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Jessie Y. C. Chen · Gino Fragomeni (Eds.)

Virtual, Augmented and Mixed Reality

13th International Conference, VAMR 2021

Held as Part of the 23rd HCI International Conference, HCII 2021

Virtual Event, July 24–29, 2021

Proceedings

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Foreword

Human-Computer Interaction (HCI) is acquiring an ever-increasing scientific and industrial importance, and having more impact on people's everyday life, as an ever-growing number of human activities are progressively moving from the physical to the digital world. This process, which has been ongoing for some time now, has been dramatically accelerated by the COVID-19 pandemic. The HCI International (HCII) conference series, held yearly, aims to respond to the compelling need to advance the exchange of knowledge and research and development efforts on the human aspects of design and use of computing systems.

The 23rd International Conference on Human-Computer Interaction, HCI International 2021 (HCII 2021), was planned to be held at the Washington Hilton Hotel, Washington DC, USA, during July 24–29, 2021. Due to the COVID-19 pandemic and with everyone's health and safety in mind, HCII 2021 was organized and run as a virtual conference. It incorporated the 21 thematic areas and affiliated conferences listed on the following page.

A total of 5222 individuals from academia, research institutes, industry, and governmental agencies from 81 countries submitted contributions, and 1276 papers and 241 posters were included in the proceedings to appear just before the start of the conference. The contributions thoroughly cover the entire field of HCI, addressing major advances in knowledge and effective use of computers in a variety of application areas. These papers provide academics, researchers, engineers, scientists, practitioners, and students with state-of-the-art information on the most recent advances in HCI. The volumes constituting the set of proceedings to appear before the start of the conference are listed in the following pages.

The HCI International (HCII) conference also offers the option of 'Late Breaking Work' which applies both for papers and posters, and the corresponding volume(s) of the proceedings will appear after the conference. Full papers will be included in the 'HCII 2021 - Late Breaking Papers' volumes of the proceedings to be published in the Springer LNCS series, while 'Poster Extended Abstracts' will be included as short research papers in the 'HCII 2021 - Late Breaking Posters' volumes to be published in the Springer CCIS series.

The present volume contains papers submitted and presented in the context of the 13th International Conference on Virtual, Augmented and Mixed Reality (VAMR 2021) affiliated conference to HCII 2021. I would like to thank the Co-chairs, Jessie Y. C. Chen and Gino Fragomeni, for their invaluable contribution in its organization and the preparation of the Proceedings, as well as the members of the program board for their contributions and support. This year, the VAMR affiliated conference has focused on topics related to designing and evaluating VAMR environments, multimodal and natural interaction in VAMR, interaction using head-mounted displays and VR glasses, and applications of VAMR in learning, culture, design, the industry and the military.

I would also like to thank the Program Board Chairs and the members of the Program Boards of all thematic areas and affiliated conferences for their contribution towards the highest scientific quality and overall success of the HCI International 2021 conference.

This conference would not have been possible without the continuous and unwavering support and advice of Gavriel Salvendy, founder, General Chair Emeritus, and Scientific Advisor. For his outstanding efforts, I would like to express my appreciation to Abbas Moallem, Communications Chair and Editor of HCI International News.

July 2021

Constantine Stephanidis

HCI International 2021 Thematic Areas and Affiliated Conferences

Thematic Areas

- HCI: Human-Computer Interaction
- HIMI: Human Interface and the Management of Information

Affiliated Conferences

- EPCE: 18th International Conference on Engineering Psychology and Cognitive Ergonomics
- UAHCI: 15th International Conference on Universal Access in Human-Computer Interaction
- VAMR: 13th International Conference on Virtual, Augmented and Mixed Reality
- CCD: 13th International Conference on Cross-Cultural Design
- SCSM: 13th International Conference on Social Computing and Social Media
- AC: 15th International Conference on Augmented Cognition
- DHM: 12th International Conference on Digital Human Modeling and Applications in Health, Safety, Ergonomics and Risk Management
- DUXU: 10th International Conference on Design, User Experience, and Usability
- DAPI: 9th International Conference on Distributed, Ambient and Pervasive Interactions
- HCIBGO: 8th International Conference on HCI in Business, Government and Organizations
- LCT: 8th International Conference on Learning and Collaboration Technologies
- ITAP: 7th International Conference on Human Aspects of IT for the Aged Population
- HCI-CPT: 3rd International Conference on HCI for Cybersecurity, Privacy and Trust
- HCI-Games: 3rd International Conference on HCI in Games
- MobiTAS: 3rd International Conference on HCI in Mobility, Transport and Automotive Systems
- AIS: 3rd International Conference on Adaptive Instructional Systems
- C&C: 9th International Conference on Culture and Computing
- MOBILE: 2nd International Conference on Design, Operation and Evaluation of Mobile Communications
- AI-HCI: 2nd International Conference on Artificial Intelligence in HCI

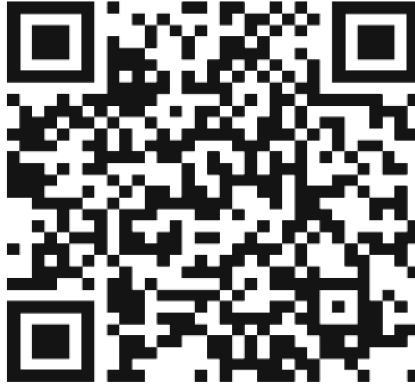
List of Conference Proceedings Volumes Appearing Before the Conference

1. LNCS 12762, Human-Computer Interaction: Theory, Methods and Tools (Part I), edited by Masaaki Kurosu
2. LNCS 12763, Human-Computer Interaction: Interaction Techniques and Novel Applications (Part II), edited by Masaaki Kurosu
3. LNCS 12764, Human-Computer Interaction: Design and User Experience Case Studies (Part III), edited by Masaaki Kurosu
4. LNCS 12765, Human Interface and the Management of Information: Information Presentation and Visualization (Part I), edited by Sakae Yamamoto and Hirohiko Mori
5. LNCS 12766, Human Interface and the Management of Information: Information-rich and Intelligent Environments (Part II), edited by Sakae Yamamoto and Hirohiko Mori
6. LNAI 12767, Engineering Psychology and Cognitive Ergonomics, edited by Don Harris and Wen-Chin Li
7. LNCS 12768, Universal Access in Human-Computer Interaction: Design Methods and User Experience (Part I), edited by Margherita Antona and Constantine Stephanidis
8. LNCS 12769, Universal Access in Human-Computer Interaction: Access to Media, Learning and Assistive Environments (Part II), edited by Margherita Antona and Constantine Stephanidis
9. LNCS 12770, Virtual, Augmented and Mixed Reality, edited by Jessie Y. C. Chen and Gino Fragomeni
10. LNCS 12771, Cross-Cultural Design: Experience and Product Design Across Cultures (Part I), edited by P. L. Patrick Rau
11. LNCS 12772, Cross-Cultural Design: Applications in Arts, Learning, Well-being, and Social Development (Part II), edited by P. L. Patrick Rau
12. LNCS 12773, Cross-Cultural Design: Applications in Cultural Heritage, Tourism, Autonomous Vehicles, and Intelligent Agents (Part III), edited by P. L. Patrick Rau
13. LNCS 12774, Social Computing and Social Media: Experience Design and Social Network Analysis (Part I), edited by Gabriele Meiselwitz
14. LNCS 12775, Social Computing and Social Media: Applications in Marketing, Learning, and Health (Part II), edited by Gabriele Meiselwitz
15. LNAI 12776, Augmented Cognition, edited by Dylan D. Schmorrow and Cali M. Fidopiastis
16. LNCS 12777, Digital Human Modeling and Applications in Health, Safety, Ergonomics and Risk Management: Human Body, Motion and Behavior (Part I), edited by Vincent G. Duffy
17. LNCS 12778, Digital Human Modeling and Applications in Health, Safety, Ergonomics and Risk Management: AI, Product and Service (Part II), edited by Vincent G. Duffy

18. LNCS 12779, Design, User Experience, and Usability: UX Research and Design (Part I), edited by Marcelo Soares, Elizabeth Rosenzweig, and Aaron Marcus
19. LNCS 12780, Design, User Experience, and Usability: Design for Diversity, Well-being, and Social Development (Part II), edited by Marcelo M. Soares, Elizabeth Rosenzweig, and Aaron Marcus
20. LNCS 12781, Design, User Experience, and Usability: Design for Contemporary Technological Environments (Part III), edited by Marcelo M. Soares, Elizabeth Rosenzweig, and Aaron Marcus
21. LNCS 12782, Distributed, Ambient and Pervasive Interactions, edited by Norbert Streitz and Shin'ichi Konomi
22. LNCS 12783, HCI in Business, Government and Organizations, edited by Fiona Fui-Hoon Nah and Keng Siau
23. LNCS 12784, Learning and Collaboration Technologies: New Challenges and Learning Experiences (Part I), edited by Panayiotis Zaphiris and Andri Ioannou
24. LNCS 12785, Learning and Collaboration Technologies: Games and Virtual Environments for Learning (Part II), edited by Panayiotis Zaphiris and Andri Ioannou
25. LNCS 12786, Human Aspects of IT for the Aged Population: Technology Design and Acceptance (Part I), edited by Qin Gao and Jia Zhou
26. LNCS 12787, Human Aspects of IT for the Aged Population: Supporting Everyday Life Activities (Part II), edited by Qin Gao and Jia Zhou
27. LNCS 12788, HCI for Cybersecurity, Privacy and Trust, edited by Abbas Moallem
28. LNCS 12789, HCI in Games: Experience Design and Game Mechanics (Part I), edited by Xiaowen Fang
29. LNCS 12790, HCI in Games: Serious and Immersive Games (Part II), edited by Xiaowen Fang
30. LNCS 12791, HCI in Mobility, Transport and Automotive Systems, edited by Heidi Krömker
31. LNCS 12792, Adaptive Instructional Systems: Design and Evaluation (Part I), edited by Robert A. Sottilare and Jessica Schwarz
32. LNCS 12793, Adaptive Instructional Systems: Adaptation Strategies and Methods (Part II), edited by Robert A. Sottilare and Jessica Schwarz
33. LNCS 12794, Culture and Computing: Interactive Cultural Heritage and Arts (Part I), edited by Matthias Rauterberg
34. LNCS 12795, Culture and Computing: Design Thinking and Cultural Computing (Part II), edited by Matthias Rauterberg
35. LNCS 12796, Design, Operation and Evaluation of Mobile Communications, edited by Gavriel Salvendy and June Wei
36. LNAI 12797, Artificial Intelligence in HCI, edited by Helmut Degen and Stavroula Ntoa
37. CCIS 1419, HCI International 2021 Posters - Part I, edited by Constantine Stephanidis, Margherita Antona, and Stavroula Ntoa

38. CCIS 1420, HCI International 2021 Posters - Part II, edited by Constantine Stephanidis, Margherita Antona, and Stavroula Ntoa
39. CCIS 1421, HCI International 2021 Posters - Part III, edited by Constantine Stephanidis, Margherita Antona, and Stavroula Ntoa

<http://2021.hci.international/proceedings>



13th International Conference on Virtual, Augmented and Mixed Reality (VAMR 2021)

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<http://www.hci.international/board-members-2021.php>



HCI International 2022

The 24th International Conference on Human-Computer Interaction, HCI International 2022, will be held jointly with the affiliated conferences at the Gothia Towers Hotel and Swedish Exhibition & Congress Centre, Gothenburg, Sweden, June 26 – July 1, 2022. It will cover a broad spectrum of themes related to Human-Computer Interaction, including theoretical issues, methods, tools, processes, and case studies in HCI design, as well as novel interaction techniques, interfaces, and applications. The proceedings will be published by Springer. More information will be available on the conference website: <http://2022.hci.international/>:

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Contents

Designing and Evaluating VAMR Environments

Narrative Cognition in Mixed Reality Systems: Towards an Empirical Framework.	3
<i>Luis Emilio Bruni, Hossein Dini, and Aline Simonetti</i>	
Exploratory Study on the Use of Augmentation for Behavioural Control in Shared Spaces.	18
<i>Vinu Kamalasanan, Frederik Schewe, Monika Sester, and Mark Vollrath</i>	
Pose Estimation and Video Annotation Approaches for Understanding Individual and Team Interaction During Augmented Reality-Enabled Mission Planning	32
<i>Sue Kase, Vincent Perry, Heather Roy, Katherine Cox, and Simon Su</i>	
GazeXR: A General Eye-Tracking System Enabling Invariable Gaze Data in Virtual Environment	47
<i>Chris Lenart, Yuxin Yang, Zhiqing Gu, Cheng-Chang Lu, Karl Kosko, Richard Ferdig, and Qiang Guan</i>	
SpatialViewer: A Remote Work Sharing Tool that Considers Intimacy Among Workers	59
<i>Sicheng Li, Yudai Makioka, Kyouzuke Kobayashi, Haoran Xie, and Kentaro Takashima</i>	
A Review of Virtual Therapists in Anxiety and Phobias Alleviating Applications.	71
<i>Oana Mitruț, Alin Moldoveanu, Livia Petrescu, Cătălin Petrescu, and Florica Moldoveanu</i>	
Designing Limitless Path in Virtual Reality Environment	80
<i>Raghav Mittal, Sai Anirudh Karre, and Y. Raghu Reddy</i>	
A Comparative Study of Conversational Proxemics for Virtual Agents	96
<i>David Novick and Aaron E. Rodriguez</i>	
Real-Time Data Analytics of COVID Pandemic Using Virtual Reality.	106
<i>Sharad Sharma, Sri Teja Bodempudi, and Aishwarya Reehl</i>	

Design Considerations for Interacting and Navigating with 2 Dimensional and 3 Dimensional Medical Images in Virtual, Augmented and Mixed Reality Medical Applications	117
<i>Jennifer N. Avari Silva, Michael K. Southworth, Christopher M. Andrews, Mary Beth Privitera, Alexander B. Henry, and Jonathan R. Silva</i>	
Virtual Reality Sickness Evaluation in Exergames for Older Hypertensive Patients: A Comparative Study of Training Methods in a Virtual Environment	134
<i>Oskar Stamm and Susan Vorwerk</i>	
Consistency in Multi-device Service Including VR: A Case Study.	147
<i>Tian Xie, Zhifeng Jin, Zhejun Liu, and Entang He</i>	
Multimodal and Natural Interaction in VAMR	
The Effect of Body-Based Haptic Feedback on Player Experience During VR Gaming	163
<i>Michael Carroll and Caglar Yildirim</i>	
User Defined Walking-In-Place Gestures for Intuitive Locomotion in Virtual Reality	172
<i>Woojoo Kim, Eunsik Shin, and Shuping Xiong</i>	
Exploring Human-to-Human Telepresence and the Use of Vibro-Tactile Commands to Guide Human Streamers	183
<i>Kevin P. Pfeil, Katelynn A. Kapalo, Seng Lee Koh, Pamela Wisniewski, and Joseph J. LaViola Jr.</i>	
Pseudo-haptic Perception in Smartphones Graphical Interfaces: A Case Study	203
<i>Edmilson Domaredzki Verona, Beatriz Regina Brum, Claiton de Oliveira, Silvio Ricardo Rodrigues Sanches, and Cléber Gimenez Corrêa</i>	
A Research on Sensing Localization and Orientation of Objects in VR with Facial Vibrotactile Display	223
<i>Ke Wang, Yi-Hsuan Li, Chun-Chen Hsu, Jiabei Jiang, Yan Liu, Zirui Zhao, Wei Yue, and Lu Yao</i>	
HaptMR: Smart Haptic Feedback for Mixed Reality Based on Computer Vision Semantic	242
<i>Yueze Zhang, Ruoxin Liang, Zhanglei Sun, and Maximilian Koch</i>	

Position Estimation of Occluded Fingertip Based on Image of Dorsal Hand from RGB Camera	259
<i>Zheng Zhao, Takeshi Umezawa, and Noritaka Osawa</i>	
Head-Mounted Displays and VR Glasses	
Usability and User Experience of Interactions on VR-PC, HoloLens 2, VR Cardboard and AR Smartphone in a Biomedical Application	275
<i>Manisha Suresh Balani and Johannes Tümler</i>	
Simulation of the Field of View in AR and VR Headsets.	288
<i>Sarah Brauns and Johannes Tümler</i>	
Exploring Perspective Switching in Immersive VR for Learning First Aid in Lower Secondary Education	301
<i>Tone Lise Dahl, Olve Storlykken, and Bård H. Røssehaug</i>	
Beyond Visible Light: User and Societal Impacts of Egocentric Multispectral Vision	317
<i>Austin Erickson, Kangsoo Kim, Gerd Bruder, and Gregory F. Welch</i>	
No One is Superman: 3-D Safety Margin Profiles When Using Head-Up Display (HUD) for Takeoff in Low Visibility and High Crosswind Conditions	336
<i>Daniela Kratchounova, Inchul Choi, Theodore Mofle, Larry Miller, Jeremy Hesselroth, Scott Stevenson, and Mark Humphreys</i>	
Robust Camera Motion Estimation for Point-of-View Video Stabilization. . . .	353
<i>Wonwoo Lee, Byeongwook Yoo, Deokho Kim, Jaewoong Lee, Sunghoon Yim, Taehyuk Kwon, Gunill Lee, and Jiwon Jeong</i>	
Rendering Tree Roots Outdoors: A Comparison Between Optical See Through Glasses and Smartphone Modules for Underground Augmented Reality Visualization	364
<i>Gergana Lilligreen, Philipp Marsenger, and Alexander Wiebel</i>	
Using Head-Mounted Displays for Virtual Reality: Investigating Subjective Reactions to Eye-Tracking Scenarios	381
<i>Crystal Maraj, Jonathan Hurter, and Joseph Pruitt</i>	
Omnidirectional Flick View	395
<i>Ryota Suzuki, Tomomi Sato, Kenji Iwata, and Yutaka Satoh</i>	

VAMR Applications in Design, the Industry and the Military

Virtual Fieldwork: Designing Augmented Reality Applications Using Virtual Reality Worlds	417
<i>Kota Gushima and Tatsuo Nakajima</i>	
Contextually Adaptive Multimodal Mixed Reality Interfaces for Dismounted Operator Teaming with Unmanned System Swarms	431
<i>Michael Jenkins, Richard Stone, Brodey Lajoie, David Alfonso, Andrew Rosenblatt, Caroline Kingsley, Les Bird, David Cipoletta, and Sean Kelly</i>	
Virtual Solutions for Gathering Consumer Feedback on Food: A Literature Review and Analysis	452
<i>Summer D. Jung, Sahej Claire, Julie Fukunaga, Joaquin Garcia, and Soh Kim</i>	
Modernizing Aircraft Inspection: Conceptual Design of an Augmented Reality Inspection Support Tool	472
<i>Clay D. Killingsworth, Charis K. Horner, Stacey A. Sanchez, and Victoria L. Claypoole</i>	
The Potential of Augmented Reality for Remote Support	486
<i>Stefan Kohn and Moritz Schaub</i>	
A Review of Distributed VR Co-design Systems	499
<i>Jean-François Lapointe, Norman G. Vinson, Keiko Katsuragawa, and Bruno Emond</i>	
The Mobile Office: A Mobile AR Systems for Productivity Applications in Industrial Environments	511
<i>Daniel Antonio Linares Garcia, Poorvesh Dongre, Nazila Roofigari-Esfahan, and Doug A. Bowman</i>	
Virtual Reality Compensatory Aid for Improved Weapon Splash-Zone Awareness	533
<i>Richi Rodriguez, Domenick Mifsud, Chris Wickens, Adam S. Williams, Kathrine Tarre, Peter Crane, and Francisco R. Ortega</i>	
Mixed Reality Visualization of Friendly vs Hostile Decision Dynamics	545
<i>Simon Su, Sue Kase, Chou Hung, J. Zach Hare, B. Christopher Rinderspacher, and Charles Amburn</i>	
Doing Versus Observing: Virtual Reality and 360-Degree Video for Training Manufacturing Tasks	556
<i>Emily S. Wall, Daniel Carruth, and Nicholas Harvel</i>	

VAMR in Learning and Culture

Design and Research on the Virtual Simulation Teaching Platform of Shanghai Jade Carving Techniques Based on Unity 3D Technology	571
<i>Beibei Dong, Shangshi Pan, and RongRong Fu</i>	
IME ^{VR} : An MVC Framework for Military Training VR Simulators	582
<i>Romullo Girardi and Jauvane C. de Oliveira</i>	
Extended Reality, Pedagogy, and Career Readiness: A Review of Literature	595
<i>Patrick Guilbaud, T. Christa Guilbaud, and Dane Jennings</i>	
Development of an AR Training Construction System Using Embedded Information in a Real Environment	614
<i>Yuki Harazono, Taichi Tamura, Yusuke Omoto, Hirotake Ishii, Hiroshi Shimoda, Yoshiaki Tanaka, and Yoshiyuki Takahashi</i>	
LibrARy – Enriching the Cultural Physical Spaces with Collaborative AR Content	626
<i>Andreea-Carmen Ifrim, Florica Moldoveanu, Alin Moldoveanu, and Alexandru Grădinaru</i>	
Supporting Embodied and Remote Collaboration in Shared Virtual Environments.	639
<i>Mark Manuel, Poorvesh Dongre, Abdulaziz Alhamadani, and Denis Gračanin</i>	
A Survey on Applications of Augmented, Mixed and Virtual Reality for Nature and Environment	653
<i>Jason Rambach, Gergana Lilligreen, Alexander Schäfer, Ramya Bankanal, Alexander Wiebel, and Didier Stricker</i>	
Flexible Low-Cost Digital Puppet System	676
<i>Nanjie Rao, Sharon Lynn Chu, and Ranger Chenore</i>	
Mixed Reality Technology Capabilities for Combat-Casualty Handoff Training	695
<i>Ryan Schubert, Gerd Bruder, Alyssa Tanaka, Francisco Guido-Sanz, and Gregory F. Welch</i>	
Author Index	713