David Michael Krum

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Research Interests

I am a computer scientist and researcher in the fields of human-computer interaction, virtual/augmented reality, and 3D interaction. My research process combines an engineering approach of designing and building technical artifacts with a scientific approach of experimentation and user evaluation. My current research examines the effects of immersive experiences on decision making, neuro-scientific implications of immersion, as well as immersive collaboration environments for humans, virtual agents, and robots. My goal is to use immersive technologies to help humans learn, communicate, and collaborate.

My prior work has explored the development of low cost virtual reality and augmented reality displays, which inspired devices such as the Google Cardboard, Samsung Gear VR, and Oculus Rift, and revolutionized the VR/AR industry. I have also studied 3D interaction issues in virtual environments, wearable computing, visualizations of 3D environments with contextualized video, and user interfaces for driver navigation systems. My dissertation explored the use of 3D visualizations and wearable computers to enhance a user's perception and spatial cognition of the surrounding environment.

Education

Georgia Institute of Technology, Atlanta, GA — December 2004
Doctor of Philosophy, Computer Science
Thesis: *Wearable Computers and Spatial Cognition*
Advisors: Dr. William Ribarsky and Dr. Larry Hodges

The University of Alabama in Huntsville, Huntsville, AL — June 1998
Master of Science, Computer Science

California Institute of Technology, Pasadena, CA — June 1994
Bachelor of Science, Engineering and Applied Science

Professional Experience

Assistant Professor — August 2020-Present
California State University, Los Angeles
Teaching students and conducting research in human-computer interaction, virtual reality, and augmented reality at the number one university in the United States for upward mobility of students.

Associate Director for Mixed Reality Technology/Research Scientist — August 2019-July 2020
Interim Lab Director/Computer Scientist — October 2018-August 2019
Associate Lab Director/Computer Scientist — August 2008-October 2018
USC Institute for Creative Technologies, Playa Vista, CA
Providing leadership in the Mixed Reality Lab (MxR) at the Institute for Creative Technologies, a University Affiliated Research Center within the University of Southern California. My responsibilities include developing and executing research vision, writing proposals, leading researchers and developers, and conducting research. Current research directions include techniques and technologies for immersive virtual reality experiences (head mounted displays, interaction techniques, social/mental effects of immersion). The lab's research has inspired and guided the recent revolution in consumer virtual reality. Influenced products include: Google Cardboard, Samsung Gear VR, and Oculus Rift.

Senior Software Engineer/Project Manager — October 2004-July 2008
Robert Bosch Research and Technology Center, Palo Alto, CA
Researcher at innovation lab of a large, multi-national corporation. Responsibilities include identifying, developing, and transferring new technologies for a variety of corporate business units. Made significant contributions to the corporate research strategies for user interaction, 3D technologies, and computer graphics/imaging. Developed 3D visualizations that integrated live video surveillance and other sensors for the security technologies business unit. Also directed a related university collaboration with Virginia Tech. Led research into novel user interfaces for driver information and

automobile multimedia systems. Supervised research projects conducted by summer interns.

Technology Consultant and Co-Founder September 2003-September 2005
GeoTravel Knowledge, Denver, CO
Provided technical consulting to a media start-up firm. Designed and developed software for a GPS location based tourist information guide.

Graduate Research Assistant September 1998-December 2003
Georgia Institute of Technology, College of Computing, Atlanta, GA
Advisors: Dr. William Ribarsky and Dr. Larry Hodges
Researched 3D interaction, collaboration, and spatial cognition issues involved in 3D terrain visualizations for mobile and wearable computers. Such visualizations used GPS tracking, wireless networking, 3D computer graphics, and eyeglass mounted displays to provide users with a spatial learning aide for understanding the surrounding environment.

- Developed and evaluated wearable computer based spatial cognition aids.
- Evaluated two-handed navigation and multimodal interaction techniques for 3D visualizations.
- Developed a server infrastructure for location based information and mobile collaboration.
- Developed software and conducted user studies for two-handed interaction on a workbench virtual reality display.
- Supervised graduate and undergraduate students in virtual reality and wearable computer research projects.

Software Engineer October 1994-June 1998
Motorola Transmission Products Division, Huntsville, AL
Developed Microsoft Windows software for upgrade, security, configuration, and installation of modems and ISDN terminal adapters. Division earned SEI CMM Level 2 and ISO 9000 certifications. Developed a patented ISDN configuration process that improved the customer experience and resulted in the BitSURFR Pro ISDN modem receiving a PC Magazine Best Product Award in 1996.

Summer Undergraduate Research Fellowship Summer 1993
California Institute of Technology, High Energy Physics Department
Advisor: Dr. Maarten Schmidt
Developed initial requirements and design for the software and electronics of the GAMCIT space shuttle experiment. This payload combined GPS, gamma ray burst detector, and camera to correlate gamma ray bursts with visible light phenomena. Payload was orbited by space shuttle Endeavour in May 1996.

TEACHING EXPERIENCE

Graduate Teaching Assistant January-December 2003
Georgia Institute of Technology, College of Computing, Atlanta, GA
Course: CS 4750, *Human-Computer Interface Design and Evaluation*
Instructors: Dr. Elaine Huang, Dr. Chris Shaw, Dr. James Foley
Teaching assistant for three semesters of an upper level undergraduate Human-Computer Interaction course. Topics included user and task modeling, human centered design principles, and evaluation methods. Developed and graded assignments. Also mentored and graded semester long team projects.

Instructor May-August 2002
Georgia Institute of Technology, College of Computing, Atlanta, GA
Course: CS 4451, *Computer Graphics*
Instructor for a graduate/senior level OpenGL computer graphics course. Enrollment of 41 undergraduates, Masters, and PhD students. Course served as part of the core requirements in graphics for PhD students.

Undergraduate Teaching Assistant September-December 1992 & 1993
California Institute of Technology, Computer Science Department, Pasadena, CA
Course: CS 1, *Introduction to Computation*
Instructor: Dr. Stephen Taylor
Teaching assistant for two terms of an introductory C programming course.

RESEARCH SUPERVISION

Undergraduate Research Mentoring

- NSF Research Experiences for Undergraduates (NSF REU): Katherine Hsiao, Robert Silverberg, 2019
- Directed Research: Anurag Syal, 2019
- Directed Research: Chaitanya Gupte, 2018-2019
- NSF REU: Jake Chanenson, Peter Cowal, Madeleine Weaver, Danielle Oltman, Faizon Williams, 2018
- Directed Research: Will Durkee, 2018
- Directed Research: Cindy Clarissa, Daniel Kawalsky, 2017
- NSF REU: Tram-Anh Nguyen, Alice Tan, 2017
- Visiting Research Assistant: Stephanie Schulze, 2017
- NSF REU/Watson Fellow: Hilliary Frank, 2017
- NSF REU: Sophia Sun, Anna Chung, and Elitanya De La Cruz, 2016
- NSF REU: Alice Zhou, 2015
- Summer Undergraduate Research Fellow: Ayaana Sikora, 2015
- Directed Research: Saurabh Hukerikar, 2009

Graduate Research Mentoring

- Directed Research: Mari Kyle, 2016
- Visiting Research Assistant: Lauren Dukes, 2013
- Visiting Research Assistant: Anamary Leal, 2011
- Bosch RTC Intern: Daniela Buhr, Regis Kooper, 2007
- Bosch RTC Intern: Shanshan Zhang, 2006-2007
- Bosch RTC Intern: Tao Ni, Yi Wang, 2006

Dissertation/Project Committee

- Thesis Project Committee Member for Ala' Diab, Interactive Media MFA Candidate, University of Southern California, 2010
- Dissertation Committee External Member for Yi Wang, Computer Science PhD Candidate, Virginia Tech, 2010

Post-Doctoral Mentoring

- Dr. J. Adam Jones (Assistant Professor in Computer & Information Science, University of Mississippi), 2012-2014
- Dr. Tyler Ard (Assistant Professor at USC Neuroimaging and Informatics Institute), 2015

Visiting Scholars Hosted

- Dr. Jusub Kim, Sogang University, 2018-2019
- Dr. Pablo Figueroa, Universidad de los Andes, Colombia, 2016

GRANTS AND CONTRACTS

External Funding Received at the University of Southern California

National Science Foundation, NRI: FND: Communicate, Share, Adapt: A Mixed Reality Framework for Facilitating Robot Integration and Customization — 2019-2022, $749,250
Maja Mataric (PI) and David M. Krum (Co-PI)

United States Air Force Academy, DisCoVR: Distributed Collaboration in Virtual Reality — 2019-2021, $500,000
David M. Krum (PI) and Sinhwa Kang (Co-PI)

DARPA, Urban Reconnaissance through Supervised Autonomy (URSA) — 2019-2020, $1,170,259
David M. Krum (PI)

Army Research Office, Tracking Sense-Making and Decision-Making in Immersive Training — 2019-2020, $1.0 Million
David M. Krum (PI) and Sinhwa Kang (Co-PI)

Army Research Office, Mixed, Virtual, and Augmented Reality Research and Development — 2018-2019, $574,000
Project Leaders: Todd Richmond, Evan Suma Rosenberg, and David M. Krum

Army Research Office, Cortically Coupled Computing in Augmented Reality — 2017-2019
David M. Krum (PI) and Sinhwa Kang (Co-PI) — $1.1 Million

Army Research Office, Team Assessment and Learner Knowledge Observational Network (TALK-ON) — 2016
David M. Krum (PI) — $216,000

Army Research Office, Omni-Directional Treadmill Unity Upgrade (ODT) — 2015
David M. Krum (PI) — $115,971

Army Research Office, Motor Adaptation and Learning in Variable Fidelity Virtual Environments — 2015-2016
David M. Krum (PI) and Sinhwa Kang (Co-PI) — $299,919

Army Research Office, Adapting to Social Interactions with Virtual Humans (ASIV), — 2015-2016
David M. Krum(Co-PI), and Sinhwa Kang(Co-PI) — $299,924

Army Research Office, Mixed Reality Research and Development — 2014-2017
Project Leaders: Todd Richmond, David M. Krum, and Evan Suma — $4.6 Million

Seoul Institute of the Arts, Immersive Narrative in Game Design — 2014-2015
Project Leaders: Sinhwa Kang and David M. Krum — $30,063

Office of Naval Research, Mapping the Field of View — 2013-2015
Mark Bolas (PI), Adam Jones, Evan Suma (Co-Investigator), and David M. Krum — $506,141

Defense Advanced Research Projects Agency, To the Tablets: Applying Immersive Body-Based Interactions to Data Analysis — 2012-2014
Project Leaders: Mark Bolas and David M. Krum — $1.68 Million

Army Research Office, Mixed Reality Research and Development — 2012-2014
Project Leaders: Mark Bolas, David M. Krum, and Evan Suma — $3.1 Million

Army Research Office, Mixed Reality Research and Development — 2010-2011
Project Leaders: Mark Bolas, David M. Krum, and Evan Suma — $1.3 Million

Internal Funding Received at the University of Southern California

ICT Seedling, Proxemics in Virtual Training — 2016
Sinhwa Kang (PI) and David M. Krum (Co-PI) — $99,604

ICT Seedling, Mobile Simcoach: Virtual Coaches over Mobile Video — 2013-2014
Sinhwa Kang (PI) and David M. Krum (Co-PI) — $90,000

PUBLICATIONS AND PATENTS

Journal Papers (Peer Reviewed) and Book Chapters

J.15 J.M. Juliano, R.P. Spicer, A. Vourvopoulos, S. Lefebvre, K. Jann, T. Ard, E. Santarnecchi, D.M. Krum, S.-L. Liew. Embodiment Is Related to Better Performance on a Brain-Computer Interface in Immersive Virtual Reality: A Pilot Study. Sensors 2020, 20, 1204.

J.14 J.A. Jones, J.E. Hopper, M.T. Bolas, and D.M. Krum. *Orientation Perception in Real and Virtual Environments.* IEEE Transactions on Visualization and Computer Graphics (TVCG) Special Issue on IEEE Virtual Reality and 3D User Interfaces (IEEE VR), Vol. 25, No. 5, February 2019, pp. 2050-2060.

J.13 Y. Gil, S. Pierce, H. Babaie, A. Banerjee, K. Borne, G. Bust, M. Cheatham, I. Ebert-Uphoff, C. Gomes, M. Hill, J. Horel, L. Hsu, J. Kinter, C. Knoblock, D. Krum, V. Kumar, P. Lermusiaux, Y. Liu, C. North, V. Pankratius, S. Peters, B. Plale, A. Pope, S. Ravela, J. Restrepo, A. Ridley, H. Samet, S. Shekhar, K. Skinner, P. Smyth, B. Tikoff, L. Yarmey, and J. Zhang. *Intelligent Systems for Geosciences: An Essential Research Agenda.* Communications of the ACM, Vol. 62, No. 1, December 2018, pp. 76-84.

J.12 S. Kang, D.M. Krum, P. Khooshabeh, T. Phan, C.Y. Chang, O. Amir, and R. Lin. *Social Influence of Humor in Virtual Human Counselor's Self-Disclosure.* Computer Animation and Virtual Worlds, Vol. 28, No. 3-4, April 19, 2017, pp. e1763.

J.11 J.A. Jones, D.M. Krum, and M.T. Bolas. *Vertical Field-of-View Extension and Walking Characteristics in Head-Worn Virtual Environments.* ACM Transactions on Applied Perception, Vol. 14, No. 2, January 2017, Article 9, 17 pages.

J.10 S. Kang, D. Krum, T. Phan, and M. Bolas. *Users' Perception of a Virtual Human over Mobile Video Chat Interactions.* Human-Computer Interaction: Novel User Experiences, Vol. 9733, June 2016, Springer, pp. 107-118.

J.9 L.J. Mariano, J.C. Poore, D.M. Krum, and J.L. Schwartz, W.D. Coskren, and E.M. Jones. *Modeling Strategic Use of Human Computer Interfaces with Novel Hidden Markov Models.* Frontiers in Psychology, July 3, 2015, pp. 319-331.

J.8 E.A. Suma, D. Krum, and M. Bolas. *Redirected Walking in Mixed Reality Training Applications.* Human Walking in Virtual Environments: Perception, Technology, and Applications, 2013, Springer, pp. 319-331.

J.7 E.A. Suma, D.M. Krum, B. Lange, S. Koenig, A. Rizzo and M. Bolas. *Adapting User Interfaces for Gestural Interaction with the Flexible Action and Articulated Skeleton Toolkit.* Computers and Graphics, Vol. 37, No. 3, May 2013, pp. 193-201.

J.6 E.A. Suma, Z. Lipps, S. Finkelstein, D.M. Krum, and M. Bolas. *Impossible Spaces: Maximizing Natural Walking in Virtual Environments with Self-Overlapping Architecture.* IEEE Transactions on Visualization and Computer Graphics, Vol. 18, No. 4, April 2012, pp. 555-564.
(Best Paper Honorable Mention, IEEE VR 2012)

J.5 L.K. Lu, J.M. Ko, J. Lee, D.M. Krum, L. Lyn Price, D. Finn, D. Lee, and G.S. Rogers. *A Random, Prospective Trail Evaluating Surgeon Preference in Selection of Absorbable Suture Material.* Journal of Drugs in Dermatology, Vol. 11, No. 2, February 2012, pp. 196-201.

J.4 D.M. Krum, E.A. Suma, and M. Bolas. *Augmented Reality using Personal Projection and Retroreflection.* Personal and Ubiquitous Computing, Vol. 16, No. 1, January 2012, pp. 17-26.

J.3 Y. Wang, D. Bowman, D.M. Krum, E. Coelho, T. Smith-Jackson, D. Bailey, S. Peck, S. Anand, T. Kennedy, and Y. Abdrazakov. *Effects of Video Placement and Spatial Context Presentation on Path Reconstruction Tasks with Contextualized Videos.* IEEE Transactions on Visualization and Computer Graphics, Vol. 14, No. 6, November/December 2008, pp. 1755-1762.

J.2 Y. Wang, D.M. Krum, E.M. Coelho, D.A. Bowman. *Contextualized Videos: Combining Videos with Environment Models to Support Situational Understanding.* IEEE Transactions on Visualization and Computer Graphics, Vol. 12, No. 6, November/December 2007, pp. 1568-1575.

J.1 B. Leibe, T. Starner, W. Ribarsky, Z. Wartell, D. Krum, J. Weeks, B. Singletary, L. Hodges. *Towards Spontaneous Interaction with the Perceptive Workbench.* IEEE Computer Graphics and Applications, Vol. 20, No. 6, November/December 2000, pp. 54-65.

Conference Full Papers (Peer Reviewed)

C.14 P. Chaffey, R. Artstein, K. Georgila, K.A. Pollard, S.N. Gilani, D.M. Krum, D. Nelson, K. Huynh, A. Gainer, S.H. Alavi, R. Yahata, and D. Traum. *Developing a Virtual Reality Wildfire Simulation to Analyze Human Communication and Interaction with a Robotic Swarm During Emergencies.* Language and Technology Conference 2019, May 17-19, 2019, Poznań, Poland.

C.13 W. Panlener, D.M. Krum, and J.A. Jones. *Effects of Horizontal Field of View Extension on Spatial Judgments in Virtual Reality.* IEEE SoutheastCon 2019, April 11-14, 2019, Huntsville, AL. IEEE Press.

C.12 S. Kang, D. Krum, P. Khooshabeh, T. Phan, and K. Chang. *Socio-Cultural Effects of Virtual Counseling Interviewers as Mediated by Smartphone Video Conferencing.* International Conference on Computer Animation and Social Agents (CASA), May 21-23, 2018, Beijing, China. ACM Press, pp. 17-22.

C.11 D. Krum, S. Kang, and T. Phan. *Influences on the Elicitation of Interpersonal Space with Virtual Humans.* IEEE Virtual Reality, March 18-22, 2018, Reutlingen, Germany. IEEE Press, pp. 223-229.

C.10 J. Thomas, M. Azmandian, S. Grunwald, Donna Le, D. Krum, S. Kang, and E. Suma Rosenberg. *Effects of Personalized Avatar Texture Fidelity on Identity Recognition in Virtual Reality.* ICAT-EGVE 2017, November 22-24, 2017, Adelaide, Australia. The Eurographics Association, pp. 97-100.

C.9 D.M. Krum, S. Kang, T. Phan, L.C. Dukes, and M. Bolas. *Social Impact of Enhanced Gaze Presentation Using Head Mounted Projection.* Human-Computer Interaction International Conference, July 9-14, 2017, Vancouver, Canada. Springer International Publishing, pp. 61-76.

C.8 S. Kang, D. Krum, T. Phan, and M. Bolas. *"Hi, It's Me Again!": Virtual Coaches over Mobile Video.* International Conference on Human-Agent Interaction (HAI), October 21-24, 2015, Daegu, Kyungpook, South Korea, ACM Press, pp. 183-186.

C.7 J.A. Jones, L.C. Dukes, D.M. Krum, M.T. Bolas, and L.F. Hodges. *Corrections of Geometric Distortions and the Impact of Eye Position in Virtual Reality Displays.* International Conference on Collaboration Technologies and Systems (CTS), June 1-5, 2015, Atlanta, Georgia, pp. 77-83.

C.6 E.A. Suma, S. Clark, S. Finklestein, Z. Wartell, D. Krum, and M. Bolas. *Leveraging Change Blindness for Redirection in Virtual Environments.* IEEE Virtual Reality Conference, March 19-23, 2011, Singapore: IEEE Press, pp. 159-166.

C.5 B. MacIntyre, J.D. Bolter, J. Vaughn, B. Hannigan, M. Gandy, E. Moreno, M. Haas, S. Kang, D. Krum, S. Voida. *Three Angry Men: An Augmented-Reality Experiment in Point-of-View Drama.* First International Conference on Technologies for Interactive Digital Storytelling and Entertainment (TIDSE), March 24-26, 2003, Darmstadt, Germany.

C.4 D.M. Krum, O. Omoteso, W. Ribarsky, T. Starner, L.F. Hodges. *Evaluation of a Multimodal Interface for 3D Terrain Visualization.* IEEE Visualization, October 27-November 1, 2002, Boston, MA: IEEE Computer Society, pp. 411-418.

C.3 D.M. Krum, O. Omoteso, W. Ribarsky, T. Starner, L.F. Hodges. *Speech and Gesture Control of a Whole Earth 3D Visualization Environment.* VisSym '02, Joint Eurographics - IEEE TCVG Symposium on Visualization, May 27-29, 2002, Barcelona, Spain: IEEE Computer Society, pp. 195-200.
(Awarded SAIC Georgia Tech Student Paper Award)

C.2 D.M. Krum, W. Ribarsky, C.D. Shaw, L. Hodges, N. Faust. *Situational Visualization.* ACM Symposium on Virtual Reality Software and Technology, November 15-17, 2001, Banff, Alberta, Canada: ACM Press, pp. 143-150.

C.1 B. Leibe, T. Starner, W. Ribarsky, Z. Wartell, D. Krum, B. Singletary, L. Hodges. *The Perceptive Workbench: Towards Spontaneous Interaction with the Perceptive Workbench.* Proceedings of the IEEE Virtual Reality 2000 Conference, March 18-22, 2000, New Brunswick, New Jersey: IEEE Computer Society, pp. 13-20.
(Awarded Best Paper Award, IEEE VR 2000)

Conference Short Papers (Peer Reviewed)

c.7 D. Krum, S. Kang, and M. Bolas. *Virtual Coaches over Mobile Video.* International Conference on Computer Animation and Social Agents (CASA), May 26-28, 2014, Houston, Texas.

c.6 D.M. Krum, E.A. Suma, and M. Bolas. *Spatial Misregistration of Virtual Human Audio: Implications of the Precedence Effect.* International Conference on Intelligent Virtual Agents (IVA), September 12-14, 2012, Santa Cruz, California: Springer-Verlag, pp. 139-145.

c.5 E.A. Suma, G. Bruder, F. Steinicke, D.M. Krum, and M. Bolas. *A Taxonomy for Deploying Redirection Techniques in Immersive Virtual Environments.* IEEE Virtual Reality Conference 2012, Costa Mesa, California: IEEE Press, pp. 43-46.

c.4 N. Burba, M. Bolas, D.M. Krum, and E.A. Suma. *Unobtrusive Measurement of Subtle Nonverbal Behaviors with the Microsoft Kinect.* IEEE Virtual Reality 2012, Workshop on Ambient Information Technologies, Costa Mesa, California: IEEE Press, pp. 10-13.

c.3 E.A. Suma, D.M. Krum, S. Finklestein, and M. Bolas. *Effects of Redirection on Spatial Orientation in Real and Virtual Environments.* IEEE Symposium on 3D User Interfaces, 2011, Singapore: IEEE Press, pp. 35-38.
(Awarded Best Technote Award, 3DUI 2011)

c.2 D.M. Krum, R. Melby, W. Ribarsky, L. Hodges. *Isometric Pointer Interfaces for Wearable 3D Visualization.* Extended Abstracts of the CHI Conference on Human Factors in Computing Systems, April 5-10, 2003, Ft. Lauderdale, FL: ACM Press, pp. 774-775.

c.1 A.F. Seay, D. Krum, W. Ribarsky, L. Hodges. *Multimodal Interaction Techniques for the Virtual Workbench.* Extended Abstracts of the ACM CHI Conference on Human Factors in Computing Systems, May 15-20, 1999, Pittsburgh, Pennsylvania: ACM SIGCHI, pp. 282-283.

Posters, Sessions, and Panels

p.20 S. Kang, J. Chanenson, P. Cowal, M. Weaver, P. Ghate, D.M. Krum. *Advancing Ethical Decision Making in Virtual Reality.* IEEE Virtual Reality, March 23-27, 2019, Osaka, Japan. pp. 1008-1009.

p.19 J. Crawford, G. Glesener, D.M. Krum, C. Dietrich, and K. Morishita. *Distinguished Panel on Artificial Intelligence and Virtual Reality.* IEEE International Conference on Semantic Computing, January 31-February 2, 2018, Laguna Hills, California: IEEE Press.

p.18 D.M. Krum, S. Liew, T. Ard, M.V. Sanchez-Vives, and M. Slater. *Virtual Reality and Neuroscience.* IEEE Virtual Reality 2017, Manhattan Beach, California: IEEE Press.

p.17 D.M. Krum, T. Phan, and S. Kang. *Motor Adaptation in Response to Scaling and Diminished Feedback in Virtual Reality.* IEEE Virtual Reality 2017, Manhattan Beach, California: IEEE Press, pp 233-234.
(Awarded Best Poster Award, IEEE VR 2017)

p.16 P. Khooshabeh, I. Choromanski, C. Neubauer, D.M. Krum, R, Spicer, and J. Campbell. *Mixed Reality Training for Tank Platoon Leader Communication Skills.* IEEE Virtual Reality 2017, Manhattan Beach, California: IEEE Press, pp. 333-334.

p.15 R. Spicer, J. Anglin, D.M. Krum, and S. Liew. *A Low-Cost, Virtual Reality Brain-Computer Interface for Severe Stroke Upper Limb Motor Recovery.* IEEE Virtual Reality 2017, Manhattan Beach, California: IEEE Press, pp. 385-386.

p.14 D.M. Krum, S. Kang, T. Phan, L.C. Dukes, and M. Bolas. *Head Mounted Projection for Enhanced Gaze in Social Interactions.* IEEE Virtual Reality 2016, Greenville, South Carolina: IEEE Press, pp. 209-210.

p.13 M. Bolas, A. Kuruvilla, S. Chintalapudi, F. Rabelo, V. Lympouridis, C. Barron, E. Suma, C. Matamoros, C. Brous, A. Jasina, Y. Zheng, A. Jones, P. Debevec, and D. Krum. *Creating Near-Field VR Using Stop Motion Characters and a Touch of Light-Field Rendering.* ACM Siggraph 2015, Los Angeles, California: ACM Press, number 19.

p.12 D.M. Krum, T. Phan, L.C. Dukes, P. Wang, and M. Bolas. *Tablet-Based Interaction Panels for Immersive Environments.* IEEE Virtual Reality 2014, Minneapolis, Minnesota: IEEE Press, pp. 91-92.

p.11 J.A. Jones, D.M. Krum, and M. Bolas. *The Effect of Eye Position on the View of Virtual Geometry.* IEEE Virtual Reality 2014, Minneapolis, Minnesota: IEEE Press, pp. 87-88.

p.10 J.A. Jones, E.A. Suma, D.M. Krum, and M. Bolas. *Comparability of Narrow and Wide Field-of-View Head-Mounted Displays for Medium-Field Distance Judgements.* ACM Symposium on Applied Perception, August 3-4, 2012, Los Angeles, California, ACM Press, pp. 119.

p.9 D.M. Krum, E.A. Suma, and M. Bolas. *Spatial Misregistration of Virtual Human Audio: Implications of the Precedence Effect.* IEEE Symposium on 3D User Interfaces, 2012, Costa Mesa, California: IEEE Press, pp. 147-148.

p.8 P. Hoberman, D.M. Krum, E.A. Suma, and M. Bolas. *Immersive Training Games for Smartphone-based Head Mounted Displays.* IEEE Virtual Reality 2012, Costa Mesa, California: IEEE Press, pp. 151-152.

p.7 E.A. Suma, D.M. Krum, and M. Bolas. *Sharing Space in Mixed and Virtual Reality Environments Using a Low Cost Depth Sensor.* IEEE International Symposium on VR Innovation, 2011, Singapore: IEEE Press, pp. 349-350.

p.6 E.A. Suma, B. Lange, A.S. Rizzo, D.M. Krum, and M. Bolas. *FAAST: The Flexible Action and Articulated Skeleton Toolkit.* IEEE Virtual Reality 2011, Singapore: IEEE Press, pp. 247-248.

p.5 J.L. Olson, D.M. Krum, E.A. Suma, and M. Bolas. *A Design for a Smartphone-based Head Mounted Display.* IEEE Virtual Reality 2011, Singapore: IEEE Press, pp. 233-234.

p.4 R. Sadek, D.M. Krum, and M. Bolas. *Simulating Hearing Loss in Virtual Training.* IEEE Virtual Reality 2010, March 20-24, Waltham, MA: IEEE Press, pp. 299-300.

p.3 D.M. Krum, J. Faenger, B. Lathrop, J. Sison, and A. Lien. Special Interest Group Session: *All Roads Lead to CHI: Interaction in the Automobile.* Extended Abstracts of the CHI Conference on Human Factors in Computing Systems, April 5-10, 2008, Florence, Italy: ACM Press, pp. 2387-2390.

p.2 D.M. Krum (Panel Moderator), D. Manstetten, C. Nass, K.V. Prasad, R. Sicconi. Panel: *Taking CHI for a Drive: Interaction in the Car.* Extended Abstracts of the CHI Conference on Human Factors in Computing Systems, April 28-May 3, 2007, San Jose, CA: ACM Press, pp. 1917-1920.

p.1 A.F. Seay, D.M. Krum, L. Hodges, W. Ribarsky. *Simulator Sickness and Presence in a High FOV Virtual Environment.* Proceedings of the IEEE Virtual Reality 2001 Conference, March 13-17, 2001, Yokohama, Japan: IEEE Computer Society, pp. 299-300.

Workshop Papers and Workshop Posters

W.8 M.S. Dennison and D.M. Krum. *Unifying Research to Address Motion Sickness.* IEEE Virtual Reality 2019 Workshop on Immersive Sickness Prevention, March 23, 2019, Osaka, Japan, pp. 1858-1859.

W.7 T. Phan, D.M. Krum, and Mark Bolas. *ShodanVR: Immersive Visualization of Text Records from the Shodan Database.* IEEE Virtual Reality 2016 Workshop on Immersive Analytics, March 20, 2016, Greenville, South Carolina.

W.6 T. Phan, D.M. Krum, and Mark Bolas. *FAAST-R: Defining a Core Mechanic for Designing Gestural Interfaces.* ACM CHI Workshop: The 3rd Dimension of CHI: Touching and Designing 3D User Inetrfaces, May 5, 2012, Austin, Texas, pp. 35-42.

W.5 M. Bolas and D.M. Krum. *Augmented Reality Applications and User Interfaces Using Head-Coupled Near-Axis Personal Projectors with Novel Retroreflective Props and Surfaces.* Pervasive 2010 Ubiprojection, May 17, 2010, Helsinki, Finland.

W.4 D.M. Krum and M. Bolas. *The Isolated Practitioner.* CHI 2010 Workshop on Researcher-Practitioner Interaction, April 11, 2010, Atlanta, GA.

W.3 D.M. Krum, D. Piepol, M. Bolas. *Sharing and Stretching Space with Full Body Tracking.* CHI 2009 Workshop on Whole Body Interaction, April 5, 2009, Boston, MA.

W.2 D.M. Krum, E.M. Coelho, J. Faenger, Y. Meng. *Supporting Interaction as a Secondary Task in Geo-Spatial Applications.* CHI 2007 Workshop on Mobile Spatial Interaction, April 28, 2007, San Jose, CA.

W.1 D.M. Krum. *Challenges in Building a Whole Earth 3D Information Space.* The Second Young Investigator's Forum in Virtual Reality, February 12-13, 2003, Phoenix Park, Kangwon Province, South Korea.

Research Demonstrations and Other Publications

O.7 T. Ard, D.M. Krum, T. Phan, D. Duncan, R. Essex, M. Bolas, and A. Toga. *NIVR: Neuro Imaging in Virtual Reality.* IEEE Virtual Reality 2017, Manhattan Beach, California: IEEE Press, pp. 465-466.

O.6 D.M. Krum, T. Phan, L.C. Dukes, P. Wang, and M. Bolas. *A Demonstration of Tablet-based Interaction Panels for Immersive Environments.* IEEE Virtual Reality 2014, Minneapolis, Minnesota: IEEE Press, pp. 175-176.

O.5 E.A. Suma, D.M. Krum, T. Phan, and M. Bolas. *Rapid Generation of Personalized Avatars.* IEEE Virtual Reality 2013, Orlando, Florida: IEEE Press, pp. 185.

O.4 M. Bolas, J. Iliff, P. Hoberman, N. Burba, T. Phan, I. McDowall, P. Luckey, and D.M. Krum. *Open Virtual Reality.* IEEE Virtual Reality 2013, Orlando, Florida: IEEE Press, pp. 183-184.

O.3 D.M. Krum, E.A. Suma, and M. Bolas. *Virtual Reality to Go: A USC ICT Mixed Reality Lab Demonstration.* IEEE Virtual Reality 2012, Costa Mesa, California: IEEE Press, pp. 179-180.
(Awarded Best Demo Award, IEEE VR 2012)

O.2 D.M. Krum, R. Sadek, L. Kohli, L. Olson, M. Bolas. *Experiments in Mixed Reality.* SPIE, Vol. 7525, 75250F, January 21, 2010, San Jose, CA.

O.1 B.J. McCall, J.M. Grunsfeld, S.D. Sobajic, C.L. Chang, D.M. Krum, A. Ratner, J.E. Trittschuh. *The GAMCIT Gamma-Ray Burst Detector.* Proceedings of the 1993 NASA Shuttle Small Payload Symposium, NASA CP-3233, pp. 47-56.

Invited Talks

IT.5 D.M. Krum, *Reigniting Virtual Reality*, presented at the Hackaday Superconference, Pasadena, California, November 5, 2016.

IT.4 D.M. Krum, *Reigniting Virtual Reality*, presented to the cel Academy, Korea Creative Content Agency, Seoul, South Korea, August 26, 2016.

IT.3 D.M. Krum, *The Use of Wearable Computers as Spatial Cognition Aids*, presented to the Center for Lifelong Learning and Design, University of Colorado at Boulder, May 19, 2004.

IT.2 D.M. Krum, *Situational Visualization and Assistive Technology*, presented at the annual conference of the Rehabilitation Engineering & Assistive Technology Society of North America (RESNA), Atlanta, GA, June 20, 2003.

IT.1 D.M. Krum, *Visualization for Wearable Computers*, presented to the Visualization and Graphics Interest Group, University of Alabama in Huntsville, December 6, 2002.

Patents

P.7 M. Bolas, J.A. Jones, and D.M. Krum. *Control of Ambient and Stray Lighting in a Head Mounted Display.* US Patent: 10,416,453. Issued: September 17, 2019.

P.6 D. Krum, J. Faenger. *Context Aware Voice Communication Proxy for Vehicle Operators.* Submitted: October 2008.

P.5 J. Faenger, D. Krum. *Spatial Display and Selection Techniques.* Submitted: December 2007.

P.4 A. Keshavarzian, D. Krum, D. Lal, B. Srinivasan. *Smart Badges for Collective Workspaces.* US Patent Application: 11/521,279. Submitted: September 2006.

P.3 D.M. Krum. *Controlling Systems Through User Tapping.* US Patent: 8,339,363. Issued: December 25, 2012.

P.2 D.M. Krum H. Schmidt. *Sensor-Initiated Exchange of Information Between Devices.* Submitted: May 2005.

P.1 C. Lee, D.M. Krum, D. Ouyang. *Apparatus for and Method of Checking the Validity of Directory Numbers in a Device for Interfacing Communications Equipment to a Telephone Line.* US Patent: 5,917,807. Issued: June 29, 1999.

SERVICE ACTIVITIES

Chairs and Committees

- Committee Member, IEEE Virtual Reality Best Dissertation Award Committee, 2021
- Conference Co-Chair: SPIE Virtual, Augmented, and Mixed Reality (XR) Technology for Multi-Domain Operations, 2020, 2021
- Research Demonstrations Chair: IEEE Conference on Virtual Reality, 2020, 2021
- Video Chair: IEEE Conference on Virtual Reality, 2019
- Exhibits Chair: IEEE Conference on Virtual Reality, 2018
- General Chair: IEEE Conference on Virtual Reality, 2017
- Student Volunteer Chair: IEEE Conference on Virtual Reality, 2016
- Local Arrangements Chair: ACM Symposium on Spatial User Interaction, 2013

Reviewer

- IEEE Virtual Reality Conference
- IEEE Symposium on 3D User Interfaces
- ACM CHI Conference
- International Journal of Human-Computer Studies

Review Panels

- National Science Foundation, 2015, 2019

Organizations

- Member, USC SensoriMotor Assessment and Rehabilitation Training in Virtual Reality Center (USC SMART-VR Center)
- Member, National Academy of Inventors (NAI)
- Member, Association for Computing Machinery (ACM)
- IEEE Impact Creator and Member, Institute of Electrical and Electronics Engineers (IEEE)
- Founding Secretary of the Caltech IEEE Student Branch, 1993

AWARDS AND HONORS

- Best Poster Award Honorable Mention, IEEE Virtual Reality Conference, 2019
- Best Poster Award, IEEE Virtual Reality Conference, 2017
- Best Demo Award, IEEE Virtual Reality Conference, 2012
- Best Paper Award Honorable Mention, IEEE Virtual Reality Conference, 2012)
- Best Technote Award, IEEE 3DUI 2011)
- Best Paper Award, IEEE Virtual Reality Conference, 2000
- SAIC Georgia Tech Student Paper Award, 2000, 2002
- Dean's List, University of Alabama in Huntsville, 1996
- National Merit Scholar, California Institute of Technology, 1990-1994
- Navy Reserve Officer's Training Corps Scholarship, 1990-1994
- Order of the Arrow, an honor society of the Boy Scouts of America, 1988
- Eagle Scout, 1987

REFERENCES

Available upon request.