

## Scientific Abstract - Scientific Posters & Demonstrations

### Enhancing Medical Image Interaction By Specializing the Mouse

#### Authors:

**Louise Carolyn Oram**, *University of British Columbia*; **Karon M. MacLean, PhD**; **Philippe Kruchten, PhD**; **Jeremy Kooyman**; **Florin Gheorghe**

#### Background:

With the advent of digital imaging, the number of images that radiologists must view to make a diagnosis has grown from around 100 to thousands [4]. Meanwhile, the user-input options available for diagnostic purposes have remained relatively unchanged and are likely limiting workflow efficiency [4]. Radiologists also experience a high rate of repetitive stress injuries from prolonged use of the workstation [1]. Innovations allowing images to be read more quickly without reducing accuracy or thoroughness, and improving ergonomics at the same time, would increase efficiency and save money.

Errors in diagnosis are of concern to any medical system, and can be caused by fatigue and errors in perception. Fatigue occurs over the workday and was seen to cause a small drop in detection of fractures in radiographic images between early and late in the day [3]. Subjective radiologist feedback related this performance drop to increased physical discomfort, sleepiness, lack of energy, and oculomotor strain; the eyestrain effect is worse for CT images [8]. Three causes of false-negative type perception errors have been observed [4]: never fully fixating on the object, not fixating long enough to recognize the object, and fixating but not recognizing or consciously dismissing the object.

Radiologists primarily use mouse and keyboard to interact with images. But are they used purely because of familiarity and lack of alternatives? The mouse was not designed for continuous use and therefore can cause repetitive stress injuries [2], as the mouse's restricted action set requires PACS interactions to be modal and repetitive. Many consumer devices have therefore been investigated as alternative inputs [9]. For instance, a pen and tablet reduces the contouring time for a 'region of interest' compared to a mouse and keyboard, likely due to a reduction in contouring errors [6]. Overall, however, the mouse generally outperforms other devices in pointing performance [2].

If the mouse interaction was more intuitive, could it decrease the mental strain that is likely contributing to the aforementioned fatigue errors? In parallel, could enhanced mouse interaction improve visual search performance, thereby reducing perception errors?

#### Approach:

We observed radiologists in order to understand how best to support the image reading tasks they perform. Preliminary prototypes of ideas were created and presented to radiologists, and (the primary focus of this report) a questionnaire was administered to quantify the need for support of different tasks. We then discuss concepts for improved computer interaction and specialization of the mouse emerging from this combination of observation, subjective feedback and early participatory design.

#### Evaluation:

Early prototyping and participatory design: We observed several radiologists performing their regular tasks in the reading room. Based on these observations, we created interaction prototypes from easily available hardware and an open-source micro-controller (Arduino). These prototypes were informally tested by the radiologists and were mostly well received. By iterating the process of observing and prototyping, four important design guidelines arose.

1. Redundant moves. Offer multiple interaction methods for repetitive tasks that are performed often. For example, alternatives to the scroll wheel and 'click and drag' scrolling could diversify the actions and thereby reducing repetitive strain. So far, a mouse with an accelerometer allowing the user to control the scroll rate by tilting has been explored.
2. More capabilities. A mouse-type device could integrate additional hardware functionality mimicking common tool interactions. For instance, a small x/y slider joystick was linked to window/level and was well received.
3. Personalizable. Since some users may perform tasks differently than other users, any commercialized device should be easily customizable. Customizable devices could allow radiologists to map mouse interactions to specific image manipulations, analogous to keyboard shortcuts.
4. Ergonomic. The device should have good affordances for ergonomic use.
5. Uncluttered. Don't add even more devices to the radiology workstation.

Rationale to improve, not replace, the mouse: The mouse is very good for accurate pointing, functionality crucial to many radiology tasks, and this is a reason to improve on it rather than start anew. Additionally, long workdays make handrest capability ergonomically critical, which devices such as a pen and tablet do not afford. Finally, extending the capabilities of the mouse, a necessary general-purpose tool, avoids bringing in another device.

Task examples: We produced 6 task examples (presented here only in short form) and verified them with our participating radiologists:

1. Identifying or finding a specific piece of anatomy
2. Defining the edge or size of an area of interest
3. Tracking objects

4. Comparing two images (e.g. old and new)
5. Identifying the makeup of an area of interest
6. Getting a second opinion

Radiologist survey: We administered a short semi-structured interview, combining open-ended questions and a Likert-style questionnaire, to 10 radiologists (8 male, 2 female). The Likert scale questionnaire broke apart each task example asking how important, frequent, difficult, and well supported each task was. Experience ranged from a first-year internship to 31 years. Most participants had worked in multiple areas including, but not exclusively, interventional radiology, diagnostics, and Neuroradiology. All had familiarity with touch-devices and most owned at least one device that requires touch interaction. Those that did not cited familiarity with those belonging to family members. Many had experienced issues with ergonomics and long durations of sitting at the PACS workstation, including shoulder pain and repetitive use of the scroll wheel.

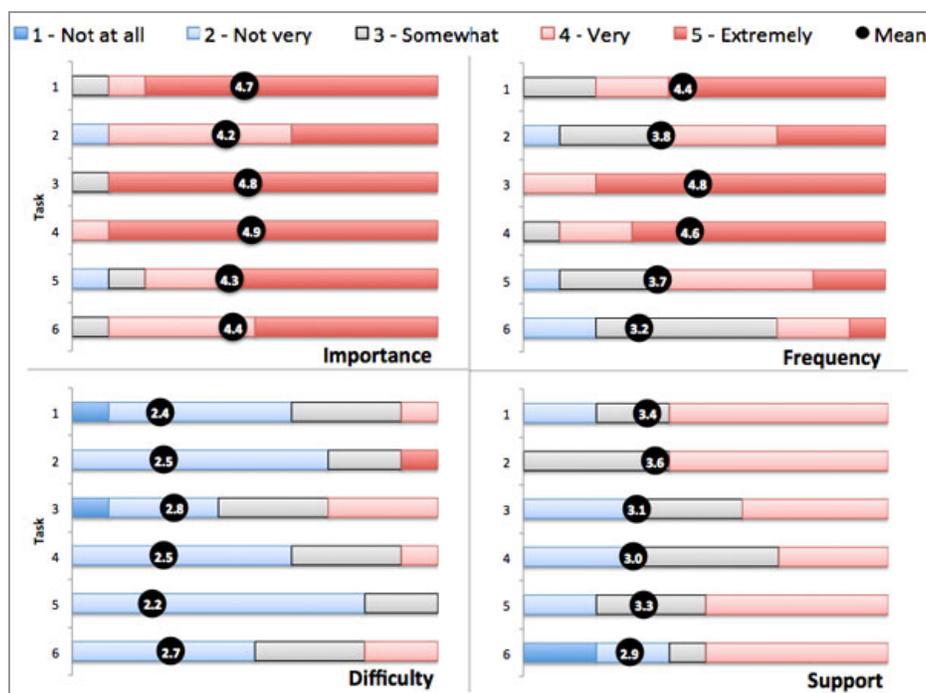


Figure 1: Questionnaire answers

Figure 1: n=10. Questionnaire answers for all 6 tasks grouped by measure (importance, frequency, difficulty, support). The left side of the bars (blue) is less of the measure, and the right side of the bars (red) is more of the measure.

Questionnaire results (Figure 1) confirmed that all of the task examples are important, and most were performed frequently. Therefore, designing interactions that better support all or a subset of these tasks could improve reading efficiency, accuracy and/or ergonomics. Assessment of difficulty and support varied (Figure 1), potentially based on their experience and areas of specialization. The least well-supported tasks appear to be (1) Getting a second opinion and (4) Comparing two images.

The interview's open-ended questions revealed that doing better at consuming the images by scrolling through them effectively is important to them. Comparing old and new images, and assimilating multiple types of images or view angles is important and cognitively challenging, leading to decision fatigue [7]. Respondents emphasized once more that as the number of images increases, they need to consume as much information as possible in the least amount of time and the interaction must support them in this.

## Discussion:

Several newer mice include a touch-sensitive surface; our larger research looks at how to leverage the gestures this affords for PACS interactions. Additionally, we will investigate the use of haptic feedback to send information through touch, which could potentially reduce the overload on the visual channel [5].

Interview participants supplied many ideas for improvement, and others arise from the issues they raised. The most relevant within the scope of our research are:

- Mouse settings that adapt based on type of image being viewed
- Mouse settings that adapt based on the location of the cursor (hovering over the image, or elsewhere)
- Haptic feedback when scrolling in the stack past images that are marked
- Better / more flexible mouse-controlled positioning image series on screen
- Touch gestures mapped to different tools (such as pinch to zoom, or 3 fingers for window level)

The next stage of this user-driven research is to physically prototype and refine these and other alternate interaction techniques, to better support our validated task examples. These prototype(s) will be user-tested on non-radiologists with abstract tasks applicable to radiology. Our participatory design process will close by choosing a final set of functionalities, refining the prototype that houses them, and presenting the ideas to radiologists and our medical imaging company partner for validation and feedback.

## Conclusion:

Increased effectiveness of mouse interaction with radiology images could potentially decrease error rates and/or lead to less repetitive stress injuries.

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## Keywords:

- Human Computer Interaction
- PACS
- User-input

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