Splash! Identifying the Grand Challenges for WaterHCI

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ABSTRACT

Bodies of water can be a hostile environment for both humans and technology, yet they are increasingly becoming sources, sites and media of interaction across a range of academic and practical disciplines. Despite the increasing number of interactive systems that can be used in-, on-, and underwater, there does not seem to be a coherent approach or understanding of how HCI can or should engage with water. This workshop will explicitly address the challenges of designing interactive aquatic systems with the aim of articulating the grand challenges faced by WaterHCI. We will first map user experiences around water based on participants' personal experiences with water and interactive technology. Building on those experiences, we then discuss specific challenges when designing interactive aquatic experiences. This includes considerations such as safety, accessibility, the environment and well-being. In doing so, participants will help shape future work in WaterHCI.

CCS CONCEPTS

• **Human-centered computing → Interaction paradigms**.

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KEYWORDS

HCI, water, fluidic user interface, aquatic play

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1 BACKGROUND

> If there is magic on this planet, it is contained in water
>
> *Loren Eiseley (anthropologist)*

Water is an element and medium that everyone on earth is familiar with. We drink it, bathe in it, and play with it. Its stark difference to air makes it a medium that is often used within playful interactions, such as children splashing each other with water in the pool or engaging in sports such as surfing on the water, and for relaxing experiences like floating in a bath. However, the inability to breathe while underwater and the high electrical conductivity of unpurified water make it a hostile environment for the human as well as most interactive technology [13]. Nonetheless, with advances in waterproofing, interactive technology is increasingly dipping its toes into the water [5, 6, 18, 19].

Not only are everyday digital devices such as phones and cameras (e.g., action cams such as GoPro) becoming more resistant to water, but the aquatic experience is engaging increasingly with advanced

technologies, such as virtual reality, which has been used to simulate scuba diving and snorkelling [8]. Furthermore, the coming together of interactive technology and water has been explored in reference to water conservation and water management for environmental sustainability [9, 10]. However, we note that these systems were mostly designed originally for land-based activities and are now being transferred into the water, which fails to factor in the unique parameters of body-aquatic interactions. As they were not designed explicitly for aquatic activities, there emerges an under-explored opportunity to deliberately support interactive aquatic experiences with systems that are intentionally designed for water.

Despite the increasing number of systems that can be used in-, on-, and under-water, there does not seem to be a coherent understanding of how HCI can or should engage with water. This might be because there has not been many opportunities for people interested in interactive technology and water to come together, limiting the growth of the field. In particular, we find that there seems to be no clear structured understanding of the different opportunities or challenges that the field of WaterHCI is facing. Our workshop aims to change this. We would like to create an interdisciplinary dialogue around designing interactive technology with, for, and around water. To our knowledge, this would be the first CHI workshop to focus on interactions in water, making waves for future interaction design research in this massive yet under-explored environment. Activities throughout the workshop will be themed using a proposed framework of user experiences in aquatic recreation. Specifically, we will be considering water as "synergy", "delight", "enabler" and "challenge".

We invite and welcome participants from diverse fields and also recommend HCI researchers to consider references outside their immediate field. With a wealth of diverse perspectives and the knowledge shared during this workshop, we plan on collectively formalising the field by creating a publication outlining the "grand challenges" faced by WaterHCI.

2 TOPICS OF INTEREST

The topics of interest for the workshop include theories, technologies, and experiences related to water interactions from an HCI perspective. We also encourage contributions that do not neatly fit in existing categories.

2.1 Theory and Methods

Topics of interest include, but are not limited to:

- The use of theoretical understandings of water properties (such as those proposed by Shmeis [21]) to inform the design of interactions with water
- Critical reflections on the potential of, and risks derived from, integrating technology into water
- Methods for designing aquatic interactions

2.2 Technology

We are also interested in contributions related to how technologies such as 3D printing, robotics, virtual and augmented reality [3, 17, 20], tracking and sensing technologies [2, 4], as well as pool design can be leveraged for interactions with water. Such technology topics of interest include, but are not limited to:

- Challenges of wired and wireless in-water communication
- Constructed aquatic environments
- Natural aquatic environments
- The various properties of water e.g. buoyancy, variable visibility, malleability, flow
- Sensing water interactions
- Actuating devices underwater
- Prototyping tools for water interactions
- Interactive devices for in-, on- and under-water

2.3 Experiential aspects of water engagement

Although water can be a medium that facilitates delight, it can also elicit fear, given that aquatic environments can be hostile [14, 15]. We are interested in the gamut of emotions that persons of varying aquatic skill levels and prior aquatic experience may feel when interacting with water and what role interaction design can play in this. We would like to hear perspectives that represent a range of aquatic backgrounds that include, but are not limited to:

- Prior positive or negative water experiences
- Pursuit of aquatic recreation
- Pursuit of aquatic sport
- Experience with professional/commercial water-activity

3 GOALS/OUTCOMES

A key goal of this workshop is to develop the foundations for writing a "grand challenges" paper on WaterHCI, like those successfully done in related HCI areas such as shape-changing interfaces [1], human-computer integration [16] and immersive analytics [7]. Doing so helps build a research community around the topic of WaterHCI and allows for the development of plans for subsequent research in the field. Workshops offer a way to compile key "grand challenges" that go beyond a single individual's work. Identified challenges provide direction for areas that need more examination and research. We also recognise that in gathering enthusiasts and experts in WaterHCI, we may be more optimistic about the future of the field than the broader HCI community. To further encourage interest in the topic, supplemental goals of the workshop include:

- Providing an enduring community and networking platform for researchers who are interested in the coming together of interactive technology and water activities
- Getting to know personal insights of in-water experiences (e.g. through play, sports, leisure, occupation) and identifying opportunities to enhance future interactions
- Exploring design strategies for water activities that leverage water properties and emerging technologies

4 ORGANISERS

4.1 Christal Clashing

Christal Clashing is a member of the Exertion Games Lab, Faculty of Information Technology, Monash University, Melbourne, Australia. She is a 2004 Olympic swimmer, a cross-Atlantic rower, a PADI Divemaster, an ASCA swim coach, an ACA stand-up paddle instructor, and a recreational freediver. She also has watersports tourism industry experience in kayaking, wakeboarding and waterskiing. As a result, she has a keen interest in interactive technologies that

support aquatic play and recreational activities. Her background is in the sports sciences with experience in event management for the volunteers at the 2012 Olympics. She also has experience with strategic planning, motion capture and eye-tracking systems.

4.2 Maria Fernanda Montoya

Maria Fernanda is a member of the Exertion Games Lab, Faculty of Information Technology, Monash University, Melbourne, Australia. Her experience is focused on the development of virtual reality environments for rehabilitation and education and the use of physiological sensors. Her interest in the water relies on the development of novel prototypes for embodied interactions in aquatic experiences. Maria has published in international conferences such as Interacción'17, VS-GAMES, and HCI in Games; and in international journals such as IEEE Transactions on Neural Systems and Rehabilitation Engineering, and the Journal of Virtual Reality.

4.3 Ian Smith

Ian Smith is a PhD student in the Human-Computer Interaction Lab and Institute of Biomedical Engineering at the University of New Brunswick in Fredericton, Canada. His research interests centre around designing feedback to improve motor learning. He is an NCCP certified competitive swimming coach and is interested in technologies that support motor learning in watersports. He previously co-authored the Inbodied Interaction workshop proposal for CHI 2020.

4.4 Joe Marshall

Joe Marshall is an Assistant Professor in the Mixed Reality Lab, University of Nottingham. He studies the use of the whole body to interact with computers, with a primary focus on entertainment and sports. He is a keen cold water swimmer and has swum in his local river weekly since September 2012.

4.5 Leif Oppermann

Leif Oppermann leads the Mixed and Augmented Reality Solutions team at the Fraunhofer Institute for Applied Information Technology FIT where he is concerned with supporting collaboration in post-desktop settings. He qualified as a BSAC Ocean Diver during his time at the Mixed Reality Lab in Nottingham in order to relax from his daily research on facilitating the development of artist-led pervasive gaming experiences, only to then discover a five star geocache at the submerged Nautilus at his training site Stoney Cove. Leif was principal investigator of the KIAT-funded, Korean-German AREEF project which built and evaluated a multi-player underwater augmented reality game for kids in swimming pools and which was selected to be presented on the occasion of the state-visit of the Korean president to Germany in 2014.

4.6 Paul H. Dietz

Paul H. Dietz is an inventor of technologies for interactive experiences. He is best known for his seminal work on multitouch that helped drive the adoption of this now ubiquitous interface. He has held senior research positions at Walt Disney Imagineering, Mitsubishi Electric Research Labs and Microsoft. Paul co-founded and led Misapplied Sciences which was formed to commercialise his display technology that can simultaneously show different images to each viewer without the need for glasses. More recently, he has been a Technical Fellow at Tactual Labs working on shape sensing. Paul is currently on sabbatical at the University of Toronto. He holds an SB from MIT, and MS and PhD degrees from Carnegie Mellon, all in Electrical Engineering. Paul has extensive experience with water-based interfaces and created the PumpSpark Fountain Development Kit which was the basis of the UIST 2013 Student Innovation Contest.

4.7 Mark Blythe

Mark Blythe is a Professor of Interdisciplinary Design at Northumbria University. He is a design ethnographer working in the field of Human-Computer Interaction with a background in critical theory. His research is concerned with the digital revolution we are stumbling and tumbling through and how this changes the ways we live, work, make art and grow old. He is a co-editor of the textbooks Funology and Funology 2. Mark Blythe is mostly made of water.

4.8 Scott Bateman

Scott Bateman is an Associate Professor and co-director of the HCI Lab at the University of New Brunswick, in Fredericton, Canada. Scott is interested in ways that technologies designed for work and play can better prioritize how our bodies and minds work to help us perform at our best. He is a lifelong recreational swimmer and is currently learning sailboating.

4.9 Sarah Jane Pell

Sarah Jane Pell is an Associate Professor at Monash University, and lead of Human Aquatic Performance research. An artist, bioastronautics researcher, and occupational diver, she contributes insights and advances in new choreographic modes of underwater operations, human-robot cooperation, human factors, habitability and the design of subsea technologies. She is best known for pioneering "aquabatics" that is performed underwater or shown in museums as films and artefacts. A former world-champion dragon boat crew member, black-ops diver, and Europe's lunar analogue undersea simulation astronaut, Pell designs and leads global space analogue missions, and produces speculative fiction, live art, and novel experiments. Her research addresses the lack of body-aquatic expertise in HCI, on the premise that embracing this provides a necessary convergence of knowledge systems for maximizing discovery and relevant HCI insights.

4.10 Swamy Ananthanarayan

Swamy Ananthanarayan is a Lecturer in the Department of Human-Centered Computing at Monash University in Melbourne, Australia. His work includes electronic toolkits for supporting healthy behaviours, tangible programming environments for facilitating computational thinking, storytelling platforms for sharing emotions, and multimodal interfaces for bicycle safety. Swamy received his PhD in computer science from the University of Colorado Boulder, while working at the Craft Technology Lab. After his graduate studies, he was a postdoctoral researcher in the Media Informatics and Multimedia Systems group at the University of Oldenburg /

OFFIS (Germany). He is interested in water-related play in the context of inclusive technology, particularly in exploring alternative experiences for individuals with disabilities.

4.11 Florian 'Floyd' Mueller

Florian 'Floyd' Mueller Prof. Florian 'Floyd' Mueller is Professor of Future Interfaces at Monash University in Melbourne, Australia, directing the Exertion Games Lab. Floyd has been a Fulbright Visiting Scholar at Stanford University and a Microsoft Research Asia Fellow, having researched bodily interactions across four continents, including at organizations such as the MIT Media Lab, Media Lab Europe, Fuji-Xerox Palo Alto Laboratories, CSIRO and Xerox Parc. Floyd has written over 250 publications, including 11 "Best Paper Honorable Mentions". Floyd has also been listed in the Top 100 HCI researchers. Floyd was general chair for CHI PLAY'18 and was selected to co-chair CHI'20. Floyd has co-organized over 10 workshops at CHI and is trying to learn how to wakeboard.

5 WEBSITE

The workshop website will include the workshop description and goals, call for participation and suggested topics, link to the submission system, workshop schedule, ways to get involved during the workshop, and information about the organisers. All accepted contributions will appear on the website. Following the workshop, videos and photos from the workshop activities will be added, with participants' consent. The workshop website address will be waterhci.exertiongameslab.org

6 PRE-WORKSHOP PLANS

We will publish a call for participation on the workshop website and circulate it widely to individuals and communities interested in the topic of the workshop. It will be open to academic researchers as well as industry professionals and independent researchers. The call for participation will also be posted to mailing lists (including CHI-announcements), social media and distributed to researchers in our networks. Prospective participants will apply to join the workshop by responding to an online form available via the website that will collect the following information:

- The aquatic backgrounds of prospective participants describing the nature of their experience with aquatic activities. Specifically, what kind of water activities the prospective participant engages in and at what level of expertise. This information will be used for introductions at the start of the workshop.
- The form will collect prospective participants' personal experiences with water and how technology has aided or disrupted a desired interaction with water. During the workshop, this information will be mapped against a user experience framework for aquatic recreation developed by some of the workshop organisers.
- Prospective participants will also be asked to indicate if they have previously designed a water-based system and to attach a pdf link and/or photo of that design as well as any additional information such as study results, etc. Those who have not yet designed aquatic systems will be asked to identify water-based systems designed by others. Following participant acceptance to the workshop, participants will be invited to submit a short video describing their choice of system. This content will be used for an asynchronous workshop activity where participants map their chosen systems against the previously introduced user experience framework for aquatic recreation.

7 WORKSHOP STRUCTURE

As CHI 2022 will be a hybrid conference, for the greatest reach, our workshop will be virtual-only and conducted on the Zoom, Miro, and Slack platforms. Participation will be capped at 20 persons (apart from the organising committee) to allow for effective small group discussions. The 1-day workshop will be 6 hours in duration with asynchronous activity options in the event of connectivity issues. Activities planned include presentations by invited speakers, home-based water activities that illustrate the unique properties of water, an asynchronous review of prior water-based systems, and future thinking activities that explore some of the grand challenges of WaterHCI. These activities will involve a mixture of breakout room group exercises and full group discussions.

In greater detail, the workshop will begin with social, networking and contextualising activities, transitioning towards "grand challenges" activities later in the day. The information supplied by participants in their position papers will form the basis of ice-breaker and networking activities. Activity 1 will also use their submissions, plotting their positive and negative experiences along a proposed framework of user experiences for aquatic recreation. During short breaks in the program, participants are invited to engage in home-based water activities that bring to life some of the aquatic concepts we would like to highlight, such as various states and properties of water. The asynchronous activity will also be introduced for participants to engage in at their convenience: mapping prior WaterHCI systems on our proposed user experience framework. After ice breakers, three presentation talks will be given by academic professionals with relevant aquatic themes. These presentation talks will contextualise the subsequent activities for participants through theory and practice relevant to HCI.

After a lunch break, Activity 3 will involve a future-thinking exercise as participants are presented with a water-based scenario for which they will design a system that considers three primary types of challenges. Challenge 1 will explore *safety and technology*, challenge 2 will consider *societal and accessibility* concerns and challenge 3 will look at *environmental and well-being* considerations. Each challenge will have its own briefing before breakout groups contextualise it and then share their findings with the wider group of participants. These breakout groups will be themed according to the user experience framework for aquatic recreation. Activity 4 is a summarising activity that will allow participants to indicate which aspects of all the design solutions presented they most gravitate toward. The workshop will conclude with an invitation for participants to collaborate on a "grand challenges"-style paper over the following months that stems from the asynchronous activity.

8 TENTATIVE WORKSHOP TIMELINE

The workshop timeline is presented in Table 1.

Table 1: Tentative Workshop Timeline

Time	Activity
10min:	Opening
15min:	Introductions / Ice breaker: what's an image that comes to mind when you think about water
10min:	Intro to asynchronous activity: mapping of prior water-based systems
40 min:	Keynote: Steve Mann on the history and development of WaterHCI [11, 12]
10min:	Break (mini activity: states of coffee/tea)
15min:	Networking activity: what are your favourite and least favourite experiences interacting with water
20min:	Presentation on movement in water - John Quarles [20]
10min:	Break (mini activity: plastic-wrap task)
20min:	Presentation on seamful design with water - Leif Oppermann [18]
30min:	Group activity 1: mapping of positive/negative activities with technology and water
30min:	Lunch break
10min:	Introduction to group activity 2: case study scenario through 3 challenge lenses
30min:	Challenge 1
10min:	Virtual coffee break
30min:	Challenge 2
30min:	Challenge 3
10min:	Virtual coffee break
20min:	Group activity 4 - summary activity
10-15min:	Wrap up

9 POST-WORKSHOP PLANS

A report on workshop activities, as well as selected photos and descriptions of outputs from the group activities (subject to authors' permissions), will be published on the workshop website. We also aim to include social media platforms for continuing knowledge sharing based on the preferences of the community. A selection of academic publications will be considered based on the outputs of the workshop sessions. These may include, but are not limited to: an ACM Interactions magazine article, a full paper submission to the CHI'23 conference based on the grand challenges and a special issue of a journal informed by the research agendas articulated at the workshop.

10 CALL FOR PARTICIPATION

WaterHCI is the exploration of how HCI can, and should, engage with water. Despite the increasing number of systems that can be used in-, on-, and under-water, there has not been an opportunity for people interested in interactive technology and water to come together with experts in aquatic performance and grow the field together. Identifying the grand challenges surrounding the creation of interactive aquatic systems will allow the community to understand and push past previous limits to interactions with water, creating new possibilities for the future. To this end, the workshop "Splash! Identifying the Grand Challenges for WaterHCI" aims to bring together a range of opinions and expertise so as to articulate these challenges. We welcome researchers and industry professionals who have an interest and/or experience in aquatic environments to contribute to WaterHCI. We invite position papers outlining a person's experiences and perceptions of water and interactive aquatic systems, both positive and negative. Submissions will be assessed for relevance by the organizing committee, and participants will use examples from their submissions in some workshop activities. Contributions must be submitted by February 20, 2022. Participants will be invited to contribute to a "grand challenges"-style paper, which will aim to be submitted for CHI 2023. For more information, please see: waterhci.exertiongameslab.org

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