Sensor-Based Interaction and Digital Reading Appliances

Outline

1 Touch Me, Squeeze Me, Tilt Me

4 Touch Mouse

2 XLibris Reading Appliance

3 Sensors for Mobile Interaction

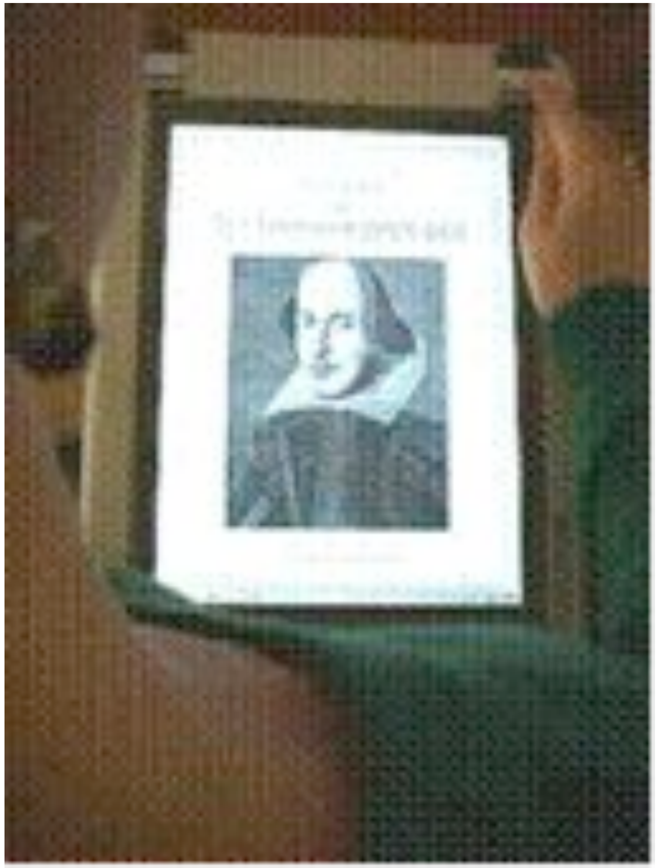
Direct Manipulation

- Coined by Shneiderman
  - Files can be dragged into folders
  - Folders can be opened up
  - Moving the mouse moves cursor and objects directly
    - (vs “move 15 to right”)

Squeeze Me, Hold Me, Tilt Me

- Group at PARC was investigating even more direct manipulation for PDAs
  - Make squeezing, holding, tilting the input
  - Xerox is the document company, also looking at e-books
- Tasks
  - #1 Navigation within a book or document
  - #2 Navigation through long sequential lists
  - #3 Document annotation

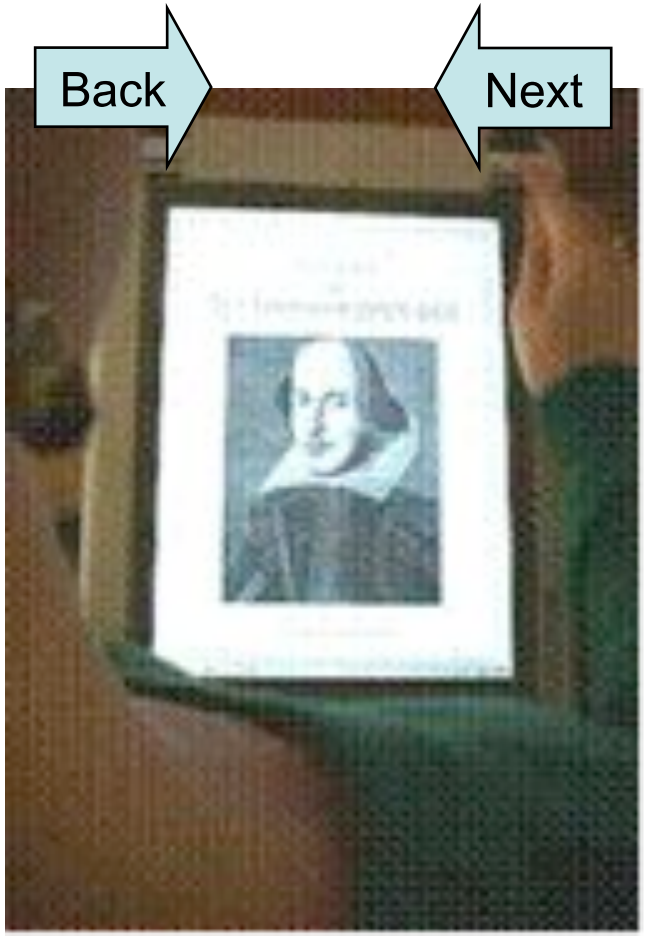
#1 – Turning Pages in a Document



- Large portable computer display
  - E-book like properties
  - page-sized screen, XGA resolution, pen input

#1 – Turning Pages in a Document

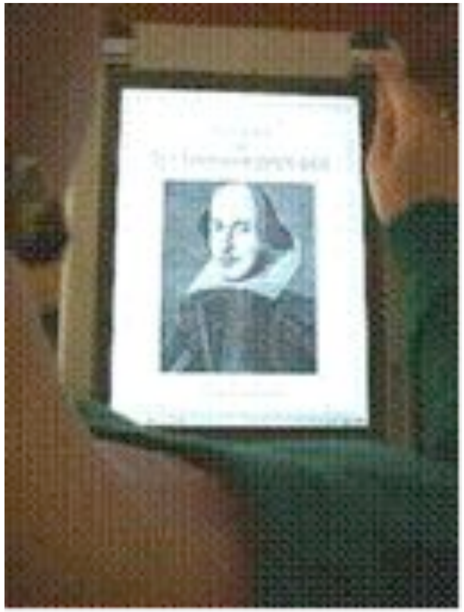
- Pressure sensors in corners
  - No extra screen real estate
  - Cheaper than pressure-sensitive screen
  - Mimics real page turning
- Interaction
  - Right-to-left in upper right → next page
  - Left-to-right in upper left → back page
  - Page flip sound
- Conjectures on user study results?



#1 – Turning Pages in a Document

- Lessons from informal user studies
  - Image looks like a book, people learned flicking quickly
  - Originally no animation, people got disoriented, later added
  - Audio feedback annoying

- Physical effects principle
  - *virtual* effect of a physical manipulation should be compatible with *physical* effect manipulation in the analog task
  - (where it makes sense)



#2 – Traversing a Sequential List

- Rolodex
  - Each card has one contact
  - Cards form circular list
  - User turns wheel by a knob
    - scroll in either direction
    - control the rate of scrolling
    - stop scrolling too

#2 – Traversing a Sequential List

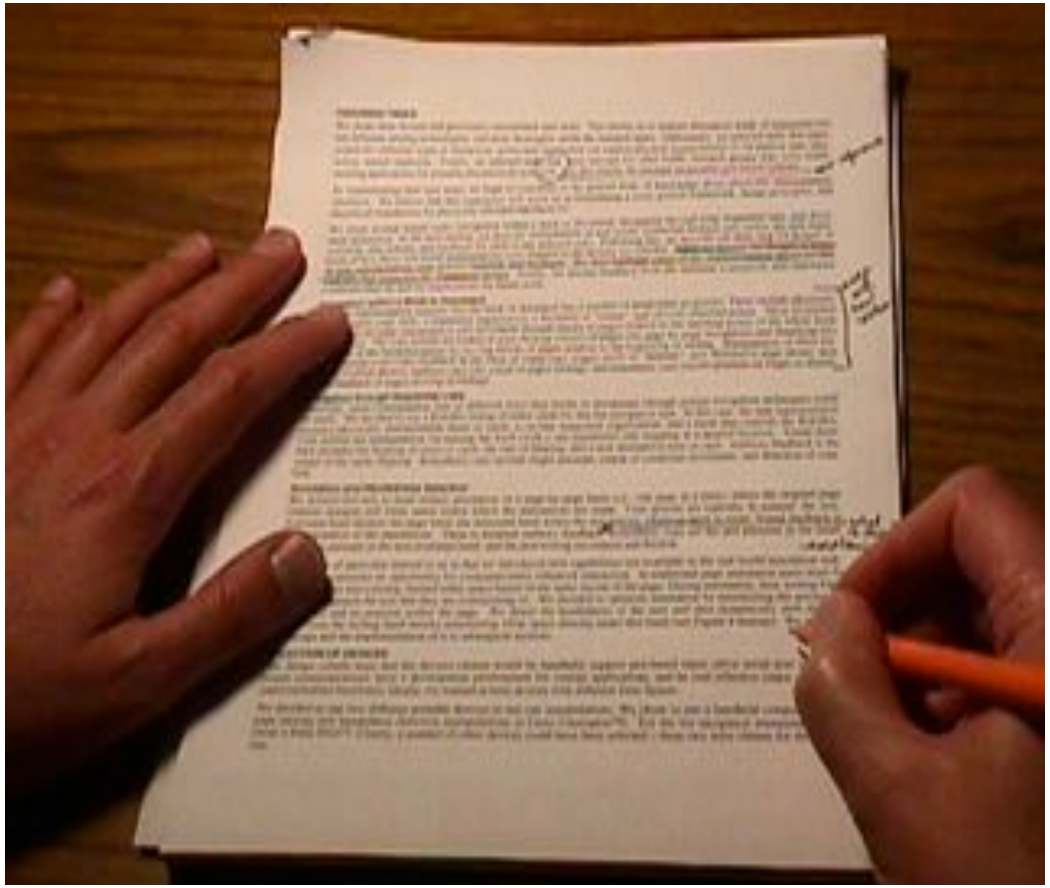
- Tilting lets you change the card shown
  - More tilt means faster
- Conjectures on user study results?

#2 – Traversing a Sequential List

- Problem with stopping
  - Going back to no tilt was annoying
  - Couldn't always see screen either
- Added a squeeze feature to stop

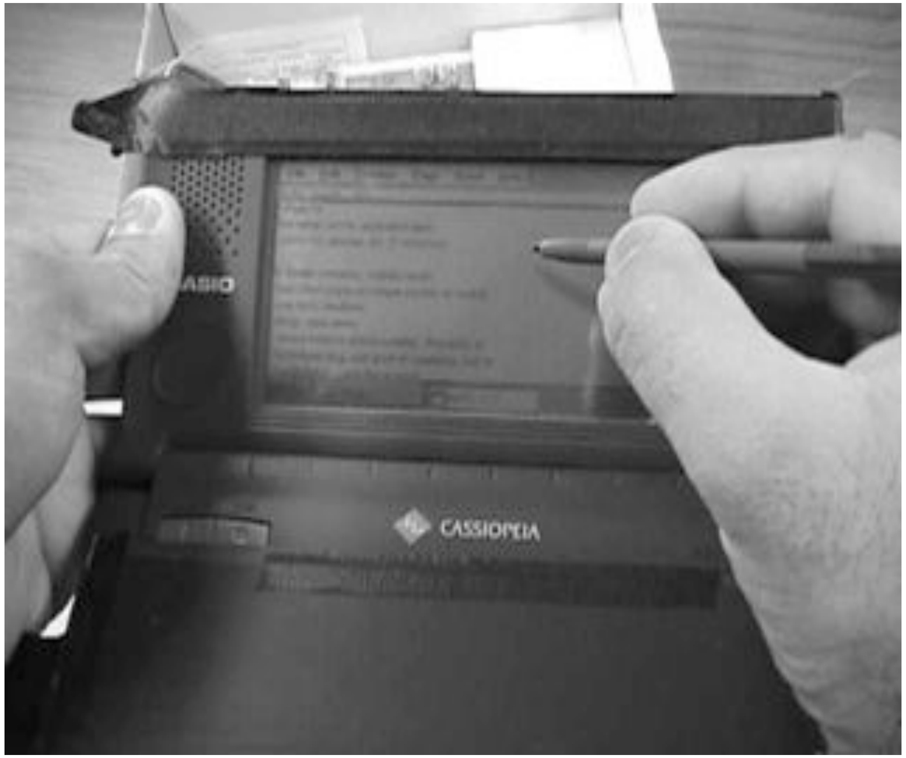
- Accidental vs intentional actions?
  - Squeeze to start as well
  - Tried adding foam on side as affordance
- User reactions
  - Have to avoid extreme angles
  - 6 different scrolling rates overall, at just noticeable difference

#3 – Annotating a Document



#3 – Annotating a Document

- Bimanual input
  - Non-dominant hand holds
  - Dominant hand writes



- Implementation
  - Pressure sensors to detect handedness
  - People tended to grip edges
  - Document shifted toward side, more space to write

#3 – Annotating a Document

- User reactions
  - Worked amazingly well
  - All users got it immediately
  - No mistakes in sensing either (sensors on lid)
- Thoughts
  - Rather than just copy real-world, can also augment it

Discussion

- Sensing worked well by leveraging familiar metaphors
  - Once people saw it, they got it
  - But also had to learn what the limits were
- Sensor issues
  - Cost (mostly cheap, but mass production costs)
  - Correct placement of sensors
  - Note that a simple switch might be good enough for page turning and traversal
- Main point:
  - Simple sensors can support natural interactions

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Building on Touch, Squeeze, Tilt

- Commercial E-Book Readers
  - Softbook and RocketBook

Building on Touch, Squeeze, Tilt

- Commercial E-Book Readers
  - EU Newspad and Librus Millennium E-Book

Building on Touch, Squeeze, Tilt

- XLibris
- Address two problems:
  - People don't like reading online
  - Paper easy to use, comfortable, portable
- So…
  - What properties of paper must we imitate?
  - What are advantages of reading online and how to support?
- Similar (but better-defined) strategy as before:
  - Imitate real world where necessary
  - Do better than real world where possible

XLibris

- **Passive vs Active Reading**

XLibris

- **Passive vs Active Reading**
- Passive reading
  - Entertainment
- Active reading
  - Critical thinking, comparing, note-taking, annotation

- **Single vs multiple**
- Single
  - Tasks include bookmarking, navigating
- Multiple
  - Tasks include piling, sorting, filtering, navigating

Table 1. Categories for reading situations.

	Passive	Active
Single text	Enjoying a novel, reading a poem aloud	Studying a textbook, reviewing a proposal, diagnosing with a manual
Multiple texts	Keeping up with e-mail, browsing the newspaper, surfing the Web	Researching a problem, surveying a field, keeping up-to-date professionally

Pros of Paper

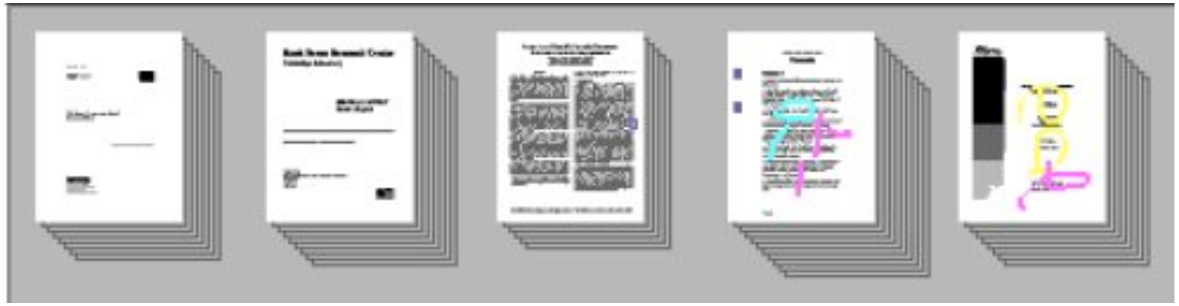
- Sharpness and resolution
- Easy to move to avoid glare, bring to focal length
- Fixed page layout, better spatial memory, easy to flip
  - In contrast to monitors, see only part of page
- Free-form annotations easy (vs mouse and keyboard)
- Physical mobility
- Multiple display surfaces
- Easy to share
- (Doesn’t crash, no power required)

Imitating Paper

- Hi-res portable display
- Fixed page layout
- Ink-based annotations
- Easy to flip pages (pressure sensors again)

Doing Better than Paper

- Distribution and mobile access
  - Timely, fast, cheap
  - Can carry lots of documents too

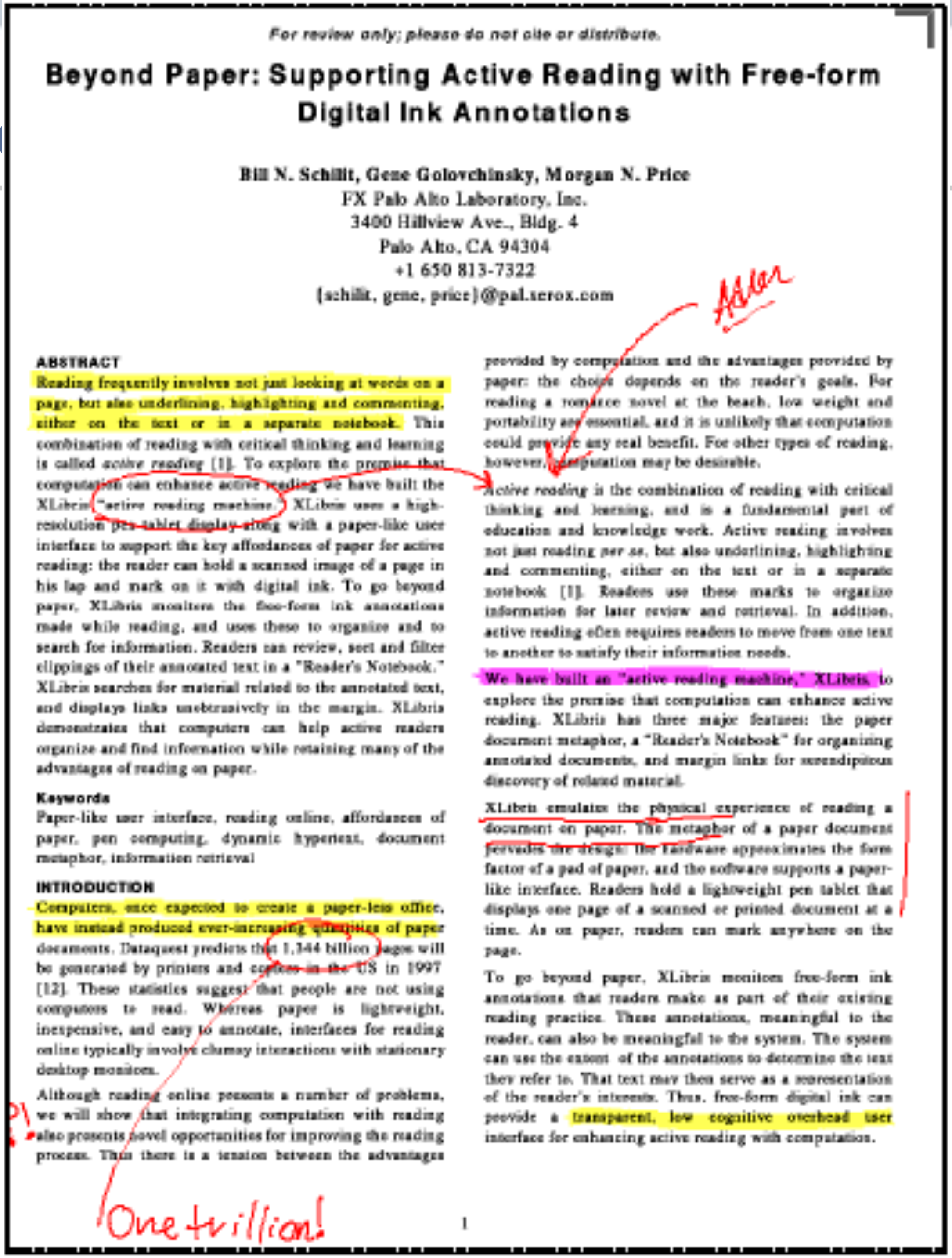


- Organizing, searching, filtering
- Further reading

Further Reading

- Automatically generated a further reading list based on your annotations
  - Marking specific words auto generates query on words
  - Marking passages looks for related phrases
  - Currently searches documents on device, could extend

Furth



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Beyond Paper: Supporting Active Reading with Free-form Digital Ink Annotations

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ABSTRACT
Reading frequently involves not just looking at words on a page, but also underlining, highlighting and commenting, either on the text or in a separate notebook. This combination of reading with critical thinking and learning is called *active reading* [1]. To explore the premise that computation can enhance active reading we have built the XLibris "active reading machine." XLibris uses a high-resolution pen tablet display along with a paper-like user interface to support the key affordances of paper for active reading: the reader can hold a scanned image of a page in his lap and mark on it with digital ink. To go beyond paper, XLibris monitors the free-form ink annotations made while reading, and uses these to organize and to search for information. Readers can review, sort and filter clippings of their annotated text in a "Reader's Notebook." XLibris searches for material related to the annotated text, and displays links unobtrusively in the margin. XLibris demonstrates that computers can help active readers organize and find information while retaining many of the advantages of reading on paper.

Keywords
Paper-like user interface, reading online, affordances of paper, pen computing, dynamic hypertext, document metaphor, information retrieval

INTRODUCTION
Computers, once expected to create a paper-less office, have instead produced ever-increasing quantities of paper documents. Dataquest predicts that 1,344 billion pages will be generated by printers and copiers in the US in 1997 [12]. These statistics suggest that people are not using computers to read. Whereas paper is lightweight, inexpensive, and easy to annotate, interfaces for reading online typically involve clumsy interactions with stationary desktop monitors.

?!

Although reading online presents a number of problems, we will show that integrating computation with reading also presents novel opportunities for improving the reading process. Thus there is a tension between the advantages provided by computation and the advantages provided by paper: the choice depends on the reader's goals. For reading a romance novel at the beach, low weight and portability are essential, and it is unlikely that computation could provide any real benefit. For other types of reading, however, computation may be desirable.

Active reading is the combination of reading with critical thinking and learning, and is a fundamental part of education and knowledge work. Active reading involves not just reading *per se*, but also underlining, highlighting and commenting, either on the text or in a separate notebook [1]. Readers use these marks to organize information for later review and retrieval. In addition, active reading often requires readers to move from one text to another to satisfy their information needs.

We have built an "active reading machine," XLibris, to explore the premise that computation can enhance active reading. XLibris has three major features: the paper document metaphor, a "Reader's Notebook" for organizing annotated documents, and margin links for serendipitous discovery of related material.

XLibris emulates the physical experience of reading a document on paper. The metaphor of a paper document pervades the design: the hardware approximates the form factor of a pad of paper, and the software supports a paper-like interface. Readers hold a lightweight pen tablet that displays one page of a scanned or printed document at a time. As on paper, readers can mark anywhere on the page.

To go beyond paper, XLibris monitors free-form ink annotations that readers make as part of their existing reading practice. These annotations, meaningful to the reader, can also be meaningful to the system. The system can use the extent of the annotations to determine the text they refer to. That text may then serve as a representation of the reader's interests. Thus, free-form digital ink can provide a transparent, low cognitive overhead user interface for enhancing active reading with computation.

One trillion!

Further Reading

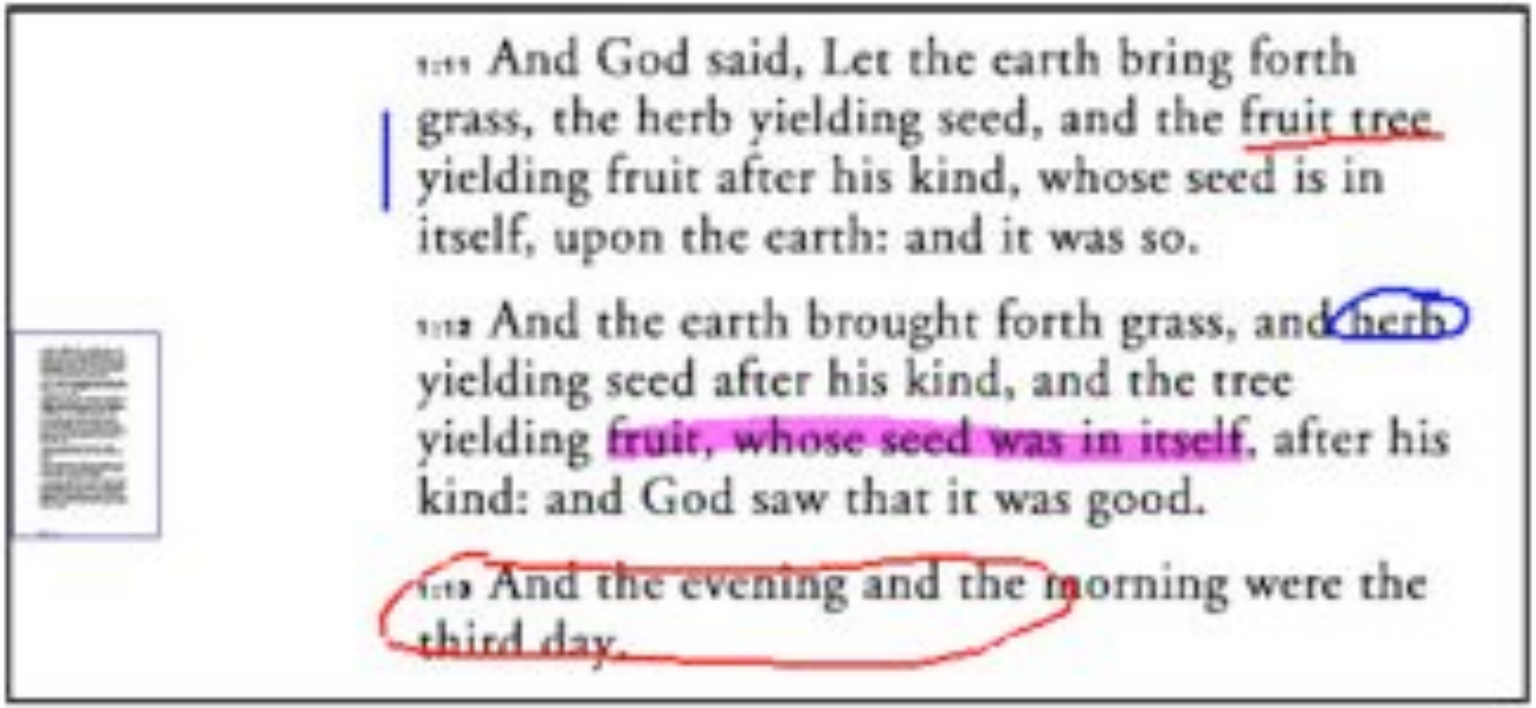


Figure 7. Examples of highlighting, underlining, circling, and margin annotations. Each annotation generates a query. If a good match is found, XLibris adds a margin link (rectangle on the left) that shows the thumbnail of the destination page.

Further Reading

Further reading list for Queries - Links - Is there a difference

What the Query Told the Link - The Integration of Hypertext and Information Retrieval

users with the power and flexibility of sophisticated information retrieval algorithms. Much additional research is necessary to determine which aspects of interfaces facilitate exploration, and what implications such interfaces have on the design of search engines.

produce effective solutions for a class of information exploration tasks.

This work also has implications for models of information exploration (e.g., [37]) that posit a distinction between selecting anchors and forming

Toward Active, Extensible, Networked Documents - Multivalent Architecture and Applications

program, and the same techniques used in graphical user interfaces could be applied. That is, functionality common to most multivalent documents, searching perhaps, would be standardized, and other

model-view-controller paradigm [Kras88] which maintains a single shared model in support of multiple views.

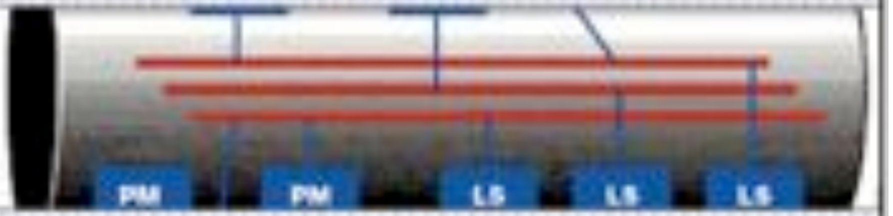
Initially in Figure 6 on the previous page, the user is studying a page from the document in his client, the client has a reference to

functions could be placed into menus of commands. Behaviors that introduce interaction modes would first be required to register the

The Stanford Digital Library Project

describes information management tasks and objects. Using the protocols, users can navigate and manage the "information space" in a consistent and unified way.

Figure 1 provides a conceptual view of the Infor-



The Roles of Digital Libraries in Teaching and Learning

with information resources specific to the goals of each organization. The main information resources for professional learning, however, are personal collections of books, reports, and files; subscriptions to journals; and

making data sets collected by scientific projects available to broader communities of users. International efforts such as the Earth Observing System and the human genome project demand large investments of

Doing Better than Paper

- Distribution and mobile access
  - Timely, fast, cheap
  - Lots of documents too
- Organizing, searching, filtering
- Further reading
- Supporting different modes of reading
  - Translation
  - Skimming

Skimming Mode

- Emphasize important words
- De-emphasize common words
- Some magazines use similar tactics

INTRODUCTION

Alan Newell's plenary address at INTERCHI '93, titled "CHI for Everyone," argued that by extending our vision of **interface design** to encompass extraordinary users, we would not be limiting the applicability of our work. Instead, we would discover and refine new **interaction techniques** which would be of use to the general user community. A current **interface design challenge** is developing interfaces which **provide access to graphical user interfaces** for people who are blind [1]. Even the goal itself sounds like an oxymoron. The **design issues** in translating an interactive, spatially presented, visually dense interface into an efficient, intuitive and non-intrusive **nonvisual interface** are numerous. Moreover, practical concerns such as using affordable hardware while **providing access** to many **application interfaces** transparently to the **graphical applications** adds to the complexity of the task [18].

Skimming Mode

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Pros of Reading Appliances

- Distribution and mobile access
  - Timely, fast, cheap
  - Lots of documents too
- Organizing, searching, filtering
- Further reading
- Supporting different modes of reading
  - Translation
  - Skimming
- Reviewing annotations

Reviewing Annotations

- Too easy to lose real-world annotations
- View all annotations across all pages

- View annotations across all docs too
  - Linked to pages
  - Organized by time


Beyond Paper: Supporting Active Reading with Free-form Digital Ink Annotations
Bill N. Schilit, Gene Golovchinsky, Morgan N. Price
good ideas
また、ROA(総資本税引き前利益率)も、前期から0.8ポイント改善し10.4%の二桁台を達成し、'92年に設定した"97年度に10%台のROA"という高い目標を達成しました。継続して資産の効率化をはかり、特に'97年度はゼロキャッシュ・マネジメントを目指し
(c) USE OF INFORMATION FOR VERIFICATION
Nothing in this chapter shall restrict any person from
XYZ Division Performance Report
Research Units
Paul, September XYZ Research Units total spending of $9.5 million was $1.5 million under Plan. The underrun was mainly due to delayed staffing and expense deferrals.
why so much?
Strengthened Fuji Xerox Partnership
Japanese market leader
Color
Digital
Rick — great ideas come from this partnership!
Xerox to Launch Digital Network Laser Printers

Recap

- Imitate paper as much as possible
  - Hi-res
  - Portable
  - Fixed page-layout
  - Annotations
- Augment e-books to increase utility
  - Distribution and mobile access
  - Organizing, searching, filtering
  - Further reading
  - Skimming
  - Reviewing annotations

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3 Sensors for Mobile Interaction

Sensing for Interaction Techniques

- Simple sensors to tell context of interaction
  - Primarily how the device is being held
  - Commodity costs
  - Low-power consumption
- Used to improve interaction techniques
  - Holding device in certain ways → intended or likely actions
  - In some cases can automatically “do the right thing”
    - Very natural if done well

Sensing in a Modified PDA

Video

IR Proximity Sensor

- Determine rough distance to an object
  - 5 to 40cm range
- Has IR emitter and receiver
  - Similar to TV remote
  - IR light modulated at 40Khz

- Works by measuring amount of reflection
  - Different readings for different surface types and sizes of object
  - But actually pretty consistent
    - Here we are mostly looking at the same thing (skin) anyway

Touch Sensors

- Conductive paint
  – Senses capacitance
  – Signal changes when you are touching it

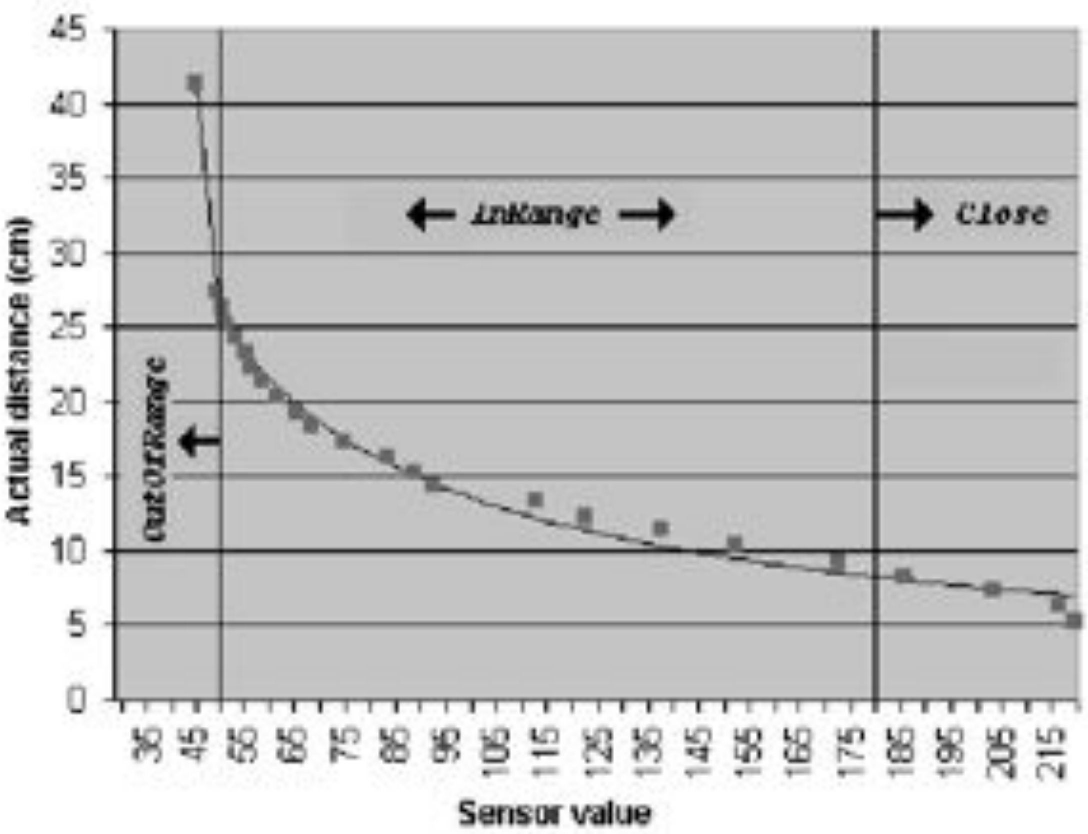
- Two separate sensors
  – “Holding” sensor on back and sides
  – “Bezel” sensor at edge of screen

Tilt Sensor

- 2D Accelerometer (in plane of device)
  - Gravity provides constant acceleration (1G)
  - Direction of acceleration vector $\Rightarrow$ x,y tilt
  - Also can detect patterns of movement
- Done with single chip
  - Cheap and relatively easy
  - Implemented with MEMS
    - Microelectromechanical systems
    - Lots of new sensors soon using this technology

Processed Values From Sensors

- Proximity
  - Estimate in cm
- ProximityState
  - Close < ~7cm
  - InRange ~7-25cm
  - OutOfRange
  - Duration in that state



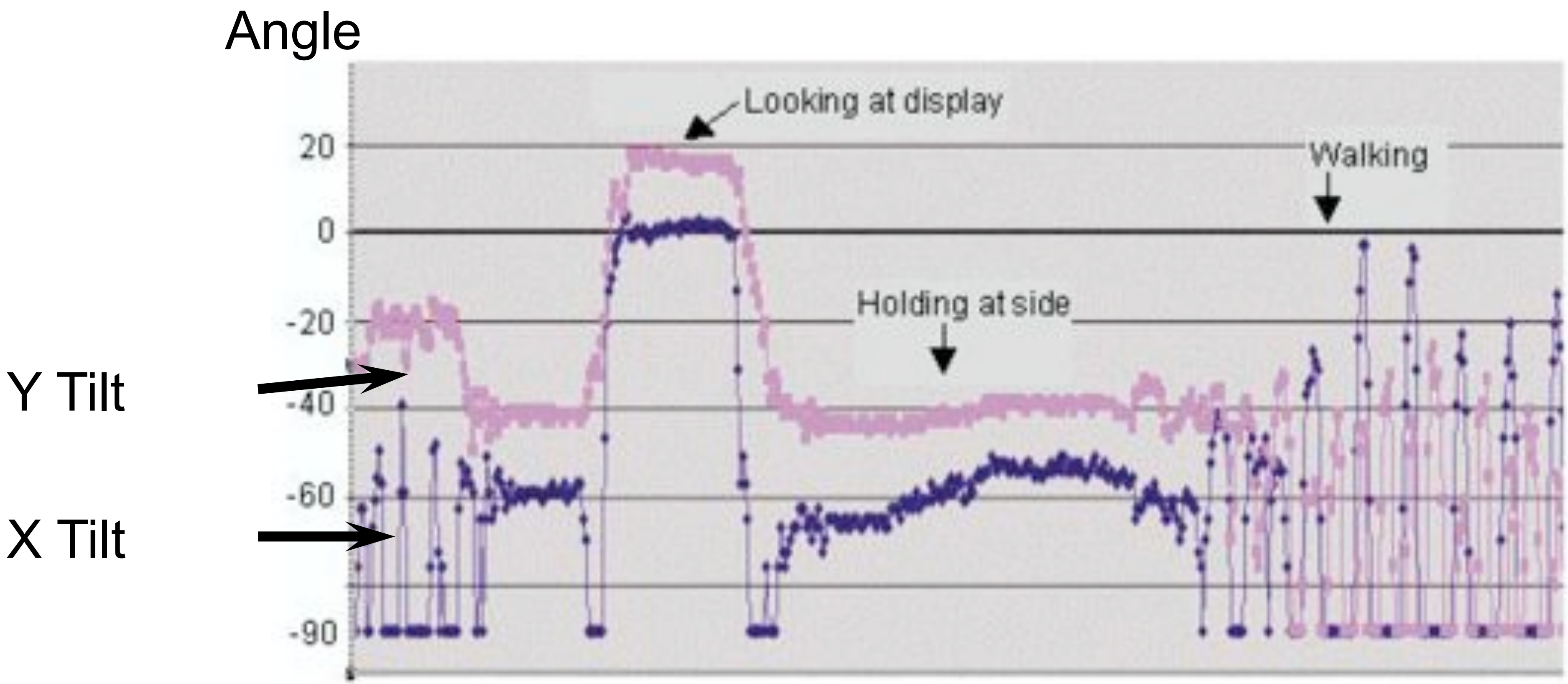
Contexts Inferred From Touch Sensors

- Holding (duration)
  - From back / side sensor
  - Is user holding the device and if so how long have they been holding it
- TouchingBezel (duration)
  - Similar for bezel touch sensor
  - Not considered to be touching it until duration > 0.2 sec
    - They use thresholds like this in a number of places

Contexts Inferred From Touch Sensors

- LookingAt(duration)
  - Small range of angles appropriate for typical viewing and how long there
  - Touch requirements added to this in later iteration
- Moving(duration)
  - Any movement and how long since last still period
- Shaking
  - Device is being shaken vigorously
- Walking(duration)
  - Detected by repetitive motion in 1.4-3Hz range

Contexts Inferred From Touch Sensors



Interaction Techniques

- Power on
- Voice memo recording
- Portrait / Landscape display mode selection
- Scrolling
  - LCD contrast compensation
- Display changes for viewing while walking

Lessons and Issues

- Sensor fusion
  - Multiple points of evidence to avoid false positives
    - E.g., “looking at” via both angle and touching instead of just angle

- Need designs tolerant of recognition errors
  - False positive or negative is not a catastrophe
  - But recognition errors can ruin interaction
    - Recovery costs can easily destroy benefits

Lessons and Issues

- Cross talk between techniques
  - Handled by explicit disabling
    - Event saying “We’re using that now”
      - Tilt for scrolling interferes vs display orientation
    - Used to disable other effects, ad hoc
  - This is a general issue that needs work
    - Probably needs some sort of general conflict resolution mechanism
    - But not clear what that is, or how to do it

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TouchMouse

- Basic idea: make computers aware of touch input
  - Augment input devices with “skin” that detects touch
  - Develop some interaction techniques demonstrating utility

TouchMouse

- Don’t touch-pads and touch-screens already support touch?
  - Goal here is to decouple position from touch
  - Argument is that touch without position is still useful

Detecting Touch

- Touch
  - Capacitive (humans are capacitors)
  - Infrared detection
- Pressure / Force
  - Weight sensors (cars)
- Proximity
  - Motion sensors (burglar alarms)
  - Electric field

- This paper uses Chemtronics conductive paint
  - Touching the mouse causes time delay in signal
  - Past threshold means “touch” or “release”

TouchMouse Apps

- *On-Demand Interface*
  - Alter screen if device is being touched or not
  - Ex. No mouse touch → toolbars no longer needed, so fade out toolbars and maximize screen real estate

TouchMouse

1

TouchMouse

2

TouchMouse

3

TouchMouse

- Useful because most toolbars don't show information about state
  - Shrink to a "compact" toolbar to maximize screen space
  - Also note that toolbars could probably be hidden when mouse has not moved for a while
- Uses alpha transparency to fade in and out
  - Less jarring transition
- Also fades out toolbars when scrolling
  - People tend to leave fingers on scroll wheel when reading

TouchMouse Apps

- *On-Demand Interface*
  - Alter screen if device is being touched or not
  - Ex. No mouse touch → toolbars no longer needed, so fade out toolbars and maximize screen real estate
- *Scrolling TouchMouse*
  - Add touch sensors at top and bottom of scroll wheel
  - Supports easy page up and page down

TouchMouse

- Also provided trackball for two-handed interaction
  - Use non-dominant hand for “toolglass”
  - Dominant hand for normal input

TouchMouse


Microsoft Word - CHI format.doc
CHI Conference Publications
John Doe

Lessons and Issues

- Big take away point
  - Knowing context of operation (e.g. how held) constrains space of possible current interactions
  - Less explicit actions needed
    - E.g., typically avoid button presses or other mode entry
  - Can result in simpler and more natural interaction

- Best case: Picking it up to do something causes it to do “the right thing”

Summary

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3 Sensors for Mobile Interaction

- Sensors can be used to enrich interaction
- Imitate real world where necessary, augment where possible

Processed \

	Context Variable	Description
Touch	Holding & Duration	Whether or not user is holding the device, and for how long. (direct reading of touch sensor)
	TouchingBezel, Dur	If the user is touching the screen bezel, and for how long. (bezel contact over 0.2 sec.)
Tilt/Accelerometer	TiltAngleLR, TiltAngleFB	The left/right and forward/back tilt angles, in degrees. (sensor reading & transform per fig. 3)
	DisplayOrientation & Refresh	*Flat*, *Portrait*, *LandscapeLeft*, *LandscapeRight*, or *PortraitUpsideDown*. A Refresh event is posted if apps need to update orientation.
	HzLR, MagnitudeLR, HzFB, MagnitudeFB	Dominant frequency and magnitude from FFT of tilt angles over the last few seconds.
	LookingAt & Dur.	If user is looking at the display.
	Moving & Duration	If device is moving in any way.
	Shaking	If the device is being shaken vigorously.
	Walking & Duration	If the user is walking.

Processed Values From Sensors

Proximity	Proximity	Estimated distance in cm to proximal object, if in range. (sensor transform per fig. 4)
	ProximityState & Duration	Close, InRange, OutOfRange (see fig. 4), AmbientLight (when out-of-range and bright ambient light is present).
Other	Scrolling	If the user is currently scrolling. (posted by scroll app)
	VoiceMemoGesture	If recording a voice memo. (posted by voice recording app)

Sensor Architecture

- Micro-controller constantly reads sensors (~400 samples / sec)
- Reports values to PDA via serial port
- “Broker” application on PDA receives and processes values
- Then makes information available to other applications via API
  - Polled values or events

Power On

- Micro-controller is on even when PDA is off
- PDA is powered up when you pick it up to use it
  - Holding in orientation for use
  - Specifically
    - Holding + LookingAt
    - In portrait orientation (but not Flat)
    - For 0.5 seconds

➢ Extremely natural interaction
  - Pick it up and its ready to use
  - Avoids most false positives

Voice Memo Recording

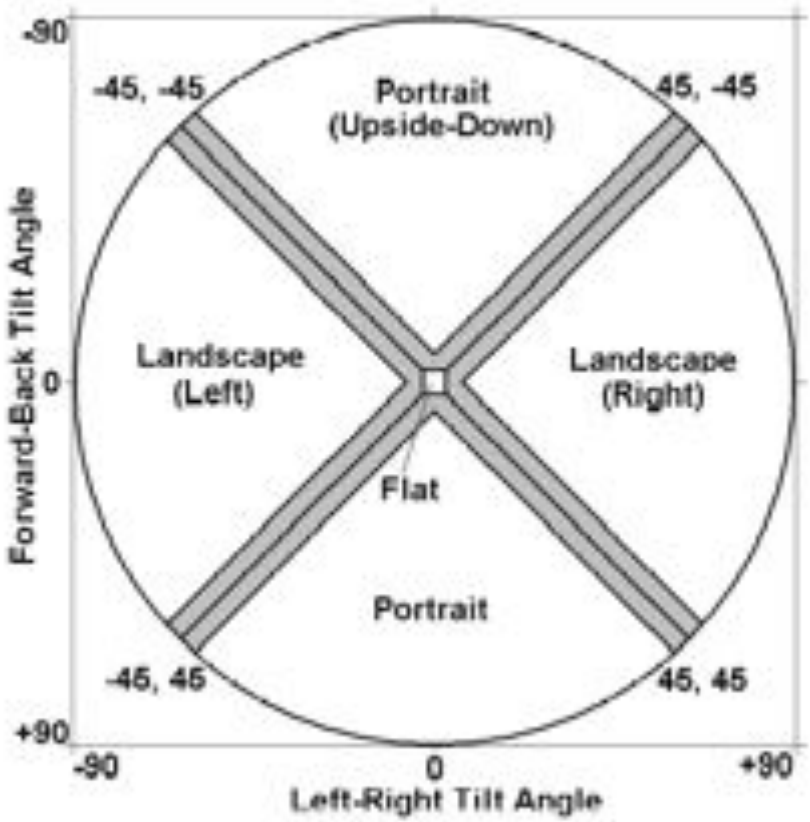
- Interaction: “Pick it up like a cell phone and talk into it”
- Holding + Proximity + proper orientation (tilt)
- Has audio feedback (critical)
  - – Click when pickup gesture recognized
  - – Beep to start recording
  - – Double beep at stop
    - Stop via loss of preconditions

➢ Again, very natural interaction:

  ➢ pick it up as necessary to do a particular thing and it does it

Display Mode Selection

- DisplayOrientation event / data
  - Flat, Portrait PortraitUpsideDown, LandscapeLeft, LandscapeRight
  - Also refresh event when changed
- Dead zones important
  - Must cross all the way through zone to count
- Flat is important
  - don’t change



Tilt Scrolling

- Must explicitly touch bezel touch area to enable
  - Not quite as nice, but still pretty easy
- Then tilt up, down, left, right to scroll
  - Rate controlled (exponential) with a dead band
- Extra touch: LCD contrast compensation
  - Adjusts contrast as you tilt to make things readable

Technique Interference

- Tilt for scrolling interferes with display orientation selection
  - Hence explicit clutch
  - Also “I’m scrolling now” event to disable across applications
- BUT… what about when you let go?
  - Can’t tilt back prior to releasing clutch
  - Not scrolling anymore once released
  - Disallow display change in direction of scroll tilt right after scroll
    - Also suggest a timeout for this effect

Viewing When Walking

- Future work in the paper (demo)
- If you hold the device in reading orientation
  - Hold + LookingAt

  and walk, it will increase font size, etc.
  - Again, detected by repetitive motion
    in 1.4-3Hz range