Gregory Francis Welch

Curriculum Vitae—August 9, 2022

Contact Information

University *of* Central Florida

College of Nursing
612 University Towers
12201 Research Parkway
Orlando, FL 32826-3298 (USA)

Computer Science
441 Harris Engineering Center
4000 Central Florida Boulevard
Orlando, FL 32816-2362 (USA)

Institute for Simulation and Training
110 Partnership III
3100 Technology Parkway
Orlando, FL 32826-3281 (USA)

welch@ucf.edu
+1 407.796.2823

Professional Experience (Summary)

2011–present **University *of* Central Florida**
Pegasus Professor (2020)
AdventHealth Endowed Chair in Healthcare Simulation (2013)
Professor, College of Nursing, Academic Health Sciences Center (2013)
Professor, Computer Science, College of Engineering and Computer Science (2011)
Professor, Institute for Simulation & Training (2011)
Co-Director, IST Synthetic Reality Lab (2011)
Faculty, Graduate Certificate in Mixed Reality Engineering (2020)
Faculty, Modeling & Simulation Graduate Program (2011)
Faculty, Interactive Computing Experiences Research Cluster (2014)

1996–2020 **University *of* North Carolina *at* Chapel Hill**
Adjunct Professor, Computer Science (2012-2020)
Research Professor (Assistant, Associate), Computer Science (1996–2012)

1990–1992 **Northrop Defense Systems Division**
Senior Engineer, Airborne Electronic Countermeasures, Digital Systems Group

1987–1990 **NASA Jet Propulsion Laboratory (California Institute of Technology)**
Voyager Spacecraft Project, Flight Command and Data Management Section

---

Education

May 1997 **Ph.D., Computer Science**
University *of* North Carolina *at* Chapel Hill, Chapel Hill, NC
Under the direction of Gary Bishop

May 1995 **M.S., Computer Science**
University *of* North Carolina *at* Chapel Hill, Chapel Hill, NC

May 1986 **B.S. with *Highest Distinction*, Electrical Engineering Technology**
Purdue University, West Lafayette, IN

Meta Platforms, Inc.
Exhibit 1004
Page 001

Personal Awards

- **IEEE Virtual Reality Academy**, IEEE Visualization and Graphics Technical Committee, March 13, 2022 during the 28th IEEE Virtual Reality Conference in Christchurch, New Zealand.
- **Scroll & Quill Society**, the University of Central Florida, October 1, 2021. The award recognizes "sustained and outstanding achievements in research and/or creative activities" at UCF.
- **Pegasus Professor**, the University of Central Florida, April 1, 2020. The award recognizes faculty excellence in the three primary areas of academic endeavor: teaching, research and service. There were approximately 50 Pegasus Professors at UCF in 2020.
- **IEEE Virtual Reality Technical Achievement Award**, IEEE Visualization and Graphics Technical Committee, "in recognition for his contributions to human motion tracking and to mixed reality applications in medicine and training," March 21, 2018 during the 25th IEEE Virtual Reality Conference in Reutlingen, Germany.
- **Luminary Award**, University of Central Florida, for "exceptional faculty whose work is advancing their discipline and making a difference," October 18, 2017.
- **Research Incentive Award** (RIA), University of Central Florida, for "outstanding research, scholarly, or creative activity that advances the body of knowledge in a particular field, including interdisciplinary research and collaborations," March 7, 2017.
- **Outstanding Performance as Co-Chairman of the IEEE VR 2014 Conference**, IEEE Computer Society, April 3, 2014.
- **Outstanding Performance as Co-Chairman of the IEEE VR 2013 Conference**, IEEE Computer Society, March 18, 2013.
- **Rock StAR Award**, 15th IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2016), for teaching role in an introductory course on Augmented Reality (AR) for approximately 40 Mexican students interested in AR, September 20, 2016. Mérida, México.
- **Excellence in Teaching Award**, UNC-Chapel Hill Computer Science Student Association, for 3D Computer Modeling and Animation, Spring 2007.
- **Outstanding Senior Design Project Award**, "The Easy Chair: A Microprocessor-Controlled Wheelchair for Children With Muscular Disorders," E.T., Purdue University, 1986

Joint Awards

- **TechConnect Innovation Award**, "Intelligent Object Magnification for Augmented Reality Displays," with Dr. Gerd Bruder, Zubin Choudhary, and Dr. Kangsoo Kim. 2021 TechConnect Innovation Showcase, October 18-21, 2021, Washington, DC. USA
- **Best Demo Award**, "Real Time Magnification in Augmented Reality," with Zubin Choudhary, Jesus Ugarte, and Gerd Bruder. ACM Spatial User Interaction 2021, November 9–10, 2021 (Virtual).
- **Best Demo Audience Choice Award**, "Towards Interactive Virtual Dogs as a Pervasive Social Companion in Augmented Reality," with Nahal Norouzi, Kangsoo Kim, and Gerd Bruder. International Conference on Artificial Reality and Telexistence and Eurographics Symposium on Virtual Environments (ICAT-EGVE 2020).
- **Best Long Paper**, "Effects of shared gaze parameters on visual target identification task performance in augmented reality," with Nahal Norouzi, Austin Erickson, Kangsoo Kim, Ryan Schubert, Joeseph J. LaViola Jr., Gerd Bruder, in *Proceedings of the ACM Symposium on Spatial User Interaction (SUI)*, page 11, New Orleans, LA USA, October 20 2019. Association of Computing Machinery.

- **Best Paper**, "The physical-virtual table: Exploring the effects of a virtual human's physical influence on social interaction," with Myungho Lee, Nahal Norouzi, Gerd Bruder, and Pamela J. Wisniewski. 24th ACM Symposium on Virtual Reality Software and Technology; Tokyo, Japan; December 1, 2018.
- **Best Paper Honorable Mention**, "Blowing in the Wind: Increasing Copresence With a Virtual Human via Airflow Influence in Augmented Reality," with Kangsoo KIM and Gerd BRUDER. ICAT-EGVE 2018 - International Conference on Artificial Reality and Telexistence and Eurographics Symposium on Virtual Environments; Limassol, Cyprus; November 9 2018.
- **Best Student Paper**, 2017 ACM Symposium on Virtual Reality Software (VRST 2017), "Exploring the effects of observed physicality conflicts on real–virtual human interaction in augmented reality," by Kangsoo Kim (student advisee), Gerd Bruder, and Greg Welch; Gothenberg, Sweden; November 10, 2017.
- **Long Lasting Impact Paper**, 15th IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2016), for a pair of 1998 papers on "Spatial Augmented Reality" (SAR), with co-authors Prof. Ramesh Raskar, Prof. Henry Fuchs, and Deepak Bandyopadhyay; Mérida, México; September 20, 2016.
- **Second Best Paper** at 5th ACM/IEEE International Conference on Distributed Smart Cameras; Ghent, Belgium; August 25, 2011.
- **Best Paper**, ACM Symposium on Virtual Reality Software and Technology 1999 (VRST 99); London, England, United Kingdom; December 22, 1999.

Advisee Awards (when Advisees)

- Jonathan Jules (undergraduate advisee), **National Action Council for Minorities in Engineering (NACME) Scholarship** for 2019–2020, September 30, 2019.
- Salam Daher (Ph.D. advisee), **Collegiate Award** from the National Center for Women in Technology (NCWIT)—four recipients total, May 15, 2018, Grapevine, TX USA.
- Salam Daher (Ph.D. advisee), **RADM Fred Lewis Scholarship Award**, Interservice/Industry Training, Simulation and Education Conference (I/ ITSEC), August 5, 2017.
- Salam Daher (Ph.D. advisee), **Link Foundation Fellowship in Modeling, Simulation, and Training** for the 2016–2017 academic year, March 16, 2016.
- Joshua Morton (undergraduate advisee), **Rodney F. Hood Undergraduate Research Award** in support of "Tremor Sensing and Quantification" (November 15, 2010–June 30, 2011).

Honors (Selected)

- **Keynote Talks** and **Other Invited Talks** as indicated below.
- **Election to the rank of Fellow**, Institute of Electrical and Electronics Engineers (IEEE), January 1, 2022.
- **Election to the rank of Fellow**, National Academy of Inventors (NAI), December 7, 2021.
- **IEEE Technical Expert** for Virtual, Augmented and Mixed Reality, IEEE Public Visibility Initiative, 2018–present.
- **Member**, World Economic Forum (WEF), Global Future Councils, Council on Virtual Reality and Augmented Reality (2018–2022).
- **Member**, National Council of Architectural Registration Boards (NCARB), Futures Task Force (2017–2019).

- **Invited participant**, ACM SIGGRAPH Frontier Workshop: Content Generation for Workforce Training, with Holly Rushmeier (Organizer), Carolina Cruz-Neira, Eakta Jain, Rajesh Jha, Jerome Solomon, and Louise Yarnall. July 28, 2019, Los Angeles, CA.
- **Invited participant**, National Science Foundation (NSF) Principal Investigator workshop on the Future of Work at the Human-Technology Frontier (FW-HTF), "Panel: Augmented Reality in the Future of Work," with Joe Gabbard (moderator), Virginia Tech; Doug Bowman, Virginia Tech; Steve Feiner, Columbia University; and Henry Fuchs, University of North Carolina at Chapel Hill. April 5, 2019, NSF Headquarters (Alexandria, VA).
- **Invited participant**, Computing Community Consortium (CCC) Visioning Workshop: Content Generation for Workforce Training, March 14–15, 2019, Atlanta, GA.
- **Invited participant**, Computing Community Consortium (CCC) Computing Research Symposium: Addressing National Priorities and Societal Needs 2017, October 23–24, 2017, Washington, DC.
- **Invited participant**, National Science Foundation (NSF) Virtual Reality (VR)/Augmented Reality (AR) Workshop, July 17–18, 2017, Washington, DC.
- **Invited participant**, Computing Community Consortium (CCC) Visioning Workshop on Discovery & Innovation in Smart & Pervasive Health, December 5–6, 2016, Washington, DC.
- **Certificate of Appreciation** for two-day course on an "Introduction to the Kalman Filter" for Autonomy Incubator Short Course Series (AISCS), NASA Langley Research Center (LaRC), Hampton, Virginia, November 5-6, 2014,
- **Invited participant**, National Research Council (NRC) Mapping Science Committee meeting, October 3, 2012, National Academies Keck Center, Washington, DC, USA.
- **Invited participant**, Computing Community Consortium (CCC) Visioning Workshop on Spatial Computing, September 10–11, 2012, National Academies Keck Center, Washington, DC, USA.
- **Featured exhibit**, Collaborations: Humanities, Arts & Technology (CHAT) Festival, "The Bathysphere: Motion Capture as Art," with Prof. Francesca Talenti, February 16–20, 2010, UNC-Chapel Hill.
- **Invited participant**, IMMERSCOM 2009 (2nd International Conference on Immersive Telecommunications), Panel with Jaron Lanier (Microsoft), Randy Harrell (CISCO), Frantz Lohier (Logitech), William C. Wickes (Hewlett Packard), and Zhengyou Zhang (Microsoft), May 29, 2009.
- Internationally-recognized **Kalman filter** web site (`http://www.cs.unc.edu/~welch/kalman/`) and associated article "An Introduction to the Kalman Filter," UNC Technical Report TR95-041, **Cited over 10,000 times** according to Google as of 29 MAY 2022.

Professional Service

- Professional Associations
  - Fellow, Institute of Electrical and Electronics Engineers (IEEE)
  - Fellow, National Academy of Inventors (NAI)
  - Member, Association for Computing Machinery (ACM)
  - Pioneer, ACM Special Interest Group on Computer Graphics and Interactive Techniques (SIGGRAPH)
  - Member, International Virtual Reality Healthcare Association (2019–present)
  - Member, Vision Sciences Society (VSS)
  - Member, European Association for Computer Graphics (Eurographics)

  - Member, Society for Simulation in Healthcare (SSIH)
  - Member, International Nursing Association of Clinical Simulation & Learning (INACSL)
  - Member, Southern Nursing Research Society (SNRS)

- Boards and Committees
  - Member, World Economic Forum (WEF), Global Future Councils, Council on Virtual Reality and Augmented Reality (2018–present)
  - Member, International Virtual Reality Healthcare Association, Advisory Board (2019–present)
  - Member, AdventHealth East Orlando Simulation Center, Steering Committee (2015–present)
  - Emeritus Member, International Symposium for Mixed & Augmented Reality, Steering Committee (2012–2014, Emeritus 2014–present)
  - Chair, UCF Search Committee for Director of School of Modeling, Simulation, and Training (2020–2021)
  - Member, UCF IST Modeling & Simulation Graduate Program, Advisory Committee (2012–present)
  - Member, UCF Information Technology Resource, Advisory Committee (2014–present)
  - Member, UCF Office of Research, COVID-19 Lab Reopening Task Force (2020)
  - Member, National Council of Architectural Registration Boards (NCARB), Futures Task Force (2017–2019)
  - Senior Advisor, TrakMark Working Group—SIG MR and VR Society of Japan (past)
  - Member, Board of Directors, HiBall Tracker, Inc. (past)
  - Member, UNC Committee on Student Conduct (past)
  - Member, UNC Computer Science Committee on Curriculum and Planning (past)
  - Member, UNC Computer Science Committee on Publications (past)

- Reviewer, Committee, and Editorial Activity
  - Reviewer/panelist, National Science Foundation (NSF), U.S. Department of Energy (DOE), and other funding organizations/units
  - Reviewer, NSF Computing Innovation Fellows
  - Associate Editor, PRESENCE: Virtual and Augmented Reality (2002–present)
  - Associate Editor, Frontiers in Virtual Reality (2014–present)
  - Editorial Board, Virtual Reality & Intelligent Hardware (2019–present)
  - Editorial Board, Journal of Virtual Reality (past)
  - Reviewer, ACM: International Conference on Graphics and Interactive Techniques (SIGGRAPH); Symposium on Virtual Reality Software and Technology (VRST); Symposium on Interactive 3D Graphics; Multimedia; User Interface Software and Technology (UIST); Transactions on Mathematical Software;
  - IEEE: Computer Graphics and Applications (CG&A); International Symposium on Mixed and Augmented Reality (ISMAR)—Area Chair; Virtual Reality (VR); Transactions on Vizualization and Computer Graphics; Transactions on Aerospace and Electronic Systems; Conference on Computer Vision and Pattern Recognition (CVPR)
  - International Symposium on 3D Data Processing, Visualization, and Transmission (3DPVT)
  - International Symposium on Ubiquitous Virtual Reality (ISUVR)
  - IEEE/ACM International Symposium on Wearable Computers
  - The combined International Conference on Artificial Reality & Telexistence and Eurographics Symposium on Virtual Environments (ICAT-EGVE)

  - EURASIP Journal of Applied Signal Processing; Transactions on Automatic Control
  - Journal of Optimal Control Applications and Methods
  - Eurographics Workshop on Virtual Environments
  - New Immersive Displays for the Near Future (Laval Virtual 2011 Symposium)

- Developer of popular free Mac OS X Mail plugins MailFollowUp and MailRecent
- Intellectual property expert witness/consultant on human-computer interaction, virtual and augmented reality, position and motion estimation, sensor fusion, handheld devices, and related technology.

- Event Organization
  - Considerations for Research Studies in XR Workshop, with Nahal Norouzi (University of Central Florida), Advertising in the Metaverse, 2022 American Academy of Advertising Annual Conference, March 24, 2022, St. Petersburg, FL USA.
  - IEEE Virtual Reality 2020, Best Paper awards committee, November 22–26, 2020. Atlanta, Georgia, USA. (Held on-line due to Covid-19.)
  - Extended Reality for Good (XR4Good) workshop, 18th IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2019), co-organized with Arindam Dey (University of Queensland), Mark Billinghurst (University of South Australia), Gun Lee (University of South Australia), and Stephan Lukosch (TU Delft). October 2019, Beijing, China.
  - VR 2019 Program Committee Co-Chair, IEEE Virtual Reality 2019 (Osaka, Japan), with Bruce Thomas (University of South Australia in Adelaide, Australia), Torsten Kuhlen (RWTH Aachen University, Aachen, Germany), and Rob Teather (Carleton University, Ottawa, Canada).
  - Augmented Reality Visioning Workshop (ARVW 2018), with Gerd Bruder (University of Central Florida) and Peter Squire (Office of Naval Research), July 30–August 3, 2018, Warrenton, VA, USA.
  - VR 2018 Program Committee Co-Chair, IEEE Virtual Reality 2018 (Germany), with Kiyoshi Kiyokawa (Osaka University, Japan), Frank Steinicke (University of Hamburg, Germany), and Bruce Thomas (University of South Australia in Adelaide, Australia).
  - Virtual and Augmented Reality for Good (VAR4Good) workshop, 25th IEEE Conference on Virtual Reality and 3D User Interfaces (VR 2018), co-organized with Bruce Thomas, Arindam Dey, and Mark Billinghurst (all University of South Australia in Adelaide, Australia), March 18, 2018, Reutlingen, Germany.
  - Augmented Reality for Good (AR4Good) workshop, 16th IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2017), co-organized with Arindam Dey and Mark Billinghurst (both University of South Australia in Adelaide, Australia), October 9, 2017, Nantes, France.
  - Combined 26th International Conference on Artificial Reality and Telexistence (ICAT 2016) and 21st Eurographics Symposium on Virtual Environments (ICAT-EGVE 2016) *Best Paper* awards committee, December 7–9, 2016. Little Rock, Arkansas, USA.
  - ACM Symposium on Virtual Reality Software and Technology (VRST 2016) *Best Paper* awards committee, November 2–4, 2016. Munich, Germany.
  - 15th IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2016), co-organized "AR101," an introductory course on Augmented Reality (AR) for a group of approx. 40 Mexican students interested in AR. September 20, 2016. Mérida, México.
  - 15th IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2016), Best Paper Award committee, September 19–23, 2016. Mérida, México.

- ISMAR 2016 Outreach Co-Chair, IEEE International Symposium on Mixed and Augmented Reality (ISMAR2016), Mérida, México, September 19–23, 2016.
- Workshop "Human Perception and Psychology in Augmented Reality (HPPAR)," with Bruce H. Thomas (The University of South Australia Mawson Lakes) and James Baumeister (University of South Australia), IEEE International Symposium on Mixed and Augmented Reality (ISMAR2015), September 29, 2015, Fukuoka, Japan.
- Dagstuhl Seminar on "Virtual Realities" (Seminar 13241), co-organized with Guido Brunnett (TU Chemnitz, Germany), Sabine Coquillart (INRIA Rhône-Alpes, France), and Robert van Liere (Center for Mathematics and Computer Science, Netherlands), June 10–14, 2013, The International Conference and Research Center for Computer Science, Dagstuhl, Germany.
- IEEE Virtual Reality 2013 (VR 2013), Co-General Chair with Ben Lok (University of Florida), March 16–23, 2013, Orlando, FL, USA.
- 11th International Symposium on Mixed and Augmented Reality (ISMAR 2012), Co-General Chair with Blair MacIntyre (Georgia Tech), November 5–8, 2012, Atlanta, Georgia, USA.
- Joint Virtual Reality Conference 2011 (JVRC 2011), International Program Committee Co-chair with Sabine Coquillart (INRIA Rhône-Alpes, France) and Anthony Steed (University College of London, UK).
- 10th International Symposium on Mixed and Augmented Reality (ISMAR 2011), Program Committee Co-Chair with Gerhard Reitmayr (Graz University of Technology) and Jun Park (Hongik University).
- VR 2011 Research Demos Co-Chair, IEEE Virtual Reality 2011 (Singapore), with Dirk Reiners (University of Louisiana at Lafayette, USA), Henry Duh (National University of Singapore), and Jiung-Yao Huang (National Taipei University, Taiwan).
- VR 2010 Research Demos Co-Chair, IEEE Virtual Reality 2010 (Waltham, MA, USA), with Yoshifumi Kitamura (Osaka University, Japan), Laura Monroe (Los Alamos National Laboratories, USA), Dirk Reiners (University of Louisiana at Lafayette, USA), and Simon Richir (Laval Virtual, France).
- Dagstuhl Seminar on "Virtual Realities" (Seminar 08231), co-organized with Guido Brunnett (TU Chemnitz, Germany) and Sabine Coquillart (INRIA Rhône-Alpes, France), June 1–6, 2008, The International Conference and Research Center for Computer Science, Dagstuhl, Germany.
- VR 2007 Local Arrangements Co-Chair, IEEE Virtual Reality 2007 (Charlotte, NC, USA), with Zachary Wartell (UNC-Charlotte, USA), Sabarish Babu (UNC-Charlotte, USA), and Regis Kopper (Virginia Tech, USA).
- Workshops/Tutorials Chair, 5th IEEE and ACM International Symposium on Mixed and Augmented Reality (Santa Barbara, CA, USA).
- Co-Chair with Chris Jaynes (University of Kentucky) of IEEE CVPR 2006 International Workshop on Projector-Camera Systems, (ProCams 2006), New York, NY, USA.
- 3DPVT 2006 Organizing Committee, Third International Symposium on 3D Data Processing, Visualization and Transmission (Chapel Hill, NC, USA).
- EDT 2006 Co-chair, IEEE Virtual Reality 2006 International Workshop on Emerging Display Technologies (Alexandria, VA, USA), with Mark Bolas (USC and Fakespace Labs) and Andreas Simon (FH-Aargau).
- ICAT 2005 Program Co-Chair, 15th International Conference on Artificial Reality and Telexistence (Christchurch, New Zealand), with Sang Chul Ahn (KIST, Korea), and Haruo Noma (ATR, Japan).

- ProCams 2005 Posters Chair, IEEE CVPR 2005 International Workshop on Projector-Camera Systems (San Diego, CA, USA).
- EDT 2005 Co-chair, IEEE Virtual Reality 2005 International Workshop on Emerging Display Technologies (Bonn, Germany), with Mark Bolas (USC and Fakespace Labs) and Andreas Simon (Fraunhofer IMK).
- I3D 2001 Registration Chair, ACM Symposium on Interactive 3D Graphics (Chapel Hill, NC, USA).

Keynote/Plenary Talks

- AI Colloquium, Pusan National University, December 2, 2021.
- Hoag Advances in Clinical Virtual Reality Symposium, October 1, 2021.
- Training XR: Workshop on 3D Content Creation for Simulated Training in eXtended Reality, IEEE Virtual Reality 2020, on line (originally Atlanta, GA USA), March 22, 2020.
- ChinaVR 2019, Shenzhen, China, November 24, 2019.
- 6th ACM Symposium on Spatial User Interaction, Berlin, Germany, October 13–14, 2018.
- New Knowledge and Innovations, Sarasota Memorial Health Care System, Sarasota, Florida, May 4, 2018.
- International Conference on Computer-Aided Design and Computer Graphics (CAD/Graphics), Zhangjiajie, China, August 26, 2017.
- Society for Design and Process Science conference (SDPS), Orlando, Florida, December 5, 2016.
- Annual Meeting of the Association for Information Science and Technology (ASIS&T), Copenhagen, Denmark, October 16, 2016.
- 22nd Annual Research Day, Sigma Theta Tau International Honor Society of Nursing, Theta Epsilon chapter, Winter Park, Florida, USA, April 8, 2014.
- Society for Computer Science, Workshop on Virtual Reality-Augmented Reality (GI VR-AR 2013), Würzburg, Germany, September 19, 2013. .
- International Symposium on Ubiquitous Virtual Reality (ISUVR), Daejeon, South Korea, August 23, 2012.
- Joint Virtual Reality Conference (JVRC), Fellbach, Germany, September 29, 2010.
- Winter Augmented Reality Meeting (WARM), Graz, Austria, February 24–25, 2010.
- Real Action, Virtual Environments (RAVE), Barcelona, Spain, March 4, 2009.
- Digital City Monitoring and Emergency Management (D2D), Shenzhen, China, October 25, 2008.
- Eurographics Symposium on Virtual Environments (EGVE), Eindhoven, The Netherlands, May 29, 2008.

Other Invited Talks (Selected)

- "How to XR: Hardware & Technology," World Economic Forum (WEF), Knowledge Lab with the Global Future Council on AR/VR 2021, April 29, 2021.
- "Personal Agents for Workplace (Nursing) Skills and Emotional Support," HCI and the Future of Work and Wellbeing: A Series of Conversations. May 7, 2020, online (Longwood, FL USA).

- "Physical-Virtual Training for Healthcare," International Women's Club of Gothenburg, May 26, 2020, Gothenburg, Sweden (via video during pandemic).
- "Aware and Influential Virtual Humans and Animals," Naval Postgraduate School, MOVES lecture, April 13, 2020, Monterey, CA (via video during pandemic).
- "Vera Real: Stroke assessment using a Physical Virtual Patient (PVP)" with Laura Gonzalez and Salam Daher (both UCF), 2019 Conference of the International Nursing Association for Clinical Simulation and Learning (INACSL), Phoenix, AZ, June 21, 2019.
- "Enhanced Perception & Cognition in Augmented Reality (EPiC AR)," Naval Postgraduate School, MOVES Open House, May 23, 2019, Monterey, CA.
- "Identifying User Physical States," XR Advance Webinar Series, Iowa State University, April 22, 2019. Lecture series was a follow-up to a June 2017 VR/AR Workshop sponsored by NSF.
- "Physical-Virtual Patients: Human Shape, Appearance, Awareness, and Influence," Virtual Reality & Health, Tucson, AZ, March 7, 2019.
- "Human Surrogates: Real, Virtual, and Augmented Shape, Appearance, and Intelligence," Rubin Center for Healthy Aging, Sarasota, Florida, March 3, 2019.
- "Awareness and Influence of Human Surrogates in Augmented Reality," 2017 International Conference on Computer-Aided Design and Computer Graphics (CAD/Graphics), Zhangjiajie, China, August 26, 2017.
- "Bridging the Telepresence Valley," 2016 Annual Meeting of the Association for Information Science and Technology (ASIS&T), Copenhagen, Denmark, October 16, 2016.
- "Human Surrogates and their Effects on Humans," Naval Postgraduate School, MOVES Institute, Simulation and Training Course, Monterey, CA, September 8, 2016.
- "Human Surrogates and their Effects on Humans," Technische Universität München (TU Munich), Garching b. Munich, Germany, June 28, 2016.
- "Interactive Rear-Projection Physical-Virtual Patient Simulators," Mini-Lecture at NextMed/MMVR22 (Medicine Meets Virtual Reality), Los Angeles, CA, April 7, 2016.
- "Making the Virtual Real: Virtual Reality, Augmented Reality, Physical-Virtual Reality," Examination Development & Research committee of the National Council of Architectural Registration Boards (NCARB), Phoenix, AZ, January 30, 2016.
- "My patient is a dummy—so why should I care?" classroom lecture, Rollins College (Winter Park, FL), hosted by Darin Hughes, November 11, 2015.
- "Making the Virtual Real: Physical Manifestations of Dynamic Virtual People, Objects, and Places," Qualcomm/Vienna University of Technology (Vienna, Austria), September 15, 2014.
- "Making the Virtual Real: Physical Manifestations of Dynamic Virtual People, Objects, and Places," Graz University of Technology (Graz, Austria), September 17, 2014.
- "Past and Current Research in Modeling and Reproducing Humans for Warfighter Training," Orlando VA Medical Center (Orlando, FL), August 26, 2014.
- "Making the Virtual Real: Physical Manifestations of Dynamic Virtual People, Objects, and Places," Harris Corporation, Melbourne, FL, February 18, 2014.
- "Face-to-Face: Interactive Simulation Using a Mobile Physical-Virtual Patient," work with Steven Talbert, Mary Lou Sole, and Karen J. Aroian, SNRS 28th Annual Conference, San Antonio, TX, February 15, 2014.
- "Physical-Virtual Humans for Healthcare," the University of Texas at San Antonio, San Antonio, TX, February 13, 2014.
- "Physical-Virtual Humans for Training and Teleportation," Max Planck Institute, Tübingen, Germany, September 17, 2013, and Bonn-Rhein-Sieg University of Applied Sciences, Bonn, Germany, September 20, 2013.

- "Interactive Shader Lamps: Projector-Based Graphics in Motion," GI VR-AR (Würzburg, Germany), September 19, 2013.
- "Physical-Virtual Humans for Training and Teleportation," TU Chemnitz (Chemnitz, Germany), June 6, 2013.
- "Physical-Virtual Humans: Challenges and Opportunities", KIST (Seoul, South Korea) and KAIST (ISUVR 2012, Daejeon, South Korea), August 22–23, 2012.
- "Physical Manifestations of Virtual Humans," Technische Universität München (TU Munich); Garching b. Munich, Germany; April 11, 2011.
- "Crossing Realities: The Convergence of Physical and Virtual Worlds," Microsoft Research; Redmond, WA; May 25, 2010.
- "Crossing Realities: An Overview of Related Work at UNC-Chapel Hill," Joint Virtual Reality Conference (JVRC); Lyon, France; December 7, 2009.
- "Virtual Artifacts and Experiences in Real Environments," second RAVE 2009 workshop (Real Action, Virtual Environments); Barcelona, Spain; March 4, 2009.
- "A Living, Breathing, Dynamic Digital City," D2D 2008 workshop (Digital City Monitoring and Emergency Management); Shenzhen, China; October 25, 2008.
- "Immersive Display Research at UNC-CH: A Sampling," with Henry Fuchs; Max Planck Institute, Tübingen, Germany; June 9, 2008..
- "Motion Tracking as an Epic Battle Between Information and Uncertainty," 14th Eurographics Symposium on Virtual Environments (EGVE 2008); Eindhoven, The Netherlands; May 29, 2008..
- "Improving, Expanding and Extending 3D Telepresence," International Workshop on Advanced Information Processing for Ubiquitous Networks, ICAT 2005; Christchurch, New Zealand; December 8, 2005..
- "3D Telepresence for Off-Line Surgical Training and On-Line Remote Consultation," 2nd CREST Symposium on Telecommunication, Teleimersion and Telexistence; University of Tokyo; December 9–10, 2004..
- "Immersive Telepresence for Surgical Teaching and Remote Consultation: Extending Medical Expertise Over Time and Space," University of Florida, Department of Computer and Information Science and Engineering; "Geometry, Graphics, Vision, Visualization/ Simulation (G2V2)" seminar series; October 17, 2003. .
- "Sensor Information Efficiency for Pose Estimation," University of Rochester, Department of Computer Science; April 13, 2001..
- "Inside the HiBall Tracking System," Siemens Corporate Research, Imaging and Visualization Department; Princeton, NJ; October 25, 2000..
- "Tracking for Interactive Computer Graphics: To the Hallway and Beyond," the Boeing Corporation, Virtual Reality Group, Seattle, WA, April 21, 1999. (Also presented at Microsoft Research; Seattle, WA; April 21, 1999.).
- "Spatially-Augmented Visualization," Walt Disney Imagineering, Virtual Reality Studio; Burbank, CA; September 1998..

Panel Participation

- **Greg Welch**, Nahal Norouzie, Rosario Casas. "Approaching the Metaverse — An Overview & the State of the Art," Advertising in the Metaverse, 2022 American Academy of Advertising Annual Conference, March 24, 2022, St. Petersburg, FL USA.
- **Greg Welch**, Salam Daher, Laura Gonzalez, Jacob Stuart. "Workshop on Collaborations with Domain Experts for Virtual Agent Research (CoVAR)," Intelligent Virtual Agents (IVA 2020), October 18, 2020, online workshop (Longwood, FL USA).
- **Greg Welch**, Laura Gonzalez, Juan Cendan, Mindi Anderson. "Simulating Patients for Healthcare Training: Appearance, Shape, Influence, and Awareness," Serious Play Conference, Healthcare Track, July 25, 2019, Orlando, FL USA.
- Joe Gabbard (Virginia Tech), Doug Bowman (Virginia Tech), Steve Feiner (Columbia University), Henry Fuchs (University of North Carolina at Chapel Hill), and **Greg Welch** (UCF). "Augmented Reality in the Future of Work," National Science Foundation (NSF) Principal Investigator workshop on the Future of Work at the Human-Technology Frontier (FW-HTF), April 5, 2019, NSF Headquarters (Alexandria, VA).
- **Greg Welch** (UCF), Albert "Skip" Rizzo (University of Southern California), Maria Sanchez-Vives (Institute of Biomedical Research August Pi i Sunyer), and Petr Legkov (University of Osnabrück), "The Future Impact of Neuroscience and Cognitive Psychology on Virtual Environments," IEEE Conference on Virtual Reality and 3D User Interfaces (VR 2018), Reutlingen, Germany.
- Anthony Steed (University College London), Doron Friedman (IDC Herzliya), **Greg Welch** (UCF), Susumu Tachi (The University of Tokyo), and moderator Mel Slater (University of Barcelona). "Instantaneous Beaming to Distance Places — A Possible and Desirable Future?" IEEE Virtual Reality 2017, March 21, Los Angeles, CA USA.
- **Greg Welch** (UCF), Charles Hughes (UCF), Linda Gibson-Young (UCF), Chait Renduchintala (UCF), Peter Kincaid (UCF), Sarah Matthews (FL DOH), Tom Herring (FL DOH), "Technology & Public Health Use Now and in the Future," 2014 Florida Public Health Educational Meeting, Orlando, FL, August 1, 2014.
- Betty Mohler (Max Planck Institute for Biological Cybernetics), **Greg Welch** (UNC-CH), Daniel Thalmann (Nanyang Technological University and EPFL), and Victoria Interrante (University of Minnesota), "Avatars in Virtual Environments," IEEE Virtual Reality 2011 (VR 2011), Singapore, March 21, 2011.
- Randy Harrell (CISCO), Jaron Lanier (Microsoft), Frantz Lohier (Logitech), **Greg Welch** (UNC-CH), William C. Wickes (Hewlett Packard), and Zhengyou Zhang (Microsoft Research), IMMERSCOM 2009 (2nd International Conference on Immersive Telecommunications), May 29, 2009.
- Henry Fuchs, Bernd Fröhlich (Bauhaus-Universität Weimar), and **Greg Welch**, "Display Technology," 14th Eurographics Symposium on Virtual Environments (EGVE 2008), Eindhoven, The Netherlands, May 30, 2008.
- Barbara Hayes-Roth, Austin Henderson, Ramesh Jain, Lev Manovich, **Greg Welch**, and Gopal Pingali, "Experiential Telepresence: How Can Telepresence Research be Guided Towards Better End User Experience?" ACM SIGMM 2003 Workshop on Experiential Telepresence 2003 (ETP 2003), November 7, 2003, Berkeley, CA USA.

Graduated Ph.D. Advisees

- Nahal Norouzi, 2021: The Social and Behavioral Influences of Interactions with Virtual Dogs as Embodied Agents in Augmented and Virtual Reality
- Jason Hochreiter, 2019: Multi-Touch Detection and Semantic Response on Non-Parametric Rear-Projection Surfaces
- Myungho Lee, 2019: Mediated Physicality: Inducing Illusory Physicality of Virtual Humans Via Their Interactions With Physical Objects
- Salam Daher, 2018: Physical-Virtual Patient Simulators: Bringing Tangible Humanity to Simulated Patients
- Kangsoo Kim, 2018: Environmental Physical-Virtual Interactivity to Improve Social Presence With a Virtual Human in Mixed Reality
- Peter Lincoln, 2017 (UNC Chapel Hill, with Henry Fuchs): Low Latency Displays for Augmented Reality
- Christoph Resch, 2016 (TU München, with Gudrun Klinker): Enhancing Projective Spatial Augmented Reality in Industry: A Model Based Approach for Registration and Calibration
- Feng Zheng, 2015: Spatio-Temporal Registration in Augmented Reality
- Jinghe Zhang, 2013: Uncertainty-Driven Adaptive Estimation with Applications in Electrical Power Systems
- Peter Keitler, 2011 (TU München, with Gudrun Klinker): Management of Tracking and Tracking Accuracy in Industrial Augmented Reality Environments
- Adrian Ilie, 2010: On-Line Control of Active Camera Networks
- Hua Yang, 2008: Differential Tracking Through Sampling and Linearizing the Local Appearance Manifold
- B. Danette Allen: 2007, Hardware Design Optimization for Human Motion Tracking Systems
- Aditi Majumder, 2003: A Practical Framework To Achieve Perceptually Seamless Multi-Projector Displays
- Ruigang Yang, 2003: View-Dependent Pixel Coloring—A Physically-Based Approach for 2D View Synthesis
- Ramesh Raskar, 2001: Projector-Based Three Dimensional Graphics

Supervised Postdoctoral Scholars

- Dr. Nahal Norouzi, Postdoctoral Scholar, University of Central Florida, College of Nursing (Computer Science), January 2022–May 2022.
- Dr. Kangsoo Kim, Postdoctoral Scholar, University of Central Florida, College of Nursing (Computer Science), January 2019–December 2020.
- Dr. Salam Daher, Postdoctoral Scholar, University of Central Florida, College of Nursing (Modeling & Simulation), January 2019–July 2019.
- Dr. Arjun Nagendran, Postdoctoral Scholar, University of Central Florida, Department of Computer Science, August 2011–January 2013, with Dr. Charles Hughes (primary advisor/mentor).

Meta Platforms, Inc.
Exhibit 1004
Page 012

Graduated M.S. and B.S. Honors Thesis Advisees

- Angelica Garcia, 2017 (UCF M.S. Modeling & Simulation, Advisor)
- Justin Grace, 2016: Recognizing Pain Using Novel Simulation Technology (UCF B.S.N. Honors in the Major, Committee Member)
- Krishna Kollu, 2012: Modeling the Neural Pathology of Parkinson's Disease (UNC B.S. C.S. Honors, Advisor)
- Caitlyn Losee, 2011: The Bathysphere: Motion Capture and Immersive Projection (UNC B.S. C.S. Honors, Advisor)

Student Advisees (All)

Zubin Choudhary (current); Austin Erickson (current); Hiroshi Furuya (current); Matthew Gottsacker (current) Tiffany Losekamp (current, College of Nursing, with Mindi Anderson); Nahal Norouzi (2021, Ph.D.); Faith Sauber (2021); Indira Avendano (2021); Nafisa Mostofa (2021); Alyssa Feagans (2020); Jonathan Jules (2020); Alexis Lambert (2020); Yazdan Jamshidi (2019); Jason Hochreiter (2019, Ph.D.); Brandon Belna (2018); Ryan Schubert (2018); Salam Daher (2018, Ph.D.); Kangsoo Kim (2018, Ph.D.); Stephanie Mutter (JUN–AUG 2018, NSF REU); Brandon Belna (JUN–AUG 2017, NSF REU); Peter Lincoln (2017, Ph.D., with Henry Fuchs); Christoph Resch (2016, Ph.D., TU München, with Gudrun Klinker); Kiran Pandit (JUN–AUG 2016, NSF REU); Feng Zheng (2015, Ph.D.); Ryan Patrick (2013, M.S.); Jinghe Zhang (2013, Ph.D.); Krishna Kollu (2012, B.S. Undergraduate Honors); Caitlyn Losee (2011, B.S. Undergraduate Honors); Peter Keitler (2011, Ph.D., TU München, with Gudrun Klinker); Adrian Ilie (2010, Ph.D.); Hua Yang (2008, Ph.D.); Danette Allen (2007, Ph.D.); Vincent Noel (2006, M.S.); Michael Noland (2006, M.S.); Aditi Majumder (2003, Ph.D.); Ruigang Yang (2003, Ph.D.); and Ramesh Raskar (2001, Ph.D.).

Student Committees

Samuel Cosgrove (current, M.S., Advisor Joe LaViola); Xinyu Hu (current, Ph.D., Advisor Ryan McMahan); Kyle Martin (current, Ph.D., Advisor Joe LaViola); Alec Moore (current, Ph.D., Advisor Ryan McMahan); Kevin Pfeil (current, Ph.D., Advisor Joe LaViola); Andres Vargas (current, Ph.D., Advisor Joe LaViola); Sarah Braeger (2021, Ph.D., Advisor Hassan Foroosh); Corey Pittman (2021, Ph.D., Advisor Joe LaViola); Min Wang (2020, Ph.D., Advisor Hassan Foroosh); Alex Blate (2019, Ph.D., UNC, Advisor Henry Fuchs); Baoyuan Liu (2016, Ph.D., Amazon, Advisor Hassan Foroosh); Rick Skarbez (2016, Ph.D., UNC, Advisor Frederick P. Brooks and Mary Whitton); Alexandra Carson (2016, BSN Honors in the Major); Justin Grace (2016, BSN Honors in the Major, Advisor Kelly Allred); Monika Schaeffer (2011, M.S., Duke University, Advisor Ron Parr); Brian Clipp (2010, Ph.D., UNC, Advisor Marc Pollefeys); David Gallup (2010, Ph.D., UNC, Advisor Marc Pollefeys); Andrew Nashel (2010, Ph.D., UNC, Advisor Henry Fuchs); Tyler Johnson (2009, Ph.D., UNC, Advisor Henry Fuchs; Seon Joo Kim (2008, Ph.D., UNC, Advisor Marc Pollefeys); Philip McLeod (2008, Ph.D., University of Otago, Advisor Geoff Wyvill); Patrick Quirk (2006, M.S., UNC, Advisor Henry Fuchs); Kok-Lim Low (2005, Ph.D., UNC, Advisor Anselmo Lastra); Lindsey McCarthy (2011, M.S. UNC Dentistry, Advisor Lucia Cevidanes); Michael Rosenthal (2005, Ph.D., UNC,

Advisor Henry Fuchs); Benjamin Lok (2002, Ph.D., UNC, Advisor Frederick Brooks); Nicholas Vallidis (2002, Ph.D., UNC, Advisor Gary Bishop); Gopi Meenakshisundaram (2001, Ph.D., UNC, Advisor Dinesh Manocha); Mark Livingston (1998, Ph.D., UNC, Advisor Henry Fuchs); and Hans Weber (UNC, Advisor Gary Bishop).

Ph.D. Thesis Examiner (International)

- Susanne Schmidt, "Blended Spaces: Perception and Interaction in Projection-Based Spatial Augmented Reality Environments," Universität Hamburg, Advisor: Dr. Simone Frintrop; 2020.
- Iana Podkosova, "Walkable Multi-User VR: The Effects of Physical and Virtual Colocation," Technische Universität Wien; Advisor: Dr. techn. Hannes Kaufmann, Priv.-Doz.; Second advisor: Dr. techn. Peter Ferschin, Ass. Prof; 2019.
- Michael Robert Marner, "Physical-Virtual Tools for Interactive Spatial Augmented Reality," The University of South Australia; Principal Supervisor: Prof. Bruce Hunter Thomas; Associate Supervisor Prof. Christian Sandor; 2013.
- Philip Grant McLeod, "Fast, Accurate Pitch Detection Tools for Music Analysis," the University of Otago; 2008.

Classroom Teaching

- *3D Computer Modeling and Animation*, First Year Seminar, UNC-CH, 2003–2007. Created the course, which was chosen by UNC from among competing First Year Seminar proposals. Awarded Computer Science Student Association *Excellence in Teaching* award, Spring 2007
- *Introduction to Programming (Java)*, UNC-CH, 2002–2003
- *Team Software Engineering*, UNC-CH, 2001 (Spring)
- *Exploring Virtual Worlds*, UNC-CH, 1997–1998
- NSF STC Center-Wide Lecture Series, coordinated within the Center, 1997
- *Computers: Power Tools for the Mind*, UNC-CH, 1995

Tutorials/Short Courses

- AR101 (An Introduction to Augmented Reality), 15th IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2016), September 18, 2016. Mérida, México. **Greg Welch** with Mark Billinghurst, Tobias Höllerer, Dieter Schmalstieg, Gerhard Reitmayr, Kiyoshi Kiyokawa, and Steve Feiner.
- **Greg Welch**. "An Introduction to the Kalman Filter," NASA Langley Research Center, National Institute of Aerospace, Hampton, VA USA, November 5–6, 2014.
- **Greg Welch**. "Tracking: Beyond 15 Minutes of Thought" and "An Introduction to the Kalman Filter," University of Würzburg, Interactive Intelligent Spaces Summer School, Würzburg, Germany, September 13–14, 2013.
- **Greg Welch** and Gary Bishop. "An Introduction to the Kalman Filter," ACM SIGGRAPH 2001 tutorial, August 12, 2001, Los Angeles, CA USA.
- **Greg Welch**, Gerhard Reitmayr (Graz Univ. of Tech.), Vincent Lepetit (Swiss Federal Institute of Tech.), and Brian Clipp (UNC-Chapel Hill), "Tracking for AR Tracking Researchers," International Symposium on Mixed and Augmented Reality (ISMAR 2009), October 19, 2009.

- **Greg Welch** and Gary Bishop. "An Introduction to the Kalman Filter," ACM SIGGRAPH 2001 tutorial, August 12, 2001, Los Angeles, CA USA.
- B. Danette Allen, Gary Bishop and **Greg Welch**. "Tracking: Beyond 15 Minutes of Thought," ACM SIGGRAPH 2001 short course, August 12, 2001, Los Angeles, CA USA.
- **Greg Welch**. "An Introduction to the Kalman Filter," multi-day seminars offered periodically at UNC Chapel Hill, 1996–2009.

Patents

- U.S. #11,410,270, "Intelligent Object Magnification for Augmented Reality Displays," with Gerd Bruder, Kangsoo Kim, and Zubin Choudhary.
- U.S. #11,287,971, "Visual-Tactile Virtual Telepresence," with Gerd Bruder and Ryan McMahan.
- U.S. #11,148,671, "Autonomous Systems Human Controller Simulation," with Gerd Bruder.
- U.S. #11,106,357, "Low Latency Tactile Telepresence," with Ryan McMahan and Gerd Bruder.
- U.S. #11,042,028, "Relative Pose Data Augmentation of Tracked Devices in Virtual Environments," with Gerd Bruder.
- U.S. #10,854,098, "Adaptive Visual Overlay Wound Simulation," with Joseph LaViola II, Francisco Guido-Sanz, Gerd Bruder, Mindi Anderson, and Ryan Schubert.
- U.S. #10,803,761, "Multisensory Wound Simulation," with Joseph LaViola II, Francisco Guido-Sanz, Gerd Bruder, Mindi Anderson, and Ryan Schubert.
- U.S. #10,410,541, "Physical-Virtual Patient Bed," with Karen Aroian, Steven Talbert, Kelly Allred, Patricia Weinstein, Arjun Nagendran, and Remo Pillat.
- U.S. #10,380,921, "Physical-Virtual Patient Bed System," with Arjun Nagendran, Mary Lou Sole, and Laura Gonzalez.
- U.S. #10,365,711, "Methods, Systems, and Computer Readable Media for Unified Scene Acquisition and Pose Tracking in a Wearable Display," with Henry Fuchs, Mingsong Dou, and Jan-Michael Frahm.
- U.S. #10,321,107, "Methods, Systems, and Computer Readable Media for Improved Illumination of Spatial Augmented Reality Objects," with Henry Fuchs.
- U.S. #9,808,549, "System for Detecting Sterile Field Events and Related Methods," with Arjun Nagendran, Jason Hochreiter, Laura Gonzalez, and Hassan Foroosh.
- U.S. #9,792,715, "Methods, Systems, and Computer Readable Media for Utilizing Synthetic Animatronics," with Kurtis Keller, Andrei State, Henry Fuchs, and Ryan Schubert.
- U.S. #9,679,500, "Physical-Virtual Patient Bed," with Karen Aroian, Steven Talbert, Kelly Allred, Patricia Weinstein, Arjun Nagendran, and Remo Pillat.
- U.S. #9,538,167, "Methods, Systems, and Computer Readable Media for Shader-Lamps Based Physical Avatars of Real and Virtual People," with Henry Fuchs, Peter Lincoln, Andrew Nashel, and Andrei State.
- U.S. #8,849,408, "Methods for Electronic Directionality of Deep-Brain Stimulation," with Richard Gilson and Nizam Razack.
- U.S. #7,068,274, "System and Method for Animating Real Objects With Projected Images," with Kok-Lim Low and Ramesh Raskar.
- U.S. #6,930,681, "System and Method for Registering Multiple Images with Three-Dimensional Objects," with Ramesh Raskar and Kok-Lim Low.
- U.S. #6,677,956, "Method for Cross-Fading Intensities of Multiple Images of a Scene for Seamless Reconstruction," with Ramesh Raskar and Kok-Lim Low.

- U.S. #5,870,136, "Dynamic Generation of Imperceptible Structured Light for Tracking and Acquisition of Three Dimensional Scene Geometry and Surface Characteristics in Interactive Three Dimensional Computer Graphics Applications," with Gary Bishop, Henry Fuchs, and Mark Livingston.

Books, Chapters, and Sections

- Kangsoo Kim, Nahal Norouzi, Dongsik Jo, Gerd Bruder, and **Greg Welch**. (2021). *The Augmented Reality Internet of Things: Opportunities of Embodied Interactions in Transreality.* Springer.
- **Greg Welch**, Kalman Filter. In: Ikeuchi K. (eds) Computer Vision. Springer, Cham. `https://doi.org/10.1007/978-3-030-03243-2_716-1`
- Nahal Norouzi, Gerd Bruder, Brandon Belna, Stephanie Mutter, Damla Turgut, and **Greg Welch**. A Systematic Review of the Convergence of Augmented Reality, Intelligent Virtual Agents, and the Internet of Things, *Artificial Intelligence in IoT*, page 37. Springer, 2019.
- Bruce H. Thomas, **Greg Welch**, Pierre Dragicevic, Niklas Elmqvist, Pourang Irani, Yvonne Jansen, Dieter Schmalstieg, Aurélien Tabard, Neven A. M. ElSayed, Ross T. Smith, Wesley Willett. Situated analytics. In K. Marriott, F. Schreiber, T. Dwyer, K. Klein, N. H. Riche, T. Itoh, W. Stuerzlinger, and B. H. Thomas, editors, *Immersive Analytics*, Lecture Notes in Computer Science book series (LNCS, volume 11190), chapter 7, pages 185–220. Springer, Cham, 2018.
- Guido Brunnett, Sabine Coquillart, Robert van Liere, **Greg Welch**, and Libor Váša, editors. *Virtual Realities: International Dagstuhl Seminar, Dagstuhl Castle Germany; June 9–14, 2013; Revised Selected Papers.* Number 8844 in Lecture Notes in Computer Science. ISBN: 978-3-319-17042-8, Springer, 2015.
- Charles Hughes, Arjun Nagendran, Lisa Dieker, Michael Hynes, and **Greg Welch**. Applications of avatar mediated interaction to teaching, training, job skills and wellness. In Brunnett, G., Coquillart, S., van Liere, R., Welch, G., and Váša, L., editors, *Virtual Realities*, volume 8844 of *Lecture Notes in Computer Science*, pages 133–146. Springer International, 2015.
- Arjun Nagendran, **Greg Welch**, Charles Hughes, and Remo Pillat. Technical report: Exploring human surrogate characteristics. In Brunnett, G., Coquillart, S., van Liere, R., Welch, G., and Váša, L., editors, *Virtual Realities*, volume 8844 of *Lecture Notes in Computer Science*, pages 215–228. Springer International, 2015.
- **Greg Welch**, Kalman Filter. In Katsushi Ikeuchi, editor, *Computer Vision: A Reference Guide*, pp. 435–437. Boston, MA: Springer US, 2014.
- Sabine Coquillart, Guido Brunnett, and **Greg Welch**, eds., *Virtual Realities: Dagstuhl Seminar 2008.* 1st Edition., 2011, XIII, 251 p. 78 illus. ISBN: 978-3-211-99177-0, Springer, 2011.
- **Greg Welch** and Larry Davis. Tracking for Training in Virtual Environments: Estimating the Pose of People and Devices for Simulation and Assessment. In J. Cohn, D. Nicholson, and D. Schmorrow, editors, *PSI Handbook of Virtual Environments for Training and Education: Developments for the Military and Beyond*, chapter 30. Praeger Security International, 2008.
- **Greg Welch**, Ruigang Yang, Bruce Cairns, Herman Towles, Andrei State, Adrian Ilie, Sasch Becker, Dan Russo, Jesse Funaro, Diane Sonnenwald, Ketan Mayer-Patel, Bonnie Danette Allen, Hua Yang, Eugene Freid, Andries van Dam, and Henry Fuchs. 3D Telepresence for Off-Line Surgical Training and On-Line Remote Consultation. In S. Tachi, editor, *Telecommunication, Teleimmersion and Telexistence II*, pages 113–152. IOS Press (English) and Ohmsha (Japanese), 2005.

Refereed Journal, Conference, and Symposium Publications

[154] Priscilla Ramos, Meelad Doroodchi, Austin Erickson, Hiiroshi Furuya, Juanita Benjamin, Gerd Bruder, and **Greg Welch**. Effects of optical see-through displays on self-avatar appearance in augmented reality. In *Proceedings of the International Symposium on Mixed and Augmented Reality (ISMAR)*. IEEE, 2022.

[153] Austin Erickson, Gerd Bruder, and **Greg Welch**. Analysis of the saliency of color-based dichoptic cues in optical see-through augmented reality. *Transactions on Visualization and Computer Graphics*, pages 1–15, 2022.

[152] Frank Guido-Sanz, Mindi Anderson, Steve Talbert, Desiree A. Diaz, **Greg Welch**, and Alyssa Tanaka. Using simulation to test validity and reliability of I-BIDS: A new handoff tool. *Simulation & Gaming*, 53(4):353–368, 2022.

[151] Nahal Norouzi, Kangsoo Kim, Gerd Bruder, Jeremy Bailenson, Pamela Wisniewski, and **Greg Welch**. The advantages of virtual dogs over virtual people: Using augmented reality to provide social support in stressful situations. *International Journal of Human Computer Studies*, 2022.

[150] Yifan Li, Kangsoo Kim, Austin Erickson, Nahal Norouzi, Jonathan Jules, Gerd Bruder, and **Greg Welch**. A scoping review of assistance and therapy with head-mounted displays for people who are visually impaired. *ACM Trans. Access. Comput.*, feb 2022.

[149] Jesus Ugarte, Nahal Norouzi, Austin Erickson, Gerd Bruder, and **Greg Welch**. Distant hand interaction framework in augmented reality. In *the 2022 IEEE Conference on Virtual Reality and 3D User Interfaces*, page 2. IEEE, 2022.

[148] Nahal Norouzi, Matthew Gottsacker, Gerd Bruder, Pamela Wisniewski, Jeremy Bailenson, and **Greg Welch**. Virtual humans with pets and robots: Exploring the influence of social priming on one's perception of a virtual human. In *Proceedings of the IEEE Conference on Virtual Reality and 3D User Interfaces (IEEE VR), Christchurch, New Zealand, 2022*, page 10, IEEE.

[147] Connor D. Flick, Courtney J. Harris, Nikolas T. Yonkers, Nahal Norouzi, Austin Erickson, Zubin Choudhary, Matthew Gottsacker, Gerd Bruder, and **Greg Welch**. Trade-offs in augmented reality user interfaces for controlling a smart environment. In *Symposium on Spatial User Interaction (SUI '21)*, pages 1–11, New York, NY, USA, 2021. Association for Computing Machinery.

[146] Zubin Choudhary, Jesus Ugarte, Gerd Bruder, and **Greg Welch**. Real-time magnification in augmented reality. In *Proceedings of the 2021 ACM Spatial User Interaction*, SUI 2021, pages 1–2. ACM, 2021.

[145] Matthew Gottsacker, Nahal Norouzi, Kangsoo Kim, Gerd Bruder, and **Greg Welch**. Diegetic representations for seamless cross-reality interruptions. In *Proceedings of the IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, page 10, 2021.

[144] Nahal Norouzi, Gerd Bruder, Austin Erickson, Kangsoo Kim, Jeremy Bailenson, Pamela J. Wisniewski, Charles E. Hughes, , and **Greg Welch**. Virtual animals as diegetic attention guidance mechanisms in 360-degree experiences. *IEEE Transactions on Visualization and Computer Graphics (TVCG) Special Issue on ISMAR 2021*, page 11, 2021.

[143] Austin Erickson, Dirk Reiners, Gerd Bruder, and **Greg Welch**. Augmenting human perception: Mediation of extrasensory signals in head-worn augmented reality. In *Proceedings of the 2021 International Symposium on Mixed and Augmented Reality*, ISMAR 2021, pages 1–4. IEEE, 2021.

[142] Mindi Anderson, Desiree Díaz, Steven Talbert, Laura Gonzalez, Syretta Spears, Melanie Keiffer, Frank Guido-Sanz, Helen Mills, Peggy Hill, and **Greg Welch**. Exploration of a capture and analysis system to identify what a good debriefer looks like. *Simulation in Healthcare*, 16(3):e46–e93, June 2021.

[141] Zubin Choudhary, Gerd Bruder, and **Greg Welch**. (2021). Scaled user embodied representations in virtual and augmented reality. In *Proceedings of the Workshop on User-Embodied Interaction in Virtual Reality (UIVR)*, pages 1–3.

[140] Hiroshi Furuya, Kangsoo Kim, Gerd Bruder, Pamela J. Wisniewski, and **Greg Welch**. (2021). *Autonomous Vehicle Visual Embodiment for Pedestrian Interactions in Crossing Scenarios: Virtual Drivers in AVs for Pedestrian Crossing.* In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*, CHI EA '21, New York, NY, USA. Association for Computing Machinery.

[139] Zubin Choudhary, Matthew Gottsacker, Kangsoo Kim, Ryan Schubert, Jeanine Stefanucci, Gerd Bruder, and **Greg Welch**. (2021). Revisiting distance perception with scaled embodied cues in social virtual reality. IEEE Virtual Reality (VR), 2021.

[138] Mindi Anderson, Francisco Guido-Sanz, Desiree Díaz, Benjamin Lok, Jacob Stuart, Ilerioluwa Akinnola, and **Greg Welch**. (2021). Augmented reality in nurse practitioner education: Using a triage scenario to pilot technology usability and effectiveness. *Clinical Simulation in Nursing*, 54:105–112.

[137] Austin Erickson, Kangsoo Kim, Gerd Bruder, and **Greg Welch**. (2021). Beyond visible light: User and societal impacts of egocentric multispectral vision. In *In Proceedings of the 2021 International Conference on Virtual, Augmented, and Mixed Reality*, Washington D.C.

[136] Ryan Schubert, Gerd Bruder, Alyssa Tanaka, Francisco Guido-Sanz, and **Greg Welch**. (2021). Mixed reality technology capabilities for combat-casualty handoff training. In Chen, J. Y. C. and Fragomeni, G., editors, *Virtual, Augmented and Mixed Reality*, pages 695–711, Cham. Springer International Publishing.

[135] Austin Erickson, Kangsoo Kim, Alexa Lambert, Gerd Bruder, Michael Browne, and **Greg Welch**. (2021). An extended analysis on the benefits of dark mode user interfaces in optical see-through head-mounted displays. *ACM Transactions on Applied Perception.*

[134] Austin Erickson, Kangsoo Kim, Gerd Bruder, and **Greg Welch** (2020). A review of visual perception research in optical see-through augmented reality. In *In Proceedings of the International Conference on Artificial Reality and Telexistence & Eurographics Symposium on Virtual Environments*, page 9.

[133] Nahal Norouzi, Kangsoo Kim, Gerd Bruder, Austin Erickson, Zubin Choudhary, Yifan Li, and **Greg Welch** (2020). A systematic literature review of embodied augmented reality agents in head-mounted display environments. In *In Proceedings of the International Conference on Artificial Reality and Telexistence & Eurographics Symposium on Virtual Environments*, page 11.

[132] Celso M. de Melo, Kangsoo Kim, Nahal Norouzi, Gerd Bruder, and **Greg Welch** (2020). Reducing cognitive load and improving warfighter problem solving with intelligent virtual assistants. *Frontiers in Psychology*, 11:3170.

[131] **Greg Welch**, Ryan Schubert, Gerd Bruder, Derrick P. Stockdreher, and Adam Casebolt, "Augmented reality promises mentally and physically stressful training in real places," *IACLEA Campus Law Enforcement Journal*, vol. 50, pp. 47–50, September/October 2020.

[130] Austin Erickson, Kangsoo Kim, Gerd Bruder, and **Greg Welch**, "Exploring the limitations of environment lighting on optical see-through head-mounted displays," in *Proceedings of the ACM Symposium on Spatial User Interaction*, pp. 1–8, 2020.

[129] Alexis Lambert, Nahal Norouzi, Gerd Bruder, and **Greg Welch**, "A systematic review of ten years of research on human interaction with social robots," *International Journal of Human-Computer Interaction*, pp. 1–14, 2020.

[128] Laura Gonzalez, Salam Daher, and **Greg Welch**, "Neurological assessment using a physical-virtual patient (PVP)," *Simulation & Gaming*, pp. 1–17, August 12 2020.

[127] Salam Daher, Jason Hochreiter, Ryan Schubert, Laura Gonzalez, Juan Cendan, Mindi Anderson, Desiree A. Diaz, and **Greg Welch**, "The physical-virtual patient simulator: A physical human form with virtual appearance and behavior," *Simulation in Healthcare*, vol. 15, no. 2, pp. 115–121, 2020. See erratum at DOI: 10.1097/SIH.0000000000000481.

[126] Austin Erickson, Nahal Norouzi, Kangsoo Kim, Ryan Schubert, Jonathan Jules, Joeseph LaViola, Gerd Bruder, and **Greg Welch**. "Sharing gaze rays for visual target identification tasks in collaborative augmented reality," *Journal on Multimodal User Interfaces: Special Issue on Multimodal Interfaces and Communication Cues for Remote Collaboration*, p. 10, 2020.

[125] Ladda Thiamwong, Mary Lou Sole, Boon Peng, **Greg Welch**, Helen J. Huang, and Jeffrey R. Stout. Assessing fall risk appraisal through combined physiological and perceived fall risk measures using innovative technology. *Journal of Gerontological Nursing*, 46(4):41–47, March 2020.

[124] Austin Erickson, Nahal Norouzi, Kangsoo Kim, Joeseph LaViola, Gerd Bruder, and **Greg Welch**. Effects of depth information on visual target identification task performance in shared gaze environments. *IEEE Transactions on Visualization and Computer Graphics (TVCG)*, vol. 26, no. 5, pp. 1934–1944, 2020.

[123] Austin Erickson, Kangsoo Kim, Gerd Bruder, and **Greg Welch**. Effects of dark mode graphics on visual acuity and fatigue with virtual reality head-mounted displays. *Proceedings of IEEE International Conference on Virtual Reality and 3D User Interfaces (IEEE VR)*, pp. 434–442, 2020.

[122] Austin Erickson, Nahal Norouzi, Gerd Bruder, Pamela J. Wisniewski, and **Greg Welch**. Examining whether secondary effects of temperature-associated virtual stimuli influence subjective perception of duration. *Proceedings of IEEE International Conference on Virtual Reality and 3D User Interfaces (IEEE VR)*, pp. 492–499, 2020.

[121] Zubin Choudhary, Kangsoo Kim, Ryan Schubert, Gerd Bruder, and **Greg Welch**. Virtual big heads: Analysis of human perception and comfort of head scales in social virtual reality. *Proceedings of IEEE International Conference on Virtual Reality and 3D User Interfaces (IEEE VR)*, pp. 425–433, 2020.

[120] Kangsoo Kim, Celso M. de Melo, Nahal Norouzi, Gerd Bruder, and **Greg Welch**. Reducing task load with an embodied intelligent virtual assistant for improved performance in collaborative decision making. *Proceedings of IEEE International Conference on Virtual Reality and 3D User Interfaces (IEEE VR)*, pp. 529–538, 2020.

[119] Andrei State, Herman Towles, Tyler Johnson, Ryan Schubert, Brendan Walters, **Greg Welch**, and Henry Fuchs. The a-desk: A unified workspace of the future. *IEEE Computer Graphics and Applications*, 40(1):56–71, Jan 2020.

[118] Myungho Lee, Nahal Norouzi, Gerd Bruder, Pamela J. Wisniewski, and **Greg Welch**. Mixed reality tabletop gameplay: Social interaction with a virtual human capable of physical influence. *IEEE Transactions on Visualization and Computer Graphics*, 2020.

[117] Alyssa Tanaka, Brian Stensrud, **Greg Welch**, Francisco Guido-Sanz, Lee Sciarini, and Henry Phillips. The development and implementation of speech understanding for medical handoff training. In *Proceedings of 2019 Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC 2019)*, Orlando, Florida, USA, December 4 2019.

[116] Kangsoo Kim, Nahal Norouzi, Tiffany Losekamp, Gerd Bruder, Mindi Anderson, and **Greg Welch**. Effects of patient care assistant embodiment and computer mediation on user experience. In *Proceedings of the IEEE International Conference on Artificial Intelligence & Virtual Reality (AIVR)*. IEEE, 2019, pp. 17–24. San Diego, CA. DOI: 10.1109/AIVR.2019.00013

[115] Nahal Norouzi, Gerd Bruder, Jeremy Bailenson, and **Greg Welch**. Investigating augmented reality animals as companions. In *Proceedings of the IEEE International Symposium on Mixed and Augmented Reality (ISMAR) Mixed/Augmented Reality and Mental Health Workshop, 2019*, page 4. IEEE, 2019.

[114] Kendra Richards, Nikhil Mahalanobis, Kangsoo Kim, Ryan Schubert, Myungho Lee, Salam Daher, Nahal Norouzi, Jason Hochreiter, Gerd Bruder, and **Greg Welch**. Analysis of peripheral vision and vibrotactile feedback during proximal search tasks with dynamic virtual entities in augmented reality. In *Proceedings of the ACM Symposium on Spatial User Interaction (SUI)*, page 9, New Orleans, LA, October 19 2019. Association of Computing Machinery, ACM.

[113] Kangsoo Kim, Austin Erickson, Aelxis Lambert, Gerd Bruder, and **Greg Welch**. Effects of dark mode on visual fatigue and acuity in optical see-through head-mounted displays. In *Proceedings of the ACM Symposium on Spatial User Interaction (SUI)*, page 9, New Orleans, LA USA, October 19 2019. ACM.

[112] Nahal Norouzi, Austin Erickson, Kangsoo Kim, Ryan Schubert, Joeseph J. LaViola Jr., Gerd Bruder, and **Greg Welch**. Effects of shared gaze parameters on visual target identification task performance in augmented reality. In *Proceedings of the ACM Symposium on Spatial User Interaction (SUI)*, page 11, New Orleans, LA USA, October 20 2019. Association of Computing Machinery., ACM. **Best Long Paper Award**.

[111] Austin Erickson, Kangsoo Kim, Ryan Schubert, Gerd Bruder, and **Greg Welch**. Is it cold in here or is it just me? Analysis of augmented reality temperature visualization for computer-mediated thermoception. In *Proceedings of the 18th IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2019), Beijing, China, October 14–18, 2019*, 2019.

[110] Nahal Norouzi, Kangsoo Kim, Myungho Lee, Ryan Schubert, Austin Erickson, Jeremy Bailenson, Gerd Bruder, and **Greg Welch**. Walking your virtual dog: Analysis of awareness and proxemics with simulated support animals in augmented reality. In *Proceedings of the 18th IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2019), Beijing, China, October 14–18, 2019*, 2019.

[109] Kangsoo Kim, Ryan Schubert, Jason Hochreiter, Gerd Bruder, and **Greg Welch**. Blowing in the wind: Increasing social presence with a virtual human via environmental airflow interaction in mixed reality. *Elsevier Computers and Graphics*, 83 (October 2019), pp. 23-32, 2019.

[108] Laura Gonzalez, Salam Daher, and **Greg Welch**, "Vera real : Stroke assessment using a physical virtual patient (PVP)," International Nursing Association for Clinical Simulation and Learning (INACSL), June 19, 2019.

[107] Mark Roman Miller, Hanseul Jun, Fernanda Herrera, Jacob Yu Villa, **Greg Welch**, and Jeremy N. Bailenson. Social interaction in augmented reality. *PLOS ONE*, 14(5), 2019. **Top cited PLOS ONE publication of 2019**.

[106] Alex Blate, Mary Whitton, Montek Singh, **Greg Welch**, Andrei State, Turner Whitted, and Henry Fuchs. Implementation & evaluation of a 50 khz, 28μs motion-to-pose latency head tracking instrument. *IEEE Transactions on Visualization and Computer Graphics*, 25(5):1970–1980, 2019.

[105] Myungho Lee, Gerd Bruder, and **Greg Welch**. The virtual pole: Exploring human responses to fear of heights in immersive virtual environments. *Journal of Virtual Reality and Broadcasting*, 14(2017)(6), 2019.

[104] Myungho Lee, Nahal Norouzi, Gerd Bruder, Pamela J. Wisniewski, and **Greg Welch**. The physical-virtual table: Exploring the effects of a virtual human's physical influence on social interaction. In *Proceedings of the 24th ACM Symposium on Virtual Reality Software and Technology*, VRST '18, pages 25:1–25:11, New York, NY, USA, 2018. ACM. **Best Paper Award**

[103] Yazdan Jamshidi and **Greg Welch**. Mine the gap: Gap estimation and contact detection information via adjacent surface observation. In *Proceedings of the International Conference on Pattern Recognition and Artificial Intelligence*, PRAI 2018, pages 54–58, New York, NY, USA, 2018. ACM.

[102] Catherine Oh, Jeremy Bailenson, and **Greg Welch**. A systematic review of social presence: Definition, antecedents, and implications. *Frontiers in Robotics and AI*, 15 October 2018.

[101] Nahal Norouzi, Kangsoo Kim, Jason Hochreiter, Myungho Lee, Salam Daher, Gerd Bruder, and **Greg Welch**. A systematic survey of 15 years of user studies published in the intelligent virtual agents conference. In *Proceedings of the 18th ACM International Conference on Intelligent Virtual Agents (IVA 2018)*, Sydney, Australia, November 5–8 2018.

[100] Salam Daher, Jason Hochreiter, Nahal Norouzi, Laura Gonzalez, Gerd Bruder, and **Greg Welch**. Physical-virtual agents for healthcare simulation. In *Proceedings of 18th ACM International Conference on Intelligent Virtual Agents (IVA 2018)*. ACM, November 5–8 2018.

[99] Steffan Haesler, Kangsoo Kim, Gerd Bruder, and **Greg Welch**. Seeing is believing: Improving the perceived trust in visually embodied alexa in augmented reality. In *Proceedings of the 17th IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2018), Munich, Germany, October 16–20, 2018*, 2018.

[98] Kangsoo Kim, Gerd Bruder, and **Greg Welch**. Blowing in the wind: Increasing copresence with a virtual human via airflow influence in augmented reality. In G. Bruder, S. Cobb, and S. Yoshimoto, editors, *ICAT-EGVE 2018 - International Conference on Artificial Reality and Telexistence and Eurographics Symposium on Virtual Environments*, Limassol, Cyprus, November 7–9 2018. **Honorable Mention for Best Paper Award**.

[97] Ryan Schubert, Gerd Bruder, and **Greg Welch**. Adaptive filtering of physical-virtual artifacts for synthetic animatronics. In G. Bruder, S. Cobb, and S. Yoshimoto, editors, *ICAT-EGVE 2018 - International Conference on Artificial Reality and Telexistence and Eurographics Symposium on Virtual Environments*, Limassol, Cyprus, November 7–9 2018.

[96] **Greg Welch** and Gerd Bruder. A novel approach for cooperative motion capture (COMOCAP). In G. Bruder, S. Cobb, and S. Yoshimoto, editors, *ICAT-EGVE 2018 - International Conference on Artificial Reality and Telexistence and Eurographics Symposium on Virtual Environments*, Limassol, Cyprus, November 7–9 2018.

[95] Kangsoo Kim, Mark Billinghurst, Gerd Bruder, Henry B.-L. Duh, and **Greg Welch**, "Revisiting trends in Augmented Reality research: A review of the 2nd decade of ISMAR (2008–2017)," *IEEE Transactions on Visualization & Computer Graphics*, 2018.

[94] Kangsoo Kim, Luke Boelling, Steffen Haesler, Jeremy N. Bailenson, Gerd Bruder, and **Greg Welch**, "Does a digital assistant need a body? The influence of visual embodiment and social behavior on the perception of intelligent virtual agents in AR," in *2018 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, 2018.

[93] Nahal Norouzi, Luke Bölling, Gerd Bruder, and **Greg Welch**, "Augmented rotations in virtual reality for users with a reduced range of head movement," in *Proceedings of the 12th international conference on disability, virtual reality and associated technologies (ICDVRAT 2018)*, p. 8, 2018.

[94] Nahal Norouzi, Gerd Bruder, and **Greg Welch**, "Assessing vignetting as a means to reduce vr sickness," in *ACM Symposium on Applied Perception 2018*, p. 8, ACM, 2018.

[92] Eike Langbehn, Frank Steinicke, Markus Lappe, **Greg Welch**, and Gerd Bruder, "In the blink of an eye –leveraging blink-induced suppression for imperceptible position and orientation redirection in virtual reality," *ACM Transactions on Graphics (ToG)*, vol. 37, no. 4, article 66, 11 pages, 2018.

[91] Glenn Taylor, Anthony Deschamps, Alyssa Tanaka, Denise Nicholson, Gerd Bruder, **Greg Welch**, and Francisco Guido-Sanz, "Augmented reality for tactical combat casualty care training," in *Human-Computer Interaction. User Interface Design, Development and Multimodality*, Springer International Publishing, 2018.

[90] Myungho Lee, Gerd Bruder, Tobias Höllerer, and **Greg Welch**, "Effects of unaugmented periphery and vibrotactile feedback on proxemics with virtual humans in ar," *IEEE Transactions on Visualization and Computer Graphics*, vol. 24, pp. 1525–1534, April 2018.

[89] Jason Hochreiter, Salam Daher, Gerd Bruder, and **Greg Welch**, "Cognitive and touch performance effects of mismatched 3D physical and visual perceptions," in *Proceedings of IEEE Virtual Reality 2018 (VR 2018)*, 18–22 March 2018 2018.

[88] Kangsoo Kim, Gerd Bruder, and **Greg Welch**, "Exploring the effects of observed physicality conflicts on real–virtual human interaction in augmented reality," in *Proceedings of the 2017 ACM Symposium on Virtual Reality Software (VRST 2017)*, (Gothenberg, Sweden), Association of Computing Machinery, November 8–10 2017. **Best Student Paper Award**.

[87] Salam Daher, Kangsoo Kim, Myungho Lee, Ryan Schubert, Gerd Bruder, Jeremy Bailenson, and **Greg Welch**, *Effects of Social Priming on Social Presence with Intelligent Virtual Agents*, vol. 10498 of *Lecture Notes in Artificial Intelligence*. Springer International Publishing, 2017.

[86] Kangsoo Kim, Arjun Nagendran, Jeremy N. Bailenson, Andrew Raij, Gerd Bruder, Myungho Lee, Ryan Schubert, Xin Yan, and **Gregory Welch**, "A large-scale study of surrogate physicality and gesturing on human–surrogate interactions in a public space," *Frontiers in Robotics and AI*, vol. 4, pp. 1–20, July 2017.

[85] Kangsoo Kim, Divine Maloney, Gerd Bruder, Jeremy N. Bailenson, and **Greg Welch**, "The effects of virtual human's spatial and behavioral coherence with physical objects on social presence in AR," *Computer Animation and Virtual Worlds*, vol. 28, no. 3-4, pp. 1–9, 2017.

[84] Ryan Schubert, Gerd Bruder, and **Greg Welch**, "Abstract: Mitigating perceptual error in synthetic animatronics using visual feature flow," in *Journal of Vision: Abstract Issue 2017*, vol. 17, No. 10, p. 331, May 2017.

[83] Myungho Lee, Gerd Bruder, and **Greg Welch**, "Abstract: Exploring the effect of vibrotactile feedback through the floor on social presence in an immersive virtual environment," in *Journal of Vision: Abstract Issue 2017*, vol. 17, no. 10, p. 357, May 2017.

[82] Myungho Lee, Gerd Bruder, and **Greg Welch**. Exploring the effect of vibrotactile feedback through the floor on social presence in an immersive virtual environment. *Proceedings of IEEE Virtual Reality 2017*, pp. 105–111, March 2017.

[81] **Greg Welch**, "Highlights of "immersive sciences" research in the U.S.A.: Augmented/virtual reality and human surrogates," in *Virtual Reality: A View from Overseas* (K. Kiyokawa, ed.), vol. 21, pp. 102–111, Virtual Reality Society of Japan, June 2016.

[80] Kangsoo Kim, Gerd Bruder, Divine Maloney, and **Greg Welch**. The influence of real human personality on social presence with a virtual human in augmented reality. In Reiners, D., Iwai, D., and Steinicke, F., editors, *ICAT-EGVE 2016 - International Conference on Artificial Reality and Telexistence and Eurographics Symposium on Virtual Environments*, pages 115–122. The Eurographics Association. Little Rock, AR, USA, December 7–9, 2016.

[79] Ryan Schubert, **Greg Welch**, Salam Daher, and Andrew Raij. HuSIS: A dedicated space for studying human interactions. *IEEE Computer Graphics and Applications*, 36(6):26–36, 2016.

[78] Myungho Lee, Kangsoo Kim, Salam Daher, Andrew Raij, Ryan Schubert, Jeremy Bailenson, and **Greg Welch**. The wobbly table: Increased social presence via subtle incidental movement of a real-virtual table. *Proceedings of IEEE Virtual Reality 2016*, Greenville, SC, USA, March 19–23, 2016.

[77] Jason Hochreiter, Salam Daher, Arjun Nagendran, Laura Gonzalez, and **Greg Welch**. Optical touch sensing on non-parametric rear-projection surfaces for interactive physical-virtual experiences. *Presence: Teleoperators and Virtual Environments*, 25(1), 2016.

[76] Eleazar Vasquez III, Arjun Nagendran, **Greg Welch**, Matthew T. Marino, Darin E. Hughes, Aaron Koch, and Lauren Delisio. Virtual learning environments for students with disabilities: A review and analysis of the empirical literature and two case studies. *Rural Special Education Quarterly*, 34(3):26–32, 2015.

[75] Jinghe Zhang, **Greg Welch**, Naren Ramakrishnan, and Saifur Rahman. Kalman filters for dynamic and secure smart grid state estimation. *Intelligent Industrial Systems*, pages 1–8, May 28, 2015.

[74] Kangsoo Kim, Arjun Nagendran, Jeremy Bailenson, and **Greg Welch**. Expectancy violations related to a virtual human's joint gaze behavior in real-virtual human interactions. *Proceedings 28th Annual Conference on Computer Animation and Social Agents (CASA 2015)*, pp. 5–8, May 11–13, 2015, Singapore, Singapore.

[73] Ning Zhou, Da Meng, Zhenyu Huang, and **Greg Welch**. Dynamic state estimation of a synchronous machine using PMU data: A comparative study. *IEEE Transactions on Smart Grid*, 6(1):450–460, 2015.

[72] Jason Hochreiter, Salam Daher, Arjun Nagendran, Laura Gonzalez, **Greg Welch**. Touch sensing on non-parametric rear-projection surfaces: A physical-virtual head for hands-on healthcare training. *Proceedings of IEEE Virtual Reality 2015*, pp. 69–74, Arles, France, March 23–27, 2015.

[71] Feng Zheng, Dieter Schmalstieg, and **Greg Welch**. Pixel-wise closed-loop registration in video-based augmented reality. *Proceedings of 2014 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, Munich, Germany, September 2014.

[70] Julian Abich and Lauren Reinerman-Jones and Gerald Matthews and **Greg Welch** and Stephanie Lackey and Charles Hughes and Arjun Nagendran. Good enough yet? a preliminary evaluation of human-surrogate interaction. In *Virtual, Augmented and Mixed Reality. Designing and Developing Virtual and Augmented Environments*, R. Shumaker and S. Lackey, Eds., vol. 8525 of *Lecture Notes in Computer Science*. Springer International Publishing, 2014, pp. 239–250.

[69] Diane H. Sonnenwald, Hanna M. Söderholm, **Greg Welch**, Bruce A. Cairns, James E. Manning, and Henry Fuchs, "Illuminating collaboration in emergency health care situations: paramedic-physician collaboration and 3d telepresence technology," *Information Research*, (19)2, June, 2014.

[68] Arjun Nagendran, Remo Pillat, Adam Kavanaugh, **Greg Welch**, and Charles Hughes, "A Unified Framework for Individualized Avatar-Based Interactions," *Presence: Teleoperators and Virtual Environments*, 23(2), Spring 2014.

[67] Alberico Menozzi, Brian Clipp, Eric Wenger, Jared Heinly, Herman Towles, Jan-Michael Frahm, and **Greg Welch**, "Development of vision-aided navigation for a wearable outdoor augmented reality system," in *Proceedings of the IEEE/ION Position Location and Navigation Symposium* (Monterey, CA, USA, May 2014), IEEE/The Institute of Navigation, pp. 760–772.

[66] Jinghe Zhang, **Greg Welch**, Gary Bishop, and Zhenyu Huang, "A two-stage kalman filtering scheme for robust and real-time power systems state tracking," *IEEE Transactions on Sustainable Energy*, 5, 2 (April 2014), 629–636.

[65] Adrian Ilie and **Greg Welch**, "Online control of active camera networks for computer vision tasks." *ACM Transactions on Sensor Networks*, Vol. 10, No. 2, Article 25 (January 2014), 25:1–25:40.

[64] Arjun Nagendran, Remo Pillat, Adam Kavanaugh, **Greg Welch**, and Charles Hughes, "AMITIES: Avatar-mediated interactive training and individualized experience system," *Proceedings of The 19th ACM Symposium on Virtual Reality Software and Technology (VRST2013)*, October 6-8 2013.

[63] David Roberts, Alberico Menozzi, James Cook, Todd Sherrill, Stephen Snarski, Pat Russler, Brian Clipp, Robert Karl, Eric Wenger, Matthew Bennett, Jennifer Mauger, William Church, Herman Towles, Stephen MacCabe, Jeffrey Webb, Jasper Lupo, Jan-Michael Frahm, Enrique Dunn, Christopher Leslie, and **Greg Welch**, "Testing and evaluation of a wearable augmented reality system for natural outdoor environments," *Proc. SPIE*, vol. 8735, pp. 87350A–87350A–16, 2013.

[62] Amela Sadagic, Mathias Kölsch, **Greg Welch**, Chumki Basu, Chris Darken, Juan P. Wachs, Henry Fuchs, Herman Towles, Neil Rowe, Jan-Michael Frahm, Li Guan, Rakesh Kumar, and Hui Cheng, "Smart instrumented training ranges: bringing automated system solutions to support critical domain needs," *The Journal of Defense Modeling and Simulation: Applications, Methodology, Technology*, vol. 10, no. 3, pp. 327–342, 2013.

[61] Adrian Ilie and **Greg Welch**, "Automated camera selection and control for better training support," in *Foundations of Augmented Cognition* (D. Schmorrow and C. Fidopiastis, eds.), vol. 8027 of *Lecture Notes in Computer Science*, pp. 50–59, Springer Berlin Heidelberg, 2013.

[60] Feng Zheng, Ryan Schubert, and **Greg Welch**, "A general approach for closed-loop registration in AR," in *Proceedings of IEEE Virtual Reality 2013*, (Orlando, FL, USA), March 16—23 2013.

[59] Arjun Nagendran, Remo Pillat, Charles Hughes, and **Greg Welch**, "Continuum of virtual-human space: Towards improved interaction strategies for physical-virtual avatars," in *Proceedings of 11th ACM SIGGRAPH International Conference on Virtual-Reality Continuum and its Applications in Industry (VRCAI 2012)*, IEEE, December 2012.

[58] Ryan Schubert, **Greg Welch**, Peter Lincoln, Arjun Nagendran, Remo Pillat, and Henry Fuchs, "Advances in shader lamps avatars for telepresence," in *Proceedings of 3DTV-Conference 2012: The True Vision: Capture, Transmission and Display of 3D Video*, (ETH Zurich, Zurich, Switzerland), October 15–17 2012.

[57] Ning Zhou, Zhenyu Huang, Yulan Li, and **Greg Welch**, "Local Sequential Ensemble Kalman Filter for Simultaneously Tracking States and Parameters," in Proceedings of 2012 North American Power Symposium, (Urbana-Champaign, IL USA), September 9–11 2012.

[56] Ning Zhou, Zhenyu Huang, **Greg Welch**, and Jinghe Zhang, "Identifying the optimal measurement subspace for the ensemble kalman filter," *IET Electronics Letters*, vol. 48, no. 11, May 2012.

[55] Diego Rivera-Gutierrez, **Greg Welch**, Peter Lincoln, Mary Whitton, Juan Cendan, David A. Chesnutt, Henry Fuchs, and Ben Lok. Shader lamps virtual patients: the physical representation of virtual patients. *Medicine Meets Virtual Reality 19 - NextMed*, Studies in Health Technology and Informatics, IOS Press, 2012.

[54] **Greg Welch**, Diego Rivera-Gutierrez, Peter Lincoln, Mary Whitton, Juan Cendan, David A. Chesnutt, Henry Fuchs, Ben Lok, and Rick Skarbez. Physical manifestations of virtual patients. In *Simulation in Healthcare*, Volume 6, Issue 6, December, 2011.

[53] Adrian Ilie and **Greg Welch**. On-Line Control of Active Camera Networks for Computer Vision Tasks. Proceedings of 5th ACM/IEEE International Conference on Distributed Smart Cameras, August 22–25, 2011. Awarded 2nd **Prize Best ICDSC 2011 Paper.**

[52] Jinghe Zhang, **Greg Welch**, and Gary Bishop. LoDiM: A Novel Power System State Estimation Method with Dynamic Measurement Selection. In *Proceedings of 2011 IEEE Power & Energy Society General Meeting*, (Detroit, MI, USA), 26–29 July 2011.

[51] Jinghe Zhang, **Greg Welch**, Gary Bishop, and Zhenyu Huang. Reduced Measurement-Space Dynamic State Estimation (REMEDYSE) for Power Systems. Proceedings of *PowerTech, 2011 IEEE Trondheim* (Trondheim, Norway), 19–23 June 2011.

[50] Jinghe Zhang, **Greg Welch**, and Gary Bishop. Power System State Estimation with Dynamic Optimal Measurement Selection. *Proceedings of 2011 IEEE Symposium on Computational Intelligence Applications in Smart Grid*, (Paris, France), 11–15 April 2011.

[49] Peter Lincoln, **Greg Welch**, and Henry Fuchs. Continual Surface-Based Multi-Projector Blending for Moving Objects. *Proceedings of the IEEE Virtual Reality 2011*, (Singapore), 19–23 March, 2011.

[48] **Greg Welch**, Diane H. Sonnenwald, Henry Fuchs, Bruce Cairns, M.D., Ketan Mayer-Patel, Ruigang Yang, Andrei State, Herman Towles, Adrian Ilie, Srinivas Krishnan, and Hanna M. Söderholm. Remote 3D Medical Consultation, in *Virtual Realities: Dagstuhl Seminar 2008* (S. Coquillart, G. Brunnett, and G. Welch, eds.), Ch. 8, pp. 139–160, Springer, 2011.

[47] Peter Lincoln, **Greg Welch**, Andrew Nashel, Andrei State, Adrian Ilie, and Henry Fuchs. Animatronic Shader Lamps Avatars. *Virtual Reality* (Springer), special issue on Augmented Reality, pp. 1–14, 2010. This is an extended version of [43].

[46] Jinghe Zhang, **Greg Welch**, Gary Bishop, and Zhenyu Huang. Optimal PMU Placement Evaluation for Power System Dynamic State Estimation. In *Proceedings of IEEE PES Conference on Innovative Smart Grid Technologies Europe (ISGT 2010)*, Chalmers Lindholmen, Göteborg, Sweden, October 10–13, 2010.

[45] Jinghe Zhang, **Greg Welch**, and Gary Bishop. Observability and Estimation Uncertainty Analysis for PMU Placement Alternatives. In *Proceedings of the 2010 North American Power Symposium (NAPS 2010)*, Arlington, TX, U.S.A., September 26–28, 2010.

[44] Amela Sadagic, **Greg Welch**, Chumki Basu, Chris Darken, Rakesh Kumar, Henry Fuchs, Hui Cheng, Jan-Michael Frahm, Mathias Kolsch, Neil Rowe, Herman Towles, Juan Wachs, and Anselmo Lastra. New Generation of Instrumented Ranges: Enabling Automated Performance Analysis. In *Proceedings of 2009 Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC-2009)*, Orlando, Florida, U.S.A., November 30–December 3 2009.

[43] Peter Lincoln, **Greg Welch**, Andrew Nashel, Adrian Ilie, Andrei State, and Henry Fuchs. Animatronic Shader Lamps Avatars. *Proceedings of 8th IEEE and ACM International Symposium on Mixed and Augmented Reality (ISMAR'09)*, October 19–22, 2009.

[42] Hua Yang, **Greg Welch**, Jan-Michael. Frahm, and Marc Pollefeys. 3D Motion Segmentation Using Intensity Trajectory. *Proceedings of the* 9th *Asian Conference on Computer Vision (ACCV 2009)*, September 23–27 2009.

[41] Peter Lincoln, Andrew Nashel, Adrian Ilie, Herman Towles, **Greg Welch**, and Henry Fuchs. Multi-View Lenticular Display for Group Teleconferencing. *Proceedings of IMMERSCOM 2009*, 27–29 May 2009.

[40] **Greg Welch**, Diane H. Sonnenwald, Henry Fuchs, Bruce Cairns, Ketan Mayer-Patel, Hanna M. Söderholm, Ruigang Yang, Andrei State, Herman Towles, Adrian Ilie, Manoj K. Ampalam, Srinivas Krishnan, Vincent Noel, Michael Noland, and James E. Manning. 3D medical collaboration technology to enhance emergency healthcare. *J Biomed Discov Collab*, 4:4, 2009.

[39] Tyler Johnson, **Greg Welch**, Eric Laforce, Herman Towles, and Henry Fuchs. A distributed cooperative framework for continuous multi-projector pose estimation. Proceedings of IEEE Virtual Reality 2009, Mar 14–18, 2009.

[38] **Greg Welch**. HISTORY: The Use of the Kalman Filter for Human Motion Tracking in Virtual Reality, Presence: Teleoperators and Virtual Environments, 18(1), 2009.

[37] Hanna M. Söderholm, Diane H. Sonnenwald, James E. Manning, Bruce Cairns, **Greg Welch**, and Henry Fuchs. Exploring the Potential of Video Technologies for Collaboration in Emergency Medical Care. Part II: Task Performance, Journal of the American Society for Information Science and Technology (JASIST), 59(14):2335–2349, 14 August 2008.

[36] Diane H. Sonnenwald, Hanna M. Söderholm, James E. Manning, Bruce Cairns, **Greg Welch**, and Henry Fuchs. Exploring the Potential of Video Technologies for Collaboration in Emergency Medical Care. Part I: Information Sharing, Journal of the American Society for Information Science and Technology (JASIST), 59(14):2320–2334, 14 August 2008.

[35] Marc Pollefeys, David Nistér, Jan-Michael Frahm, Amir Akbarzadeh, Philippos Mordohai, Brian Clipp, Chris Engels, David Gallup, Seon Joo Kim, Paul Merrell, C. Salmi, Sudipta Sinha, Brad Talton, Liang Wang, Qing-Xiong Yang, Henrik Stewénius, Ruigang Yang, **Greg Welch**, and Herman Towles, Detailed Real-Time Urban 3D Reconstruction From Video, International Journal of Computer Vision (IJCV), special issue on "Modeling Large-Scale 3D Scenes, 2007.

[34] Hanna M. Söderholm, Diane H. Sonnenwald, Bruce Cairns, James Manning, **Greg Welch**, and Henry Fuchs, The Potential Impact of 3D Telepresence Technology on Task Performance in Emergency Trauma Care, proceedings of the ACM Group 2007 Conference, November 4–7 2007.

[33] Brian Clipp, **Greg Welch**, Jan-Michael Frahm, and Marc Pollefeys, Structure From Motion via a Two-Stage Pipeline of Extended Kalman Filters, in Proceedings of the British Machine Vision Conference (BMVC 2007), September 10–13 2007.

[32] Hua Yang, Marc Pollefeys, **Greg Welch**, Jan-Michael Frahm, and Adrian Ilie, Differential Camera Tracking Through Linearizing the Local Appearance Manifold, in Proceedings of the 2007 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR' 07), 2007.

[31] Diane H. Sonnenwald, Hanna Maurin, Bruce Cairns, Eugene Freid, James Manning, **Greg Welch**, and Henry Fuchs. Experimental Comparison of the Use of 2D and 3D Telepresence Technologies in Distributed Emergency Medical Situations. In Proceedings of the American Society of Information Science and Technology (ASIS&T 2006), Austin, Texas, November 3–9, 2006.

[30] Hua Yang and **Greg Welch**. Illumination Insensitive Model-Based 3D Object Tracking and Texture Refinement. In Proceedings of the Third International Symposium on 3D Data Processing, Visualization and Transmission (3DPVT 2006), The University of North Carolina at Chapel Hill, Chapel Hill, NC USA, June 14-16, 2006.

[29] **Greg Welch**, Diane Sonnenwald, Ketan Mayer-Patel, Ruigang Yang, Andrei State, Herman Towles, Bruce Cairns, and Henry Fuchs, Remote 3D Medical Consultation. In Proceedings of *BROADNETS: 2nd IEEE/CreateNet International Conference on Broadband Networks*, (Boston, MA, USA), pp. 103-110, Omnipress, October 2005.

[28] B. Danette Allen and **Greg Welch**. A general method for comparing the expected performance of tracking and motion capture systems. In *VRST '05: Proceedings of the ACM symposium on Virtual reality software and technology*, (Monterey, CA, USA), pp. 201–210, ACM Press, New York, NY, USA, November 2005.

[27] Adrian Ilie and **Greg Welch**. Ensuring Color Consistency Across Multiple Cameras. In Proceedings of the 2005 International Conference on Computer Vision (ICCV 2005), October, 2005 (Beijing, China).

[26] **Greg Welch**, Ruigang Yang, Sascha Becker, Adrian Ilie, Dan Russo, Jesse Funaro, Andrei State, Kok-Lim Low, Anselmo Lastra, Herman Towles, Bruce Cairns, M.D., Henry Fuchs, and Andy van Dam. Immersive Electronic Books for Surgical Training. *IEEE Multimedia*, 12(3):22–35, July–September 2005.

[25] Ruigang Yang, Marc Pollefeys, Hua Yang, and **Greg Welch**. A Unified Approach to Real-Time, Multi-Resolution, Multi-Baseline 2D View Synthesis and 3D Depth Estimation Using Commodity Graphics Hardware. *International Journal of Image and Graphics (IJIG)*, 4(4):1–25, 2004.

[24] Adrian Ilie, Kok-Lim Low, **Greg Welch**, Anselmo Lastra, Henry Fuchs, and Bruce Cairns. Combining Head-Mounted and Projector-Based Displays for Surgical Training. *Presence: Teleoperators and Virtual Environments*, 13(2), April 2004. This is an extended version of [22].

[23] Ruigang Yang, Marc Pollefeys, and **Greg Welch**. Dealing With Textureless Regions and Specular Highlights—A Progressive Space Carving Scheme Using a Novel Photo-Consistency Measure. In Bill Triggs and Andrew Zisserman, editors, *Proceedings of 9th International Conference on Computer Vision*, pages 576–584, Nice, France, 2003. IEEE Computer Society.

[22] Kok-Lim Low, Adrian Ilie, **Greg Welch**, and Anselmo Lastra. Combining Head-Mounted and Projector-Based Displays for Surgical Training. In *Proceedings of the IEEE Virtual Reality 2003*, pages 110–117. IEEE Computer Society, 2003.

[22] Ruigang Yang and **Greg Welch**. Real-time consensus-based scene reconstruction using commodity graphics hardware. Computer Graphics Forum (invited submission), 22(2):207–216, 2003.

[20] Ruigang Yang, **Greg Welch**, Gary Bishop, and Herman Towles. (2002). Real-time view synthesis using commodity graphics hardware. In *ACM SIGGRAPH 2002 Conference Abstracts and Applications*, SIGGRAPH '02, pages 240–240, New York, NY, USA. ACM.

[19] **Greg Welch** and Eric Foxlin. Motion Tracking: No Silver Bullet, But a Respectable Arsenal. *IEEE Computer Graphics and Applications*, 22(6):24–38, 2002.

[18] Ruigang Yang, **Greg Welch**, and Gary Bishop. Real-Time Consensus-Based Scene Reconstruction Using Commodity Graphics Hardware. In *Proceedings of Pacific Graphics 2002*, Tsinghua University, Beijing, China, October 9–11 2002.

[17] Rich Superfine, Gary Bishop, Jeremy Cummings, Jay Fisher, Kurtis Keller, G. Matthews, D. Sill, Russell M. Taylor II, Leandra Vicci, Chris Weigle, **Greg Welch** and Benjamin Wilde. Touching In Biological Systems: A 3D Force Microscope. MSA—Microscopy and Microanalysis 2002, Quebec City, Canada. published in Proceedings of MSA—Microscopy and Microanalysis 2002.

[16] Ruigang Yang and **Greg Welch**. Fast Image Segmentation and Smoothing Using Commodity Graphics Hardware. J. Graph. Tools, 7(4):91–100, 2002.

[15] Ruigang Yang and **Greg Welch**. Automatic Projector Display Surface Estimation Using Every-Day Imagery. In *Proceedings of the 9th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision 2001*. Plzen, Czech Republic, 2001.

[14] **Greg Welch**, Gary Bishop, Leandra Vicci, Stephen Brumback, Kurtis Keller, and D'nardo Colucci. High-Performance Wide-Area Optical Tracking: The Hiball Tracking System. *Presence: Teleoperators and Virtual Environments*, 10(1):1–21, 2001. This is an invited (but refereed) extended version of [7].

[13] Kok-Lim Low, **Greg Welch**, Anselmo Lastra, and Henry Fuchs. Life-sized Projector-Based Dioramas. In *Proceedings of the ACM Symposium on Virtual Reality Software and Technology*, page 8. ACM SIGGRAPH, AddisonWesley, Banff Cantre, Banff, Alberta, Canada (November 15–17, 2001), 2001.

[12] Wei-Chao Chen, Herman Towles, Lars Nyland, **Greg Welch**, and Henry Fuchs. Toward a Compelling Sensation of Telepresence: Demonstrating a Portal to a Distant (Static) Office. In *Proceedings of IEEE Visualization 2000*. IEEE Computer Science Press, Salt Lake City, UT, USA (October 8–13), 2000.

[11] Aditi Majumder, Zhu He, Herman Towles, and **Greg Welch**. Achieving color uniformity across multi-projector displays." In *Proceedings of the conference on Visualization '00*, VIS '00, (Los Alamitos, CA, USA), pp. 117–124, IEEE Computer Society Press, 2000.

[10] **Greg Welch**, Henry Fuchs, Ramesh Raskar, Michael Brown, and Herman Towles. Projected Imagery in Your Office in the Future. *IEEE Computer Graphics and Applications*, 20(4):62–67, July/August 2000.

[9] Gary Bishop and **Greg Welch**. Working in the Office of 'Real Soon Now'. *IEEE Computer Graphics and Applications*, 20(4):76–78, July/August 2000.

[8] Ramesh Raskar, Michael Brown, Ruigang Yang, Wei-Chao Chen, **Greg Welch**, Herman Towles, Brent Seales, and Henry Fuchs. Mutli-Projector Displays Using Camera-Based Registration. In *Proceedings of the Conference on Visualization 99*, IEEE Visualization, pages 161–168. San Francisco, CA, USA (October 24–29), 1999.

[7] **Greg Welch**, Gary Bishop, Leandra Vicci, Stephen Brumback, Kurtis Keller, and D'nardo Colucci. The Hiball Tracker: High-Performance Wide-Area Tracking for Virtual and Augmented Environments. In *Proceedings of the ACM Symposium on Virtual Reality Software and Technology*, pages 1–11. ACM SIGGRAPH, Addison-Wesley, University College London, London, United Kingdom (December 20–23), 1999.

[6] Brent Seales, **Greg Welch**, and Christopher Jaynes. Real-Time Depth Warping for 3-D Scene Reconstruction. In *1999 IEEE Aerospace Conference*, Snowmass at Aspen, CO USA, 1999.

[5] Ramesh Raskar, **Greg Welch**, and Henry Fuchs. Seamless Projection Overlaps Using Warping and Intensity Blending. In *Fourth International Conference on Virtual Systems and Multimedia (VSMM)*, Gifu, Japan, 1998.

[4] Ramesh Raskar, **Greg Welch**, Matt Cutts, Adam Lake, Lev Stesin, and Henry Fuchs. The Office of the Future: A Unified Approach to Image-Based Modeling and Spatially Immersive Displays. In Michael F. Cohen, editor, *Computer Graphics*, Annual Conference on Computer Graphics & Interactive Techniques, pages 179–188. ACM Press, Addison-Wesley, Orlando, FL, USA (July 19–24), SIGGRAPH conference proceedings edition, 1998.

[3] **Greg Welch** and Gary Bishop. SCAAT: Incremental Tracking with Incomplete Information. In Turner Whitted, editor, *Computer Graphics*, Annual Conference on Computer Graphics & Interactive Techniques, pages 333–344. ACM Press, Addison-Wesley, Los Angeles, CA, USA (August 3–8), SIGGRAPH 97 Conference Proceedings edition, 1997.

[2] **Greg Welch**. *SCAAT: Incremental Tracking with Incomplete Information*. Ph.D. dissertation, University *of* North Carolina *at* Chapel Hill, 1996.

[1] **Greg Welch**. A Survey of Power Management Techniques in Mobile Computing Operating Systems. *ACM Operating Systems Review (SIGOPS-OSR)*, 29(4):47–56, 1995.

Refereed Workshop Publications

[14] Kangsoo Kim and **Greg Welch**. Maintaining and Enhancing Human-Surrogate Presence in Augmented Reality. *Proceedings of IEEE ISMAR 2015 Workshop on Human Perception and Psychology in Augmented Reality*, September 29, 2015 (Fukuoka, Japan).

[13] Adrian Ilie, **Greg Welch**, and Marc Macenko. A Stochastic Quality Metric for Optimal Control of Active Camera Network Configurations for 3D Computer Vision Tasks, in Proceedings of ECCV 2008 workshop on Multi-camera and Multi-modal Sensor Fusion Algorithms and Applications, Marseille, France, October 18 2008. European Conference on Computer Vision (ECCV).

[12] Brian Clipp, Rahul Raguram, Jan-Michael Frahm, **Greg Welch**, and Marc Pollefeys, A Mobile 3D City Reconstruction System, IEEE Virtual Reality 2008 workshop on Cityscapes, March 9, 2008, Reno, Nevada, USA

[11] Philippos Mordohai, Jan-Michael Frahm, Amir Akbarzadeh, Brian Clipp, Chris Engels, David Gallup, Paul Merrell, C. Salmi, Sudipta Sinha, Brad Talton, Liang Wang, Qing-Xiong Yang, Henrik StewŐnius, Herman Towles, **Greg Welch**, Ruigang Yang, Marc Pollefeys, and David Nistér, Real-time video-based reconstruction of urban environments, in Proceedings of the ISPRS Working Group V/4 Workshop 3D-ARCH 2007: 3D Virtual Reconstruction and Visualization of Complex Architectures, (ETH Zurich, Switzerland), July 12–13 2007.

[10] **Greg Welch**, B. Danette Allen, Adrian Ilie, and Gary Bishop, Measurement Sample Time Optimization for Human Motion Tracking/Capture Systems, Proceedings of Trends and Issues in Tracking for Virtual Environments, Workshop at the IEEE Virtual Reality 2007 Conference (Charlotte, NC USA) (Gabriel Zachmann, ed.), Shaker, March 11 2007.

[9] **Greg Welch**, Michael Noland, and Gary Bishop, Complementary Tracking and Two-Handed Interaction for Remote 3D Medical Consultation with a PDA, Proceedings of Trends and Issues in Tracking for Virtual Environments, Workshop at the IEEE Virtual Reality 2007 Conference (Charlotte, NC USA) (Gabriel Zachmann, ed.), Shaker, March 11 2007.

[8] Ruigang Yang, Liang Wang, **Greg Welch**, and Marc Pollefeys. Stereovision on GPU. In Proceedings of the 2006 Workshop on Edge Computing Using New Commodity Architectures (EDGE 2006), May 23–24 (Chapel Hill, NC, USA).

[7] **Greg Welch**, Hua Yang, Andrei State, Vincent Noel, Adrian Ilie, Ruigang Yang, Marc Pollefeys, and Henry Fuchs. GPU-Based View Synthesis Using an Orbital Reconstruction Frustum. In Proceedings of the 2006 Workshop on Edge Computing Using New Commodity Architectures (EDGE 2006), May 23–24 (Chapel Hill, NC, USA).

[6] Ramesh Raskar, **Greg Welch**, Kok-Lim Low, and Deepak Bandyopadhyay. Shader Lamps: Animating Real Objects with Image-Based Illumination. In S. J. Gortler and K. Myszkowski, editors, *Rendering Techniques 2001, Proceedings of the Eurographics Workshop in London, United Kingdom*, pages 89–102. Springer, NewYork, University College London (UCL), London, England, 2001.

[5] Aditi Majumder and **Greg Welch**. Computer Graphics Optique: Optical Superposition of Projected Computer Graphics. In *Fifth Immersive Projection Technology Workshop, in conjunction with the Seventh Eurographics Workshop on Virtual Environments*, Stuttgart, Germany, 2001. Springer-Verlag.

[4] Ramesh Raskar, **Greg Welch**, and Wei-Chao Chen. Table-top Spatially-Augmented Reality: Bringing Physical Models to Life with Projected Imagery. In *Second International Workshop on Augmented Reality (IWAR?99)*, pages 64–71. San Francisco, CA, USA, 1999.

[3] Ramesh Raskar, **Greg Welch**, and Henry Fuchs. Spatially Augmented Reality. In Reinhold Behringer, Gudrun Klinker, and David Mizell, editors, *Augmented Reality; Placing Artificial Objects in Real ScenesProceedings of the First IEEE Workshop on Augmented Reality (IWAR?98)*, pages 63–72. A.K. Peters Ltd., San Francisco, CA, USA (November 1, 1998), 1998. ISBN 1-56881-098-9. "Long Lasting Impact Paper" award, 15th IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2016).

[2] Ramesh Raskar, Matthew Cutts, **Greg Welch**, and Wolfgang Stüerzlinger. Efficient Image Generation for Multiprojector and Multisurface Displays. In George Drettakis and Nelson Max, editors, *Proceedings of the Eurographics Workshop in Vienna, Austria*, pages 139–144. Springer Verlag, Vienna, Austria (June 29–July 1), rendering techniques 98 edition, 1998. ISBN 3-211-83213-0.

[1] Ronald T. Azuma, Bruce R. Hoff, Howard E. Neely III, Ronald Sarfaty, Michael J. Daily, Gary Bishop, Vernon Chi, **Greg Welch**, Ulrich Neumann, Suya You, Rich Nichols, and Jim Cannon. Making Augmented Reality Work Outdoors Requires Hybrid Tracking. In *First International Workshop on Augmented Reality*, pages 219–224, San Francisco, CA, USA, 1998.

Invited and Other Publications

[16] Pearly Chen, Mark Griswold, Hao Li, Sandra Lopez, Nahal Norouzi, and **Greg Welch**. Immersive media technologies: The acceleration of augmented and virtual reality in the wake of COVID-19. *World Economic Forum*, June 20, 2022.

[15] **Greg Welch**, Gerd Bruder, Peter Squire, and Ryan Schubert. Anticipating widespread augmented reality: Insights from the 2018 ar visioning workshop. Faculty Scholarship and Creative Works 786, University of Central Florida and Office of Naval Research, August 6 2019.

[14] **Greg Welch**. The rise of allocentric interfaces and the collapse of the virtuality continuum. In *Proceedings of the Symposium on Spatial User Interaction*, SUI '18, pages 192–192, New York, NY, USA, 2018. ACM.

[13] Laura Gonzalez, Salam Daher, Jason Hochreiter, and **Greg Welch**. (2016). Student nursing assessment of discrete neurology symptoms using an interactive physical virtual head. Presentation at the 2016 meeting of the *International Nursing Association for Clinical Simulation and Learning*, June 16, 2016.

[12] **Greg Welch**, Arjun Nagendran, Jeremy Bailenson, Charles Hughes, Pete Muller, and Peter Squire (2014). Mastering the Human Element of Immersive Training, in *Naval Science and Technology Future Force*, Fall 2014:10–13.

[11] Giodo Brunnett, Sabine Coquillart, Robert van Liere, and **Greg Welch**, "Virtual Realities (Dagstuhl Seminar 13241)," *Dagstuhl Reports*, vol. 3, no. 6, pp. 38–66, 2013.

[10] **Greg Welch**, Physical-virtual humans: Challenges and opportunities. In *Ubiquitous Virtual Reality (ISUVR), 2012 International Symposium on*, pp. 10 –13, aug. 2012.

[9] Guido Brunnett, Saine Coquillart, and **Greg Welch**, "08231 abstracts collection – virtual realities," in *Virtual Realities* (Guido Brunnett, Sabine Coquillart, and **Greg Welch**, eds.), no. 08231 in Dagstuhl Seminar Proceedings, (Dagstuhl, Germany), Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik, Germany, 2008.

[8] Amir Akbarzadeh, Jan-Michael Frahm, Philippos Mordohai, Brian Clipp, Chris Engels, David Gallup, Paul Merrell, Michael Phelps, Sudipta Sinha, Brad Talton, Liang Wang, Qing-Xiong Yang, Henrik Stewenius, Ruigang Yang, **Greg Welch**, Herman Towles, David Nistér, and Marc Pollefeys. Towards Urban 3D Reconstruction From Video. In Proceedings of the Third International Symposium on 3D Data Processing, Visualization and Transmission (3DPVT 2006), Chapel Hill, NC, June 2006.

[7] Andrei State, **Greg Welch**, and Adrian Ilie. An Interactive Camera Placement and Visibility Simulator for Image-Based VR Applications. In *Proceedings of the Engineering Reality of Virtual Reality 2006 (3D Imaging, Interaction, and Measurement; IS&T/SPIE 18th Annual Symposium on Electronic Imaging Science and Technology)*, San Jose, CA, January 2006.

[6] **Greg Welch**, Henry Fuchs, Bruce Cairns, Ketan Mayer-Patel, Diane H. Sonnenwald, Ruigang Yang , Andrei State, Herman Towles, Adrian Ilie, Michael Noland, Vincent Noel, and Hua Yang. Improving, Expanding and Extending 3D Telepresence. In *Proceedings of the 2005 International Workshop on Advanced Information Processing for Ubiquitous Networks*, with ICAT 2005, Christchurch, New Zealand, December 8, 2005.

[5] Hua Yang and **Greg Welch**. Model-Based 3D Object Tracking Using an Extended-Extended Kalman Filter and Graphics Rendered Measurements. In *Proceedings of* 1st *Computer Vision for Interactive and Intelligent Environments (CV4IIE) workshop*, University of Kentucky, Lexington, KY.

[4] **Greg Welch**, Ruigang Yang, Bruce Cairns, M.D., Herman Towles, Andrei State, Adrian Ilie, Sascha Becker, Dan Russo, Jesse Funaro, Diane Sonnenwald, Ketan Mayer-Patel,B. Danette Allen, Hua Yang, Eugene Freid, M.D., Andy van Dam, and Henry Fuchs. 3D Telepresence for Off-Line Surgical Training and On-Line Remote Consultation. Susumu Tachi, editor, *Proceedings of ICAT CREST Symposium on Telecommunication, Teleimmersion, and Telexistence*, The University of Tokyo, Tokyo, Japan, December 2004.

[3] Andries van Dam, Henry Fuchs, Sascha Becker, Loring Holden, Adrian Ilie, Kok-Lim Low, Anne Morgan Spalter, Ruigang Yang, and **Greg Welch**. Immersive Electronic Books for Teaching Surgical Procedures. In Susumu Tachi, editor, *Proceedings of ICAT CREST Symposium on Telecommunication, Teleimmersion, and Telexistence*, The University of Tokyo, Tokyo, Japan, December 2002.

[2] **Greg Welch** and Gary Bishop. An Introduction to the Kalman Filter: SIGGRAPH 2001 course 8. In *Computer Graphics*, Annual Conference on Computer Graphics & Interactive Techniques. ACM Press, Addison-Wesley, Los Angeles, CA, USA (August 12–17), SIGGRAPH 2001 course pack edition, 2001.

[1] Bonnie Danette Allen, Gary Bishop, and **Greg Welch**. Tracking: Beyond 15 Minutes of Thought: SIGGRAPH 2001 course 11. In *Computer Graphics*, Annual Conference on Computer Graphics & Interactive Techniques. ACM Press, Addison-Wesley, Los Angeles, CA, USA (August 12–17), SIGGRAPH 2001 course pack edition, 2001.

Refereed Posters and Presentations

[33] Austin Erickson, Gerd Bruder, **Greg Welch**, Isaac Bynum, Tabitha Peck, and Jessica Good. Perceived Humanness Bias in Additive Light Model Displays. In *Vision Sciences Society (VSS) Abstracts* (Poster Presentation), 2022.

[32] Jesus Ugarte, Nahal Norouzi, Austin Erickson, Gerd Bruder, and **Greg Welch**. Distant Hand Interaction Framework in Augmented Reality. In *Proceedings of IEEE Virtual Reality (VR)*, pages 1–2, 2022.

[31] Zubin Choudhary, Jesus Ugarte, Gerd Bruder, and **Greg Welch**. Real-Time Magnification in Augmented Reality. In *Proceedings of ACM Symposium on Spatial User Interaction (SUI)*, pages 1–2, 2021 (Best Demo Award).

[30] Zubin Choudhary, Gerd Bruder, and **Greg Welch**. Scaled User Embodied Representations in Virtual and Augmented Reality. In *Proceedings of the Workshop on User-Embodied Interaction in Virtual Reality (UIVR)*, pages 1–3, 2021.

[29] Austin Erickson, Dirk Reiners, Gerd Bruder, and **Greg Welch**. Augmenting Human Perception: Mediation of Extrasensory Signals in Head-Worn Augmented Reality. In Poster Proceedings of the *IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pages 1–4, 2021.

[28] Francisco Guido-Sanz, Mindi Anderson, Desiree Díaz, **Greg Welch**, and Laura Gonzalez. (2021). POSTER: Using XR Technology to Innovate Healthcare Education. In *2021 International Nursing Association for Clinical Simulation and Learning Conference (INACSL 2021)*.

[27] Nafisa Mostofa, Indira Avendano, Ryan P. McMahan, and **Greg Welch**. (2020). POSTER: Tactile Telepresence for Isolated Patients. In Kulik, A., Sra, M., Kim, K., and Seo, B.-K., editors, *ICAT-EGVE 2020 - International Conference on Artificial Reality and Telexistence and Eurographics Symposium on Virtual Environments - Posters and Demos*, pages 7–8. The Eurographics Association.

[26] Sharare Zehtabian, Siavash Khodadadeh, Kangsoo Kim, Gerd Bruder, **Greg Welch**, Ladislau Bölöni, and Damla Turgut. (2020). An Automated Virtual Receptionist for Recognizing Visitors and assuring mask wearing. In *Proceedings of the International Conference on Artificial Reality and Telexistence & Eurographics Symposium on Virtual Environments*, pages 9–10.

[25] Jacob Stuart, Ileri Akinnola, Frank Guido-Sanz, Mindi Anderson, Desiree Diaz, **Greg Welch**, Ben Lok J. Stuart, I. Akinnola, F. Guido-Sanz, M. Anderson, D. Diaz, G. Welch, and B. Lok, "Poster: Applying stress management techniques in augmented reality: Stress induction and reduction in healthcare providers during virtual triage simulation," in *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, pp. 171–172, 2020.

[24] Kangsoo Kim, Austin Erickson, Alexis Lambert, Gerd Bruder, and **Greg Welch**. Effects of dark mode on visual fatigue and acuity in optical see-through head-mounted displays. In *32nd ACM User Interface Software and Technology Symposium (UIST 2019)*, New Orleans, LA USA, October 2019.

[23] Nahal Norouzi, Austin Erickson, Kangsoo Kim, Ryan Schubert, Joeseph LaViola, Gerd Bruder, and **Greg Welch**. Effects of shared gaze parameteres on visual target identification task performance in augmented reality. In *32nd ACM User Interface Software and Technology Symposium (UIST 2019)*, New Orleans, LA USA, October 2019.

[22] Kendra Richards, Nikhil Mahalanobis, Kangsoo Kim, Ryan Schubert, Myungho Lee, Salam Daher, Nahal Norouzi, Jason Hochreiter, Gerd Bruder, and **Greg Welch**. Analysis of peripheral vision and vibrotactile feedback during proximal search tasks with dynamic virtual entities in augmented reality. In *32nd ACM User Interface Software and Technology Symposium (UIST 2019)*, New Orleans, LA USA, October 2019.

[21] Salam Daher, Jason Hochreiter, Nahal Norouzi, Ryan Schubert, Gerd Bruder, Laura Gonzalez, Mindi Anderson, Desiree Diaz, Juan Cendan, and **Greg Welch**. Matching vs. non-matching visuals and shape for embodied virtual healthcare agents. IEEE VR 2019 (Osaka, Japan), March 27, 2019.

[20] Ladda Thiamwong, Nahal Norouzi, and **Greg Welch**, "Fear of falling and eye movement behavior in young adults and older adults during walking: A case study," in *39th Annual Southern Gerontological Society Meeting*, (Buford, GA USA), April 11–14 2018.

[19] Dongsik Jo, Kangsoo Kim, **Greg Welch**, Woojin Jeon, Yongwan Kim, Ki-Hong Kim, Gerard Kim, "The Impact of Avatar-Owner Visual Similarity on Body Ownership in Immersive Virtual Reality," ACM Symposium on Virtual Reality Software and Technology (VRST), November 8–10, Gothenburg, Sweden.

[18] Myungho Lee, Gerd Bruder, and **Greg Welch**, "Exploring the effect of vibrotactile feedback through the floor on social presence in an immersive virtual environment," Vision Sciences Society 2017.

[17] Ryan Schubert, Gerd Bruder, and **Greg Welch**, "Mitigating perceptual error in synthetic animatronics using visual feature flow," Vision Sciences Society 2017.

[16] Richard Skarbez, **Greg Welch**, Frederick P. Brooks Jr., and Mary C. Whitton, "Coherence changes gaze behavior in virtual human interactions," in *Proceedings of IEEE Virtual Reality 2017*, pp. 287–288, March 2017.

[15] Salam Daher, Kangsoo Kim, Myungho Lee, Gerd Bruder, Ryan Schubert, Jeremy Bailenson, and **Greg Welch**, "Can social presence be contagious? Effects of social presence priming on interaction with virtual humans," in *Proceedings of IEEE Symposium on 3D User Interfaces 2017*, (Los Angeles , CA), March 18–19 2017.

[15] Kangsoo Kim, Ryan Schubert, and **Greg Welch**. Poster: Exploring the impact of environmental effects on social presence with a virtual human. In *Proceedings of the 16th International Conference on Intelligent Virtual Agents (IVA 2016)*, volume 10011, pages 470–474, Los Angeles, CA, September 20–23, 2016.

[14] **Greg Welch**, Salam Daher, Jason Hochreiter and Laura Gonzalez. Interactive Rear-Projection Physical-Virtual Patient Simulators. Poster presented at the 22nd Medicine Meets Virtual Reality (NextMed / MMVR) conference, Los Angeles, CA, April 7–9, 2016.

[13] Salam Daher and **Greg Welch**. Humanikins: Humanity Transfer to Physical Manikins. Poster presented at the 22nd Medicine Meets Virtual Reality (NextMed / MMVR) conference, Los Angeles, CA, April 7–9, 2016.

[12] Salam Daher, Kangsoo Kim, Myungho Lee, Andrew Raij, Ryan Schubert, Jeremy Bailenson, and **Greg Welch**. Poster: Exploring social presence transfer in real-virtual human interaction. In *Proceedings of IEEE Virtual Reality 2016*, Greenville, SC, USA, March 19–23, 2016.

[11] Salam Daher, Laura Gonzalez, **Greg Welch**. Preliminary Assessment of Neurologic Symptomatology Using an Interactive Physical-Virtual Head with Touch. Poster presented at the 17th International Meeting on Simulation in Healthcare (IMSH 2016), January 16–20, 2016.

[10] Feng Zheng, Ryan Schubert, and **Greg Welch**, "A General Approach for Closed-Loop Registration in AR," in *ISMAR '12: Proceedings of the Eleventh IEEE International Symposium on Mixed and Augmented Reality (ISMAR'12)*, (Atlanta, GA, USA), November 2012.

[9] **Greg Welch**, Diego Rivera-Gutierrez, Peter Lincoln, Mary Whitton, Juan Cendan, David A. Chesnutt, Henry Fuchs, Ben Lok, and Rick Skarbez. Physical manifestations of virtual patients. Poster presented at the 12th International Meeting on Simulation in Healthcare (IMSH 2011), 2011.

[8] Jinghe Zhang, **Greg Welch**, Gary Bishop, and Zhenyu Huang. Adaptive kalman filtering for robust power system state tracking. Poster presented at the DOE Applied Mathematics Program meeting, October 17–18 2011.

[7] Brian Clipp, **Greg Welch**, Jan-Michael Frahm, and Marc Pollefeys. Structure from motion via a two-stage pipeline of extended kalman filters. Proceedings of the British Machine Vision Conference (BMVC 2007), September 10–13 2007.

[6] Hua Yang and **Greg Welch**. Illumination Insensitive Model-Based 3D Object Tracking and Texture Refinement. In Proceedings of the Third International Symposium on 3D Data Processing, Visualization and Transmission (3DPVT 2006), The University of North Carolina at Chapel Hill, Chapel Hill, NC USA, June 14-16, 2006.

[5] Ruigang Yang, Liang Wang, **Greg Welch**, and Marc Pollefeys. Stereovision on GPU. Poster presentation at the 2006 Workshop on Edge Computing Using New Commodity Architectures (EDGE 2006), May 23–24 (Chapel Hill, NC, USA).

[4] **Greg Welch**, Hua Yang, Andrei State, Vincent Noel, Adrian Ilie, Ruigang Yang, Marc Pollefeys, and Henry Fuchs. GPU-Based View Synthesis Using an Orbital Reconstruction Frustum. Poster presentation at the 2006 Workshop on Edge Computing Using New Commodity Architectures (EDGE 2006), May 23–24 (Chapel Hill, NC, USA).

[3] Adrian Ilie and **Greg Welch**. Ensuring Color Consistency Across Multiple Cameras. International Conference on Computer Vision (ICCV), October, 2005 (Beijing, China).

[2] Bruce A. Cairns, **Greg Welch**, Adrian Ilie, Ruigang Yang, Kok-Lim Low, Anselmo Lastra, Henry Fuchs, and Anthony Meyer. Three Dimensional (3D) Acquisitition and Display of Reality: The Potential for a 'Holodeck' in Trauma Surgery. Presented at *The American Association for the Surgery of Trauma 2003 Annual Meeting.*

[1] Kok-Lim Low, **Greg Welch**, Anselmo Lastra, and Henry Fuchs. Life-sized projector-based dioramas: Spatially real and visually virtual. In *ACM SIGGRAPH 2001 Sketches and Applications*, August 2001.

Technical Reports

[13] Tyler Johnson, Herman Towles, Andrei State, Fu-Che Wu, **Greg Welch**, Anselmo Lastra, and Henry Fuchs. A Projector-based Physical Sand Table for Tactical Planning and Review. Technical Report TR09-017, University *of* North Carolina *at* Chapel Hill, Department of Computer Science, 2009.

[12] Ramesh Raskar, Kok-Lim Low and **Greg Welch**. Shader Lamps: Animating Real Objects with Image-Based Illumination. Technical Report TR00-027, University *of* North Carolina *at* Chapel Hill, Department of Computer Science, 2000.

[11] Ruigang Yang and **Greg Welch**. Automatic Display Surface Estimation using Everyday Imagery. Technical Report TR00-015, University *of* North Carolina *at* Chapel Hill, Department of Computer Science, 2000.

[10] Ramesh Raskar, Henry Fuchs, **Greg Welch**, Adam Lake, and Matt Cutts. 3D Talking Heads: Image Based Modeling at Interactive Rates Using Structured Light Projection. Technical Report TR98-017, University *of* North Carolina *at* Chapel Hill, Department of Computer Science, 1998.

[9] **Greg Welch**. SCAAT: Incremental Tracking with Incomplete Information. Technical Report TR96-051, University *of* North Carolina *at* Chapel Hill, Department of Computer Science, 1996.

[8] **Greg Welch** and Gary Bishop. One-Step-at-a-Time Tracking. Technical Report TR96-021, University *of* North Carolina *at* Chapel Hill, Department of Computer Science, 1996.

[7] **Greg Welch**. Hybrid Self-tracker: An Inertial/Optical Hybrid Three-Dimensional Tracking System. Technical Report TR95-048, University *of* North Carolina *at* Chapel Hill, Department of Computer Science, 1995.

[6] **Greg Welch** and Gary Bishop. An Introduction to the Kalman Filter. Technical Report TR95-041, University *of* North Carolina *at* Chapel Hill, Department of Computer Science, 1995. **Cited over 10,000 times** according to Google as of 29 MAY 2022. Translated into Chinese (modern and traditional) by others.

[5] **Greg Welch** VERSICOM: Versatile communications software. NASA Jet Propulsion Laboratory, July 13, 1989.

[4] **Greg Welch** and James P. Williams. The easy chair: A microprocessor-controlled wheelchair for children with muscular disorders. Purdue University, E.E.T. 490/491 Senior Design Project, Final Report, May 1986.

[3] **Greg Welch**. The infrared touch-pad. Purdue University, E.E.T. 421 Report, February 26, 1986.

[2] **Greg Welch** and James P. Williams. The easy chair: A microprocessor-controlled wheelchair for children with muscular disorders. Purdue University, E.E.T. 490/491 Senior Design Project, Preliminary Report, December 1985.

[1] James Williams and **Greg Welch**. The pressure sensitive touch-pad. Purdue University, E.E.T. 454 Project Report, April 30, 1985.

Dissertation

Title:	SCAAT: Incremental Tracking with Incomplete Information
Date:	October 1996
Advisor:	Gary Bishop
Committee:	Gary Bishop, Henry Fuchs, Leandra Vicci (née Vernon Chi), Anselmo Lastra, Russell Taylor, and John Poulton
PDF	`http://www.cs.unc.edu/~welch/media/pdf/scaat_dissertation.pdf`

Active Funding

- ONR DURIP Award# N00014-21-1-2882 for "Testbed for Enhanced Perception and Cognition via Augmented Reality (EICAR)," **Greg Welch** (PI). Dr. Peter Squire, Program Manager. $177,484 for August 18, 2021–August 17, 2022.
- ONR Awards# N00014-21-1-2578 for "Enhanced Information Comprehension via Augmented Reality (EICAR)," **Greg Welch** (PI) and Gerd Bruder (Co-PI). Dr. Peter Squire, Program Manager. $1,290,291 total for June 2021–May 2024.
- NSF Award# 1852002 for "REU Site: Research Experiences for Undergraduates Site on Internet of Things (IoT)," Damla Turgut (PI), Student Mentors: Damla Turgut, Ladislau Boloni, **Greg Welch**, Gerd Bruder, Samiul Hasan, Qun Zhou, Hyoung Jin Cho, and Andrew Dickerson at the University of Central Florida. NSF PO: Jonathan Sprinkle, $323,945 for May 1, 2019–April 30, 2022
- NSF Award# 1800961 for "CHS: Medium: Collaborative Research: Augmented Reality Agents with Pervasive Awareness, Appearance, and Abilities," **Greg Welch** (PI), Gerd Bruder (Co-PI), and Damla Turgut (Co-PI) at UCF; Jeremy Bailenson (Co-PI) at Stanford University; and Benjamin Lok (Co-PI) at the University of Florida. NSF PO: Ephraim P. Glinert (IIS CHS), $674,264 for August 15 , 2018–July 31, 2023
- NSF Award# 1564065 for "CHS: Medium: Physical-Virtual Patient Bed for Healthcare Training and Assessment," **Greg Welch** (PI), Juan Cendan (Co-PI), and Laura Gonzalez (Co-PI), NSF PO: Ephraim P. Glinert (IIS CHS), $894,431 for August 1 , 2016–July 31, 2022

Past Funding

- Soar Technology, Inc., "Handoff Training for Combat Casualty Care (HTC3) CCHAT System PHASE II" **Greg Welch** (PI), Gerd Bruder (Co-PI), and Francisco Guido-Sanz (Co-PI). SoarTech PI: Alyssa Tanaka. $463,949 for June 15, 2019–April 30, 2022
- Florida High Tech Corridor Council (FHTCC), Handoff Training for Combat Casualty Care (HTC3), PIs: **Greg Welch** (PI), Gerd Bruder (Co-PI), and Francisco Guido-Sanz (Co-PI). SoarTech PI: Alyssa Tanaka. $248,928 for December 16, 2019–April 30, 2022.
- University of Central Florida, Exploratory Effort Aimed at a Center for Virtual and Augmented Reality for Healthcare, PIs **Greg Welch** and Carolina Cruz-Neira (CS), Co-PIs Mindi Anderson (CON), Gerd Bruder (IST), Juan Cendan (COM), Lisa Dieker (CCIE), Charlie Hughes (CS), and Ben Noel (FIEA). $40K for 2020–2021.
- ONR Award# N00014-18-1-2927 for "Enhanced Perception and Cognition in Augmented Reality (EPiC AR)," **Greg Welch** (PI) and Gerd Bruder (Co-PI). Dr. Peter Squire, Program Manager. $1,175,000 total for January 2018–December 2021.
- SA Photonics, Inc. "Blended Reality Solution for Live, Virtual, and Constructive Field Training PHASE II." **Greg Welch** (PI) and Gerd Bruder (Co-PI). SA Photonics PI: Michael Browne. $156,138.50 for December 21, 2018–May 22, 2021.
- Soar Technology, Inc., "Intelligent Diagnostic Trauma Algorithms for a Ruggedized Autonomous Combat Casualty Care Capability." Francisco Guido-Sanz (PI) and **Greg Welch** (Co-PI). SoarTech PI: Alyssa Tanaka. $7,500 for September 4, 2018–April 3, 2019
- Soar Technology, Inc., "Combat Casualty Care Augmented Reality Intelligent Training System - C3ARESYS Phase II," **Greg Welch** (PI), Gerd Bruder (Co-PI), and Francisco Guido-Sanz (Co-PI). SoarTech PI: Glenn Taylor. $145,900 for April 6, 2018–April 5, 2019.

- Florida High Tech Corridor Council, "FHTCC: Combat Casualty Care Augmented Reality Intelligent Training System (C3ARESYS)," **Greg Welch** (PI), Gerd Bruder (Co-PI). $49,760 for April 6, 2018–April 5, 2019.
- REU Grant (Award# 1560302) for "REU Site: Research Experiences in the Internet of Things," led by Damla Turgut (PI) and Yier Jin (Co-PI), **Greg Welch** (Investigator) et al. $359,912.00 for June 2016–May 2019
- ONR DURIP grant for "Transportable Human-Surrogate Interaction System (THuSIS)," **Greg Welch** (PI). Dr. Peter Squire, Program Manager. $148,216 for September 15, 2016–March 14, 2017.
- Lockheed Martin Corporation grant for "Improving Augmented Reality Technology," Joseph LaViola (PI), **Greg Welch** (Co-PI), and Malcolm Butler (Co-PI), $100,000, September 1, 2016–August 29, 2017.
- UCF Office of Research and Commercialization, Mentoring Program Award, "Fear of Falling in Older Adults," Ladda Thiamwong (PI) and **Greg Welch** (Mentor), $3,000, July 1, 2017–June 30, 2018.
- Soar Technology, Inc., "Handoffs for Joint Service Casualty Care (HJSCC)," Francisco Guido-Sanz (PI) and **Greg Welch** (Co-PI). SoarTech PI: Alyssa Tanaka. $59,763.00 for November 15, 2017–June 14, 2018.
- Soar Technology, Inc., "Handoff Training for Combat Casualty Care (HTC3)," **Greg Welch** (PI), Francisco Guido-Sanz (Co-PI), and Gerd Bruder (Co-PI). SoarTech PI: Alyssa Tanaka. $60,000.00 for December 17, 2017–July 17, 2018.
- SA Photonics, Inc., "Blended Reality Solution for Live, Virtual, and Constructive Field Training," **Greg Welch** (PI) and Gerd Bruder (Co-PI). SoarTech PI: Michael Browne. $31,000.00 for November 16, 2017–June 1, 2018.
- Soar Technology, Inc., "A16-076 Augmented/Mixed Reality for Force-on-Force Combat Casualty Care Training- Phase 1 Option," **Greg Welch** (PI). SoarTech PI: Glenn Taylor. $6,000.00 for November 27, 2017–March 26, 2018.
- ONR grant for "Human-Surrogate Interaction," **Greg Welch** (PI) at UCF; and Jeremy Bailenson at Stanford University. Dr. Peter Squire, Program Manager. $2,312,188 total for March 2014–December 2017.
- SoarTech/Department of the Army SBIR grant for "Combat Casualty Care Augmented Reality Intelligent Training System (C3ARESYS)," **Greg Welch** (UCF PI) and Frank Guido-Sanz (UCF), $18,000 + $6,000 option, July 1, 2016–December 31, 2016
- ONR DURIP grant for "A Testbed for Evaluating Human Surrogates for Live-Virtual Training," **Greg Welch** (PI) and Arjun Nagendran (Co-PI). Dr. Peter Squire, Program Manager. $178,437.
- ONR DURIP grant for "A Physical-Virtual Human-Robot Interaction System for Training, Education, and Rehabilitation," **Greg Welch** (PI), Charlie Hughes (Co-PI), and Arjun Nagendran (Investigator). Dr. Peter Squire, Program Manager. $268,598. July 2012–July 2014.
- ONR grant for "3D Display and Capture of Humans for Live-Virtual Training," led by **Greg Welch** (PI) and Charlie Hughes (Co-PI) at UCF, Jeremy Bailenson at Stanford University, and Mel Slater at the University of Barcelona. Dr. Peter Squire, Program Manager. $1,316,334 total for October 2011–September 2014.
- University of Central Florida, Major Research Equipment grant for "Comparative Evaluations of Display and Control Paradigms for Surrogate Humans," **Greg Welch** and Charlie Hughes, $57,500, February 2013–June 2013.
- University of Central Florida, Institute for Simulation & Training, Simulation for Healthcare Education and Learning Laboratory (SHELL) grant for "Simulating Subtle Clinical Changes and Realistic Conversation: Going Beyond Mannequins," Kelly Allred (PI), Patricia Weinstein,

Greg Welch, Steve Talbert, Erica Hoyt, Karen J. Aroian, Anne E. Norris, Mary Lou Sole, Susan K. Chase. $125,000 in October 2012.

- DOE grant for "Advanced Kalman Filter for Real-Time Responsiveness in Complex Systems," led by **Greg Welch** (PI) at UNC and Zhenyu Huang (PI) at the Pacific Northwest National Laboratory. $320,502 total for September 2009–August 2013.
- ARA/DARPA contract for "ULTRA-Vis Phase 3: Sensor Fusion Methods/Software to Achieve Robust Pose Estimation," **Greg Welch** (PI). Alberico Menozzi, TPOC (ARA). $73,438 total for June 2012–June 2013.
- ONR grant for "3D Display and Capture of Humans for Live-Virtual Training," led by **Greg Welch** (lead PI) and Henry Fuchs (PI) at UNC, and Amela Sadagic (PI) at the Naval Postgraduate School. Roy Stripling and Clarke Lethin, Program Managers. $2.3M total for May 2009–September 2012. Welch led on the proposal and leads the subsequent research at UNC.
- NSF CRI:IAD grant for "Integrated Projector-Camera Modules for the Capture and Creation of Wide-Area Immersive Experiences," led by Henry Fuchs (PI), **Greg Welch** (Co-PI), Leonard McMillan (Co-PI), Mary Whitton (Co-PI), and Svetlana Lazebnik (Co-PI). $310K total for April 2008–March 2012. Welch led on the proposal at UNC.
- ONR contract for "Behavior Analysis and Synthesis for Intelligent Training (BASE-IT)," led by **Greg Welch** (PI) at UNC, Amela Sadagic (PI) at the Naval Postgraduate School, and Rakesh Kumar (PI) and Hui Cheng (Co-PI) at Sarnoff. Roy Stripling, Ph.D., Program Manager. $2.2M total for February 2008–September 2011. Welch led on the proposal and leads the subsequent research at UNC.
- ONR SBIR Phase II contract for "Deployable Intelligent Projection Systems for Training," led by Henry Fuchs (PI) and **Greg Welch** (PI), sub-contract from Renaissance Sciences Corporation (RSC), Jeff Clark, CEO, $374,920 for March 2009–February 2011. Welch led on the proposal and leads the subsequent research at UNC.
- UNC-Chapel Hill "Scholarship, Creative Activity or Research in the Humanities and Fine Arts" led by Francesca Talenti (PI) and **Greg Welch** (Co-PI), $10K for June 2009–May 2010.
- IARPA A-SpaceX contract for "Mockup Future Analyst Workspace (A-Desk)," led by **Greg Welch** (lead PI) and Henry Fuchs (PI). Jeff Morrison, Ph.D., Program Manager. $260K for April 2008–December 2008. Welch led the proposal and the subsequent research at UNC.
- ONR SBIR contract for "Deployable Intelligent Projection Systems for Training," led by **Greg Welch** (PI) at UNC and Karl Matias (PI) of Renaissance Sciences Corporation, sub-contract to UNC-Chapel Hill (Henry Fuchs, PI), $80K for Phase 1, June 2007–September 2008. Welch led on the proposal and led the subsequent research at UNC.
- IARPA VACE contract for "3D Content Extraction from Video Streams," led by Marc Pollefeys (PI) and **Greg Welch** (Co-PI), with Jan-Michael Frahm. Dan Aldridge, Program Manager. $660K October 2006–September 2008.
- Cisco Systems grant for "Telepresence Wall: Research Exhibit," with Henry Fuchs. $439K for August 2007–July 2008. Welch co-led the proposal and the subsequent research at UNC.
- ONR STTR contract for "Deployable Intelligent Projection Systems for Training: Enhanced Integrated Pose Estimation Technologies," led by **Greg Welch** (PI) at UNC and Karl Matias (PI) of Renaissance Sciences Corporation, sub-contract to UNC-Chapel Hill (Henry Fuchs, PI), $70K for Phase 1, August 2007–February 2008. Welch led on the proposal and led the subsequent research at UNC.
- Cisco Systems grant for "Prototype for Two-station, Four-Person, Proper Eye-Gaze Telepresence System," with Henry Fuchs. $376K total for August 2006–July 2007. Welch co-led on the proposal and co-led the subsequent research at UNC.
- National Library of Medicine contract for "3D Telepresence for Medical Consultation" led by **Greg Welch** (lead PI) and Prof. Henry Fuchs (PI) at UNC, Prof. Bruce Cairns, M.D. (Co-PI)

at UNC, Prof. Ketan Mayer-Patel (Co-PI) at UNC, and Prof. Diane Sonnenwald (Co-PI) at Göteborg University and the University College of Borås. $2.5M total for October 2003–December 2007. Welch led on the proposal and led the subsequent research at UNC.

- ONR VIRTE contract for "Front-Projective Display For Virtual Environments: Phase 2," with Henry Fuchs and Herman Towles. Dylan Schmorrow, Ph.D. CDR MSC USN, Program Manager. $560K total for October 2004–December 2007.
- Office of Naval Research DURIP 2006 grant for "Computing for Real World Acquisition, Display and Immersive Training," with Henry Fuchs and Marc Pollefeys. $136K total.
- DARPA DSO contract for "Wide Area Visuals for a Simulator in a Box," with Henry Fuchs and Herman Towles. Ralph Chatham, DARWARS Program Manager. $1.2M total for 2003–2006.
- NSF ITR grant "Electronic Books for the Tele-Immersion Age: A New Paradigm for Teaching Surgical Procedures," led by **Greg Welch** (PI) at UNC and Andy van Dam (PI) at Brown University, $609K (UNC) for Sep 2001–Aug 2005. Welch led on the proposal and led the subsequent research at UNC.
- DOE contract "Front-Projection Display Wall, Group Tele-Immersion, and Tracking," with Henry Fuchs and Herman Towles, $1.8M for September 2001–August 2004.
- "3D Tele-Immersion Over Next Generation Internet," UNC/UPenn DARPA contract with Henry Fuchs, Herman Towles, Kostas Danillidis, and Ruzena Bajcsy, $550K (UNC) for June 2001–December 2002.
- Argonne National Laboratories contract "Compensating for Color Variations Across Multi-Projector Displays," $61K for September 2001–August 2002. Led by **Greg Welch** (PI).
- NSF grant "High-Fidelity Tele-Immersion for Advanced Surgical Training," UNC/UPenn/Brown, with Henry Fuchs, Kostas Danillidis, and Andy van Dam, $750K (UNC) for January 2001–December 2001.
- Naval Research Lab contract "Technology for Full-Body Tracking," with Gary Bishop. Larry Rosenblum, NRL program manager. $100,271 over October 2000–September 2001.
- NSF Research Infrastructure grant for the NSF Graphics and Visualization Science and Technology Center. The entire Center participated in the proposal process, **Greg Welch** played a significant role in the proposal content/realization. This grant supported equipment for Center-wide televideo and several related research projects. Support under this grant totaled $1.3M for the Center over October 1998–September 2001. The UNC portion was $304K.
- "The National Tele-Immersion Initiative," with Henry Fuchs. Gift from Advanced Network and Services, Inc., Al Weiss, Terry Rogers, and Jaron Lanier. $750K per year over January 1998–December 2000.
- NSF Graphics and Visualization Science and Technology Center, 5-year Renewal. The entire Center participated in the renewal proposal process, including a major site visit at the University of Utah, summer 1997. In addition to contributing to the written proposal, **Greg Welch** played a significant role in the Utah site visit. Total Center support under this renewal totals approximately $13.7M for the entire Center for the final four years (February 1998–January 2002). The UNC portion totaled approximately $2.7M over those four years.
- DARPA contract "Geospatially Registered Information for Dismounted Infantry" (GRIDS), with Gary Bishop and Vernon Chi. Joint effort with Raytheon Defense Systems, Hughes Research Labs, UNC, and the University of Southern California. Total support over two years (May 1997–April 1999) was approximately $3.1M, UNC portion was approximately $1.2M.

Activities as a Student

- President, UNC-Chapel Hill Computer Science Student Association, 1994–1995
- Graduated with *Highest Distinction* from Purdue University (among three-tenths of the baccalaureate graduates having the highest graduation indexes)
- *Outstanding Senior Design Project*, "The Easy Chair: A Microprocessor-Controlled Wheelchair for Children With Muscular Disorders," E.T., Purdue University, 1986
- *Distinguished Student*, Purdue University, 1982–1986 (all semesters)
- Residence Hall Counselor, Purdue University, 1985–1986
- Tau Alpha Pi National Honor Society, Pi Alpha Chapter, 1986
- Golden Key National Honor Society, 1984
- Phi Eta Sigma National Honor Society, 1983

Professional Experience

University *of* Central Florida, Orlando, Florida
AdventHealth Endowed Chair in Healthcare Simulation, October 2013–present
Professor, College of Nursing, October 2013–present
Professor, Computer Science Division of CECS, November 2013–present
Professor, Institute for Simulation & Training, November 2013–present
Co-Director, IST Synthetic Reality Lab (SREAL), August 2011–present
Co-Director, Interactive Computing Experiences Research Cluster of Excellence (2014–2017)
Research Professor, Institute for Simulation & Training (IST), August 2011–October 2013
Research Professor, Department of Computer Science, CECS, October 2011–October 2013

University *of* North Carolina *at* Chapel Hill, Chapel Hill, North Carolina
Adjunct Research Professor, Computer Science, September 2012–September 2020
Research Professor, Computer Science, July 2010–August 2012
Research Associate Professor, Computer Science, September 2001–June 2010
Adjunct Associate Professor, Applied & Materials Sciences, 2005–2008
Adjunct Assistant Professor, Applied & Materials Sciences, 2000–2003
Research Assistant Professor, Computer Science, September 1996–August 2001
UNC Site Coordinator, NSF Graphics and Visualization STC, September 1996–August 1998

University College Dublin (2011–2016)
Visiting Professor, School of Information and Library Studies

Keio University (2010–2012)
Visiting Professor, Graduate School of Media Design

Renaissance Sciences Corporation, Chandler, Arizona
Principal Investigator II, June 2007–2008

- Part-time research and development efforts related to "intelligent projector units" for deployable training systems.
- Work with Jeff Clark and Karl Mathias at RSC to coordinate UNC-RSC joint efforts.

Northrop Defense Systems Division, Rolling Meadows, Illinois
Senior Software Engineer, Digital Systems, June 1990–June 1992 (Secret Clearance)

- Developed, integrated, and maintained embedded software for the AN/ALQ-135, the electronic (radar) countermeasures system currently deployed on the USAF F-15 Eagle.
- Responsible for the AN/ALQ-135 Receiver-Transmitter Compatibility Feature which ensures that radar countermeasures do not interfere with radar or threat acquisitions.

NASA Jet Propulsion Laboratory (Caltech), Pasadena, California
CCS/COMSIM Programmer and Analyst, Voyager Sequence Team, January 1987–May 1990

- Enhanced and maintained the software Command Simulator for the Voyager spacecraft. This simulator is (still) used to validate all instructions sent to the spacecraft.
- Programmed and maintained the Voyager spacecraft Computer Command Subsystem (CCS), the master processor on both Voyager spacecraft.
- Simulated and validated Voyager spacecraft command sequence activity. Responsible for the simulation and validation of all sequenced commanding during Voyager II closest approach to the planet Neptune.

Significant Projects (developed under own initiative)

- Developed MEMMAN, a ground-based software system that optimizes the allocation of the limited Voyager spacecraft memory. Savings during the Voyager II Neptune encounter (August, 1989) enabled additional planetary imaging.
- Developed specialized IBM PC/AT telecommunications software for the Voyager Flight Team. Software submitted to NASA for distribution under COSMIC. Still used today.

Purdue University, West Lafayette, Indiana
Undergraduate, Electrical Engineering Technology, August 1982–May 1986

- Co-developed "The Easy Chair: A Microprocessor-Controlled Wheelchair for Children With Muscular Disorders." The wheelchair included an ultrasonic "bumper" system, a custom infrared touchpad, motor controllers, and a user-programmable 8085-based control unit.
- The Easy Chair project was awarded *Outstanding Senior Design Project* by the Purdue University Department of Electrical Engineering Technology, May 1986.
- Residence Hall Counselor (Resident Assistant) at Cary Quadrangle, August 1985–May 1986.