



# ACM MMVE'19

June 18, 2019 in Amherst, Massachusetts, USA



Proceedings of the 11<sup>th</sup> ACM Workshop on  
**Immersive Mixed and Virtual Environment  
Systems**  
**(MMVE'19)**



**sigops**



Association for  
Computing Machinery

*Advancing Computing as a Science & Profession*

ISBN 978-1-4503-6299-3

# Welcome to the Proceedings of the 11<sup>th</sup> Immersive Mixed and Virtual Environment Systems Workshop



Association for  
Computing Machinery

*Advancing Computing as a Science & Profession*

**The Association for Computing Machinery**  
**2 Penn Plaza, Suite 701**  
**New York New York 10121-0701**

**ACM COPYRIGHT NOTICE.** Copyright © 2019 by the Association for Computing Machinery, Inc. Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post on servers, or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from Publications Dept., ACM, Inc., fax +1 (212) 869-0481, or [permissions@acm.org](mailto:permissions@acm.org).

For other copying of articles that carry a code at the bottom of the first or last page, copying is permitted provided that the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, +1-978-750-8400, +1-978-750-4470 (fax).

## **Notice to Past Authors of ACM-Published Articles**

ACM intends to create a complete electronic archive of all articles and/or other material previously published by ACM. If you have written a work that was previously published by ACM in any journal or conference proceedings prior to 1978, or any SIG Newsletter at any time, and you do NOT want this work to appear in the ACM Digital Library, please inform [permissions@acm.org](mailto:permissions@acm.org), stating the title of the work, the author(s), and where and when published.

**ACM ISBN:** 978-1-4503-6299-3

# Foreword

The 11<sup>th</sup> ACM SIGMM Workshop on Immersive Mixed and Virtual Environment Systems (MMVE 2019) received 18 high-quality (long and short papers) submissions, covering a variety of multimedia topics, including video streaming, virtual reality, augmented reality, Quality of Experience (QoE), spatial audio and gaming.

Based on the hard work from 28 Technical Program Committee (TPC) members, each submission received 3 to 4 reviews. 5 papers were accepted for the full paper oral session and 4 papers were accepted for the short paper session. We have structured the program this year such that MMVE 2019 will be highly engaging, by encouraging authors to showcase demos of their works, and boost discussion as part of a break out poster session.

We would like to thank all authors for their high-quality papers and the TPC members for their insightful inputs, which helped in producing a technical program of high quality.

We hope that the MMVE 2019 will be engaging, informative and enjoyable.

**Mario Montagud**, i2CAT Foundation & University of Valencia, Spain  
**Francesca De Simone**, CWI, Netherlands  
MMVE 2019 TPC Co-chairs

**Niall Murray**, Athlone Institute of Technology, Ireland  
MMVE 2019 General Chair

**Andrew Hines**, University College Dublin, Ireland  
**Ragnhild Eg**, Kristiania University College, Norway  
**Alexandra Covaci**, University of Kent, United Kingdom  
**Conor Keighrey**, Athlone Institute of Technology, Ireland  
**Jesús Gutiérrez**, University of Nantes, France  
MMVE 2019 Organizing Committee

# Organization

General Chair:	Niall Murray, Athlone Institute of Technology, Ireland
TPC Co-chairs:	Mario Montagud, i2CAT Foundation & University of Valencia, Spain Francesca De Simone, CWI, Netherlands
Organizing Committee:	Alexandra Covaci, University of Kent, UK Andrew Hines, University College Dublin, Ireland Conor Keighrey, Athlone Institute of Technology, Ireland Ragnhild Eg, Kristiania University College, Norway Jesús Gutiérrez, University of Nantes, France
Program Committee:	Carsten Griwodz, Simula Research Laboratory, Norway Cedric Westphal, University of California (Santa Cruz), USA Fernando Boronat Seguí, Universitat Politècnica de València, Spain Gabriel Muntean, Dublin City University, Ireland George Ghinea, Brunel University, UK Gregor Schiele, Universität Duisburg-Essen, Germany Herman Engelbrecht, Stellenbosch University, South Africa Jaume Segura, University of Valencia, Spain Jean Botev, The University of Luxembourg, Luxembourg Kim Nevelsteen, MiTM AB, Sweden Laura Ricci, University of Pisa, Italy Magda El Zarki, University of California, USA Maha Abdallah, Pierre and Marie Curie University, France Mylène Farias, Universidade de Brasilia, Brazil Ryan Shea, Simon Fraser University, Canada Shun Yun Hu, Imonology Inc., Taiwan Stefano Ferretti, University of Bologna, Italy Vanissa Wanick, University of Southampton, UK Wei Tsang Ooi, National University of Singapore, Singapore Xueyan Tang, Nanyang Technological University, Singapore

# Keynote

## Experience media: moving towards an age of digital experience

Nimesha Ranasinghe  
University of Maine



### Abstract:

When humans interact with the outside world or one another, all of the senses are engaged; a true conversation is considered a full sensory experience. From early ages to the present world, people desire to have multisensory experiences in every aspect of their lives. From trying different foods, going to different places to playing games on virtual reality, they continuously seek sensory stimuli to be a wholesome experience, yet the current technology lacks the inclusion of many essential sensory channels. This talk highlights several research works focusing on "Experience Media" that explore possibilities for novel multisensory interactive digital media technologies towards achieving total immersion in day-to-day digital interactions. This talk also emphasizes the need for looking beyond the current 'age of information' and step into a new 'age of experience'.

### Bio:

Nimesha Ranasinghe is an Assistant Professor at the School of Computing and Information Science and directs the Multisensory Interactive Media lab (MIM lab - [www.mimlab.info/](http://www.mimlab.info/)) at University of Maine. He completed his Ph.D. at the Department of Electrical and Computer Engineering, National University of Singapore (NUS) in 2013. Dr. Ranasinghe's research interests include Multisensory Interactive Media, Human-Computer Interaction, Augmented and Virtual Reality. He is well-known for his Digital Taste (a.k.a. Virtual Flavors) and Virtual Cocktail (Vocktail) inventions and featured in numerous media around the world including New Scientist, New York Times, Time Magazine, BBC Radio, Discovery Channel, and Reuters. Furthermore, he has published his work in several prestigious academic conferences and journals including ACM conference on Human Factors in Computing Systems (CHI), ACM conference on Multimedia, and Journal of Human-Computer Studies. He has received numerous awards for his research works; in 2014 his work on Digital Lollipop was selected as one of the ten best innovations in the world by the Netexplo forum in UNESCO HQ, Paris.

# Table of Contents

## **On the first JND and Break in Presence of 360-degree content: An exploratory study (Page 1)**

Roberto G. de A. Azevedo, EPFL

Neil Birkbeck, Google

Ivan Janatra, Google

Balu Adsumilli, Google

Pascal Frossard, EPFL

## **Immersive Mixed Reality Object Interaction for Collaborative Context-Aware Mobile Training and Exploration (Page 4)**

Jean Botev, University of Luxembourg

Joe Mayer, University of Luxembourg

Steffen Rothkugel, University of Luxembourg

## **A Quality of Experience Evaluation System and Research Challenges for Networked Virtual Reality based Teleoperation applications (Page 10)**

David Concannon, Athlone Institute of Technology

Ronan Flynn, Athlone Institute of Technology

Niall Murray, Athlone Institute of Technology

## **Summarizing E-Sports Matches and Tournaments: The Example of Counter-Strike: Global Offensive (Page 13)**

Mathias Lux, Alpen-Adria-Universität Klagenfurt

Pål Halvorsen, SimulaMet and OsloMet

Duc-Tien Dang-Nguyen, University of Bergen

Håkon Stensland, Simula Research Laboratory and Oslo University

Manoj Kesavulu, Dublin City University

Martin Potthast, Universität Leipzig

Michael Riegler, SimulaMet

## **Playing with delay: An interactive VR demonstration (Page 19)**

Kjetil Raaen, Kristiania University College

Ragnhild Eg, Kristiania University College

Ivar Kjellmo, Kristiania University College

## **Influence of Primacy, Recency and Peak effects on the Game Experience Questionnaire (Page 22)**

Saeed Shafiee Sabet, Simula Research Laboratory

Carsten Griwodz, University of Oslo

Sebastian Möller, Quality and Usability Lab TU Berlin

**Fusion Confusion: Exploring Ambisonic Spatial Localisation for Audio-Visual Immersion Using the McGurk Effect (Page 28)**

Abubakr Siddig, University College Dublin

Alessandro Ragano, University College Dublin

Hamed Z. Jahromi, University College Dublin

Andrew Hines, University College Dublin

**Towards a Distributed Reality: a multi-video approach to xR (Page 34)**

Alvaro Villegas, Nokia Bell Labs

Pablo Perez, Nokia Bell Labs

Ester Gonzalez-Sosa, Nokia Bell Labs

**Field-of-View Prediction in 360-Degree Videos with Attention-based Neural Encoder-Decoder Networks (Page 37)**

Jiang Yu, New York University

Yong Liu, New York University

# Author Index

## A

Balu Adsumilli, Google

On the first JND and Break in Presence of 360-degree content: An exploratory study (Page 1)

Roberto G. de A. Azevedo, EPFL

On the first JND and Break in Presence of 360-degree content: An exploratory study (Page 1)

## B

Neil Birkbeck, Google

On the first JND and Break in Presence of 360-degree content: An exploratory study (Page 1)

Jean Botev, University of Luxembourg

Immersive Mixed Reality Object Interaction for Collaborative Context-Aware Mobile Training and Exploration (Page 4)

## C

David Concannon, Athlone Institute of Technology

A Quality of Experience Evaluation System and Research Challenges for Networked Virtual Reality based Teleoperation applications (Page 10)

## D

Duc-Tien Dang-Nguyen, University of Bergen

Summarizing E-Sports Matches and Tournaments: The Example of Counter-Strike: Global Offensive (Page 13)

## E

Ragnhild Eg, Kristiania University College

Playing with delay: An interactive VR demonstration (Page 19)

## F

Ronan Flynn, Athlone Institute of Technology

A Quality of Experience Evaluation System and Research Challenges for Networked Virtual Reality based Teleoperation applications (Page 10)

Pascal Frossard, EPFL

On the first JND and Break in Presence of 360-degree content: An exploratory study (Page 1)

## G

Ester Gonzalez-Sosa, Nokia Bell Labs



Towards a Distributed Reality: a multi-video approach to xR (Page 34)

**Carsten Griwodz, University of Oslo**

Influence of Primacy, Recency and Peak effects on the Game Experience Questionnaire (Page 22)

## **H**

**Pål Halvorsen, SimulaMet and OsloMet**

Summarizing E-Sports Matches and Tournaments: The Example of Counter-Strike: Global Offensive (Page 13)

**Andrew Hines, University College Dublin**

Fusion Confusion: Exploring Ambisonic Spatial Localisation for Audio-Visual Immersion Using the McGurk Effect (Page 28)

## **J**

**Hamed Z. Jahromi, University College Dublin**

Fusion Confusion: Exploring Ambisonic Spatial Localisation for Audio-Visual Immersion Using the McGurk Effect (Page 28)

**Ivan Janatra, Google**

On the first JND and Break in Presence of 360-degree content: An exploratory study (Page 1)

## **K**

**Manoj Kesavulu, Dublin City University**

Summarizing E-Sports Matches and Tournaments: The Example of Counter-Strike: Global Offensive (Page 13)

**Ivar Kjellmo, Kristiania University College**

Playing with delay: An interactive VR demonstration (Page 19)

## **L**

**Yong Liu, New York University**

Field-of-View Prediction in 360-Degree Videos with Attention-based Neural Encoder-Decoder Networks (Page 37)

**Mathias Lux, Alpen-Adria-Universität Klagenfurt**

Summarizing E-Sports Matches and Tournaments: The Example of Counter-Strike: Global Offensive (Page 13)

## **M**

**Joe Mayer, University of Luxembourg**

Immersive Mixed Reality Object Interaction for Collaborative Context-Aware Mobile Training and Exploration (Page 4)

**Niall Murray, Athlone Institute of Technology**

A Quality of Experience Evaluation System and Research Challenges for Networked Virtual Reality based Teleoperation applications (Page 10)

**Sebastian Möller, Quality and Usability Lab TU Berlin**

Influence of Primacy, Recency and Peak effects on the Game Experience Questionnaire (Page 22)

## **P**

**Pablo Perez, Nokia Bell Labs**

Towards a Distributed Reality: a multi-video approach to xR (Page 34)

**Martin Potthast, Universität Leipzig**

Summarizing E-Sports Matches and Tournaments: The Example of Counter-Strike: Global Offensive (Page 13)

## **R**

**Kjetil Raaen, Kristiania University College**

Playing with delay: An interactive VR demonstration (Page 19)

**Alessandro Ragano, University College Dublin**

Fusion Confusion: Exploring Ambisonic Spatial Localisation for Audio-Visual Immersion Using the McGurk Effect (Page 28)

**Michael Riegler, SimulaMet**

Summarizing E-Sports Matches and Tournaments: The Example of Counter-Strike: Global Offensive (Page 13)

**Steffen Rothkugel, University of Luxembourg**

Immersive Mixed Reality Object Interaction for Collaborative Context-Aware Mobile Training and Exploration (Page 4)

## **S**

**Saeed Shafiee Sabet, Simula Research Laboratory**

Influence of Primacy, Recency and Peak effects on the Game Experience Questionnaire (Page 22)

**Abubakr Siddig, University College Dublin**

Fusion Confusion: Exploring Ambisonic Spatial Localisation for Audio-Visual Immersion Using the McGurk Effect (Page 28)

**Håkon Stensland, Simula Research Laboratory and Oslo University**

Summarizing E-Sports Matches and Tournaments: The Example of Counter-Strike: Global Offensive (Page 13)

## **V**

**Alvaro Villegas, Nokia Bell Labs**

Towards a Distributed Reality: a multi-video approach to xR (Page 34)

## **Y**

**Jiang Yu, New York University**

Field-of-View Prediction in 360-Degree Videos with Attention-based Neural Encoder-Decoder Networks (Page 37)

# Sponsors & Supporters

## Sponsors



## In Cooperation With



## Gold Supporters



## Silver Supporters

