Emerging Opportunities for Computer Games, VR/AR and the Internet of Things

Walt Scacchi

Institute for Virtual Environments and Computer Games

and

Donald Bren School Information and Computer Sciences
University of California, Irvine
Irvine, CA 92697-3445
USA

Overview

- Background

- Sample of R&D projects at UCI involving Computer Games, Virtual/Augment Reality (VR/AR), and/or Internet of Things (IoT)

  - (informal) STEAM education, military command and control, medicine, smart manufacturing, collaborative virtual environments, and more.

- Emerging R&D opportunities along the way

Informal Classical Music Learning Game Environment: *SFSKids.org* (STEM+Arts=*STEAM*)

SFSKIDS
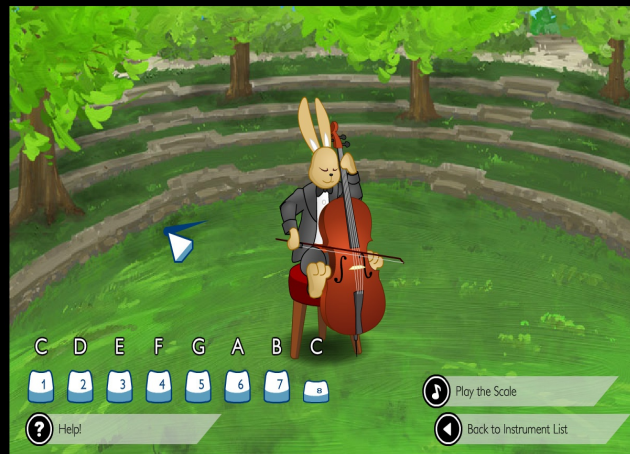FUN & GAMES WITH MUSIC

Discover Music
Under the Sea of Knowledge.

The Brass Family +2
The Percussion Family +2
Instruments
Instrument Families
The Woodwind Family +1
The String Family +2
Search / Start Over
Visit History
Help!

Play with Music
Above the Musical Skies

49,600
Ludwig van Beethoven
Ode to Joy
from Symphony No. 9

Perform Music
In the Instrument Garden

C D E F G A B C
1 2 3 4 5 6 7 8
Play the Scale
Back to Instrument List
Help!

Conduct Music
At the Symphony Hall

9,270
Sergei Prokofiev
Dance of the Knights
from Romeo and Juliet

Compose Music
Atop the Mountain of Muses

Adagio   tr
4/4

Symbols (Others)
♭ ♯ staccato tr more... ▼
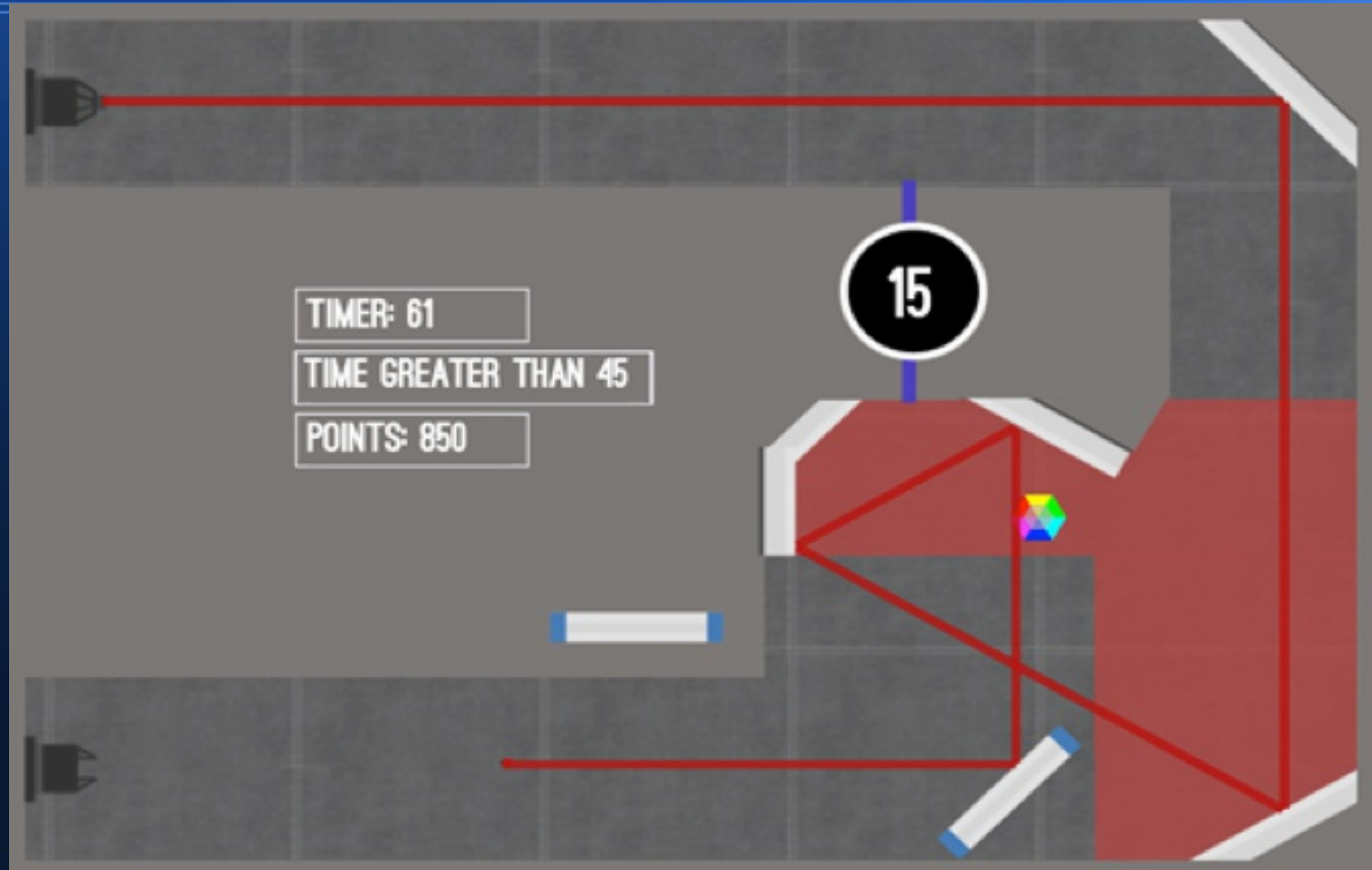Music Options
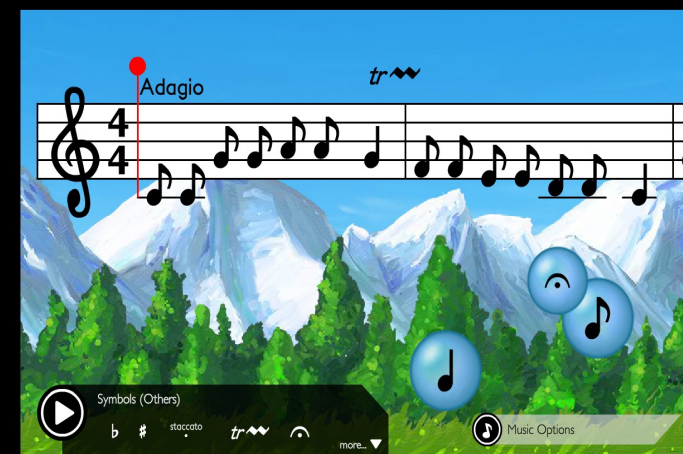
BEAM game prototype for play-based learning of optical/beam physics

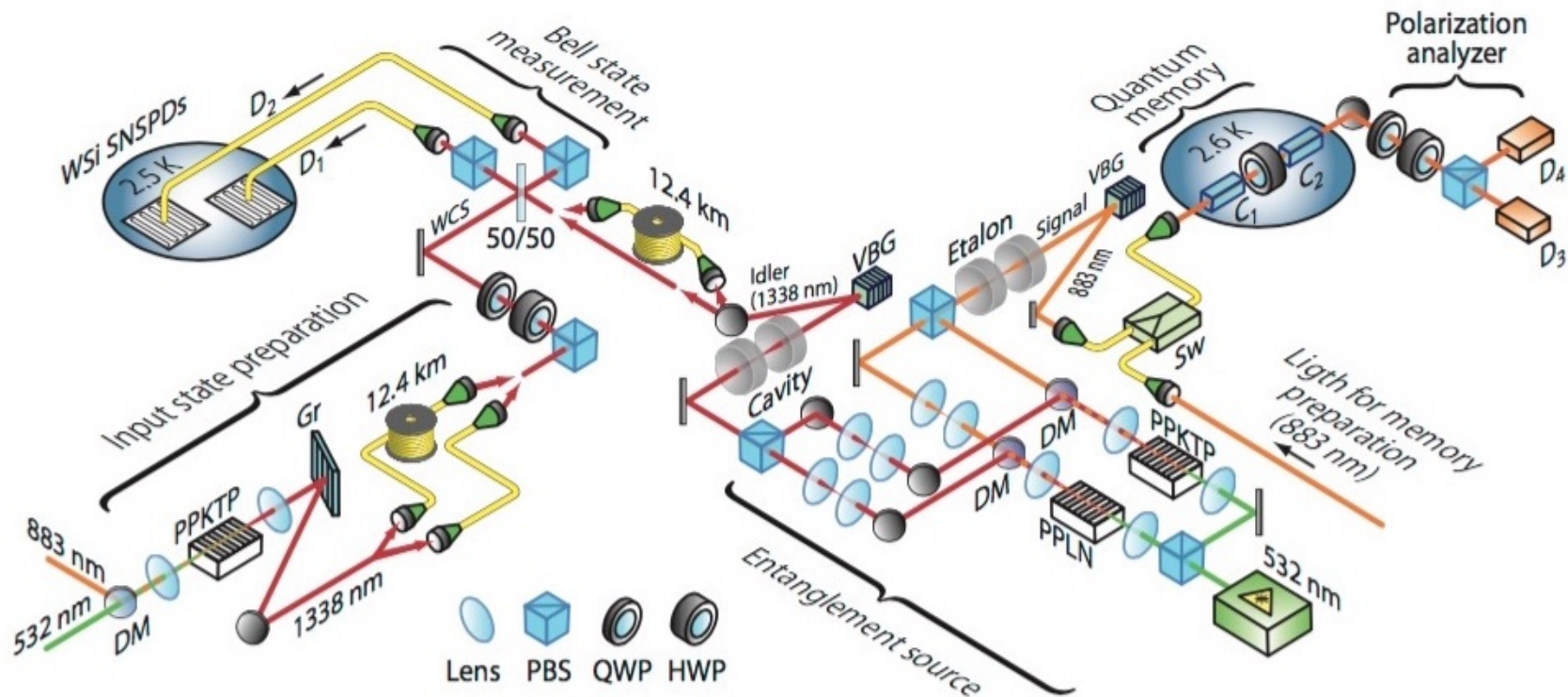# Ultimate *BEAM* game challenge: learning to play with *quantum teleportation*

FIG. 1. **Experimental setup.** The system comprises the source of polarization-entangled photons at 883 nm (the signal) and 1338 nm (the idler) using filtered spontaneous parametric down conversion from two nonlinear waveguides (PPLN and PPKTP)

The Virtual/Augmented Reality Spectrum

- Hallucinations via brain injury or psychoactive substances

- Dreams and lucid dreaming

- Imagined physical, everyday socio-cultural worlds

- Symbolic worlds: literary, cosmological, musical, gustatory, etc.

- Cinema, theater, concert venues

- Panorama, cyclorama ("circlevision"/360° video), dome venues

- Head-Mounted Displays (+audio,+ haptics?) for PCs, consoles, or mobile devices (smartphones, tablets)

- CAVE room, wall, or table-top interactive visualization

- Volumetric video and mixed reality

- Physically tangible fantasy worlds (Disneyland, *Burning Man*)

The Virtual/Augmented Reality Legacy

- What is a *virtual (augmented) reality*?
  - Computer-mediated immersive presentation that encapsulates one or more senses that renders (overlays) a virtual world (objects) for play, work, or learning activities
  - VR/AR is:
    - Embodied as *technological mechanisms*
    - Engaged and rendered as *interactive content*
    - Recognized as immersive and present *user experience* ("it's like being there")
  - VR is <u>not</u> one technology, content, or experience

Networked Things for Games and VR/AR

- Things either as *sensors*, *effectors*, *controllers*, or *actuators*.

- Things are most interesting when integrated with embedded computation.

- Things are singular or networked (app area, local-area, or cloud).

- *IoT enables physical environments to be treated as digital platforms open to computational thinking, modeling/simulator apps, and app ecosystems.*

# Games, Virtual Worlds, VR/AR and IoT Projects

- Game-based virtual worlds (GBVW) for research, education/training and healthcare applications [Sca12].

- Networked AR and body-worn sensors for Smart Workers (Advanced Manufacturing).

- Massively multi-user virtual worlds for STEM research/education using *hypergrids* (multi-VR world interoperation platform) [DVL15, Lop11].

Embedded sensor network-based science learning game environment for K-6th students and families

DinoQuest Research Team and Collaboratories:
Diverse Science Role Models (ethnicity, age, gender)

Scacchi, W., Nideffer, R., and Adams, J. (2008). Collaborative Game Environments for Informal Science Education: DinoQuest and DinoQuest Online, *IEEE Conf. Collaboration Technology and Systems*, (CTS 2008), Irvine, CA 229-236, May 2008.

Online science learning game for informal life science education for K-6ᵗʰ grade students with virtual things [Sca10]
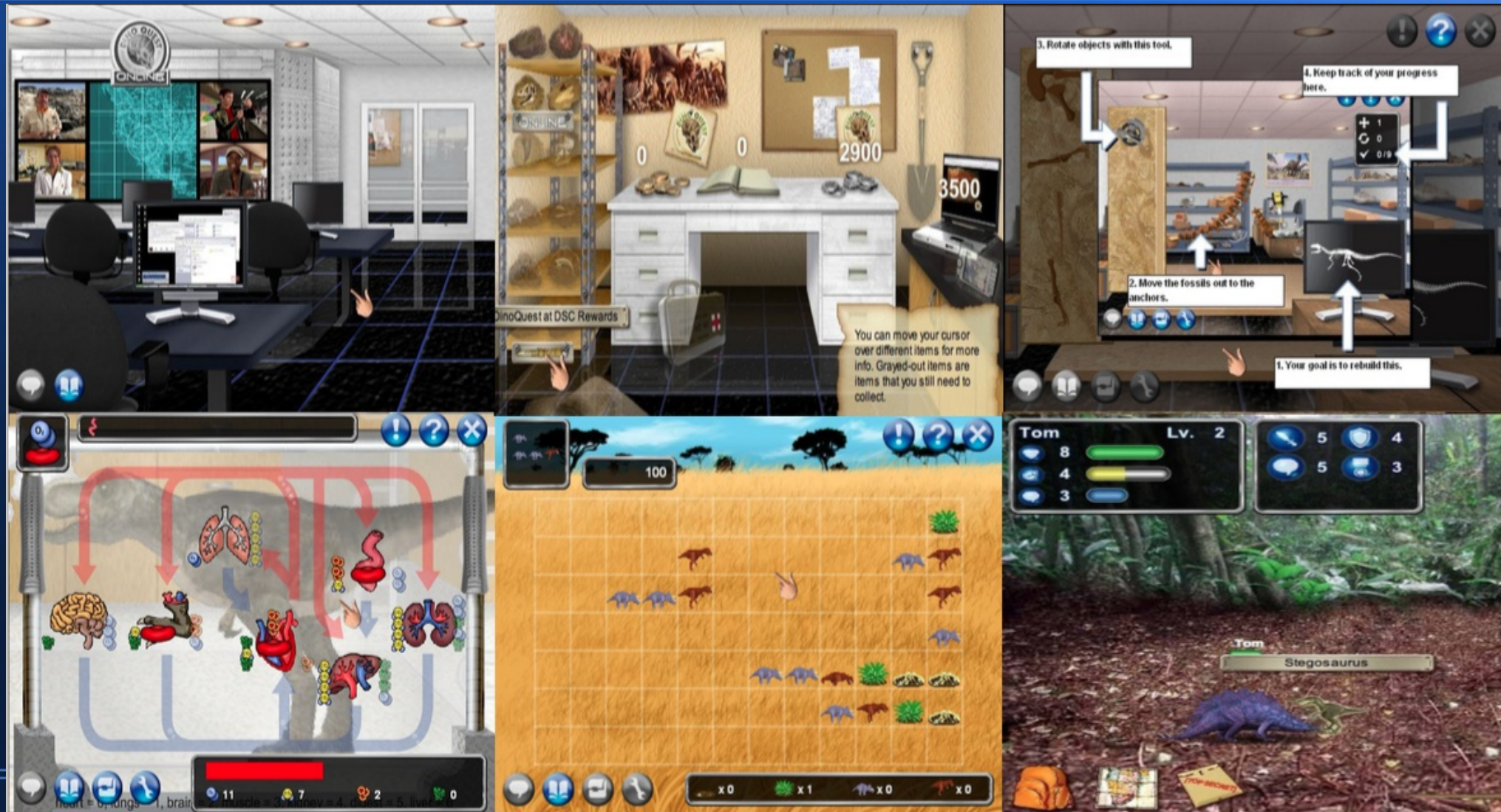
Planetary science data visualization and "spherecasting" support for *NOAA Science on a Sphere* interoperation in a networked GBVW platform (OpenSim).
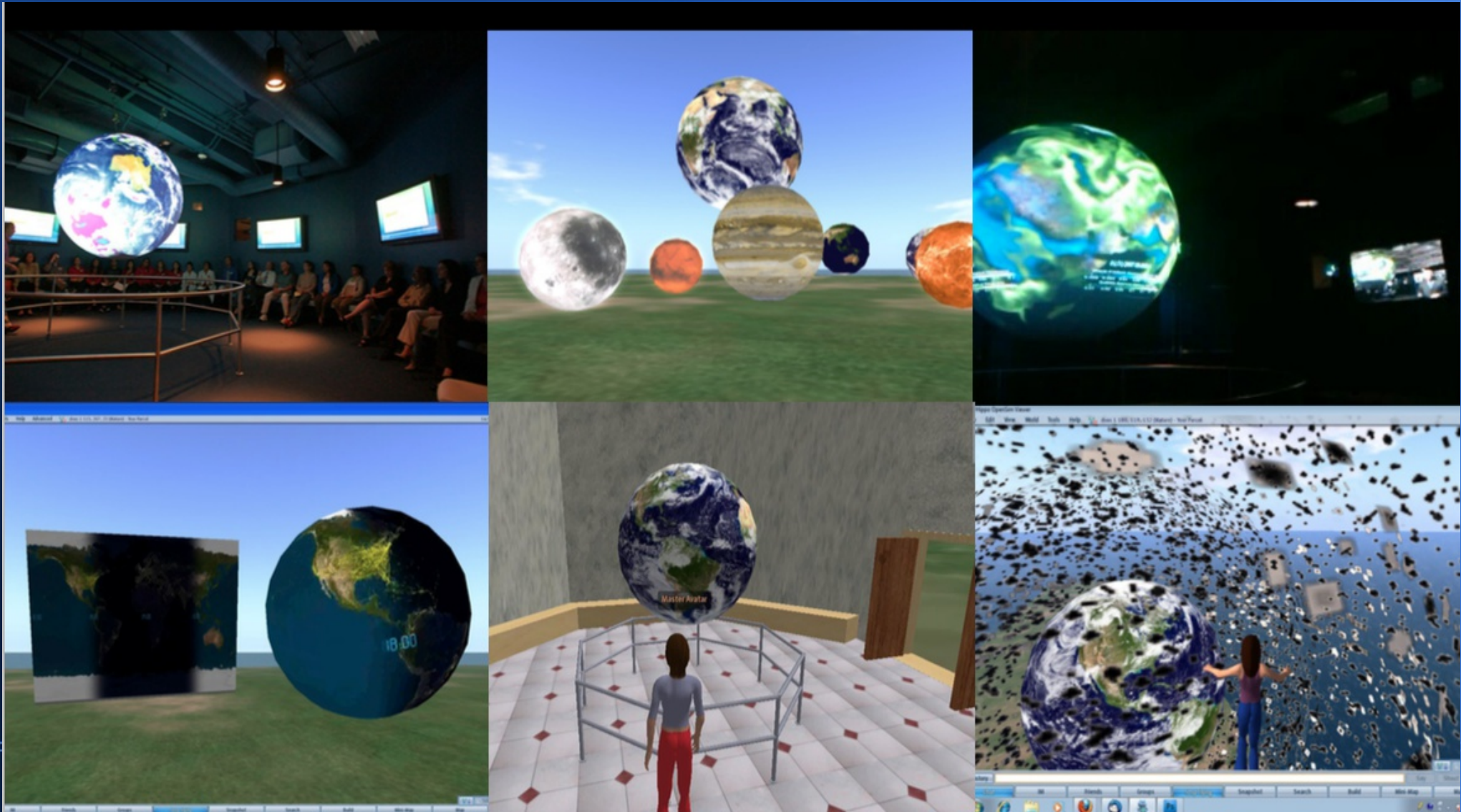
DECENT: GBVW for experimentation in secure decentralized command and control
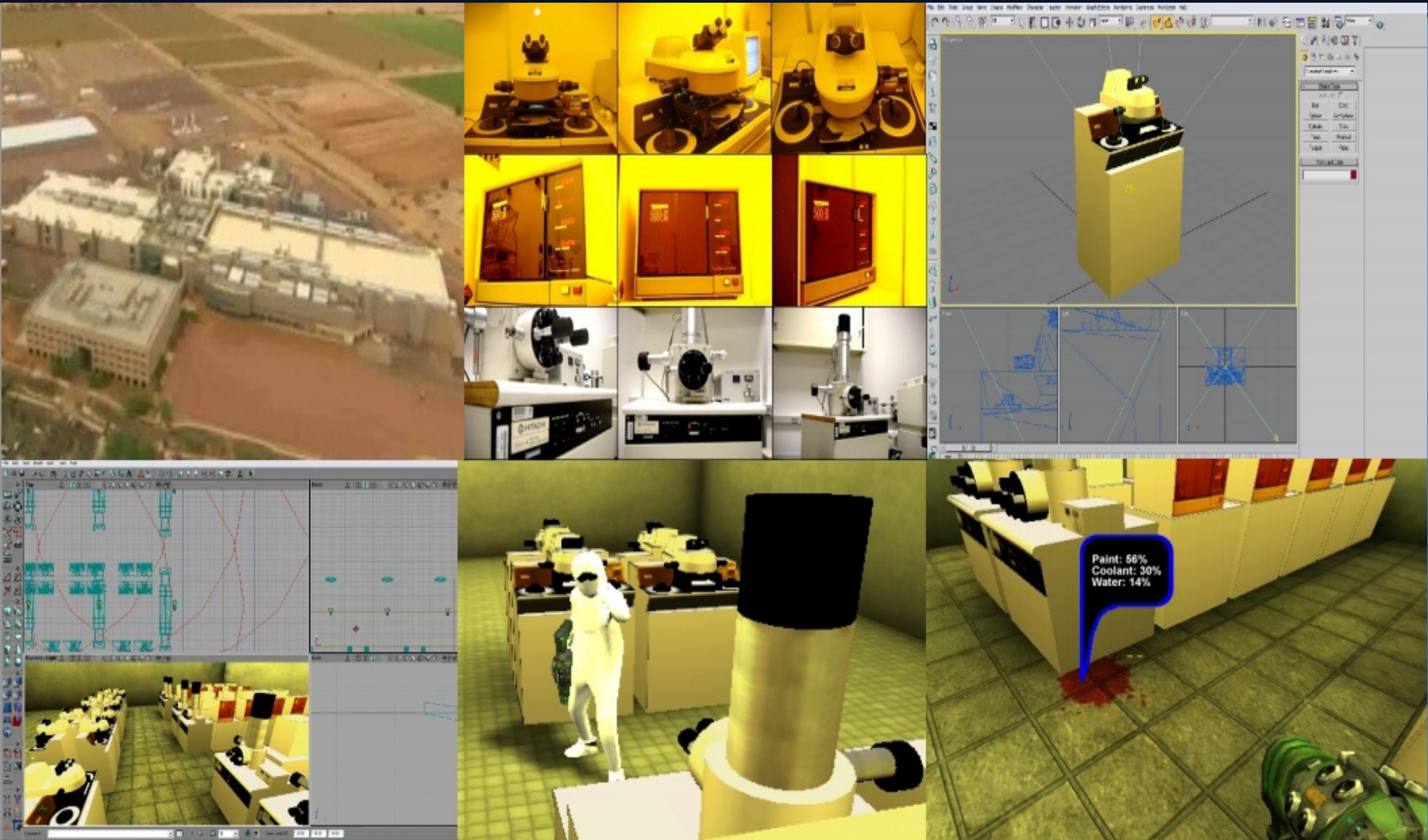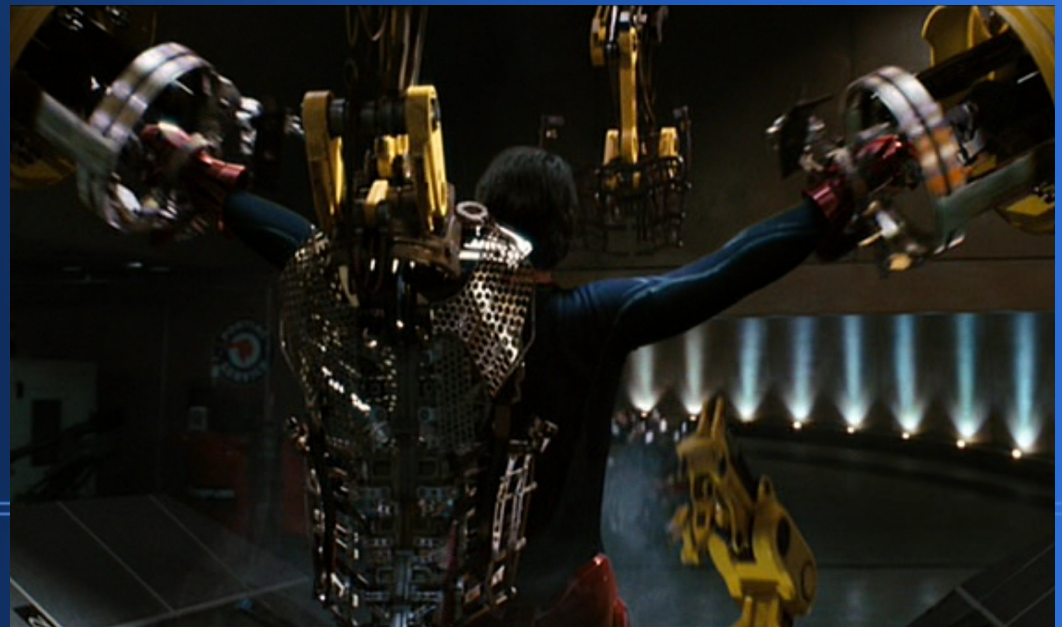
OpenSim: Large Group Virtual Research Conferences

Image credit: C. Lopes/Diva Canto

FabLab: Semiconductor fabrication operations and diagnostics training game world [Sca10]

# *FabLab* semi-fab operations training game: "gowning process"

Future: IoT-based AR for Smart Workers in Smart Manufacturing (Calit2)

MADE IN U. S. A.

EMBEDDED WIRELESS COMPUTER

VIDEO CAPTURE

HEAT IMAGER

AUGMENTED REALITY GOGGLES

ACOUSTIC HEADPHONES

DIRECTIONAL MICROPHONES

PROXIMITY SENSOR

UCI Stroke Telerehabilitation game console

Stroke Telerehabilitation game console and a sample game (for dial rotation movement)
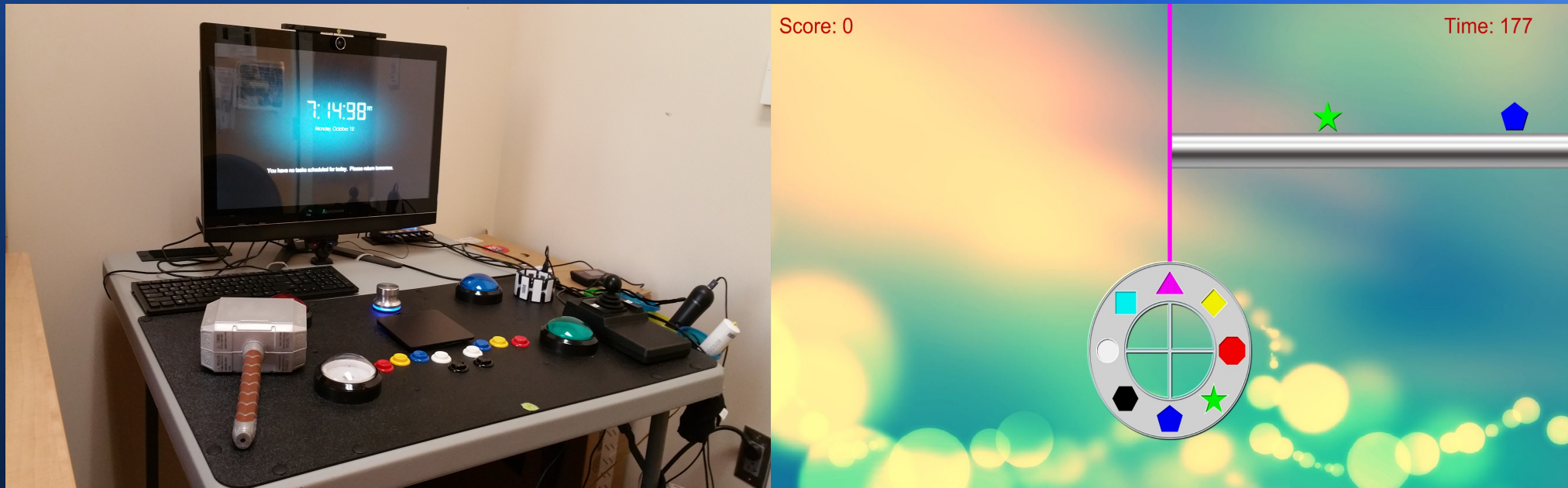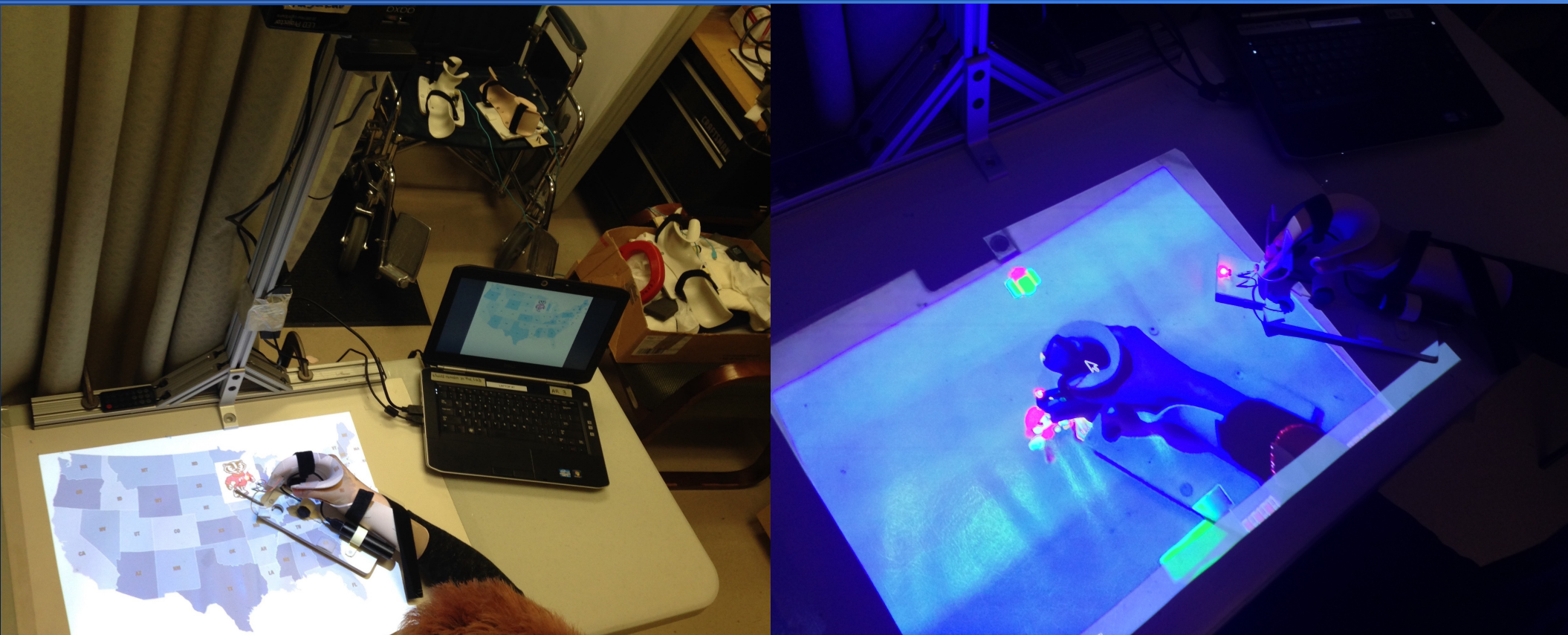

Human motor control things: Game console buttons (large, small), continuous dial, Myo armband, touchpad, joystick, WiiMote, PS Eye, finger and grip pressure sensors.

All devices integrated to act like PC mouse/keyboard inputs.

40 consoles currently deployed in nationwide clinical trial.

# *Extension candidate*: AR Stroke Rehab Game Interface

Features: (a) 1st person view, (b) functional tasks with high ecology and affordance, (c) mirror neural activation,(d) embodied action observation/priming, (e) explicit motor imagery, (f) playful interaction experience and (g) safety.

Extension candidate: PC versus AR stroke rehabilitation game play UI/UX efficacy

A. Personal computer version of the game
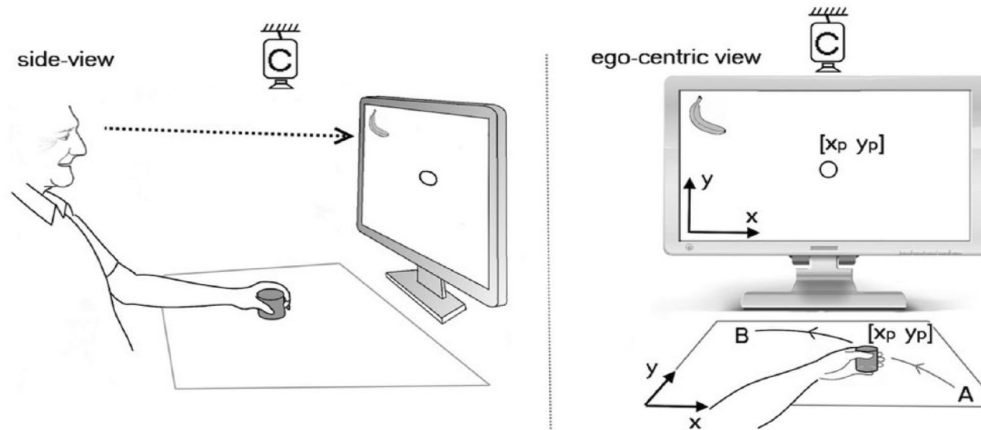
B. Augmented reality version of the game

C. camera
P. projector
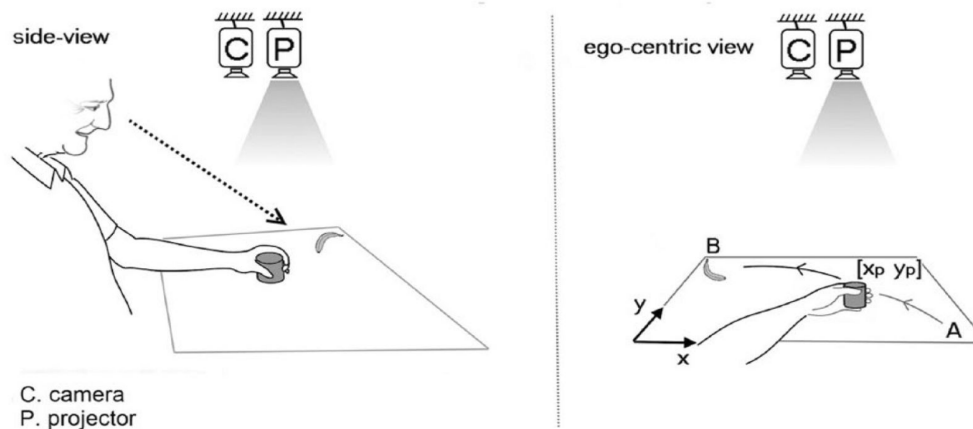
AR user interface associated with ~20% improved therapeutic movement accuracy (positional score), reaction times, and 15% less movement variability vs. PC UI.
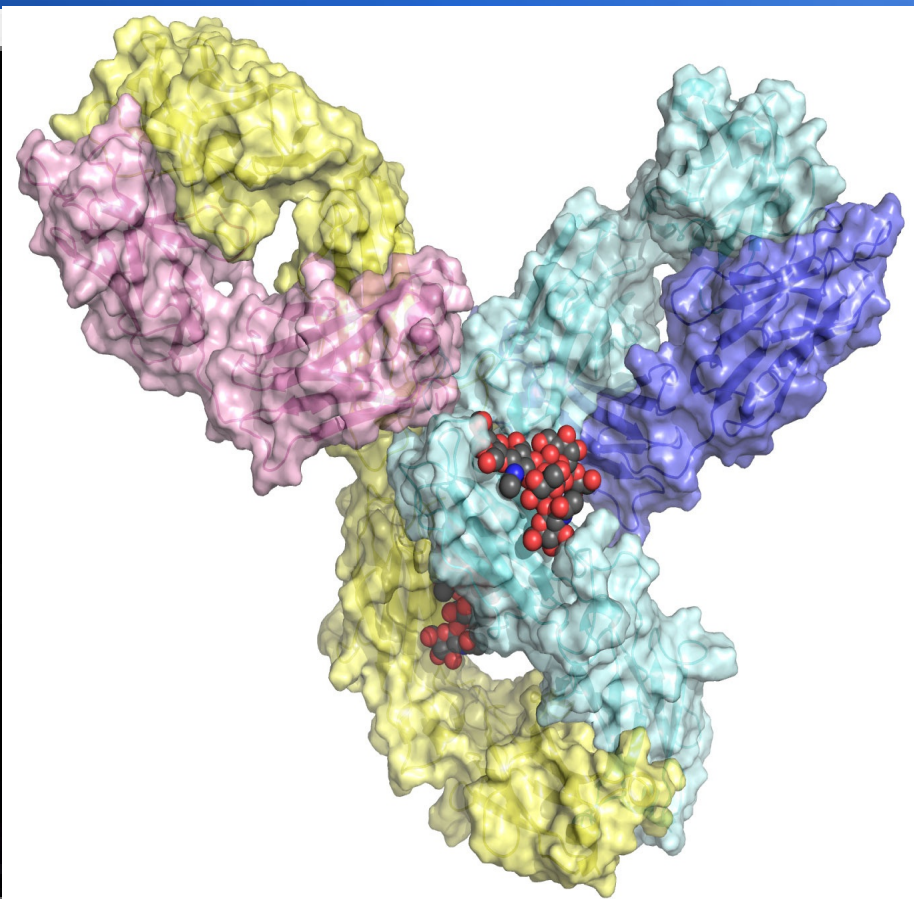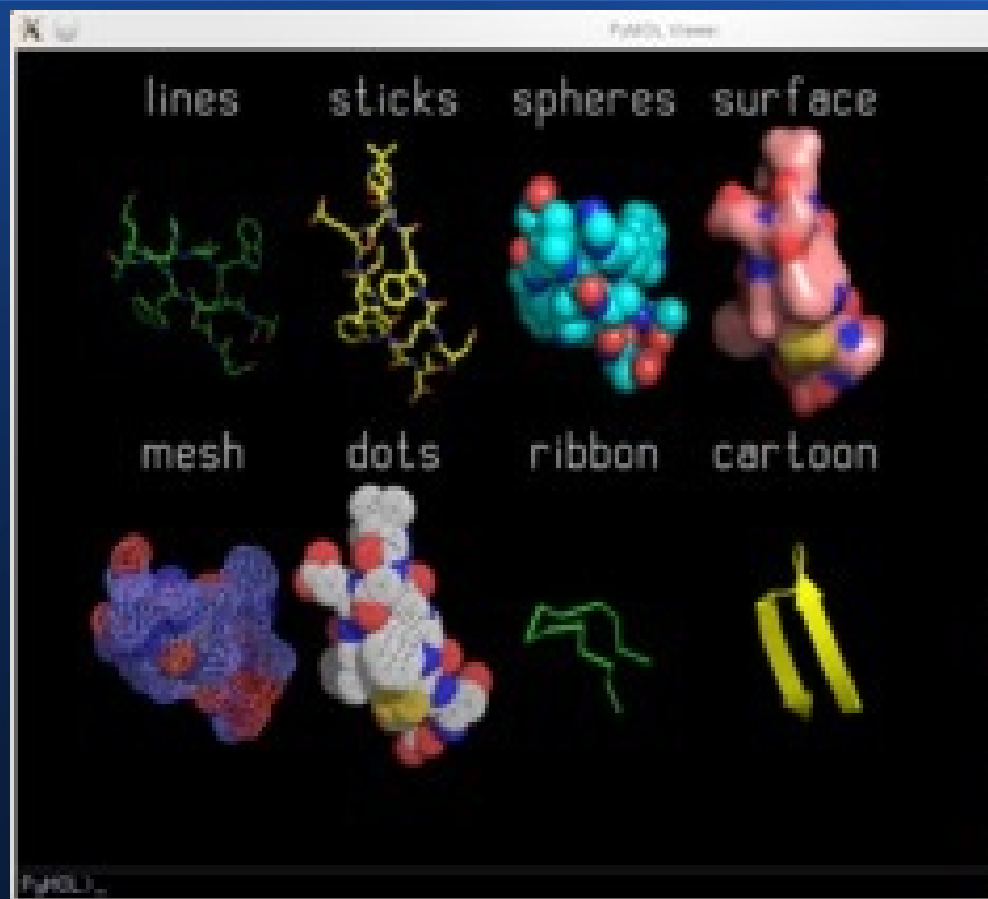
Mousavi Hondori H, Khademi M, Dodakian L, McKenzie A, Lopes CV, Cramer SC. (2016). Choice of Human-Computer Interaction Mode in Stroke Rehabilitation. *Neurorehabilation & Neural Repair*. 30(3):258-65. doi: 10.1177/1545968315593805.

Future: GBVWs transforming STEAM education (e.g., via personal virtual labs)

Future: VR/AR+IoT (haptics) for Computational Molecular Design?

Future: UCI eSports and eSports Arena (opening Fall 2016)

Conclusions: Into the Future

- Game-based virtual worlds, VR/AR concepts, techniques, and IoT technologies will *transform* STEAM research and education.

    – More personal, more participatory, more open.

- IoT-based industrial internet will further extend the reach of GBVW and VR/AR applications to *transform* health care, manufacturing and workforce development.

Research Collaborators

Faculty

– Robert Nideffer (RPI), Thomas Alspaugh, Jill Berg, Yunan Chen, Steve Cramer, Garnet Hertz (Emily Carr U), Alfred Kobsa, G.P. Li, Jung-Ah Lee, Crista Lopes, Gloria Mark, Allison MacKenzie (Chapman), Bonnie Nardi, Andrea Nicholas, David Redmiles, Richard Taylor, and many others.

Research Staff

– Craig Brown (NomNom Games), Lucy Dodakian (Neurology), Yuzo Kanomata (IGB), Vu Le (Neurology), Kari Nies (ISR), Alex Szeto (American Honda, ISR), and others.

Students

– UCI Video Game Developers Club and others

Acknowledgements

Additional References

[DVL15] Debeauvais, T., Valadares, A., and Lopes, C. (2015). RCAT: A Scalable Architecture for Massively Multiuser Online Environments, in K. Cooper and W. Scacchi (Eds.), *Computer Games and Software Engineering*, CRC Press, Francis & Taylor, Baco Raton, FL.

[Lop11] Lopes, C.V., (2011). Hypergrid: Architecture and Protocol for Virtual World Interoperability, *IEEE Internet Computing*, 15(5), 22-29, Sept-Oct 2011.

[Sca10] Scacchi, W. (2010). Game-Based Virtual Worlds as Decentralized Virtual Activity Systems, in W.S. Bainbridge (Ed.), *Convergence of the Real and the Virtual*, 225-236, Springer, NY.

[Sca12] Scacchi, W. (Ed.), (2012). The Future of Research in Computer Games and Virtual Worlds: NSF Workshop Report, Technical Report UCI-ISR-12-8, University of California, Irvine, Irvine, CA.

Additional References

[Sca15] Scacchi, W. (2015). Repurposing Game Play Mechanics as a Technique for Developing Game-Based Virtual Worlds, in K. Cooper and W. Scacchi (Eds.), *Computer Games and Software Engineering*, CRC Press, Francis & Taylor, Baco Raton, FL.

[Sca16] Scacchi, W. (2016). Game-Based Stroke Telerehabilitation: Challenges in Scaling to National Clinical Trials, *US-UK Workshop on Serious Games for Health*, Philadelphia, PA, 22 March 2016.

[ScA13] Scacchi, W. and Alspaugh. T.A. (2013). Challenges in the Development and Evolution of Secure Open Architecture Command and Control Systems, *Proc. 18th. Intern. Command and Control Research and Technology Symposium*, Paper 098, Alexandria, VA, June 2013.

[SNA08] Scacchi, W., Nideffer, R., and Adams, J. (2008). Collaborative Game Environments for Informal Science Education: DinoQuest and DinoQuest Online, *IEEE Conf. Collaboration Technology and Systems*, (CTS 2008), Irvine, CA 229-236, May 2008.