

PenLight: Combining a Mobile Projector and a Digital Pen for Dynamic Visual Overlay.
Song, et al. CHI 2009.

What are the core research questions addressed by the work?

- What is the interaction space of embedding a spatially-aware miniature projector on a digital pen?

What motivates the work?

- Difficulty of using digital pen due to lack of visual feedback

How does the work understand the usage, capabilities, and limitations of paper?

- Paper is versatile and simple
- Significant through the current practices of the design, construction, and review phases of architecture

What is the target application domain of the work?

- General use case digital pens
- Architecture was chosen for proof-of-concept demonstration

What are some proposed extensions to paper proposed by the work?

- Provide rich dynamic visual feedback in paper interactions
- Enable spatial input (spatial awareness)
- Enables following interactions:
 - Multiple display layers
 - Creating and managing ink: virtual ink, tracing, virtual guides
 - Enabling presentation of overlaid content
 - Copy and pasting
 - Enabling overlaid computations
 - Search
 - Finding dimensions
 - Enabling alternate views
 - 2D Section View
 - 3D Snapshot View
 - 2D Walkthrough
 - Enabling remote collaboration
 - Interactive menus

How are the proposed extensions implemented?

- Pen input with a Destiny IO2 Bluetooth digital pen
- 3D tracking with a Polhemus FastTrak 3D magnetic tracker
- Projection using a top mounted projector (Mitsubishi XL4U, 1280x960 px)

What findings have been obtained from either the implementation process or an evaluation of the proposed system?

- The location of the projector on the pen determines the size of the projected image and the pen's center of mass.
- Hand-held projectors provide a dynamic resolution and brightness
 - Focus will be an issue for a lens based projector

- Brightness could be accounted for, using a projector that modulates the brightness based on its distance and rendering software that takes the dynamic dpi into account
- The proposed system has the following limitations:
 - Stability achievable with an overhead projector not immediate replicable with a pen-mounted projector
 - Assumes pen-integrated camera based tracking will be available in the future
 - Significant issues remain to be researched: Providing mobile 3D location sensing, providing projector power, continued miniaturization of pen computation and mass storage, ergonomic considerations of the pen shape

What are the core research questions addressed by the work?

- How can visual feedback improve user understanding of digital product manipulation

What motivates the work?

- Difficulty of interpreting outputs from digital pen use

How does the work understand the usage, capabilities, and limitations of paper?

- Reliance on paper as a primary medium
- Digital pens used to expand paper functionality have little/no output
- o More difficult for users to interpret work

What is the target application domain of the work?

- Design spaces using digital pens to edit static documents
- o Specifically architectural domains (for proof-of-concept)

What are some proposed extensions to paper proposed by the work?

- Spatially aware digital pen projection to provide real-time feedback on digital manipulation
- o Level overlay, interactive menus, copy & paste information

How are the proposed extensions implemented?

- Proof-of-concept design: digital pen linked w. external projector
- o Sufficient projection technology not existent at time of writing

What are the results of the work?

- Dependence on projection design improvement
- Stability of ceiling-mounted projector must be compensated for (ideas presented)
- Proof-of-concept successfully displayed many functionalities

What are the implications of the results for future designs and implementations of paper-based technologies?

- Future implementations using sufficiently advanced technology to develop on proof-of-concept