HaptiMouse : Favoriser la perception multisensorielle de l'environnement dans les salles de contrôle

HaptiMouse: Supporting Multisensory Situational Awareness in Control Rooms

Anchit Mishra, Arnaud Prouzeau, Sacha Sabatier, Nicolas Rouit-Leduc, Marine Rouit-Leduc, Matthew Brehmer, Oliver Schneider

Abstract / **Resume**—Situational awareness is essential in control rooms for large infrastructure facilities, where multiple operators monitor different indicators of system health but no one person can directly apprehend the entire state of the facility at once. In these settings, safe operation depends on coordination across distributed roles, yet collaborative monitoring can also produce divergent mental models of facility state, particularly under time pressure. We present HaptiMouse, a computer mouse with vibrotactile feedback designed to support situational awareness in wastewater treatment control rooms. Through early ideation sessions and prototyping, we converged on haptic metaphors based on machine vibration and heartbeat-like signals. We then conducted an on-site workshop with wastewater treatment control room staff to probe the appropriateness of these metaphors and to identify design constraints for deployment. Participants emphasized the value of low-intensity ambient cues, stronger escalation near operational thresholds, and mappings that reflect familiar phenomena such as flow, temperature change, and overall facility "health." We conclude with design implications from this formative work and outline plans for a controlled study comparing visual monitoring with and without HaptiMouse support.

1 Introduction

Control rooms are a key part of critical infrastructure such as factories, wastewater treatment plants, and electrical grids. Such facilities are highly coupled systems, whose scale and interdependence exceed the cognitive grasp of any single operator. Safe and efficient operation depends on teams of people working in control rooms, continuously monitoring system state, interpreting alarms, and coordinating with one another and with on-site technicians. In wastewater treatment facilities, pumps, tanks, valves, and treatment stages influence each other through pressure, temperature, level, and fluid flow, so disturbances in one subsystem can propagate to others. While existing visual analytics tools often support routine work, unexpected events can quickly lead to situations where operators are overwhelmed with visually saturated displays, competing alarms, and limited alert provenance, increasing cognitive load [1], [5], [8] and the risk that team members form mismatched mental models of plant state [2].

In this project, we explore whether ambient haptic feedback [6] (i.e., haptic feedback always present in an environment to communicate information) can complement visual monitoring in this collaborative environment. Rather than introducing a new dedicated device, we chose a computer mouse because pointing devices are already embedded in control room work: operators use them to navigate dashboards, inspect values, and acknowledge alarms. This offered a plausible path toward lightweight adoption while keeping feedback physically close to routine visual interaction. Through initial ideation sessions and prototyping, we converged on a design direction that treats haptics not as abstract notifications, but as continuously-felt vital signs of the facility.

The HaptiMouse is our prototype that we brought to an on-site workshop with wastewater treatment staff to understand how a haptic device might fit into daily practice, and which haptic metaphors felt meaningful when using it. Participants responded most positively to familiar, low-intensity cues: machine-like vibrations for communicating fluid flow, heartbeat-like pulses for representing either a critical parameter or synoptic signals indicating facility "health," and threshold-based thermal feedback for temperature-related alerts. Across these discussions, participants emphasized that feedback should remain ambient during normal operation and intensify only as values approach thresholds or enter alert conditions. This work will form the basis of more controlled evaluation, which we describe below.

- *Mishra, Brehmer and Schneider are with Univ. Waterloo, Waterloo, Canada*
  E-mail: amishra@uwaterloo.ca
- *Prouzeau is with is with Univ. Paris-Saclay, CNRS, Inria, Paris, France*
- *Sabatier, Rouit-Leduc and Rouit-Leduc are with Meaningful Design, Paris, France*

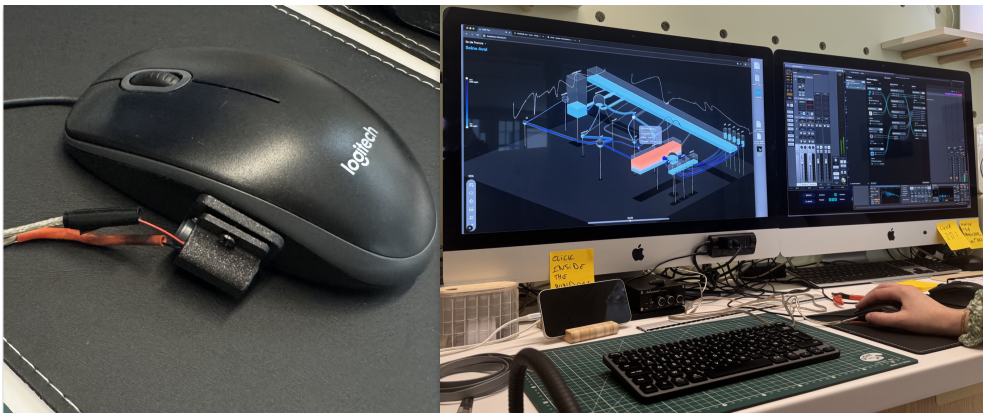

Fig. 1. On the left, a low-fidelity prototype of the HaptiMouse is shown - this was used to prototype vibrations during the early ideation phase and workshop with control room operators. On the right, a workstation running a visualization that makes use of the HaptiMouse.

2 Methods

We developed HaptiMouse through an iterative, practice-centred process that combined early concept generation with domain visits to a major urban wastewater treatment facility. In an initial design session, our divergent ideation yielded multiple prototypes informed by haptic sketching [7] and the Tickle Trunk haptic toolkit [3]. We then converged on the idea of a facility as an organism, a deconstruction of the human as facility metaphor [4]. This framing treated plant monitoring as a kind of diagnosis through touch, analogous to how a physician assesses a patient by feeling for signs such as pulse, breathing, or abnormal vibration. Facility visits allowed us to ground this concept in the realities of the control room. Because operators already relied on flat-screen displays together with keyboard-and-mouse input, we chose to embed vibrotactile feedback into a conventional mouse rather than introduce a new standalone device. Our early prototype used a Titan Haptics TacHammer Drake LFi actuator [9] mounted onto a mouse using a custom 3D-printed fixture.

We used this prototype in a one-day formative workshop with wastewater treatment control room operators. We introduced participants to the factory-as-organism metaphor and asked whether the resulting haptic encodings matched their experience of monitoring plant behaviour. We used the prototype as a conversational probe, asking about the quality of the vibrations, whether the mappings felt intuitive, and what other encodings such a device should support to provide synoptic awareness. These discussions reinforced the promise of details on demand value retrieval based on tactile cues that resemble familiar plant phenomena and also surfaced new directions for iteration. In particular, participants suggested thermal rendering for communicating water-temperature-related data, which we have since begun initial prototyping on using Peltier cells.

3 Future Work

The next phase of this project is a controlled study that compares visual-only monitoring against monitoring augmented with HaptiMouse. We plan to abstract a set of tasks associated with control room scenarios in which participants must detect system-level changes, interpret their significance, and coordinate responses while tracking multiple indicators at once, maintaining situational awareness of a simulated control room facility. This study will allow us to evaluate whether ambient haptics improve anomaly detection, response time, and subjective workload, and whether they help teams maintain more aligned mental models of system state during time-sensitive events.

3.1 Open Research Questions and Interdisciplinary Exchange

This work sits at the intersection of haptics, visual analytics, Computer-Supported Cooperative Work (CSCW), and safety-critical infrastructure, and we intend for it to spark new exchanges between these areas. Haptics researchers can help refine tactile encodings, visualization and CSCW researchers can study how such cues shape shared awareness and coordination, and wastewater treatment experts can ground the design in real operational constraints. A central challenge is to design haptic cues communicating system-wide coupling without oversimplifying system behaviour or interfering with other information.

References

[1] U. Afzal, A. Prouzeau, L. Lawrence, T. Dwyer, S. Bichinepally, A. Liebman, and S. Goodwin. Investigating cognitive load in energy network control rooms: Recommendations for future designs. *Frontiers in psychology*, 13:812677, 2022.

[2] L. Bainbridge. Ironies of automation. In *Analysis, design and evaluation of man–machine systems*, pages 129–135. Elsevier, 1983.

[3] A. L. Diaz de Leon Derby. Tickle trunk: a toolkit for communication and brainstorming between hapticians and non-hapticians. 2023.

[4] F. Kahn. Der mensch als industrielpalast (man as industrial palace): Kahn, fritz, Jan 1970.
[5] M. Kim Hoang, S. Goodwin, R. Dargaville, and T. Dwyer. How do operators use network diagrams? characterising visualisation tasks in an energy control room. In *Proceedings of the 2026 CHI Conference on Human Factors in Computing Systems*, CHI '26, New York, NY, USA, 2026. Association for Computing Machinery.
[6] K. E. MacLean. Putting haptics into the ambience. *IEEE Transactions on Haptics*, 2(3):123–135, 2009.
[7] C. Moussette. *Simple haptics: Sketching perspectives for the design of haptic interactions*. PhD thesis, Umeå Universitet, 2012.
[8] R. J. Simonson, J. R. Keebler, E. L. Blickensderfer, and R. Besuijen. Impact of alarm management and automation on abnormal operations: A human-in-the-loop simulation study. *Applied Ergonomics*, 100:103670, 2022.
[9] TITAN Haptics. DRAKE high definition haptic motor technology, 2026. https://titanhaptics.com/drake/titanhaptics.com/drake.