Bring Your Own Interface: Exploring Tactile Interaction in Maritime Automation

David Goedicke
University of Duisburg-Essen
HCI Group
Essen, NRW, Germany
david.goedicke@uni-due.de

Stacey Li
Cornell Tech
Information Science
New York, New York, USA
sl3326@cornell.edu

Donald Degraen
University of Canterbury
HIT Lab NZ
Christchurch, New Zealand
donald.degraen@gmail.com

Kevin John
Arizona State University
School of Computing and Augmented Intelligence
Tempe, Arizona, USA
kevin.john@asu.edu

Yuta Sugiura
Keio University
Lifestyle Computing Laboratory
Yokohama, Kanagawa, Japan
sugiura@keio.jp

Tian Min
Keio University
Lifestyle Computing Laboratory
Yokohama, Kanagawa, Japan
welkinmin@keio.jp

Hyunyoung Kim
University of Birmingham
School of Computer Science
Birmingham, United Kingdom
h.kim.4@bham.ac.uk

Sonya S. Kwak
KIST
Intelligence and Interaction Research Center
Seoul, Republic of Korea
sonakwak@kist.re.kr

Valkyrie Savage
University of Copenhagen
Department of Computer Science
Copenhagen, Denmark
vasa@di.ku.dk

Tom Igoe
New York University
Arts Professor (ITP, Tisch School of the Arts)
New York, New York, USA
tom.igoe@nyu.edu

David Sirkin
Stanford University
Stanford, California, USA
sirkin@alum.mit.edu

Wendy Ju
Cornell Tech
Information Science
New York, New York, USA
wendyju@cornell.edu

Stefan Schneegass
University of Duisburg-Essen
HCI Group
Essen, NRW, Germany
stefan.schneegass@uni-due.de

Abstract

For centuries, seafarers have developed an intuitive relationship with their vessels, reading the wind and feeling a ship's movement through embodied engagement. However, as maritime systems become more automated, this connection shifts toward abstract, screen-based controls.

In a collaborative workshop, participants will prototype interaction ideas that balance automation and human control through simulated maritime tasks. They will develop tactile and multimodal interface concepts and test their effectiveness in a simulator for situational awareness and decision-making in dynamic environments.

The workshop's three key outcomes are: (1) **Insights into Tactile Interfaces** – Participants will explore physical controls and their importance in safety-critical tasks. (2) **Simulation-Based Evaluation** –The workshop will explore the use of simulation as an evaluation method for interface prototypes. (3) **Research Community Development** – It will foster collaboration among researchers beyond the workshop by creating communication channels such as Discord.

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CCS Concepts

• **Human-centered computing** → **Interaction design**; **Interface design prototyping**; **Haptic devices**; **Systems and tools for interaction design**; **Accessibility design and evaluation methods**.

Keywords

tactile augmentation, vibrotactile interface, tactile design, simulation, interaction design

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1 Motivation

Traditional tangible user interfaces (TUIs) have long provided a more "intuitive" form of interaction, where users could understand and manipulate system states through touch alone. This kind of interaction symmetry, where the physical feel of the control reflects its functional state, enabled operators to perform tasks safely and effectively without relying solely on visual confirmation [11]. However, there has been a growing shift toward digital interfaces, such as touchscreens and graphical user interfaces (GUIs), prioritizing flexibility and cost-effectiveness but often sacrificing usability.

This shift is particularly problematic in high-workload environments like automotive and maritime systems. For example, automated vehicles (AVs) and other systems have increasingly adopted touchscreens, which can result in higher cognitive load and reduced safety [4]. Notable incidents, such as the touchscreen-induced failure aboard the USS John S. McCain [15], highlight the risks of relying on digital interfaces for safety-critical applications. These examples underscore the urgent need to reconsider the role of multisensory, stateful controls in complex, autonomous systems.

While a considerable body of research has explored tactile interface designs aimed at reintroducing tactile feedback and stateful interaction [5], gaps remain in bridging these innovations with practical applications, particularly in environments where immediate feedback and precise control are critical. Bringing experts from Haptics, Digital Fabrication, Human-Robot Interaction, Interaction Design, and Simulation together at DIS provides a unique opportunity to advance this discussion. A strong collaboration between these communities can help address the usability challenges and explore new research directions. Given the challenges of testing and contextually exploring physical user interfaces, in-person collaboration is crucial to moving the field forward, which is why this is an excellent fit for a DIS workshop.

2 Background

2.1 History of Interface Designs

Traditional ship controls were rooted in tangible, mechanical interfaces that provided direct, physical feedback to operators. Ships relied on large, clearly labeled levers, wheels, and throttle controls that ensured immediate and unambiguous interaction, enabling precise maneuvering even in high-stakes environments. As digital technologies advanced, these physical mechanisms were increasingly replaced by automated and touchscreen-based systems, often in the name of streamlining operations and reducing hardware complexity.

A more recent example highlighting the risks of this transition comes from the *USS John S. McCain* collision, where a touchscreen-based navigation system contributed to a critical failure. Steering and throttle adjustments, once intuitive through mechanical inputs, were integrated into digital touchscreens, leading to confusion and unintended control transfers. Crucial parameters changed without operators' awareness, exacerbated by unclear interface feedback and inadequate training. These factors resulted in delayed responses and miscommunication during a high-risk maneuver, underscoring the limitations of touch-based controls in environments requiring immediate and precise adjustments [15].

Unlike mechanical controls, which provide tactile resistance and haptic confirmation, touchscreen systems require visual attention and menu navigation, increasing cognitive load. This shift has led to designs prioritizing minimalism over usability, detaching operators from their systems and reducing situational awareness. Automation in critical domains such as maritime navigation, automotive systems, infrastructure, and industrial control must reconsider the role of physical interfaces, ensuring that essential controls remain tangible, responsive, and intuitive, rather than obscured behind digital abstraction.

2.2 Existing In-Vehicle Interface Research

Prior research on vehicle interface design has examined how users allocate attentional resources while managing secondary tasks in high-distraction environments [20]. Studies have also highlighted the significance of designing interfaces that account for both the physical and cognitive state of users to optimize information presentation and interaction efficiency [6].

Unimodal interfaces, which rely on one sensory modality (i.e. touch or voice) can unintentionally increase distraction. For example, using a voice assistant like Siri was found to add visual distraction and reduce situational awareness [13]. In using the voice interface, people still looked to their devices to confirm input and experienced increased cognitive load. As a result, the design of multimodal interfaces, which integrate multiple sensory channels to present information, has become increasingly important to mitigate these issues and enhance user performance.

There have been efforts to investigate TUIs and touchscreens in driving situations. One study found that physical dials can lower cognitive load and eyes-off-time when compared to a touchscreen [16], while another study shows that physical dials take longer to operate for certain tasks than touchscreens [18]. In these studies, slightly different versions of the interfaces, such as the size of target or tactile feedback, are needed. This implies that minor variations in interfaces can change user experience and performance. Similarly, the location of a touchscreen and types of tasks impacted the user performance and eyes-off-time [2].

Beyond TUIs and touchscreens, shape-changing control has been explored that can be used in cars, such as shape-changing dials [11, 12, 14, 24] or shape-changing surfaces [7]. Mid-air gesture controls augmented with ultrasonic haptic feedback [9] and the impact of voice assistant's personalities [3] and emotion [17] in driving settings were tested. The location of the interfaces also varied, ranging from car seats [1, 8, 21] to a steering wheel [22].

2.3 Interfaces in Special Application areas

In environments where unwanted movement, high background noise, and safety-critical decision-making are prevalent, such as industrial settings [19], it is crucial to design touchscreens and tactile affordances that prioritize safety and usability. Autonomous systems are currently deployed in maritime environments, such as ships' navigation systems[1], where automation assists in critical decisions. In aviation, touchscreens such as Intellisense's multi-core processing Avionics Displays[2] can be integrated into cockpits to enhance operational control.

2.4 Improving comparability in Tactile Interfaces research

The design of tactile interfaces lacks evaluation tools to support haptic design processes [23, 25]. One inherent challenge in testing tactile interfaces is that they often rely heavily on context (e.g., task, environment) to evaluate their usability and effectiveness [10]. A lack of standardized simulations and environments makes cross-comparisons between different interfaces difficult. Therefore, standardized testing frameworks are needed in tactile interface research to facilitate meaningful comparisons between devices, scenarios, and design approaches. Such tests can promote replicability and wider adoption of new tactile technologies across different fields, from industrial manufacturing to transportation.

3 Workshop Goals

We put forward the following goals as an output for our workshop.

3.1 Summary Results

The workshop provides a valuable opportunity to explore tactile interfaces in practical, simulated scenarios. Our primary goal is to facilitate collaboration and gather expert insights by having participants test and compare their interface ideas. Each participant's submission paper will be published separately on ArXiv, providing a standalone contribution to the community. The workshop organizers will also compile an overarching paper summarizing the workshop discussions, findings, and insights gained from the submissions. This summary paper will contextualize the workshop results and outline future research directions, further advancing the development of tactile interfaces within critical environments and sharing first insights on how the community can use simulation to standardize evaluation methods.

3.2 Community Building

Tactile interfaces and physical prototypes often face challenges in replication and testing due to the need for specialized equipment (e.g., specialized 3D printers) and the inherent hidden knowledge required to build and test published prototypes. This workshop aims to bring researchers together to share knowledge and create easy means of communication to help with this hurdle.

The shared activity in the workshop is designed to encourage researchers to quickly engage in in-depth discussions about their designs, techniques, and challenges. By sharing the overarching research goals they are addressing and the scenarios and prototypes they have developed, we hope to foster an environment of technical exchange that leads to fast-tracked discussions and valuable insights.

These focused discussions aim to accelerate replication efforts and foster meaningful collaboration. To support these goals further, we will launch a Discord server before the workshop. This platform will help participants form groups and build comfort with one another early on, encouraging ongoing dialogue and ensuring continued collaboration. Our goal is for this network to inform and accelerate future work in tactile interfaces and interaction design within the community and future workshop events.

3.3 Research Directions and Standardized Evaluation

One key focus of this workshop is introducing simulation technology into the tactile interface field. Testing these systems is often complicated, and we will use this opportunity to discuss with researchers how they envision using simulations to evaluate new designs. Specifically, we aim to explore what other scenarios they would want to simulate, how they would modify them, and the time they would allocate for such adaptations.

Following this workshop, we plan to host a DIS 2026 workshop that incorporates the insights gained. This subsequent event aims to strengthen community bonds, revisit established goals, and introduce new simulated scenarios. We advocate for in-person conferences to foster cross-disciplinary collaboration, encouraging participants to engage and discuss the mutual benefits of their work.

[1]MEGURI2040 Fully Autonomous Ship Program – https://www.nippon-foundation.or.jp/en/what/projects/meguri2040
[2]Avionics Displays by Intellisense Systems, Inc. – https://www.intellisenseinc.com/products/avionics-displays/

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