# Novel Input Devices for Large, High-Resolution Displays Design, Interaction and Evaluation

**PhD Dissertation Proposal**

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### SUMMARY

Large, high-resolution displays (LHRD) are capable of visualizing a large amount of very detailed information but also introduce new challenges for human-computer interaction. Besides potential information overload and disorientation, limited visual acuity and field of view force users to physically move around in front of these displays to perceive either object details or an overview. However, conventional input devices such as mouse and keyboard restrict users' mobility by requiring a stable surface on which to operate and thus impede fluid interaction and collaborative work settings. Therefore, we introduce our Laserpointer-Interaction as a direct and absolute pointing technique, which is especially designed to satisfy the demands of LHRDs in the areas of mobility, precision, interaction speed and collaboration. We developed novel filter methods which compensate effectively the natural hand tremor of the user in real time, identify adaptively if the user wants to drag or click an object, and support precise selection by temporal and spatial interpolation. These filters and the laserpointer as input device itself as well as other devices like multi-touch surfaces, Phidget sensors, finger-, hand-, and eye-tracking were integrated as independent components in a common interaction library named "Squidy". This library facilitates the flexible reutilization of the filters with diverse input devices and improves comparability for formal evaluations due to the common test environment. Instead of implementing monolithic device drivers with redundant filter techniques, researchers and interaction designers thus have the ability to realize multi-device interaction techniques offering enhanced multimodal interaction concepts to one or multiple users. In principal, the research objectives of this thesis are the design, implementation and evaluation of the Laserpointer-Interaction as a suitable input device for LHRDs and the development of the interaction library Squidy as well as its graphical user interface concept, which allows interactive configuration of input devices, filter techniques and the interaction between them.


### SQUIDY – INTERACTION LIBRARY

Based on our experiences with the design and evaluation of input devices and filter techniques, we identified three major requirements for an improved input device design approach for research and industry:

- Interactivity
- Reusability
- Comparability

*Interactivity* – Most input devices and filter techniques are dependent on their environment setting, the capabilities of the user, their tasks, and the applied interaction strategies. Thus, there is neither an optimal device nor an optimal configuration but the need for a highly interactive and iterative design process in which tradeoffs can be quickly resolved and different version can be directly compared in order to efficiently converge to suitable compromises.

*Reusability* – Researchers and interaction designers are confronted with a very heterogeneous device driver landscape. There are monolithic standard drivers for conventional devices, advanced drivers from manufacturers for enhanced functions and specific software toolkits for unconventional devices such as data gloves. Thus, filter techniques such as hand tremor compensation need to be implemented and integrated in each driver and toolkit to take advantage of them. Furthermore, combining multiple devices to an advanced interaction concept (e.g. speech recognition & finger pointing) is either not realizable or give rise to individual, mostly single-purpose solutions.

*Comparability* – A desirable test environment allows for changing solely the independent variables. Thus, correlations and effects can be determined with minimized uncertainty. When comparing empirically two different input devices one has to take into account, that the measurement also involves differences in terms of device drivers, filter techniques, data transmission etc. Therefore a fully controllable or common test environment would be beneficial for the comparability.

In order to improve the research in the domain of input devices we addressed these requirements by developing a common interaction library named "Squidy". Technically, we extract the filter techniques (data processing) from the device drivers (data acquisition) and separate them in an abstraction layer. Thus, the device drivers sample data and send it over standardized internet protocols (e.g. UDP, TCP/IP, TUIO/OSC) in well-defined atomic data types to the filter techniques which are implemented as independent components. The researcher or interaction designer defines the data flow and the application and sequence of filters interactively by connecting visual nodes representing devices and filters in a zoomable user interface (Fig. 1a). The changing of data processing and filtering or combination of multiple input devices are less a matter of coding, recompilation and execution but more a visual task supported by direct-manipulation and semantic zooming. If a user wants to change parameters of a component or the component itself, they zoom into the node and are able to access and modify the items directly without losing the context or starting up additional applications (Fig. 1b).

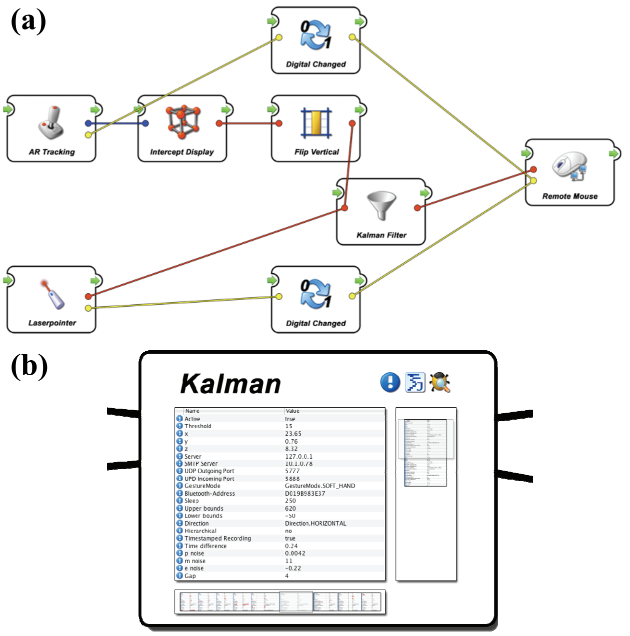


**Figure 1: Squidy – Zoomable user interface with device & filter nodes (a), zoomed Kalman-node with parameters (b).**

## LASERPOINTER-INTERACTION

The interaction library Squidy is not restricted to desktop environments, but also applicable to handheld computers or even LHRDs. Especially the latter case introduces difficult challenges to the design of input devices and filter techniques. Users need the freedom to move around in front of the display, they want to switch flexibly between collaborative and individual work, and they require fast as well as precise pointing and selection techniques. In order to address these challenges we designed an absolute and direct pointing technique named "Laserpointer-Interaction" which allows identical use from any point and distance. Basically, a laserpointer is used to control the virtual cursor by visually tracking the laser reflection on the screen with one or more video cameras. Due to the low-divergence laser beam users have full flexibility to interact directly in front of the display or from distant positions. Furthermore, laserpointers provide a very direct and intuitive manner of interaction by reason of their similarity to the human pointing gesture. As an absolute device, users can simply point to interesting information on the screen and the cursor is right where they expect it – at the intersection between pointing vector and display plane. Using a relative device like a mouse on LHRDs, clutching or similar time-intensive techniques are needed to entirely cross the whole display. Using a laserpointer this is just a matter of angle variation. In order to provide multiple selection and feedback modalities we developed a custom-build laserpointer with three buttons as actuators and an embedded ZigBee module for wireless data transfer (Fig. 2). In addition to status changes visualized on the display, we provide personal feedback for the user directly on the device. Multicolor LEDs are installed at both ends of the laserpointer and an integrated vibrator can be activated for tactile stimulation. For presentation situations in which speakers are mainly facing the audience and absolute pointing is therefore not feasible, we integrated an accelerometer which allows recognition of simple gestures independent from visual tracking. The laserpointer emits invisible infrared light (785nm) with a very low intensity (0.55mW), which is safe to use even in public spaces. Further advantages of the invisible light are that no displayed information is occluded by the laser reflection and that the user does not realize their own jittering caused by the natural hand tremor. To support responsive but smooth movements as well as precise hovering, we developed an adaptive jitter compensation filter as a reusable component directly in Squidy. It is based on a multi-model Kalman filter which dynamically adjusts the model choice and weights on current user behavior. EasyClick – a further filter developed and integrated in Squidy – ensures selection precision for absolute pointing devices which provide mechanical buttons directly on the device (Fig. 2). Since the user exerts force on the device by clicking a mounted button, the pointing position changes unintentionally. To compensate this discrepancy the EasyClick filter analyzes the previous movement path and estimates the intended position by heuristics combined with temporal and spatial interpolation. In order to test the general usability of the developed Laserpointer-Interaction we conducted a comparative evaluation study with 16 participants on the Powerwall comparing a conventional mouse and our laserpointer by means of a one-directional tapping test (ISO 9241-9). The results showed a quantitative performance advantage of the mouse (13%), but qualitatively the laserpointer offered more freedom of movement and a direct and intuitive mode of interaction.

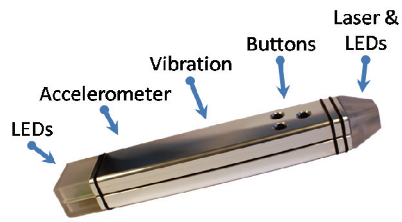


**Figure 2: Laserpointer with actuators, accelerometer, multi-color LEDs for visual and vibrator for tactile feedback.**

## PUBLICATIONS

[1] König, W. A., Böttger, J., Völzow, N., Reiterer, H., Laserpointer-Interaction between Art and Science, *IUI'08: International Conference on Intelligent User Interfaces*, ACM Press, p. 423 - 424, 2008.

[2] Föhrenbach, S., König, W. A., Gerken, J., Reiterer, H., Natural Interaction with Hand Gestures and Tactile Feedback for large, high-res Displays, *MITH'08: Workshop on Multimodal Interaction Through Haptic Feedback, AVI'08*, Napoli, Italy, 2008.

[3] König, W. A., Bieg, H.-J., Reiterer, H., Laserpointer-Interaktion für große, hochauflösende Displays, *Mensch & Computer 2007: Interaktion im Plural*, Oldenbourg Verlag, p. 69 - 78, 2007.

[4] König, W. A., Bieg, H.-J., Schmidt, T., Reiterer, H., Position-independent interaction for large high-resolution displays, *IHCI'07: IADIS International Conference on Interfaces and Human Computer Interaction 2007*, IADIS Press, p. 117-125, 2007.