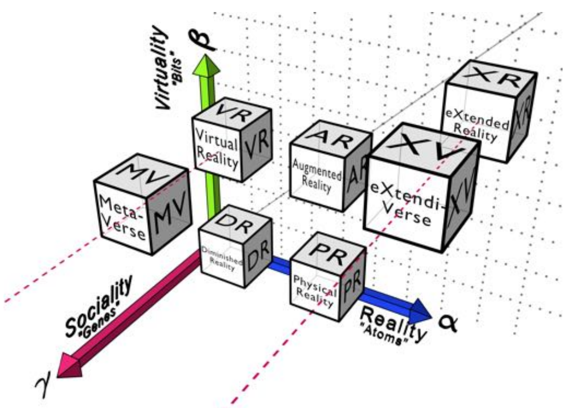

Figure 4. Atoms (α), bits (β), and genes (γ): the three axes of the XV continuum.

STATE OF THE ART

XV offers immersive and meaningful computational experiences, but its full potential is still being explored. In this section, we examine the arrangement of the β axis, briefly outlining some relevant use cases for consumer electronics and the possibilities of AI integration in XV. Indeed, this is just an overview of the many exciting possibilities and challenges presented by XV and related technologies.

One of the key open points of XV pertains to the arrangement of the β axis for the extensive computational world of virtuality, AI, machine learning, etc. that is emerging. Regarding the first aspect, there are many alternatives to be considered in devising those elements of the virtual and computational XV that replicate portions of the real world. They can range from static 3D reconstructions of pieces of α to be visualized and explored in the XV, to analogs or digital twins.

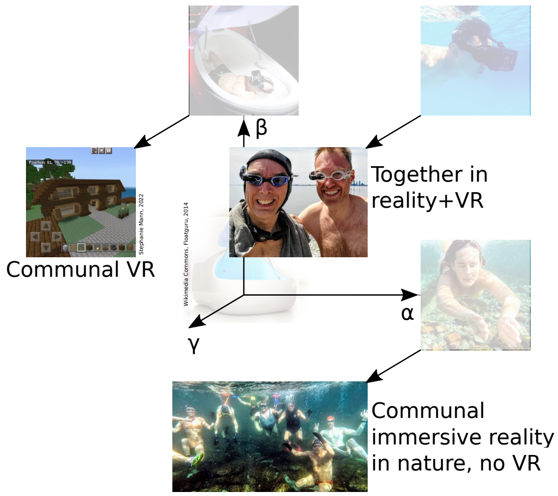

Figure 5. Examples of XV continuum: (leftmost) Playing together in a virtual world (0% real, 100% virtual, and 100% social), (center) icewater swimming together, wearing immersive XR eyewear to communicate safety information and share maps, overlays, warnings, etc., and (bottom) swimming together in a natural setting with no distractions from any phone, Internet, or other devices (100% real, 0% virtual, 100% social).

IBM defines a digital twin as "a virtual model designed to accurately reflect a physical object." with no mention of "digital", i.e. this is what used to be called "analog". An analog is "a thing seen as comparable to another." [Oxford Languages] which is the basis of analog computers that simulate the real world. In 1938 when Artaud introduced virtual reality, through "The Theatre and Its Double" he presented theatre as that analog of the real world. Digital twins integrate real-time data from the physical world in order to synchronize the virtual replica with artificial intelligence and machine learning [24], [25]. Both the approaches have their strengths and shortcomings. In the case of static replicas, the interactivity may be sacrificed to facilitate reconstructing elements of the α as they were in a different time of the past or future, or another reality. Digital twins, in turn, are hampered by technological difficulties related to sensing the changes in α, but at the same time offer the possibility of a seemless transition between α and β while experiencing the XV. The term "digital" generates a great deal of confusion as we can have digital reality (e.g. a hundred-year-old on/of switch), analog reality (a potentiometer), digital virtuality (a virtual switch), or analog virtuality (a virtual "slider" adjustment) which we often refer to as "undigital". In this sense we prefer the simplicity of XV to the confusion of "digital twins" or anything else using the term "digital" ambiguously.

Another key technology for XV is blockchain [26] and other distributed ledgers to secure digital or "undigital" assets and ensure integrity, privacy, and reputation of users' content and transactions.

There are many different scenarios and use-cases that can be enabled by the availability of a copy of the α axis, e.g. via consumer devices. For instance, a 3D reconstruction can be used for cultural heritage to let visitors access and interact with locations and artifacts which no longer exist, are too delicate to handle, or difficult to access. Education and training can benefit as well from a replica in different ways. This is the case, e.g. of first responders, who can practice in the XV with faithful reconstructions of typically harsh environments and required tools. Learners from both formal and non-formal contexts could also benefit from a more "cyber-physical" learning experience that can be enabled by digital twins or computational analogs, in terms of democratized access to institutions through the XV. The persistence of the XV can additionally empower the collaboration among students and teachers in unprecedented ways, by using a virtaul (β) form of stigmergy to enable the sharing of knowledge, opinions, and ideas among millions of individuals. Replicas from α to β also enable "cyber-physical" systems.

AI can enhance the XV in many different ways. AI-powered chatbots and virtual assistants, for instance, can facilitate social interactions within XV, suggesting other users to connect with and even offering personalized tips and advice to help in building connections. From users' past behaviors, the XV system can provide customized recommendations for real-world activities, such as places or events where to meet and collaborate with others. Using AI algorithms to analyze users' behaviors, XV can be more engaging, with procedurally-generated content tailored to individual users' preferences, personality traits, and skill sets. Applying AI to XV can help create a more immersive, social, and personalized experience – spanning from β to not only α but also γ – which can keep users engaged and connected with the real and virtual worlds around them.

Figure 6. Experimental “Unicorn Vision” system functions as a “bird’s-eye-view” seeing aid for persons having a back injury, allowing a clear downwards-facing “foot first” view of the ground immediately beneath the wearer’s feet, to be streamed live to a “headup” display. Left: live video feed from camera. Right: experimental apparatus (underwater). Thanks to Dan Bowman + SwimOP for the underwater picture.

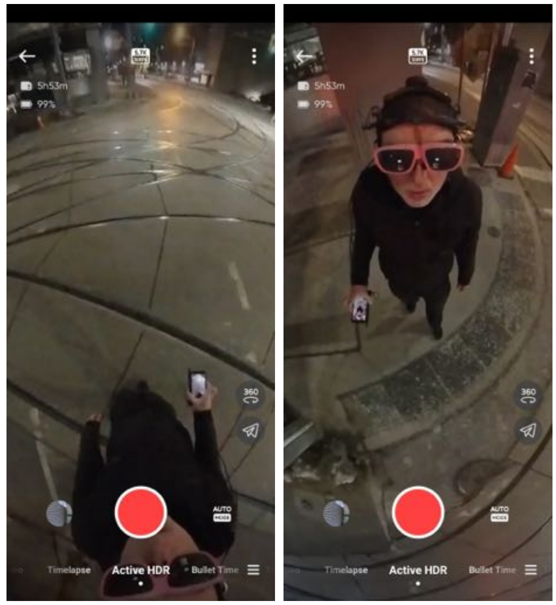

Figure 7. “Unicorn Vision” with Northwards bird’s-eye-view (map coordinates): (left) crossing the street northward, (right) crossing the street southward.

EXAMPLES

Some of the most exciting new developments in XV are among the simplest. In this section, some examples are provided.

Moveillance™

The first example is represented by commonly available 360 degree capture cameras. A camera of this type can be worn on a “headup” display in a way that provides a “foot first” downwards-facing view in front of the wearer, and works in a variety of situations, including outdoors, in the rain, and even underwater (Fig 6).

This forms a useful seeing aid for persons who need to be able to see their feet to walk and find their way but, for instance, have suffered a back injury that makes looking down difficult or problematic. This allows overlay of maps, compass, and other forms of wayfinding tools, in body-centered coordinates (egocentric vision [27]) or map coordinates, e.g. North at the top (Fig 7 and Fig 8). Interestingly, this also suggests a choice of first-person versus third-person orientation when choosing body-centered coordinates. Similarly, for teachers or professors with a shoulder injury who have difficulty e.g. writing on a regular chalkboard, it provides a sort of existential document camera for use with a horizontally-mounted chalkboard.

New artistic possibilities emerge as well (Fig. 9), and, perhaps more importantly, it becomes possible to capture and share the everyday world as an environment map by simply walking around in it.

Freehicles™

The second example concerns the relation between XV and vehicles for freedom of mobility.

There is an inherent social bias that “permits” inanimate objects to be “smart” but stigmatizes people who are “smart” (tech-equipped). In some sense, cars or vehicles in general, including micromobility devices, enjoy a certain “right” to “wear” computer vision systems that people often do not.

15.6% of people (approximately 1.1 billion) have a disability [28]. This is the world’s largest minority, and the only minority into which anyone might end up becoming a member. 3.5% of people have a visual impairment [28]. Moreover, the growing population of elderly suggests that these percentages are on the rise, and will increase greatly in the future.

In this context, the word “mobility” means being able to walk, as assisted by wheelchairs, but also walkers and other similar technologies; it also means knowing how to navigate, e.g. in the context of Orientation and Mobility (abbreviated O&M) within the community of the blind and visually impaired. Likewise “cane” means something that can help the infirm walk and support their weight, but also something that

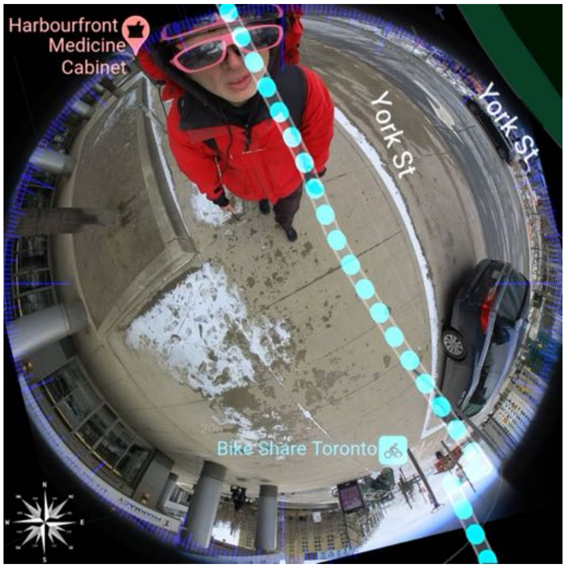

Figure 8. Bird's-eye-view commonly available only to vehicles is now available to people, thanks to "Unicorn Vision". Here a pharmacy can be seen to the person's left, and York St. to the person's right, and Bike Share straight ahead.

Figure 9. The vision system of Fig. 6 has potential as a new form of visual art (circle portrait in spherical and compressed cylindrical coordinates), and perhaps more importantly, in capturing the real world by simply walking around in it.

can help the blind feel their way.

Within this scenario, one may wish to develop a seeing and mobility aid that helps persons with vision and mobility needs, specifically wayfinding, visual memory, and lower back issues that make it difficult to sit, thus precluding the use of a standard wheelchair or other seat-based mobility solutions. Our current research aims to create a stand-up mobility aid that can operate indoors or outdoors while offering the ability to vary spine pressure through a variety of modes of operation such as kneeling on both or one knee, standing, leaning, and supported in various positions and by various means that can be quickly and constantly changed during use. The mobility aid could also be equipped with numerous cameras, lidar, radar, and sonar in order to add wayfinding functionality. The mobility solution could allow for exercise during portions of a trip, on land, or water.

Previously a machine was invented to carry heavy objects for the disabled and follow behind a person. It used a PIIID (Proportional, Integral, Integral, Integral, Derivative) controller, to encapsulate not just acceleration and its derivative and integral, but also to capture position and absement and velocity [29]. Presently we're developing a self-driving mobility aid that rides in front of a person to provide guidance (O&M) and/or physical support (mobility), and/or carrying cargo. Additionally, the ability to stand upon the vehicle and ride it is also an option, so that the user can ride it part of the way and get exercise walking or running some of the time. The Freehicle is a smart seeing aid that "sees" and "remembers" what it experiences, thus providing value in vision, memory, as well as physical support.

A very compact version of the Freehicle is a smart walker/rollator/cane/aid that transitions between a cane and a wheeled walker, and which can transform from modest support at times, to full support, as required at other times. This provides adaptive time-varying independence to people with disabilities.

CHALLENGES AND FUTURE DIRECTIONS

Looking toward the future, there are many challenges still to face and several promising directions

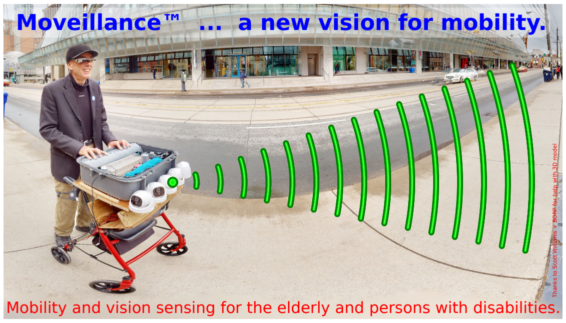

Figure 10. The Strollator™ smart self-driving walker provides spinal support as well as wayfinding and vision assistance.

to consider for the continued development and implementation of XV technology. First, there is a need for further exploration of the full potential of XV and enhancements of its value for humanity. This exploration will include ongoing research and development to refine the accuracy, speed, and reliability of XV systems. The need for standardization and integration is also crucial to ensure seamless collaboration and compatibility between different XV components, allowing for streamlined operations and enhanced overall performance. In addition, efforts will be required to expand the range of applications and contexts in which XV can be used, such as education, entertainment, healthcare, and assistive devices for those with disabilities. For example, there are efforts in progress for putting all of the technologies found in a self-driving car into a smart walker [30].

There is a great opportunity for the development of systems that provide O&M assistance while scanning the world to help in wayfinding, memory, physical support, guidance, exercise, physical activity, and independence for those with disabilities as well as the growing population of elderly (Fig 10). The Strollator™, for example, transitions between a motor-assist jogging stroller (long wheelbase for reduced danger of falls) and a rollator (short wheelbase). It transforms its shape or size by recognizing rough terrain and automatically lengthening the wheelbase when rough terrain is detected, and then retracting again for smooth terrain (such as indoors, where the shorter wheelbase affords increased maneuverability). Such systems can significantly enhance the quality of life for individuals who experience difficulties with mobility or sensory processing, and potentially open up new avenues for social and economic participation.

Finally, it will be important to address the ethical, social, and technological implications of XV and work to address many challenges that arise. This includes ongoing discussions about issues such as privacy, data ownership, and the potential impact of XV on employment and social relations. Additionally, efforts will be made to ensure that XV technology is accessible and beneficial to diverse populations, including those from historically marginalized communities. By proactively addressing these issues, we can work to ensure that XV technology is used in a way that maximizes its potential benefits while minimizing any potential harms.

CONCLUSION

XV represents a promising frontier with numerous possibilities for innovation and advancement.

Further aspects remain to be explored to unlock the full potential of XV and enhance its value for users. The reported examples represent the basis for systems that provide O&M assistance while scanning the world to help in wayfinding, memory, as well as physical support, guidance, exercise, physical activity, and independence to those with disabilities as well as the growing population of elderly.

These examples cover just a subset of the many scenarios XV will bring value to. They also suggest that, while continuing to advance in this exciting field, it is essential to remain mindful of the ethical, social, and technological implications of XV and work to address any challenges that arise.

REFERENCES

1. Antonin Artaud. The theater and its double, 1958. first published reference to “La Réalité Virtuelle”.
2. Paul Milgram. Augmented reality: A class of displays on the reality-virtuality continuum, 1994.
3. S. Mann. Mediated reality. TR 260, M.I.T. M.L. Vismod, Cambridge, Massachusetts, 1994.
4. P. Bach y Rita, M.E. Tyler, and K.A. Kaczmarek. *Seeing with the Brain*, volume 15(2), pages 285–295. Hillsdale, NJ: Lawrence Erlbaum Associates Inc, 2003.
5. Steve Mann. Wearable, tetherless computer–mediated reality: WearCam as a wearable face–recognizer, and other applications for the disabled. TR 361, MIT, 1996-02-02. AAAI Fall Symposium on Developing Assistive Technology for People with Disabilities, Cambridge, Massachusetts, Nov. 9-11 1996.
6. James Fung, Felix Tang, and Steve Mann. Mediated

reality using computer graphics hardware for computer vision. In *Proc. 6th International Symposium on Wearable Computers*, pages 83–89, 2002.

7. Raphael Grasset, Laurence Boissieux, Jean D Gascuel, and Dieter Schmalstieg. Interactive mediated reality. In *Proc. 6th Australasian User Interface Conference*, pages 21–29, 2005.
8. R. Janzen, N. Yasrebi, J. Bose, A. Subramanian, and S. Mann. Walking through sight: Seeing the ability to see, in a 3-D augmediated reality environment. In *IEEE GEM 2014*, pages 1–2, 2014.
9. Raymond Lo, Alexander Chen, Valmiki Rampersad, Jason Huang, Han Wu, and Steve Mann. Augmediated reality system based on 3D camera selfgesture sensing. In *Proc. IEEE International Symposium on Technology and Society: Social Implications of Wearable computing and Augmediated Reality in Everyday Life*, pages 20–31, 2013.
10. Pete Scourboutakos. *New sequential wave imprinting machines visualize waves in real-space and real-time by augmediating reality*. University of Toronto (Canada), 2016.
11. Raymond Chun Hing Lo. *Embodied Humanistic Intelligence: Design of Augmediated Reality Digital Eye Glass*. University of Toronto (Canada), 2017.
12. Monique Morrow, Jay Iorio, Greg Adamson, BC Biermann, Katryna Dow, Takashi Egawa, Danit Gal, ann Greenberg, John C. havens, Sara R. Jordan, Lauren Joseph, Ceyhun Karasu, Hyo-eun Kim, Scott Kesselman, Steve Mann, Preeti Mohan, Lisa Morgan, Pablo Noriega, Stephen Rainey, Todd Richmond, Skip Rizzo, Francesca Rossi, Leanne Seeto, Alan Smithson, Mathana Stender, and Maya Zuckerman. Extended reality in A/IS. *The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems*, 2020.
13. S. Mann and C. Wyckoff. Extended reality. 1991.
14. Sepehr Alizadehsalehi, Ahmad Hadavi, and Joseph Chuenhuei Huang. From bim to extended reality in aec industry. *Automation in Construction*, 116:103254, 2020.
15. Arzu Çöltekin, Ian Lochhead, Marguerite Madden, Sidonie Christophe, Alexandre Devaux, Christopher Pettit, Oliver Lock, Shashwat Shukla, Lukáš Herman, Zdeněk Stachoň, et al. Extended reality in spatial sciences: A review of research challenges and future directions. *ISPRS International Journal of Geo-Information*, 9(7):439, 2020.
16. Steve Mann, Yu Yuan, Tom Furness, Joseph Paradiso, and Thomas Coughlin. Beyond the metaverse: Xv (extended meta/uni/verse). *arXiv preprint arXiv:2212.07960*, 2022.
17. Yu Yuan. Digitalization 5.0: Metaverse. *Proc. IEEE Metaverse Congress*.
18. Zahy Ramadan. Marketing in the metaverse era: Toward an integrative channel approach. *Virtual Reality*, pages 1–14, 2023.
19. Matteo Zallio and P John Clarkson. Designing the metaverse: A study on inclusion, diversity, equity, accessibility and safety for digital immersive environments. *Telematics and Informatics*, 75:101909, 2022.
20. Lik-Hang Lee, Tristan Braud, Pengyuan Zhou, Lin Wang, Dianlei Xu, Zijun Lin, Abhishek Kumar, Carlos Bermejo, and Pan Hui. All one needs to know about metaverse: A complete survey on technological singularity, virtual ecosystem, and research agenda. *arXiv preprint arXiv:2110.05352*, 2021.
21. Pronaya Bhattacharya, Deepti Saraswat, Darshan Savaliya, Sakshi Sanghavi, Ashwin Verma, Vatsal Sakariya, Sudeep Tanwar, Ravi Sharma, Maria Simona Raboaca, and Daniela Lucia Manea. Towards future internet: The metaverse perspective for diverse industrial applications. *Mathematics*, 11(4):941, 2023.
22. Georg David Ritterbusch and Malte Rolf Teichmann. Defining the metaverse: A systematic literature review. *IEEE Access*, 11:12368–12377, 2023.
23. Dapeng Wu, Zhigang Yang, Puning Zhang, Ruyan Wang, Boran Yang, and Xinqiang Ma. Virtual-reality inter-promotion technology for metaverse: A survey. *IEEE Internet of Things Journal*, pages 1–1, 2023.
24. Akhilesh Mohan Srivastava, Priyanka Ajay Rotte, Arushi Jain, and Surya Prakash. Handling data scarcity through data augmentation in training of deep neural networks for 3D data processing. *International Journal on Semantic Web and Information Systems*, 18(1):1–16, 2022.
25. Jinghui Chu, Xiaoqian Zhao, Dan Song, Wenhui Li, Shenyuan Zhang, Xuanya Li, and An-An Liu. Improved semantic representation learning by multiple clustering for image-based 3d model retrieval. *International Journal on Semantic Web and Information Systems*, 18(1):1–20, 2022.
26. Thien Huynh-The, Thippa Reddy Gadekallu, Weizheng Wang, Gokul Yenduri, Pasika Ranaweera, Quoc-Viet Pham, Daniel Benevides da Costa, and Madhusanka Liyanage. Blockchain for the metaverse: A review. *Future Generation Computer Systems*, 143:401–419, 2023.
27. Steve Mann, Kris M Kitani, Yong Jae Lee, MS Ryoo,

and Alireza Fathi. An introduction to the 3rd workshop on egocentric (first-person) vision. In *Computer Vision and Pattern Recognition Workshops (CVPRW), 2014 IEEE Conference on*, pages 827–832. IEEE, 2014.
28. Gloria L Krahn. WHO World report on disability: A review. *Disability and Health Journal*, 4(3):141–142, 2011.
29. Steve Mann, Jaden Bhimani, Samir Khaki, and Calum Leaver-Preyra. Smart paddleboard and other assistive veyances. In *Proc. IEEE International Symposium on Cyborg and Bionic Systems*, pages 1–8, 2022.
30. Steve Mann. "Moveillance™, A new vision for mobility – Mobility and vision sensing for the elderly and persons with disabilities.". In *Proc. First International Conference on Science-Technology Openness & Cooperation, Keynote Address*, pages 1–45.

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