ITU KALEIDOSCOPE
ONLINE 2021

6-10 December 2021

Accelerating world's transition to medical VR training: Computational medical XR

Prof. George Papagiannakis
University of Crete, FORTH, ORamaVR

Invited speaker

Overview

- How many realities?
- Computational science?
- Key grand challenges of computational medical XR?
- Our approach towards these challenges
- Ethics & Privacy?

TECHNOLOGIE Réalité et images de synthèse mêlées

LE TOURISME EN 3D EST NÉ

INNOVATION Grâce à des lunettes spéciales, le touriste peut se promener dans Pompéi en voyant à la fois la pièce dans laquelle il se trouve, et des personnages d'époque, créés par ordinateur, qui évoluent à ses côtés!

GENÈVE Le système révolutionnaire, créé par une équipe de spécialistes européens, permet de visiter des sites archéologiques comme si on voyageait dans le temps.

Frédéric Julliard

Une technique révolutionnaire, née en Suisse romande, pourrait bouleverser le monde du tourisme. Pour la première fois, des chercheurs sont parvenus à superposer en temps réel un paysage et des images de synthèse. Pour dire les choses en français, le système présenté à Genève permet à un touriste, muni de lunettes spéciales, de se promener dans Pompéi (site choisi pour le prototype) en voyant à la fois la pièce bien réelle dans laquelle il se trouve, et des personnages d'époque, créés par ordinateur, qui évoluent à ses côtés!

Contrairement à la réalité virtuelle, qui construit des scènes entièrement artificielles, la «réalité augmentée» mélange monde réel et images de synthèse. Le cinéma s'en sert, par exemple, pour ajouter des dinosaures à un paysage. Mais, jusqu'ici, il fallait calculer les images une à une. L'exploit de l'équipe basée à Genève a consisté à réduire le temps de calcul à une fraction de seconde. L'ordinateur peut ainsi suivre les mouvements du spectateur et lui donner l'impression qu'il se promène dans Pompéi au temps des Romains...

Un prototype à alléger

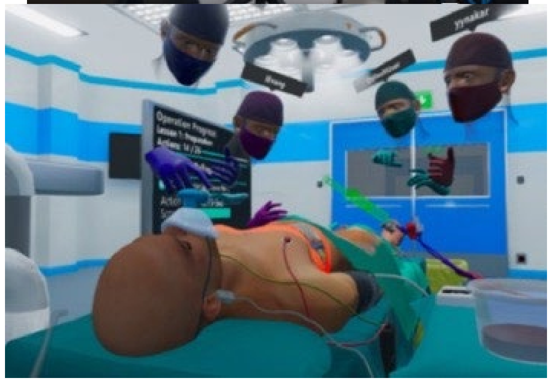
Baptisé Lifeplus, le projet est financé par l'Union européenne à hauteur de 2,8 millions de francs. Il réunit une brochette de spécialistes européens autour de Nadia Magnenat-Thalmann, de l'Université de Genève. L'équipe doit encore peaufiner le prototype, mais aussi l'alléger: l'utilisateur doit transporter avec lui un ordinateur portable, nécessaire aux calculs très complexes des images en 3D. A terme, le logiciel pourrait tenir dans un simple agenda électronique de type PDA, branché sur les lunettes servant à projeter les images.

Le XVIIIe siècle comme si on y était

Avec ce matériel réduit, on pourra arpenter n'importe quel site. «Les touristes pourraient, par exemple, se balader sur la plaine de Plainpalais, à Genève, et la voir telle qu'elle était au XVIIIe siècle», imagine Nadia Magnenat-Thalmann.

Les applications ne se limitent pas au tourisme: le système intéresse la pub, le cinéma, la télévision... Il devrait être opérationnel dans les cinq ans. «Comme l'industrie s'en mêle, explique Nadia Magnenat-Thalmann, ça pourrait même aller bien plus vite.»

SITE INTERNET
www.miralab.unige.ch/subpages/lifeplus/



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FORTH Foundation for Research & Technology - Hellas

ORama VR

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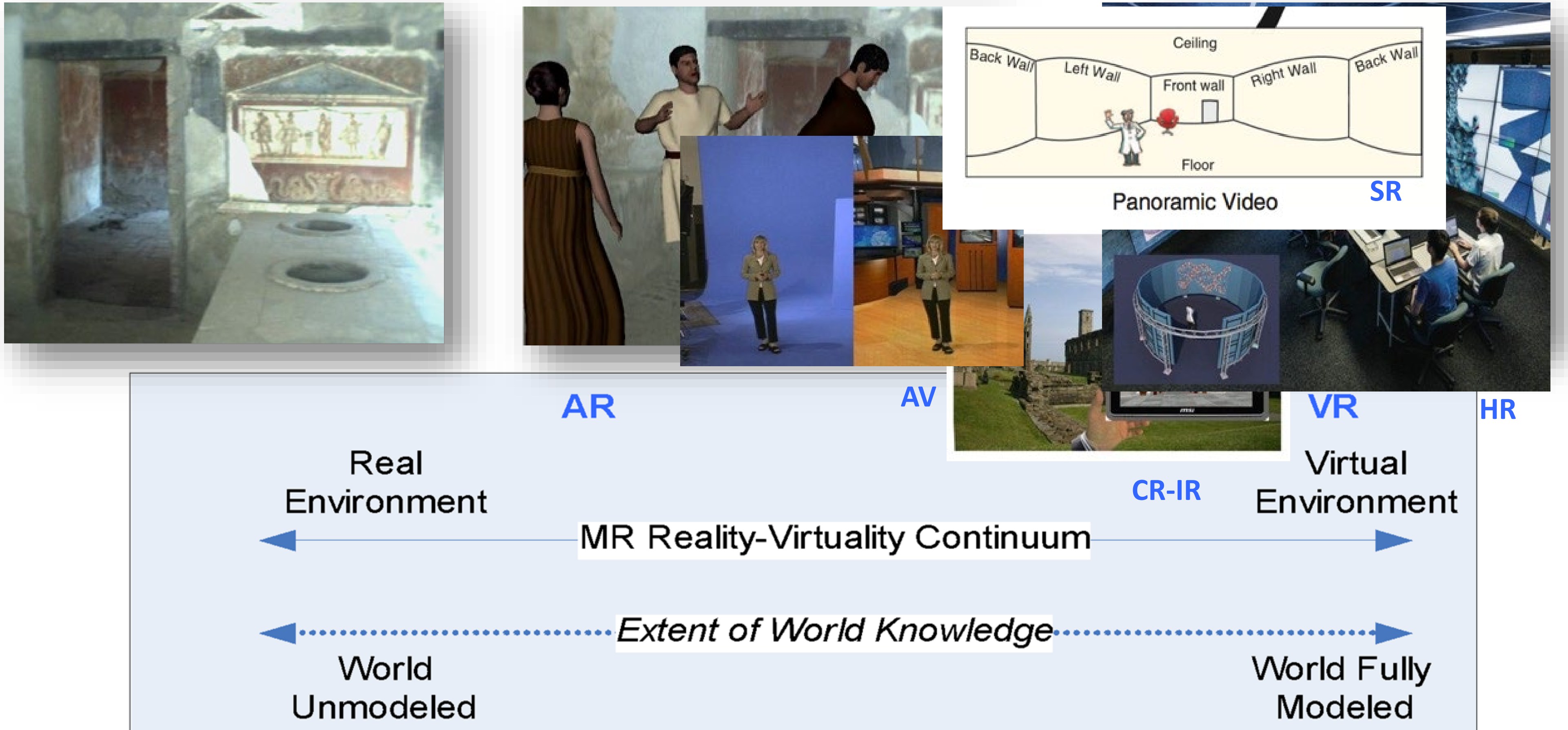
How many Realities? MR = AR + VR + AV+ CR+ IR+ HR+ SR…



The Mixed ('X') Reality (MR) Continuum [Milgram99] [Azuma01]

AR-VR: Papagiannakis, G., Schertenleib, S., O'Kennedy, B., Poizat, M., Magnenat-Thalmann, N., Stoddart, A., Thalmann, D., 2005. Mixing Virtual and Real scenes in the site of ancient Pompeii. *Computer Animation and Virtual Worlds, John Wiley and Sons Ltd 16*, 1, 11–24.

Cross-Reality (CR): Davies, C.J., Miller, A., and Allison, C. 2012. Virtual Time Windows: Applying cross reality to cultural heritage. *Proceedings of the Postgraduate Conference on the Convergence of Networking and Telecomunications, ISBN: 978-1-902560-26-7*.

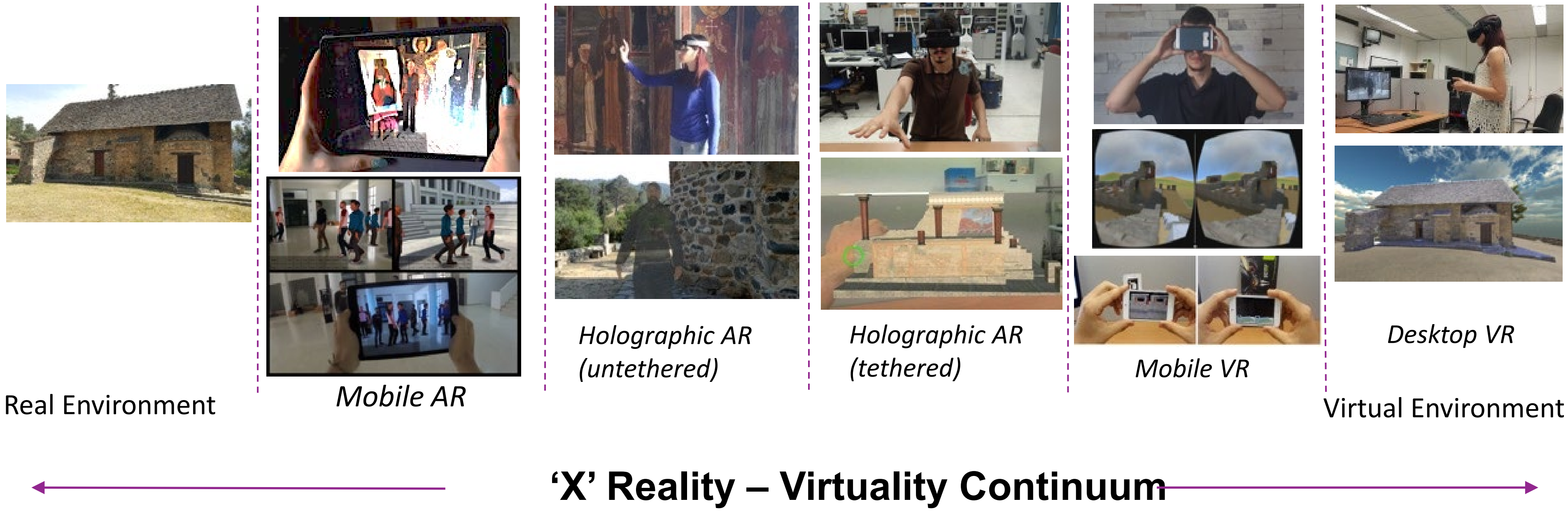
Hybrid-Reality (HR): Reda, K., Febretti, A., Knoll, A., et al. 2013. Visualizing Large, Heterogeneous Data in Hybrid-Reality Environments. *Computer Graphics and Applications, IEEE 33*, 4, 38–48.

Indirect Reality (IR): Wither, J., Tsai, Y.-T., and Azuma, R. 2011. Indirect augmented reality. Computers & Graphics 35, 4, 810–822.

Substitutional Reality (SR): K. Suzuki, S. Wakisaka, and N. Fujii, "Substitutional Reality System: A Novel Experimental Platform for Experiencing Alternative Reality," *Sci. Rep., vol. 2, pp. 1–9, Jun. 2012.*

‘X’ Reality (XR) Continuum

(X = A,V, M for AR, VR, MR…)

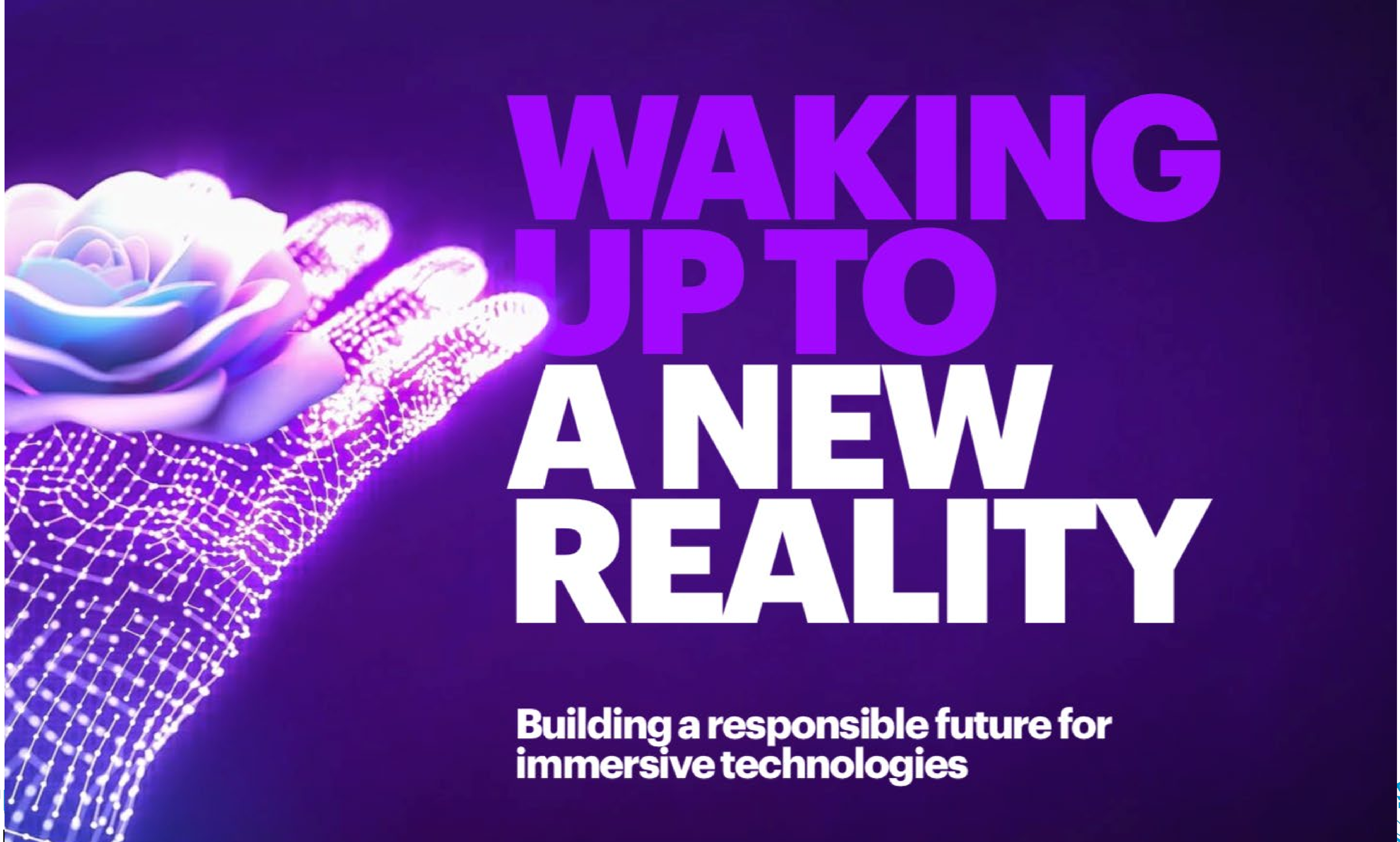


Ioannides, M., Magnenat-Thalmann, N., Papagiannakis, G., (Eds), Mixed Reality and Gamification for Cultural Heritage, Springer-Nature, DOI: 10.1007/978-3-319-49607-8, 2017

‘X’ Reality (XR) Continuum

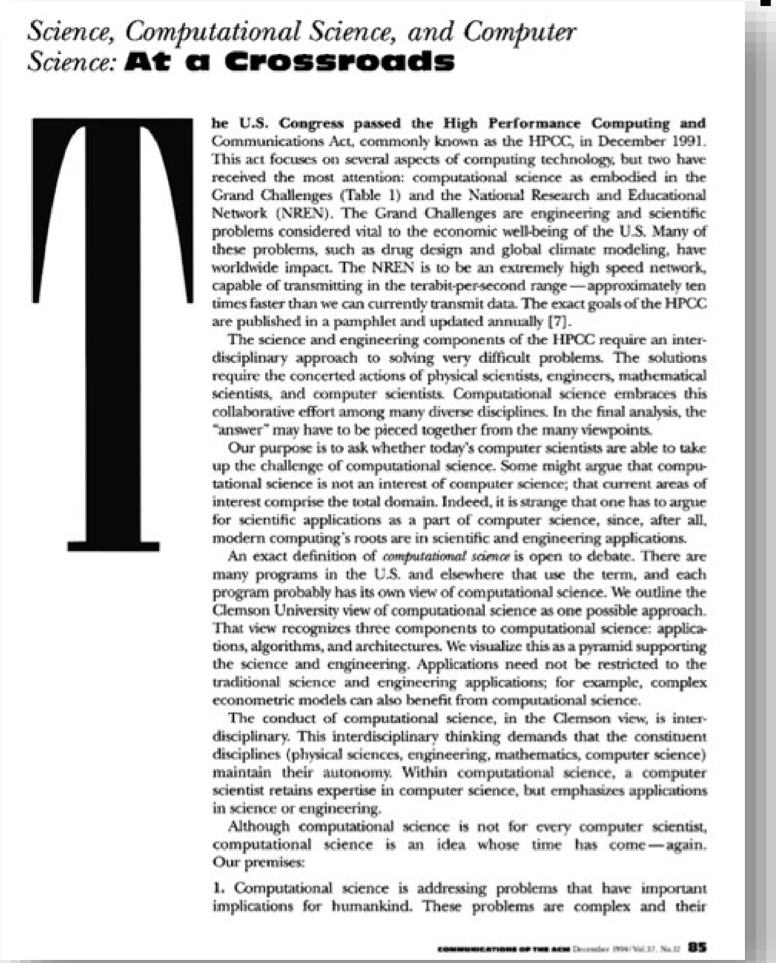
(X = A,V, M for AR, VR, MR…)

Ioannides, M., Magnenat-Thalmann, N., Papagiannakis, G., (Eds), Mixed Reality and Gamification for Cultural Heritage, Springer-Nature,
DOI: 10.1007/978-3-319-49607-8, 2017



Source: Accenture Consulting. WAKING UP TO A NEW REALITY | Accenture. 2019.

Science, Computational Science and Computer Science?



Science, Computational Science, and Computer Science: At a Crossroads

The U.S. Congress passed the High Performance Computing and Communications Act, commonly known as the HPCC, in December 1991. This act focuses on several aspects of computing technology, but two have received the most attention: computational science as embodied in the Grand Challenges (Table 1) and the National Research and Educational Network (NREN). The Grand Challenges are engineering and scientific problems considered vital to the economic well-being of the U.S. Many of these problems, such as drug design and global climate modeling, have worldwide impact. The NREN is to be an extremely high speed network, capable of transmitting in the terabit-per-second range — approximately ten times faster than we can currently transmit data. The exact goals of the HPCC are published in a pamphlet and updated annually [7].

The science and engineering components of the HPCC require an interdisciplinary approach to solving very difficult problems. The solutions require the concerted actions of physical scientists, engineers, mathematical scientists, and computer scientists. Computational science embraces this collaborative effort among many diverse disciplines. In the final analysis, the "answer" may have to be pieced together from the many viewpoints.

Our purpose is to ask whether today's computer scientists are able to take up the challenge of computational science. Some might argue that computational science is not an interest of computer science; that current areas of interest comprise the total domain. Indeed, it is strange that one has to argue for scientific applications as a part of computer science, since, after all, modern computing's roots are in scientific and engineering applications.

An exact definition of *computational science* is open to debate. There are many programs in the U.S. and elsewhere that use the term, and each program probably has its own view of computational science. We outline the Clemson University view of computational science as one possible approach. That view recognizes three components to computational science: applications, algorithms, and architectures. We visualize this as a pyramid supporting the science and engineering. Applications need not be restricted to the traditional science and engineering applications; for example, complex econometric models can also benefit from computational science.

The conduct of computational science, in the Clemson view, is interdisciplinary. This interdisciplinary thinking demands that the constituent disciplines (physical sciences, engineering, mathematics, computer science) maintain their autonomy. Within computational science, a computer scientist retains expertise in computer science, but emphasizes applications in science or engineering.

Although computational science is not for every computer scientist, computational science is an idea whose time has come — again. Our premises:

1. Computational science is addressing problems that have important implications for humankind. These problems are complex and their

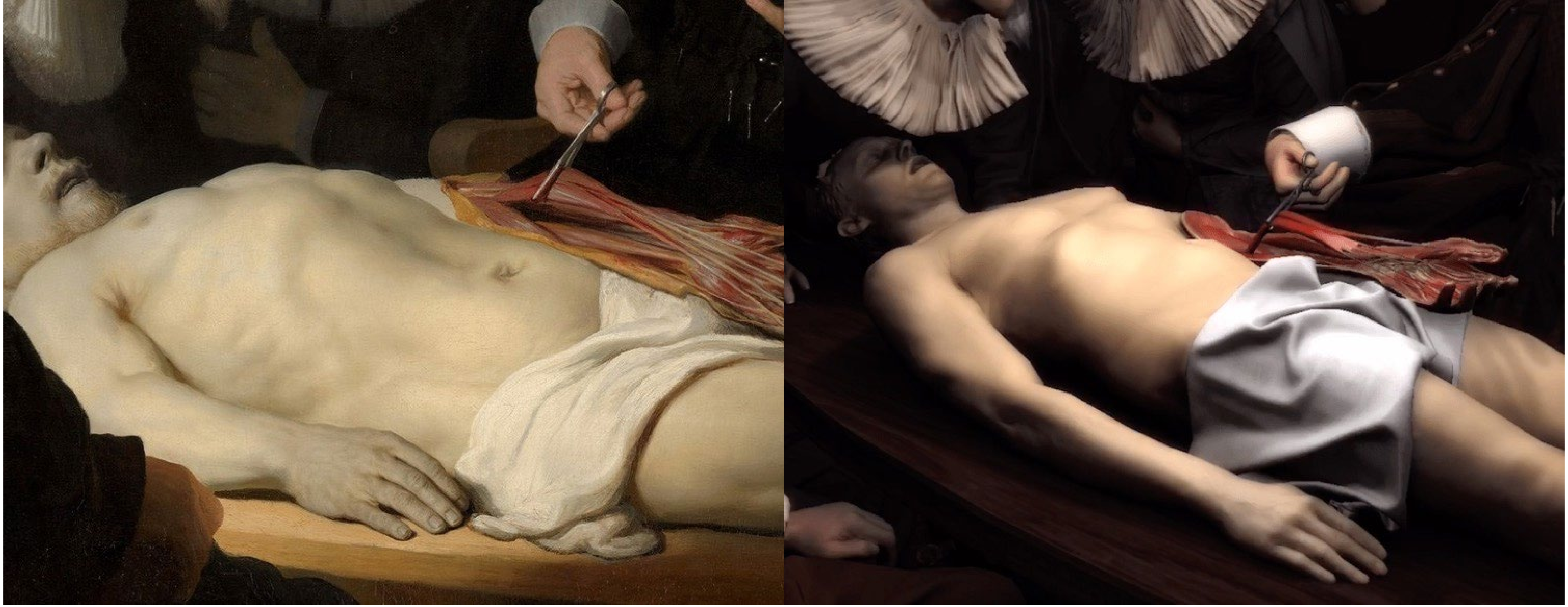
D. E. Stevenson. 1994. Science, computational science, and computer science: at a crossroads. Commun. ACM 37, 12 (Dec. 1994), 85–96. DOI:https://doi.org/10.1145/198366.198386

Why Computational Science?

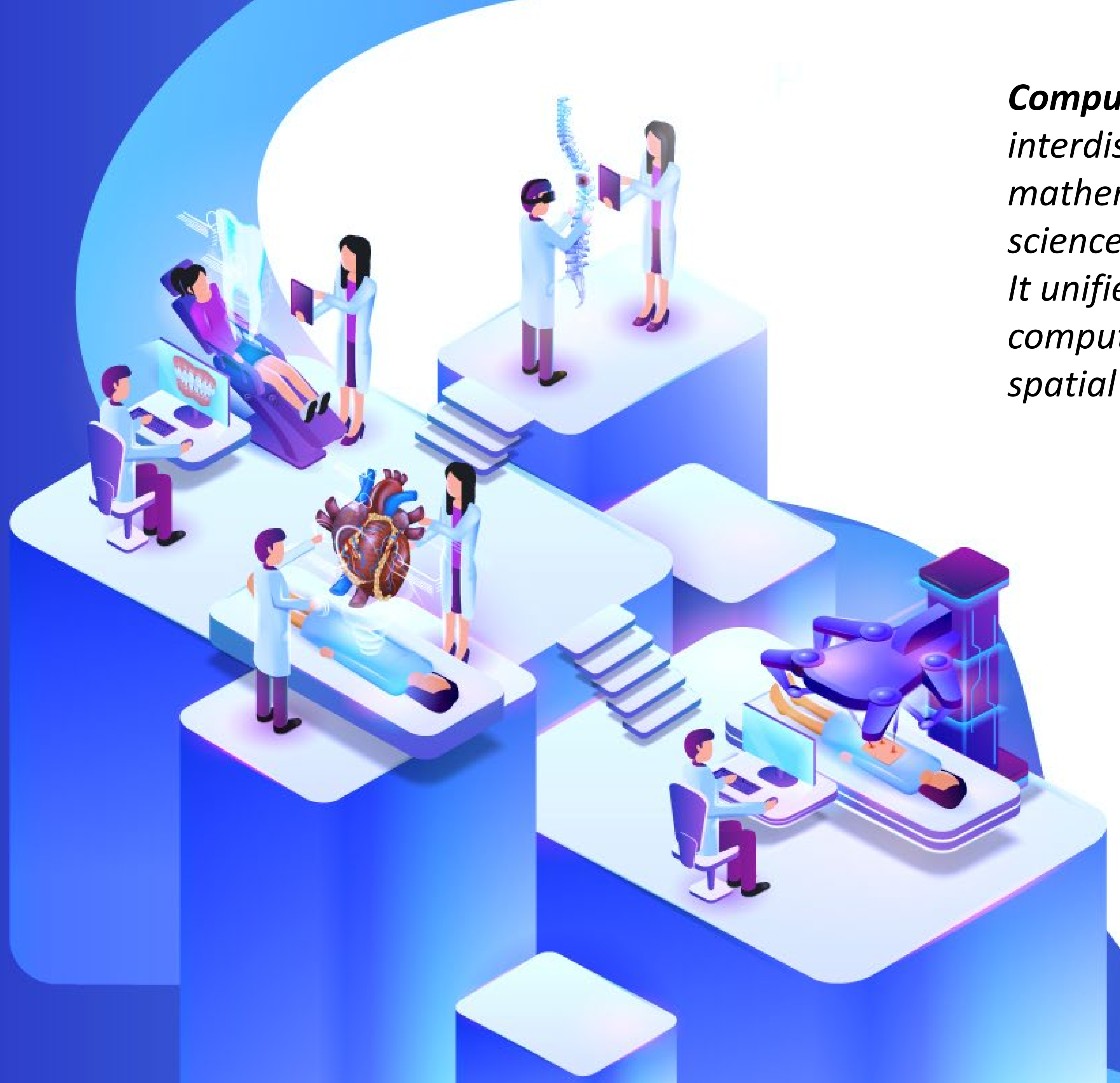
An interdisciplinary field (physical sciences, engineering, mathematics, computer science) whose time has come – again:

- Addressing complex problems that have important implications to humankind,
- Unlikely to succeed in near term without further advances in software and hardware
- Computer science is generally not participating in science or engineering applications or preparing students to do so

https://www.mauritshuis.nl/en/press/persarchief/2019/rembrandt-reality/



Computational science + XR experiential technologies for medicine?



***Computational medical XR** is a new interdisciplinary field, bridging life sciences, with mathematics, engineering and computer science.*
*It unifies **computational** science (scientific computing) with intelligent **extended reality** and spatial computing for the **medical** field.*

It extends significantly clinical XR by

- bringing on computer **simulation** and other forms of **computation**
- from **numerical** analysis, computational **geometry**, computational **vision** and computer **graphics** with theoretical computer science and machine **learning**, in order to solve **hard problems** in medicine

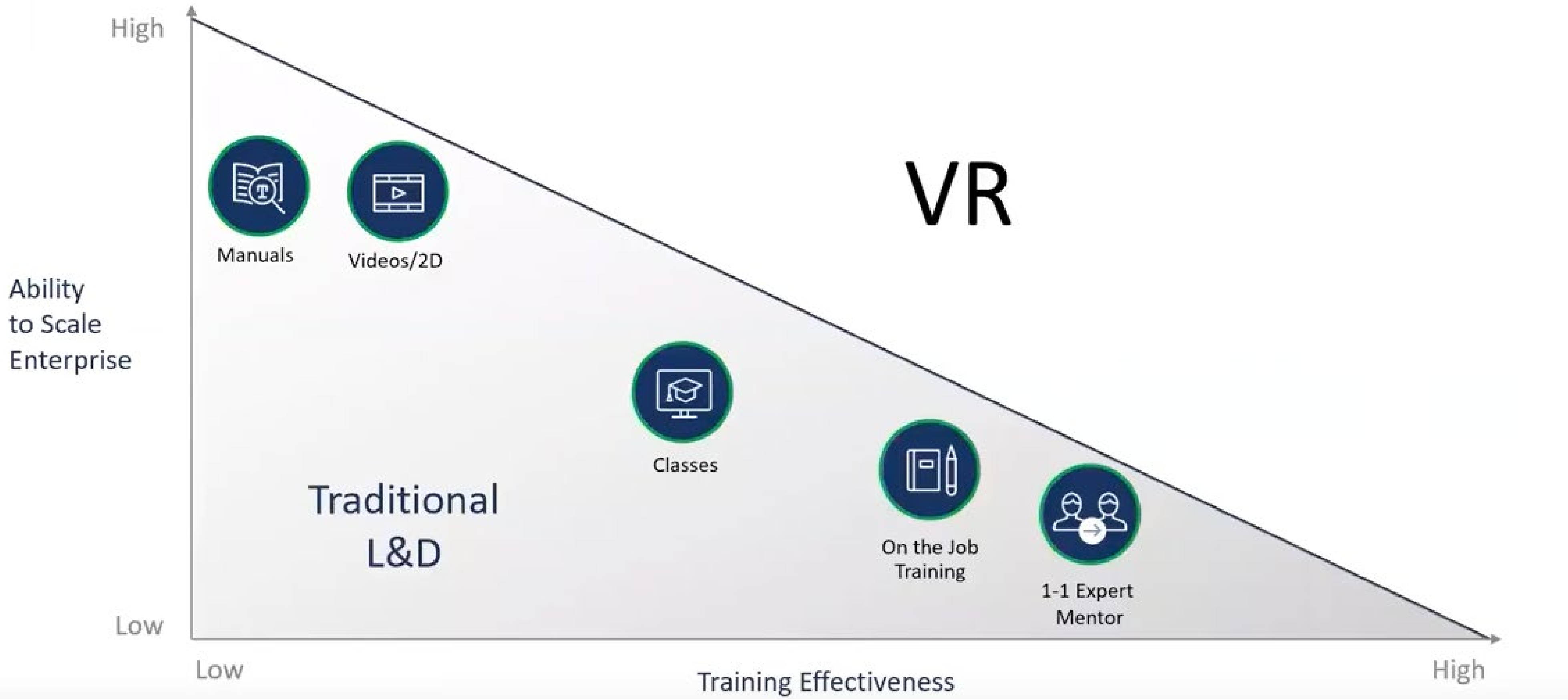
https://george-papagiannakis.medium.com/a-new-xr-computational-medicine-discipline-9a48ae1550c

Why Computational XR medicine?

- Medical schools, dental schools, nursing academies, medical device companies, hospitals and surgical training centers are now leading in-house the “**VRification**” of their curricula,
- hence driving themselves further the **adoption** and **customization** of their medical VR simulations.
- Through the ability to **control** and **develop** their **own XR training** material, they can ensure their medical professionals are **properly** and (continuously) **trained**
- while **ensuring** optimal patient outcomes and **fewer medical errors**/complications.

Papagiannakis, G., “A computational medical XR discipline”, https://arxiv.org/abs/2108.04136

Transforming the Enterprise Training Landscape

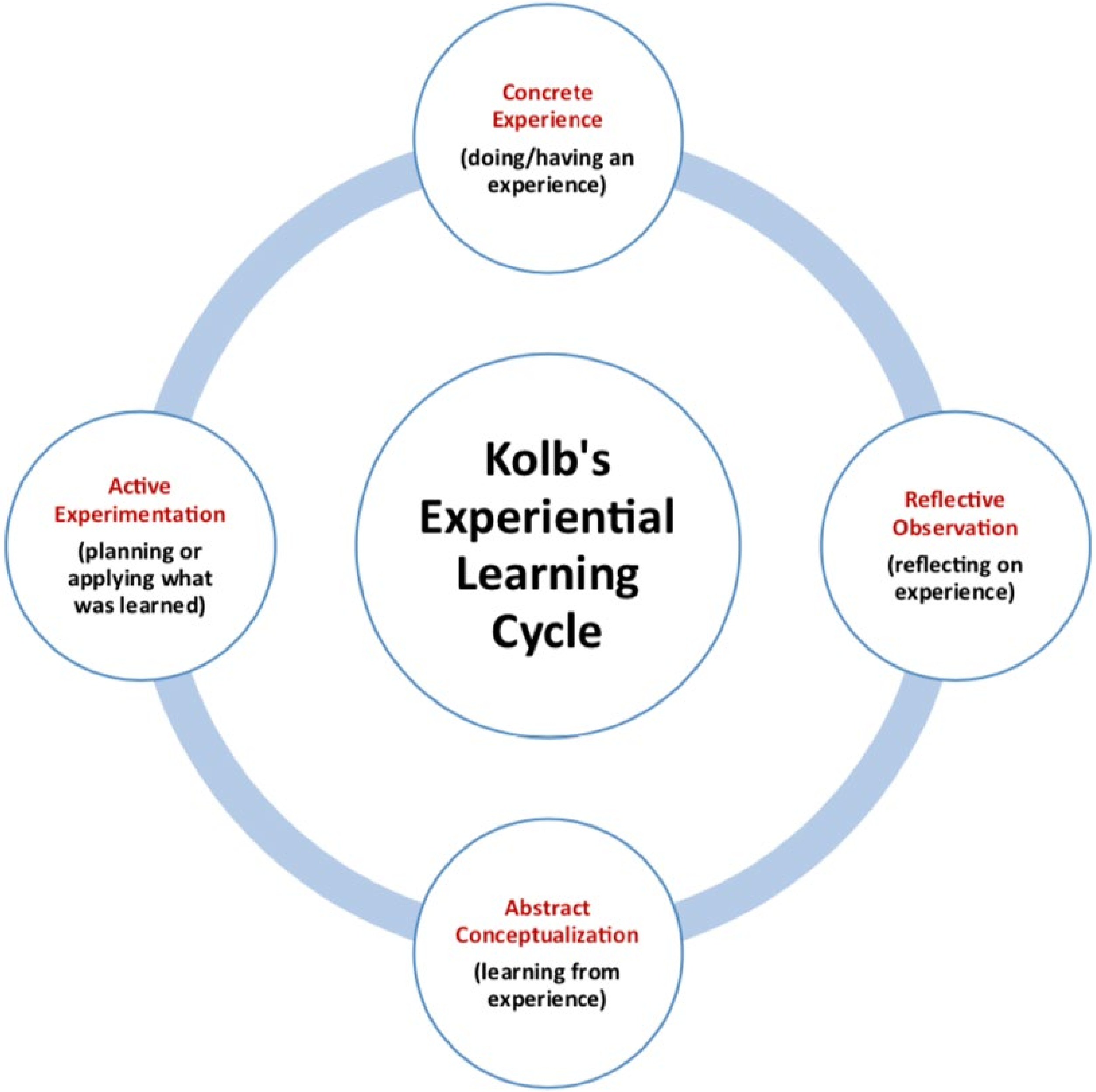


Source: STRIVR webinar: http://www.virtualrealityrental.co/blog-post/applications-of-virtual-reality
Webinar - STRIVR - Virtual Reality for Employee Training

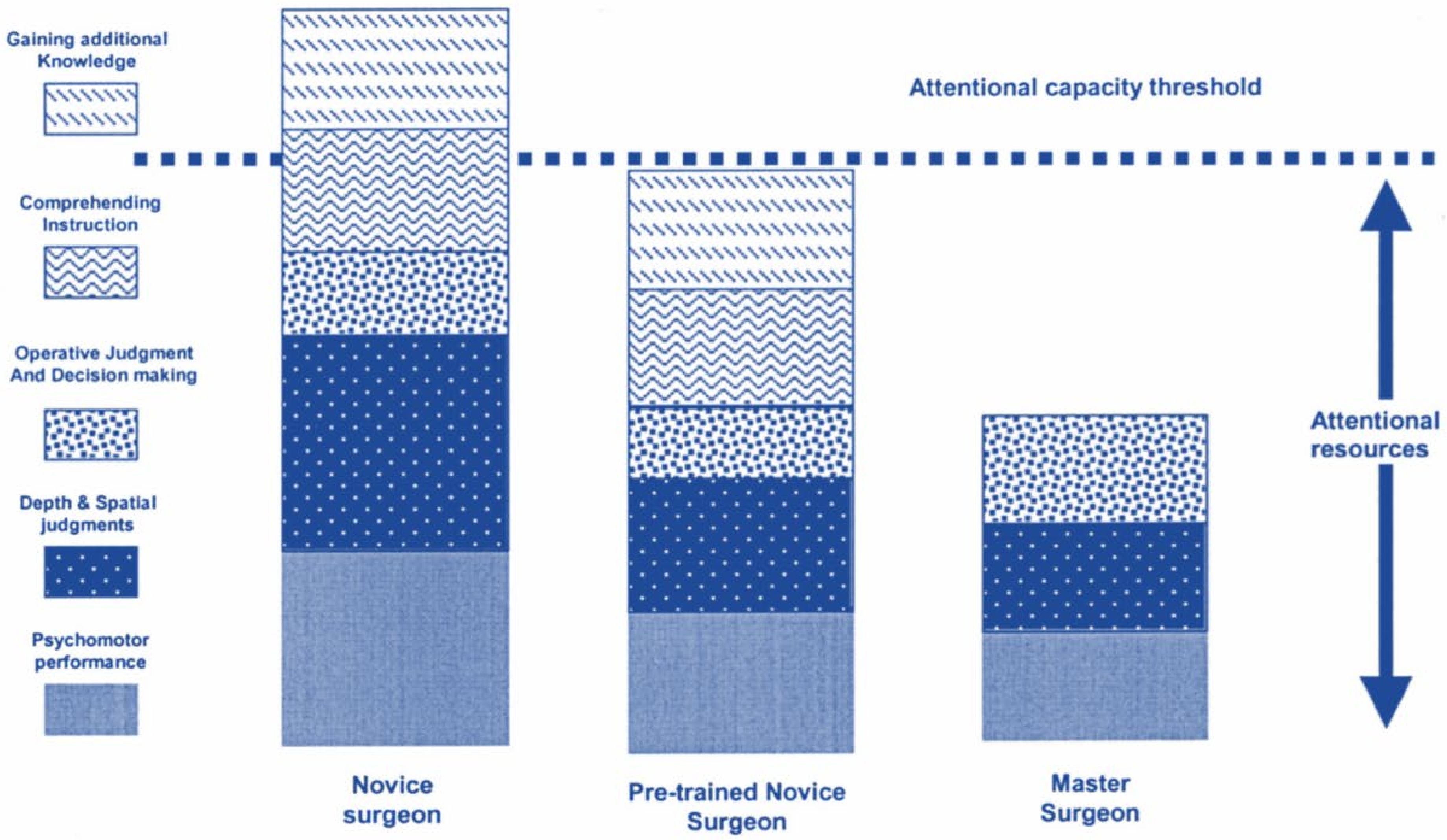
Strong Use Cases

Best Way is "Learning by Doing", BUT…

Source: STRIVR webinar: http://www.virtualrealityrental.co/blog-post/applications-of-virtual-reality
Webinar - STRIVR - Virtual Reality for Employee Training



Source: Kolb DA. Experiential learning. Englewood Cliffs (NJ): Prentice Hall; 1984



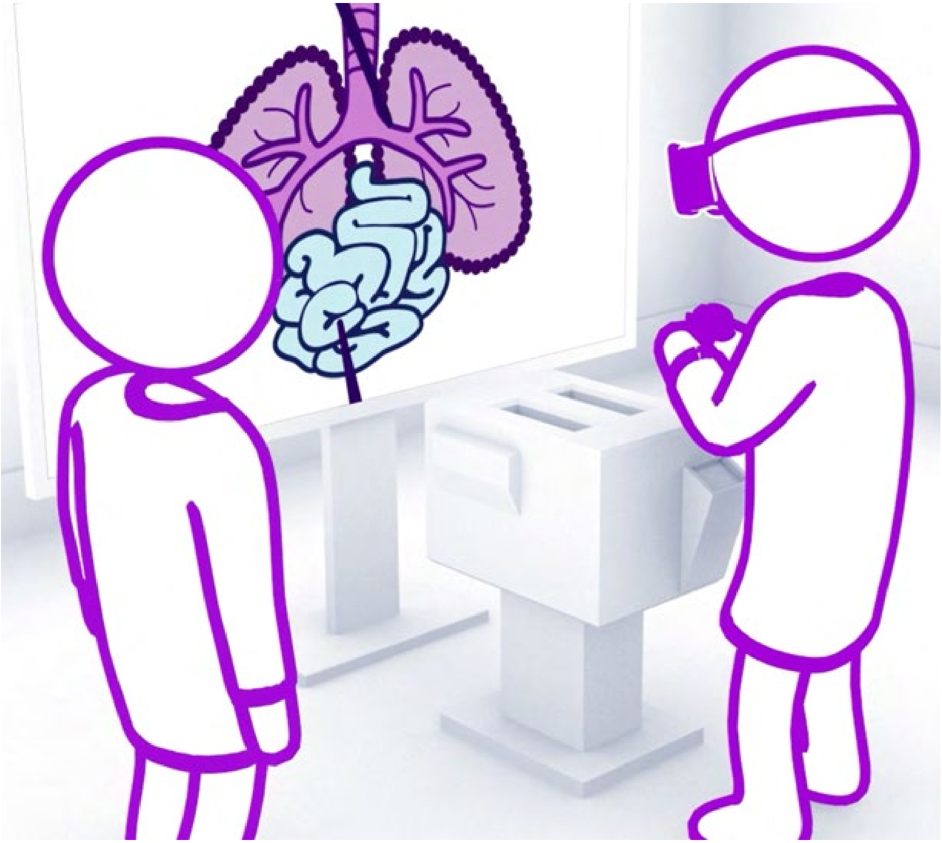
Source: Gallagher AG, Ritter EM, Champion H, Higgins G. Virtual reality simulation for the operating room: proficiency-based training as a paradigm shift in surgical skills training. Annals of Surgery. 2005. doi:10.1097/01.sla.0000151982.85062.80.

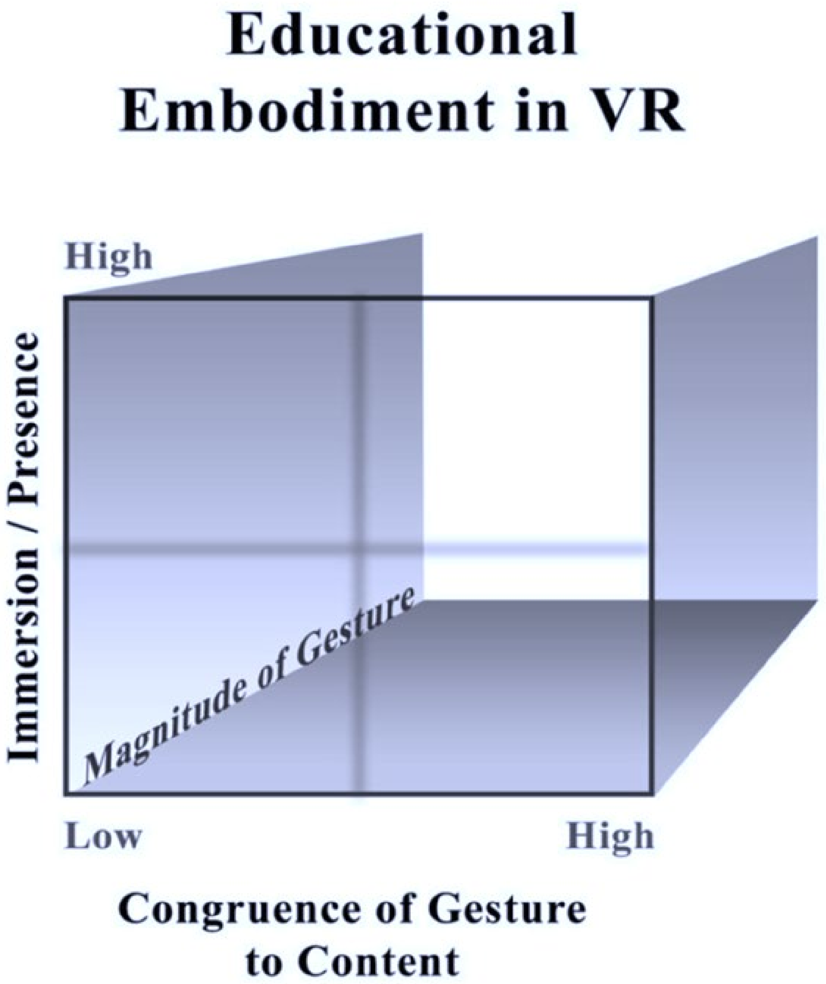
William Clifford

THE JOHNS HOPKINS UNIVERSITY PRESS

Applications of Grassmann's Extensive Algebra
Author(s): Professor Clifford
Source: *American Journal of Mathematics*, Vol. 1, No. 4 (1878), pp. 350-358
Published by: The Johns Hopkins University Press
Stable URL: https://www.jstor.org/stable/2369379
Accessed: 06-08-2018 12:02 UTC

CLIFFORD, W.K. 1878. Applications of Grassmann's extensive algebra. *American Journal of Mathematics 1*, 4, 350–358.





Source: Johnson-Glenberg MC. Immersive VR and Education: Embodied Design Principles That Include Gesture and Hand Controls. Front Robot AI. 2018;5:27. doi:10.3389/frobt.2018.00081.

> "
> **The scene is set for massive change**

which are the key grand challenges for medical VR training?

Source: Accenture Consulting. WAKING UP TO A NEW REALITY | Accenture. 2019.

Virtual Reality Technology For Medicine

- Current technologies and concepts are founded on more than *30 years of research and development*
- Recent changes in cost and access make VR affordable
- VR tech is currently used for prevention, evaluation, treatment and chronic disease management
- After years of validation and use by early adopters - VR technology is poised to move to the mainstream
- On the horizon: enhanced, ubiquitous, informative and integrated

Dr. Walter Greenleaf,
Stanford Health Care & Virtual Human Interaction Lab


ORama VR
Operation Progress:
esson 1: Knee Incision
tions: 0 / 68
Cut Epidermis
Operation Start
Action Time: 13.98 Sec
Score: 100%
Errors: 1

Grand challenges in computational medical XR

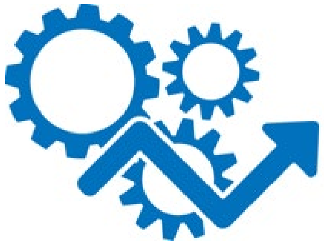
Networked collaboration
5G Edge computing technology for unlimited, networked collaboration across all XR, desktop/mobile devices

SDK platform tools
Unity & Unreal?

Real clinical validation
published clinical trials in high-impact scientific journals

Low-code authoring
days instead of 6-8 months for a high-fidelity medical VR learning module

Development cost
decrease in VR dev hours, code complexity and size



Optimize cut-tear-drill
develop more VR content, deploy it faster with cutting-edge features

Challenge: clinical trial validation on psychomotor surgical skills

Title:

Virtual Reality Facilitates Training in the Performance of Total Hip Arthroplasty: A Randomized Controlled Trial,

The Journal of Arthroplasty, 2019, ISSN 0883-5403, https://doi.org/10.1016/j.arth.2019.04.002,

Results:

The VR cohort demonstrated ***greater improvement in all score categories*** (procedural steps, technical performance, visuospatial skills, efficiency, and flow) compared to the standard group

- Measured 8% improvement in all categories above right just after **2 VR trials**
- *Future trial: after 20 VR trials what will be the measured improvement?*

https://www.sciencedirect.com/science/article/pii/S0883540319303341

ELSEVIER

The Journal of Arthroplasty

Available online 8 April 2019

In Press, Accepted Manuscript

Virtual Reality Simulation Facilitates Resident Training in Total Hip Arthroplasty: A Randomized Controlled Trial

Jessica Hooper [1], Eleftherios Tsiridis [2, 3], James E. Feng [1], Ran Schwarzkopf [1], Daniel Waren [1], William J. Long III [1], Lazaros Poultsides [1], William Macaulay [1]

the NYU Virtual Reality Consortium[5]

George Papagiannakis [4], Eustathios Kenanidis [6, 7], Eduardo D. Rodriguez [5], James Slover [5], Kenneth A. Egol [5], Donna P. Phillips [5], Scott Friedlander [5], Michael Collins [5]

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Challenge: clinical trial validation on cognitive skills and physical training for Mild Cognitive Impairment

Title:

A Virtual Reality App for Physical and Cognitive Training of Older People With Mild Cognitive Impairment: Mixed Methods Feasibility Study

https://games.jmir.org/2021/1/e24170/

Results:

1. VRADA is an acceptable, usable, and tolerable system for physical and cognitive training of older people with MCI
2. Participants showed **a significant preference for the VR condition** (students: mean 0.66, SD 0.41, t29=8.74, P<.001; patients with MCI: mean 0.72, SD 0.51, t26=7.36, P<.001),
3. as well as **high acceptance scores** for intended future use, attitude toward VR training, and enjoyment.
4. System usability scale scores (82.66 for the students and 77.96 for the older group) were well above the acceptability threshold (75/100)

Published on 24.3.2021 in Vol 9, No 1 (2021): Jan-Mar
Preprints (earlier versions) of this paper are available at https://preprints.jmir.org/preprint/24170, first published September 08, 2020.

A Virtual Reality App for Physical and Cognitive Training of Older People With Mild Cognitive Impairment: Mixed Methods Feasibility Study

Mary Hassandra [1]; Evangelos Galanis [1]; Antonis Hatzigeorgiadis [1]; Marios Goudas [1]; Christos Mouzakidis [2]; Eleni Maria Karathanasi [2]; Niki Petridou [2]; Magda Tsolaki [2, 3]; Paul Zikas [4]; Giannis Evangelou [4]; George Papagiannakis [4, 5]; George Bellis [6]; Christos Kokkotis [1, 6]; Spyridon Rafail Panagiotopoulos [6]; Giannis Giakas [1]; Yannis Theodorakis [1]

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- Abstract
- Introduction
- Methods
- Results
- Discussion
- Abbreviations
- Copyright

Abstract

Background:
Therapeutic virtual reality (VR) has emerged as an effective treatment modality for cognitive and physical training in people with mild cognitive impairment (MCI). However, to replace existing nonpharmaceutical treatment training protocols, VR platforms need significant improvement if they are to appeal to older people with symptoms of cognitive decline and meet their specific needs.

Objective:
This study aims to design and test the acceptability, usability, and tolerability of an immersive VR platform that allows older people with MCI symptoms to simultaneously practice physical and cognitive skills on a dual task.

Methods:
On the basis of interviews with 20 older people with MCI symptoms (15 females; mean age 76.25, SD 5.03 years) and inputs from their health care providers (formative study VR1), an interdisciplinary group of experts developed a VR system called VRADA (VR Exercise App for Dementia and Alzheimer's Patients). Using an identical training protocol, the VRADA system was first tested with a group of 30 university students (16 females; mean age 20.86, SD 1.17 years) and then with 27 older people (19 females; mean age 73.22, SD 9.26 years) who had been diagnosed with MCI (feasibility studies VR2a and VR2b). Those in the latter group attended two Hellenic Association Day Care Centers for Alzheimer's Disease and Related Disorders. Participants in both groups were asked to perform a dual task training protocol that combined physical and cognitive exercises in two different training conditions. In condition A, participants performed a cycling task in a lab environment while being asked by the researcher to perform oral math calculations (single-digit additions and subtractions). In condition B, participants performed a cycling task in the virtual environment while performing calculations that appeared within the VR app. Participants in both groups were assessed in the same way; this included questionnaires and semistructured interviews immediately after the experiment to capture perceptions of acceptability, usability, and tolerability, and to determine which of the two training conditions each participant preferred.

Results:
Participants in both groups showed a significant preference for the VR condition (students: mean 0.66, SD 0.41, t_{29}=8.74, P<.001; patients with MCI: mean 0.72, SD 0.51, t_{26}=7.36, P<.001), as well as high acceptance scores for intended future use, attitude toward VR training, and enjoyment. System usability scale scores (82.66 for the students and 77.96 for the older group) were well above the acceptability threshold (75/100). The perceived adverse effects were minimal, indicating a satisfactory tolerability.

Conclusions:
The findings suggest that VRADA is an acceptable, usable, and tolerable system for physical and cognitive training of older people with MCI and university students. Randomized controlled trial studies are needed to assess the efficacy of VRADA as a tool to promote physical and cognitive health in patients with MCI.

Citation

Please cite as:

Hassandra M, Galanis E, Hatzigeorgiadis A, Goudas M, Mouzakidis C, Karathanasi EM, Petridou N, Tsolaki M, Zikas P, Evangelou G, Papagiannakis G, Bellis G, Kokkotis C, Panagiotopoulos SR, Giakas G, Theodorakis Y
A Virtual Reality App for Physical and Cognitive Training of Older People With Mild Cognitive Impairment: Mixed Methods Feasibility Study
JMIR Serious Games 2021;9(1):e24170
doi: 10.2196/24170
PMID: 33759797

Challenge: clinical trial validation on cognitive skills and memory retention

Title:

Effectiveness and utility of virtual reality simulation as educational tool for safe performance of COVID-19 diagnostics: a prospective, randomized pilot trial

JMIR, (accepted)

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Published on 8.10.2021 in Vol 9, No 4 (2021): Oct-Dec

Preprints (earlier versions) of this paper are available at https://preprints.jmir.org/preprint/29586, first published April 26, 2021.

Effectiveness and Utility of Virtual Reality Simulation as an Educational Tool for Safe Performance of COVID-19 Diagnostics: Prospective, Randomized Pilot Trial

Tanja Birrenbach [1,2]; Josua Zbinden [1]; George Papagiannakis [3,4,5]; Aristomenis K Exadaktylos [1]; Martin Müller [1]; Wolf E Hautz [1]; Thomas Christian Sauter [1]

Article | Authors | Cited by | Tweetations | Metrics

- Abstract
- Introduction
- Methods
- Results
- Discussion
- References
- Abbreviations
- Copyright

Abstract

Background: Although the proper use of hygiene and personal protective equipment (PPE) is paramount for preventing the spread of diseases such as COVID-19, health care personnel have been shown to use incorrect techniques for donning/doffing of PPE and hand hygiene, leading to a large number of infections among health professionals. Education and training are difficult owing to the social distancing restrictions in place, shortages of PPE and testing material, and lack of evidence on optimal training. Virtual reality (VR) simulation can offer a multisensory, 3-D, fully immersive, and safe training opportunity that addresses these obstacles.

Objective: The aim of this study is to explore the short- and long-term effectiveness of a fully immersive VR simulation versus a traditional learning method regarding a COVID-19–related skill set and media-specific variables influencing training outcomes.

Methods: This was a prospective, randomized controlled pilot study on medical students (N=29; intervention VR training, n=15, vs control video-based instruction, n=14) to compare the performance of hand disinfection, nasopharyngeal swab taking, and donning/doffing of PPE before and after training and 1 month later as well as variables of media use.

Results: Both groups performed significantly better after training, with the effect sustained over one month. After training, the VR group performed significantly better in taking a nasopharyngeal swab, scoring a median of 14 out of 17 points (IQR 13-15) versus 12 out of 17 points (IQR 11-14) in the control group, $P=.03$. With good immersion and tolerability of the VR simulation, satisfaction was significantly higher in the VR group compared to the control group (median score of User Satisfaction Evaluation Questionnaire 27/30, IQR 23-28, vs 22/30, IQR 20-24, in the control group; $P=.01$).

Conclusions: VR simulation was at least as effective as traditional learning methods in training medical students while providing benefits regarding user satisfaction. These results add to the growing body of evidence that VR is a useful tool for acquiring simple and complex clinical skills.

Citation

Please cite as:

Birrenbach T, Zbinden J, Papagiannakis G, Exadaktylos AK, Müller M, Hautz WE, Sauter TC
Effectiveness and Utility of Virtual Reality Simulation as an Educational Tool for Safe Performance of COVID-19 Diagnostics: Prospective, Randomized Pilot Trial
JMIR Serious Games 2021;9(4):e29586
doi: 10.2196/29586
PMID: 34623315

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Virtual Reality and Virtual Worlds (229)

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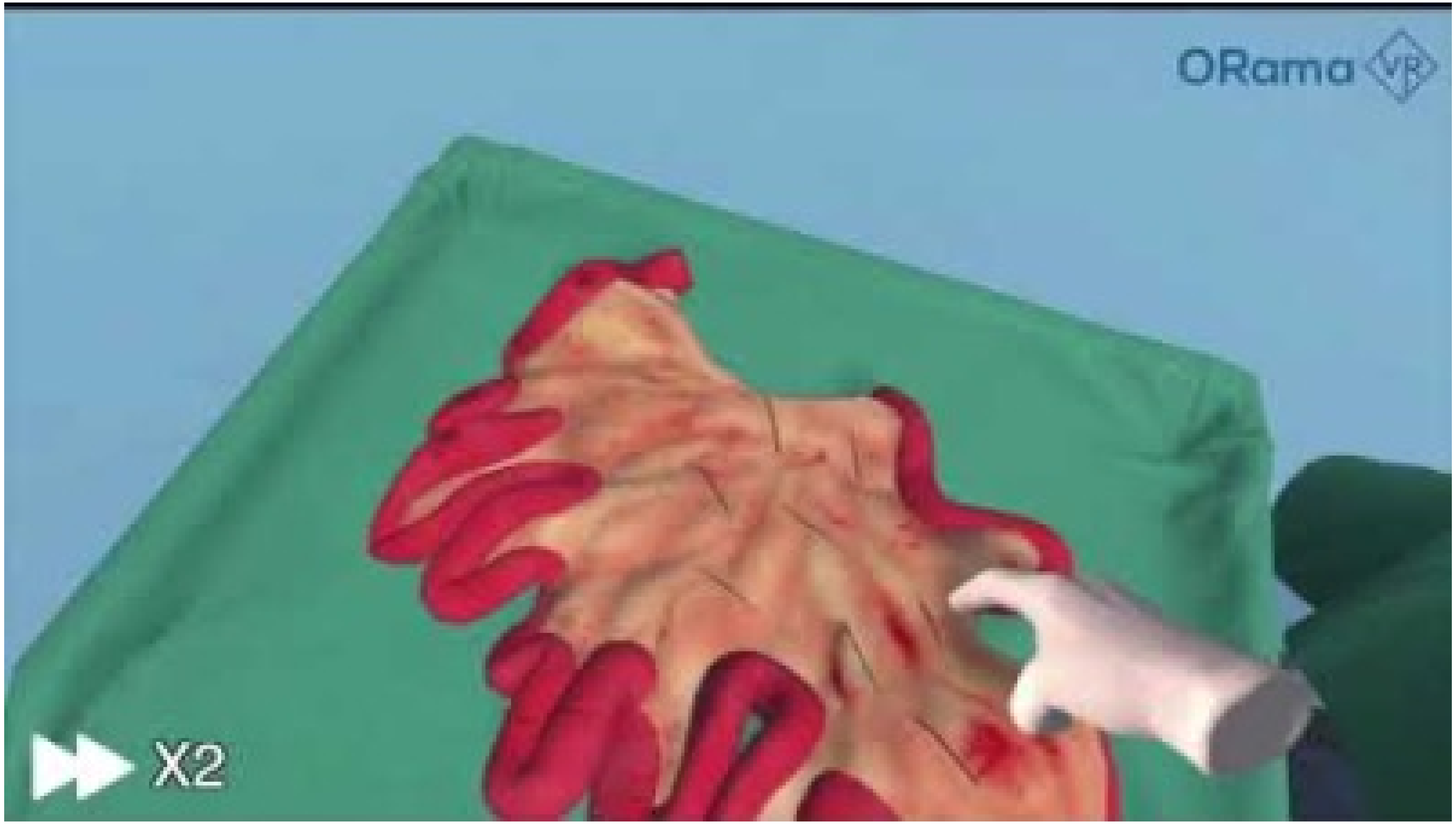
Results:

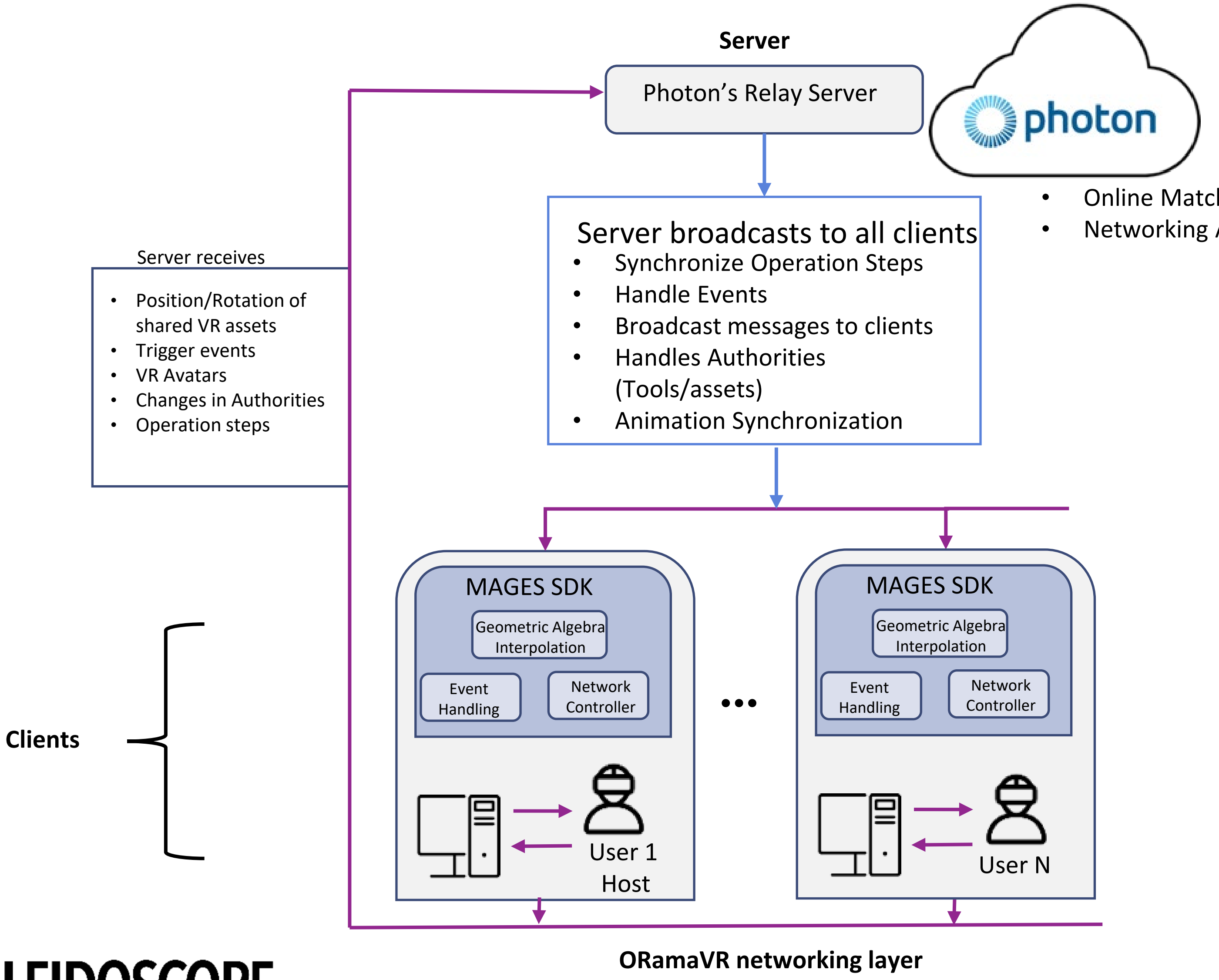
1. the short- and long-term **effectiveness** of a novel virtual reality simulation vs. traditional learning methods (e-learning) regarding proper hand hygiene and PPE proficiency and correct acquisition of a nasopharyngeal specimen for covid-19 testing
2. the correlation of **performance** of nasopharyngeal swab taking **in virtual reality (test mode) and real life** (manikin)
3. a statistically **significant improvement on sensorimotor performance of the trainees of the VR group: 16%** and higher satisfaction in the VR group

Challenge:
cut, tear, drill on deformable soft-bodies in VR



Kamarianakis, M., Lydatakis, N., Protopsaltis, A., Petropoulos, J., Tamiolakis, M., Zikas, P., Papagiannakis, G., “"Deep Cut": An all-in-one Geometric Algorithm for Unconstrained Cut, Tear and Drill of Soft-bodies in Mobile VR”, arXiv:2108.05281 **[cs.GR]**

Challenge: Low-latency, collaborative, networked shared medical environments



- Online Matchmaking
- Networking API

- Tethered/Untethered VR HMDs
- Remote Collaboration
- GA interpolation to broadcast less data
- h/w independence

Kamarianakis, M., Lydatakis, N., Papagiannakis, G., "Never 'Drop the Ball' in the Operating Room: An efficient hand-based VR HMD controller interpolation algorithm, for collaborative, networked virtual environments", ENGAGE workshop, Computer Graphics International 2021

Challenge: Low-latency, collaborative, networked shared medical environments II

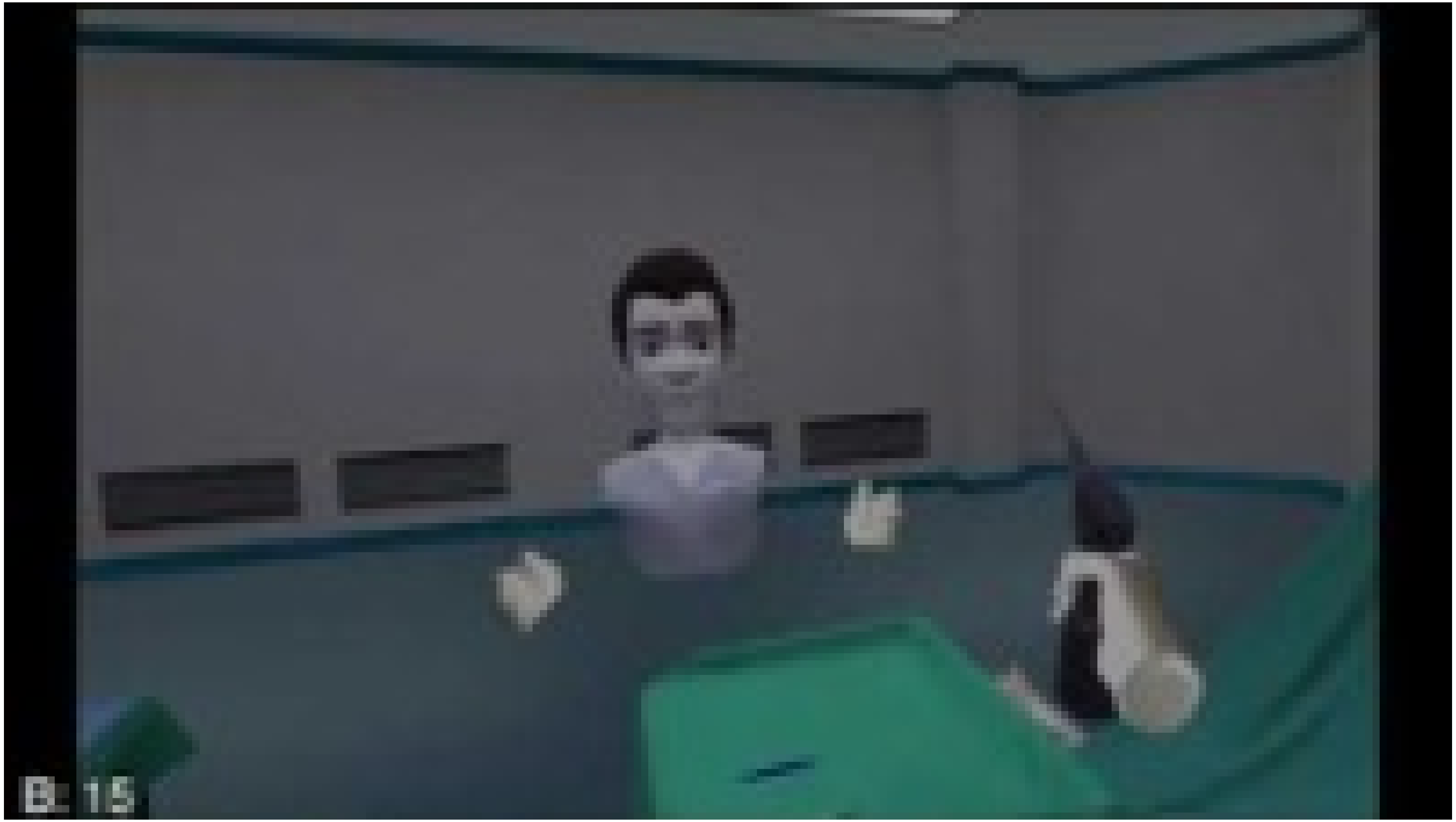
1. GA Interpolation engine
2. Build-in Co-op support
3. Reducing network traffic up to 58%
4. 16% performance boost
5. Efficient and smooth transformations

Network Quality	How to Achieve Best QoE	Metrics on Our Methods
Excellent	SoA: 30 updates/sec Ours: 20 updates/sec	33% less bandwidth 16.5% lower running time
Good	SoA: 20 updates/sec Ours: 10 updates/sec	50% less bandwidth 16.5% lower running time
Mediocre	SoA: 15 updates/sec Ours: 7 updates/sec	53% less bandwidth 16.5% lower running time
Poor	SoA: 12 updates/sec Ours: 5 updates/sec	58% less bandwidth 16.5% lower running time

Summary of the metrics of our methods (Ours) versus the state-of-the-art methods (SoA).

Kamarianakis, M., Lydatakis, N., Papagiannakis, G., "Never 'Drop the Ball' in the Operating Room: An efficient hand-based VR HMD controller interpolation algorithm, for collaborative, networked virtual environments", ENGAGE workshop, Computer Graphics International 2021

Challenge: Low-latency, collaborative, networked shared medical environments III



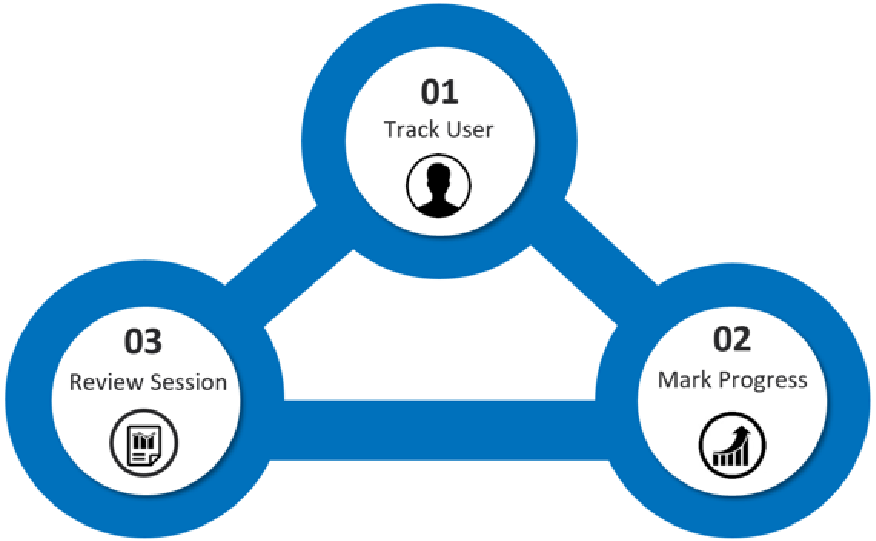
Kamarianakis, M., Lydatakis, N., Papagiannakis, G., "Never 'Drop the Ball' in the Operating Room: An efficient hand-based VR HMD controller interpolation algorithm, for collaborative, networked virtual environments", ENGAGE workshop, Computer Graphics International 2021

Challenge: VR s/w design patterns for rapid prototyping?

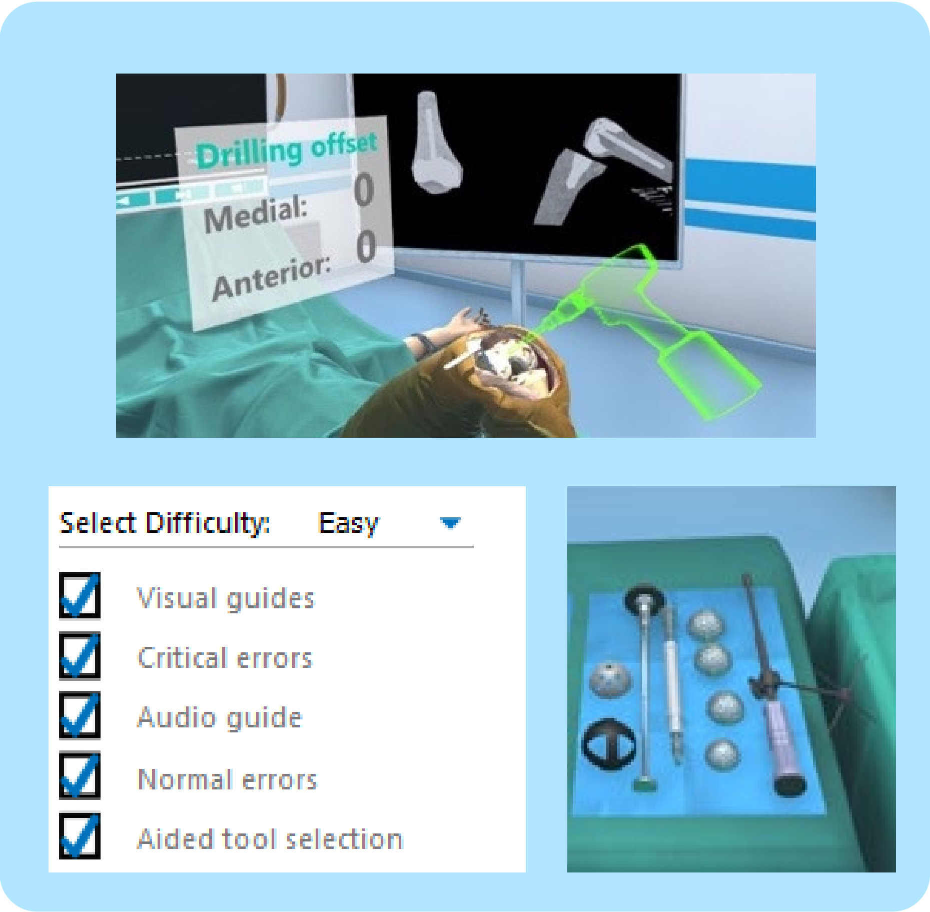
P. Zikas, G. Papagiannakis, N. Lydatakis, S. Kateros, S. Ntoa, I. Adami, and C. Stephanidis, "Immersive visual scripting based on VR software design patterns for experiential training.," Visual Computer Journal, 2020

Challenge: Analytics engine with cloud-based user assessment

- Tracking psychomotor & cognitive skills
- Cloud-based user assessment
- Realtime error tracking
- User report in VR application

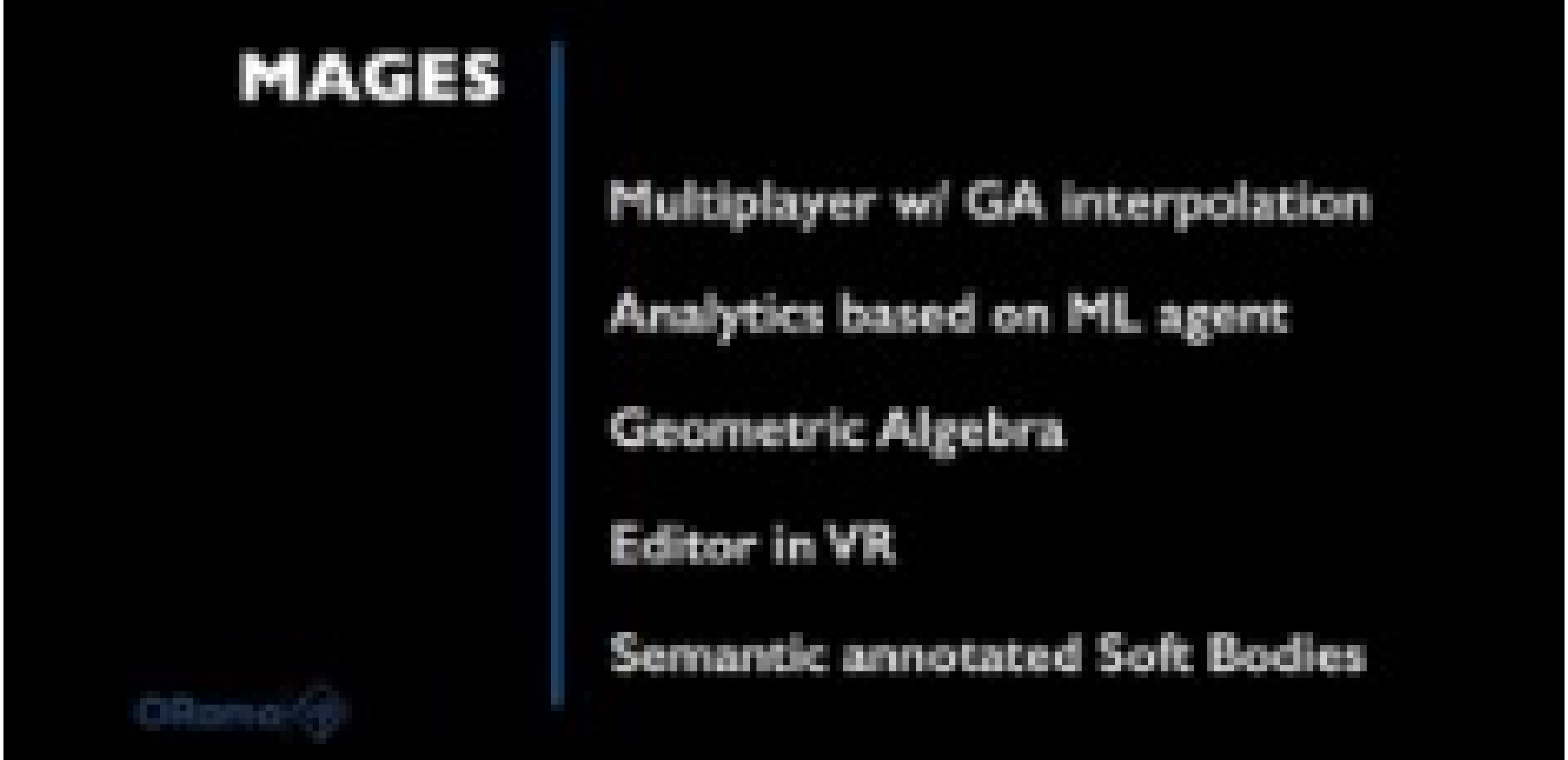


Adaptive difficulty levels



ORamaVR, Analytics Engine, 2021, https://docs.oramavr.com/en/latest/index.html

Challenge: Low-code authoring for medical XR ?



George Papagiannakis, Paul Zikas, Nick Lydatakis, Steve Kateros, Mike Kentros, Efstratios Geronikolakis, Manos Kamarianakis, Ioanna Kartsonaki, and Giannis Evangelou. 2020. MAGES 3.0: Tying the knot of medical VR. In ACM SIGGRAPH 2020 Immersive Pavilion (SIGGRAPH '20). Association for Computing Machinery, New York, NY, USA, Article 6, 1–2. DOI:https://doi.org/10.1145/3388536.3407888, 2020

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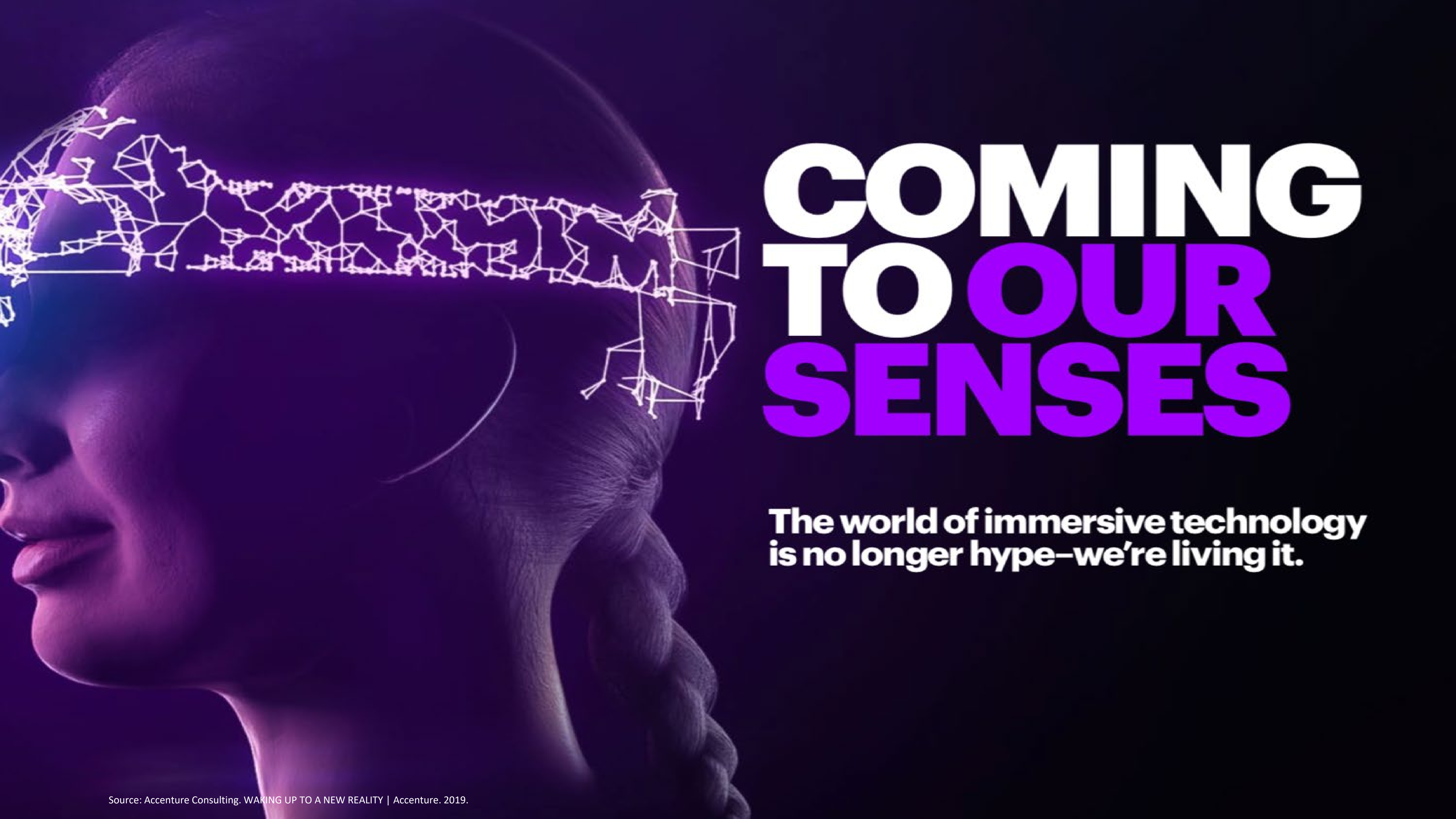
Challenge: rapid prototyping for medical XR ?

Zikas, P., Kamarianakis, M., Kartsonaki, I., Lydatakis, N., Kateros, S., Kentros, M., Geronikolakis, E., Evangelou, G., Catilo, P.A., Papagiannakis, G., "Covid-19 VR Strikes Back: Innovative medical VR training", In ACM SIGGRAPH 2021 Immersive Pavilion (SIGGRAPH '21), Association for Computing Machinery, New York, NY, USA, 2021



Source: Accenture Consulting. WAKING UP TO A NEW REALITY | Accenture. 2019.

Ethics & privacy?

- Self biometric data
- Consciousness hacking
- Surveillance capitalism? (third party doctrine)
- Digital divide?

Conclusions

- **Accelerate skills acquisition** through the use of recent experiential XR technology innovations is possible
- **Educators** and **trainers** need to **drive adoption** of experiential technologies in their curricula via Computational medical XR
- **Presence** in not enough, **embodiment** and **agency/manipulation** are key enabling learning factors

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Thank you!