
A Pen-top Interface for Interactive Paper

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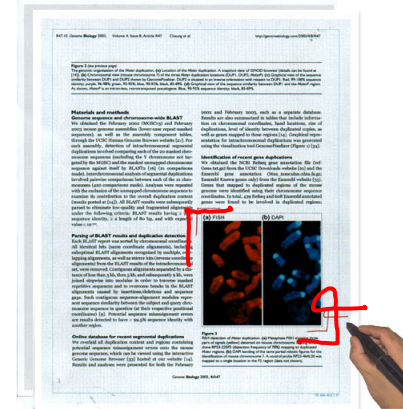
Paper + Computer ?

- PapierCraft

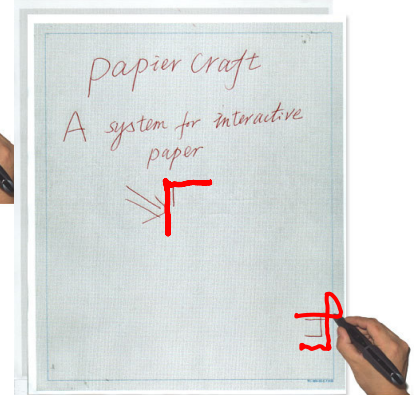
- A pen gesture based command system well adapted for paper

- Key aspects

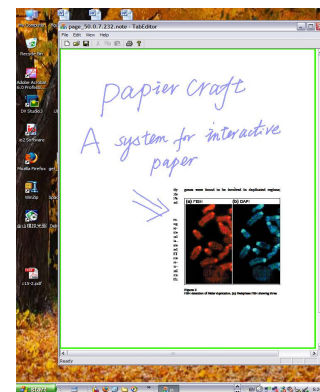
- Manipulate digital documents directly on paper
 - Copy/paste, hyperlink, email
- Keep **ALL** paper flexibilities
- Highly portable



Copy/paste on paper



pen synchronization



Browse, search and manage results on computers

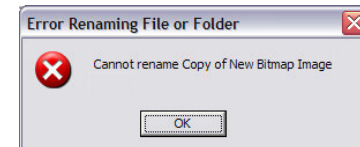
Challenge : real time feedback is limited

- Users want feedback on paper
 - Status
 - Mode, colors, selection confirmation
 - Error detection
 - Gesture recognition errors
 - *Interface discovery*
 - Special for paper interfaces
 - Information for specific applications
 - Search a word in printout
 - Use digital dictionaries on paper

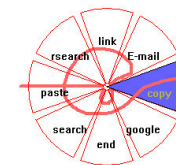
interfaces on computers :



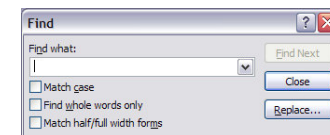
mode



error message



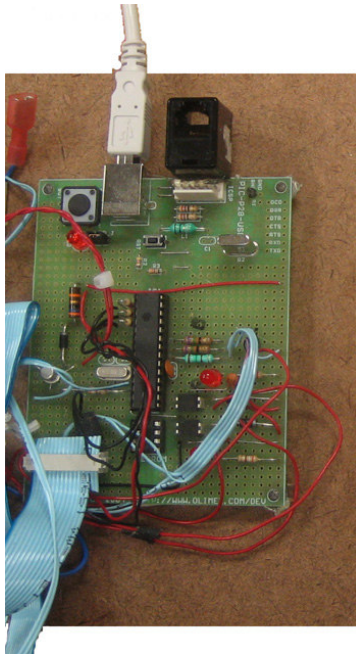
Pie menu



dialog box of "search"

A multimodal pen for paper only interfaces

- Introduce real time pen-top feedback to PapierCraft
- Explore applications with paper-pen only interfaces



Microcontroller for the pen-top LEDs and vibration motors



Tactile
(Vibration motors)



Auditory
(sound and speech
simulated by a PC)



Visual (LEDs)

Video



Related work

- Pen-top feedback
 - Haptic Pen [Lee, et al., UIST'04]
 - FLY Pen [Leapfrog Corp.]
- Computer-coupled feedback
 - Digital Desk [Wellner, ACM Comm'93]
 - PaperLink [Arai, et al., CHI'97]
 - A-Book [Mackay, et al., UIST'02]






FLY Pen

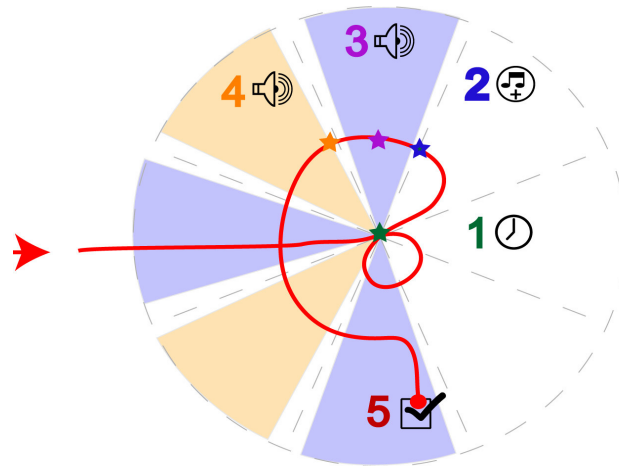
Designs goals about feedback schemes

- Quick, salient but unobtrusive
 - Easy to learn
 - Maximize performance both novices and experts
-

Findings through pilot user studies

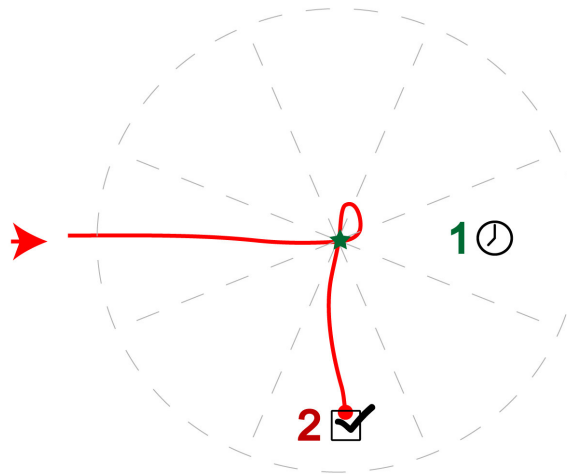
modality	Bad experiences	Good experiences
 Visual	<ul style="list-style-type: none">♦ Flashing LEDs for a long time♦ Complex color coding♦ Tracing marking menu	<ul style="list-style-type: none">♦ LEDs in solid color♦ Slow change for status indication
 Auditory	<ul style="list-style-type: none">♦ Lasting and repetitive sounds♦ Tracing marking menu	<ul style="list-style-type: none">♦ Speech for details
 Tactile	<ul style="list-style-type: none">♦ Vibrating for a long time♦ Tracing marking menu	<ul style="list-style-type: none">♦ Short vibrations for error indication

Gesture level feedback scheme for novices



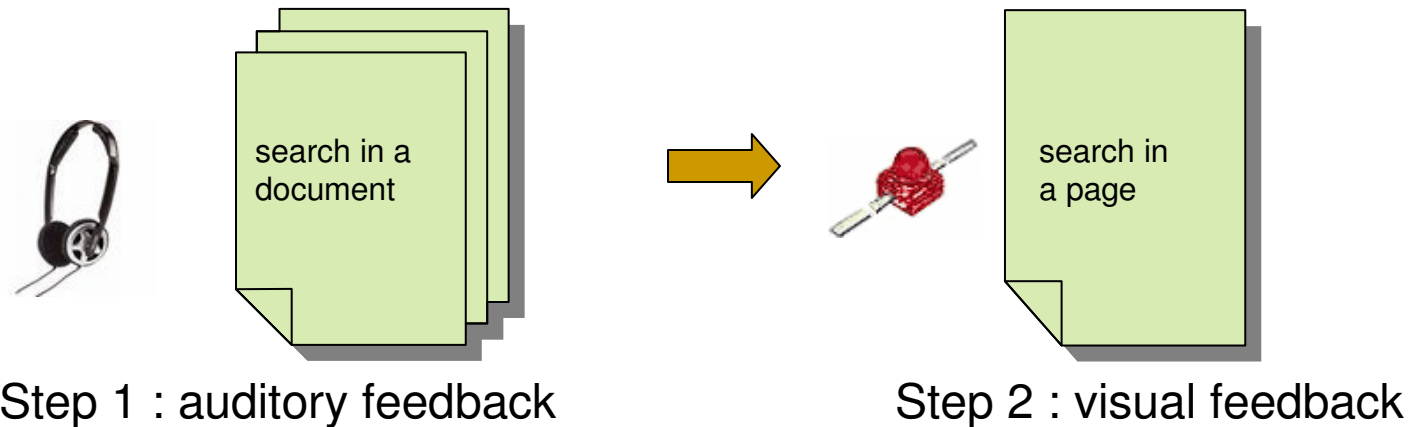
Events/Operations	Feedback
<i>Mode</i>	A LED in solid color
<i>Boundary warning</i>	Brief vibration; a short “bubble” sound
<i>Command selection</i>	A brief LED pulse for confirmation
<i>Error detection</i>	A flashing LED, vibration and optional speech (for detailed error messages)
<i>Interface discovery</i>	Speech and a LED in solid color (with 500ms delay)

Gesture level feedback scheme for experts



Events/Operations	Feedback
<i>Mode</i>	A LED in solid color
<i>Boundary warning</i>	Brief vibration; a short “bubble” sound
<i>Command selection</i>	A brief LED pulse for confirmation
<i>Error detection</i>	A flashing LED, vibration and optional speech (for detailed error messages)

Application level feedback scheme



Events/Operations	Feedback
<i>Search</i>	Speech for rough scope; a LED for precise position within the target page

User study

■ Hypotheses

- H1 : The pen helps novice users learn paper interfaces
- H2 : The pen helps experts reduce error without loss performance

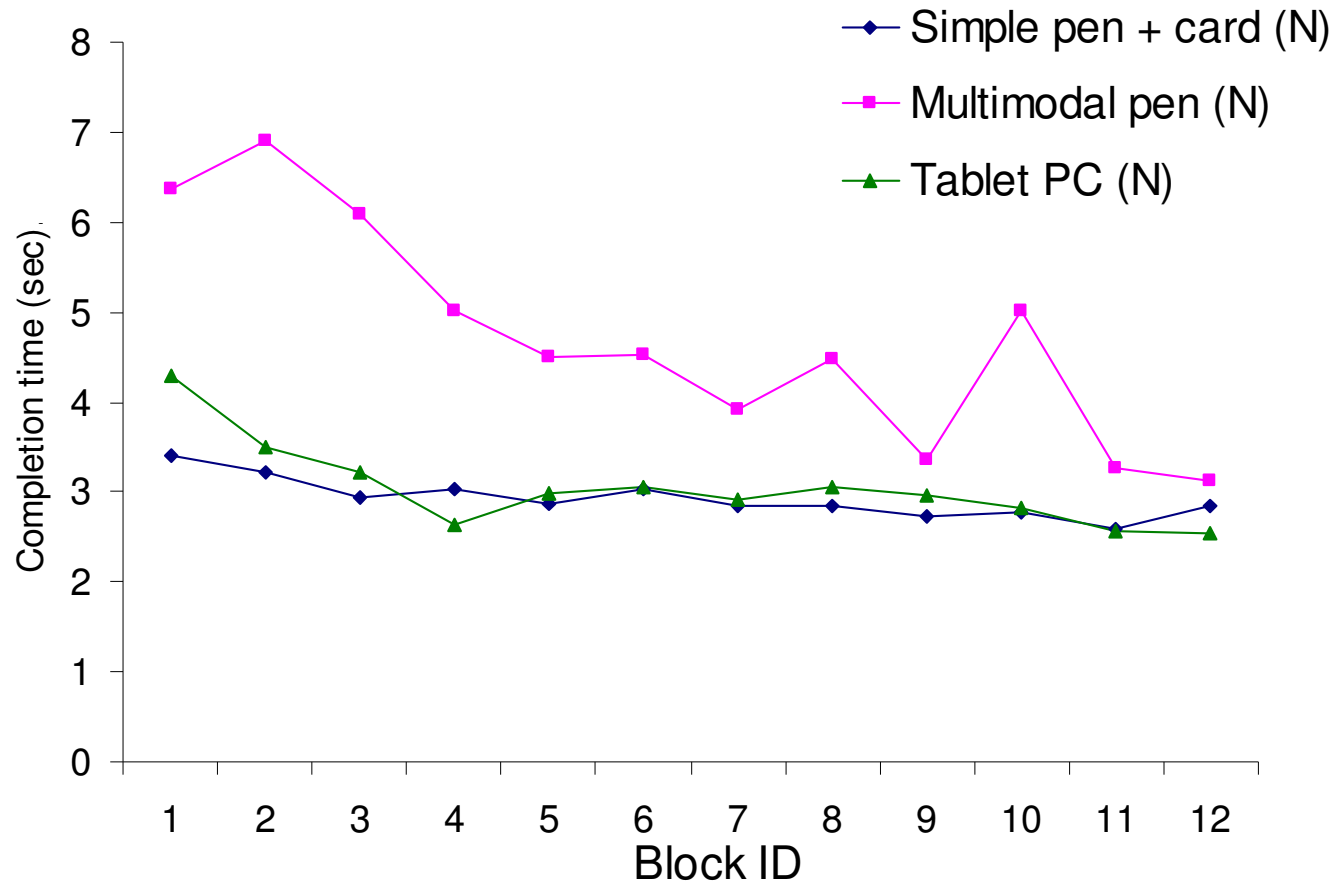
■ Experiment setting

- Three conditions :
 - Simple, Multimodal pen and Tablet
- Two sessions :
 - Novice, expert
- Task :
 - draw PapierCraft gestures



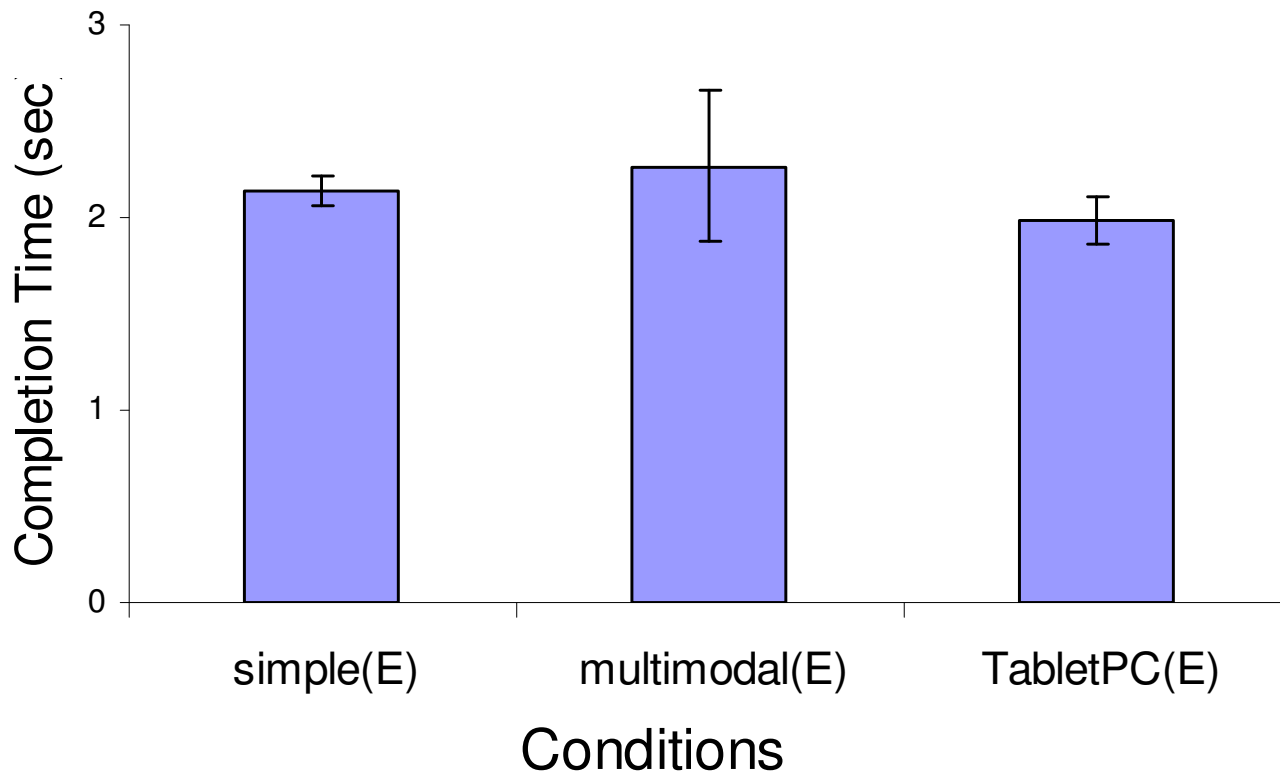
Learning effect

- Users are able to learn a new paper interface quickly



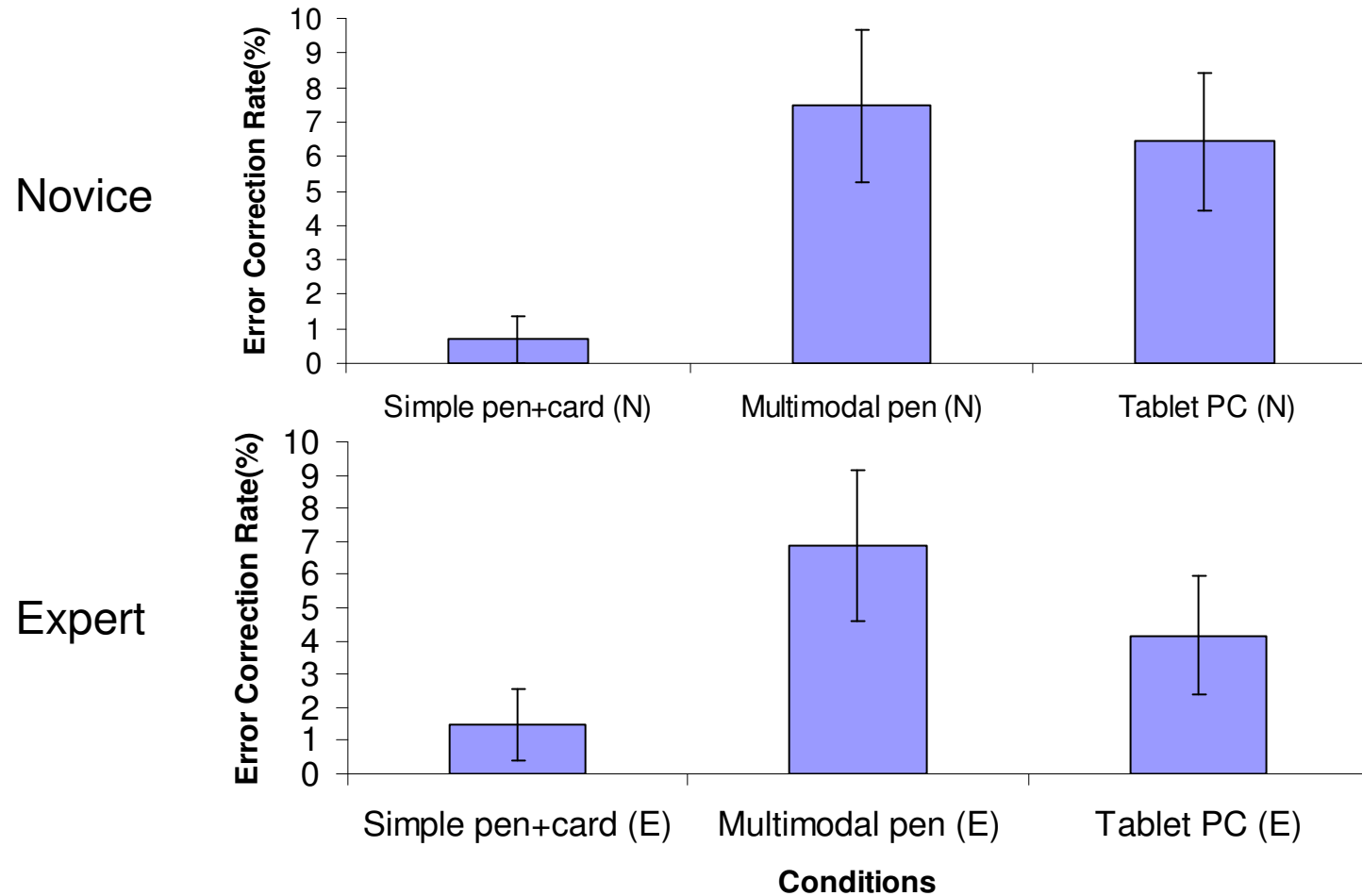
Impact on completion time

- No significant performance loss for expert users



Impact on error correction behavior

- Users are more confident and tend to more corrections



Future work

- Evaluation of task level interactions
 - Lookup dictionary
 - Navigate hyperlinks within printouts
 - Explore more visual feedback mechanisms
 - LCD, portable laser projector and PDA
 - Adaptive feedback based on available resources
 - Discovery and use of auxiliary displays and mobile devices
 - for example “Google on paper”
-

Conclusion & Take-away Messages

- An experiment platform to explore pen-top feedback mechanism and potential applications with paper-pen only interfaces.
 - A pen provides multimodal feedback to enhance paper-based interfaces such as PapierCraft.
 - User study shows that the feedback design is effective for novice users to learn new interfaces and generally encourage more error corrections.
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Questions ?

