CS 338: Graphical User Interfaces

Lecture 8-1: Assistive Technology

Some materials adapted from / inspired by
Alistair Edwards & Elizabeth Mynatt's CHI tutorial notes

Today's topic

- GUIs and impairment
- What is impairment?
  - users with disabilities / special needs
  - users concentrating on other things
- Designing / building GUIs with impairment in mind

Some definitions (UN, 1981)

- Impairment

Any loss or abnormality of psychological, physiological, or anatomical structure or function.

- Disability

Any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being.

- Handicap

A disadvantage for a given individual, resulting from an impairment or disability, that limits or prevents the fulfillment of a role (depending on age, sex, and cultural factors) for that individual.

Some definitions

- Examples:

Impairment	Disability	Handicap
visual	seeing	orientation
skeletal	walking	mobility
cardio-respiratory	walking	mobility

Designing for disabled users

- Some interesting inventions were originally aimed to aid people with disabilities
  - telephone (as a hearing aid)
  - cassette tape (as "book on tape" for the blind)
  - ballpoint pen (easier than fountain pen)
- Many current attempts to design FOR ALL
  - "redundant interfaces"
    - e.g., Windows / MacOS file manipulation

Access vs. Prosthesis

- Computers for access
  - increasingly a part of daily life
    - email, web surfing, word processing, etc.
  - allowing all users to do basic computer tasks
    - e.g., typing with a modality other than your fingers
- Computers as prostheses
  - using a computer for a task for which you may not otherwise use a computer
    - cooking? cleaning? controlling the lights?

Practicality of designing for all

- How many people have disabilities?
  - varies by country, ~2-15% severe disabilities

Practicality of designing for all

- How many people have disabilities?
  - varies by country, ~2-15% severe disabilities
  - in the US population…
    - ~20% have some disability
      (limits their activity)
    - ~10% have severe disabilities
      (unable to perform major activity: working, etc.)
  - trends show these %s are increasing
- What is a "normal" computer user?
  - We're all disabled at some time, in some way!

Practicality of designing for all

- Rehabilitation Act, Section 508 (1998)
  - computer applications must be accessible to users with special needs
- What are the implications?
  - government is a big customer
  - manufacturers wouldn't normally make two versions
  - improvements are often good for all anyway

Types of impairment

- Motor
- Vision
- Speech
- Hearing
- Language

- Aging
- Multitasking

Motor impairment

- Lack of function
  - absence of limb
  - paralysis
- Lack of strength
- Lack of accuracy
- Lack of speed

- All these will likely affect GUI use
- Often, motor impairments have other effects
  - e.g., impaired speech

Keyboard modifications

- Main problem with a keyboard
  - small keys require fairly good accuracy
- Don't need to use your fingers!
  - stick w/ rubber tip, in mouth or on headband
- Bigger keys, different layouts

Alternative input

- Speech
- Joystick
  - easiest implementation: 4 switches
  - other implementation: proportional
  - commonly used on wheelchairs for control

- Trackball
  - less movement needed
  - buttons may be a difficulty

Alternative input

- Other basic switches
  - "sip-and-puff" switches
  - Morse code input
- Head movements
  - attach pointer to head to manipulate keyboard
  - use sensor to detect head turn/tilt and map to software functionality
- Eye movements
  - detect "gaze" and map to software functionality
  - we'll look at this more later

https://youtu.be/uWHkHOAwZA8

Vision impairment

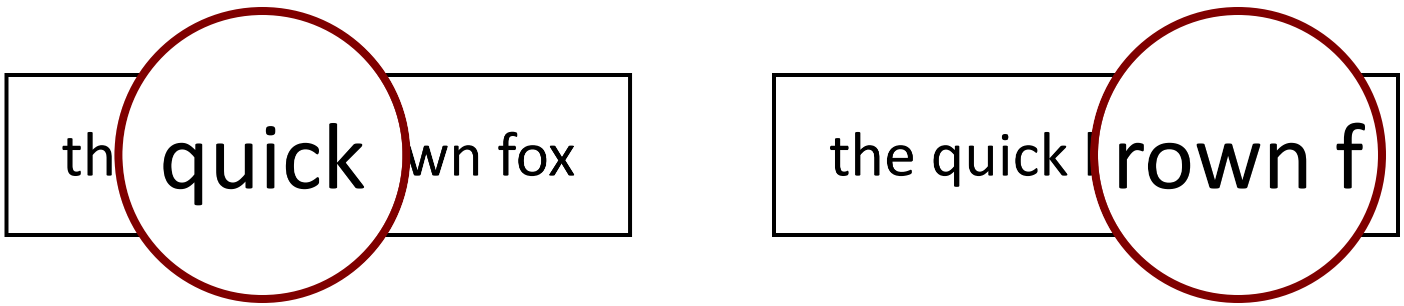
- 1.5 million Americans with "severe" visual impairment (unable to read a newspaper)
- Gradations of impairment
  - slight impairment
  - partially sighted / low vision:
    make use of whatever vision exists
  - blind / no sight: must use other modalities
- Different solutions for different severities
  - e.g., slight impairment --> wear glasses!

Low-vision solutions

- Sticking to basics can help a lot!
  - large monitor — keep things big
  - glare protection
  - fonts & font size
  - landmarks on keyboard — make things easy to find

Low-vision solutions

- Software magnification



  - track with mouse? eye tracker??

- Q: Why might this be a bad idea in some circumstances?

Solutions for the blind

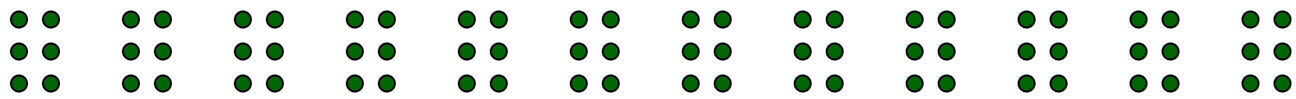
- Blind users can usually touch-type, so input isn't a problem
- Two common output methods
  - speech
  - Braille

Solutions for the blind

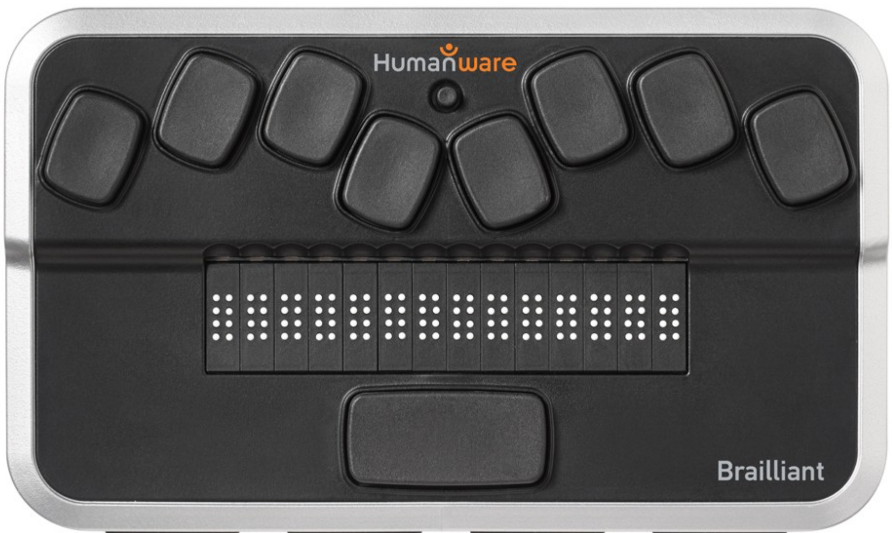
- Speech synthesis
  - good for almost all users
  - important issues
    - must be fast (~500 words/minute!)
    - must be interactive (shut up!)
    - must be synchronized (low latency)
    - must allow echoing of input
    - must indicate punctuation
  - quality of speech is actually less important
    - users hear the voice a great deal and get used to it

Solutions for the blind

- Braille output



  - changes pins to display Braille on a device
  - note: only 10% of adult blind user read Braille
  - still especially useful for very specific tasks (e.g. programming)



https://www.youtube.com/watch?v=390VQnmsqHM

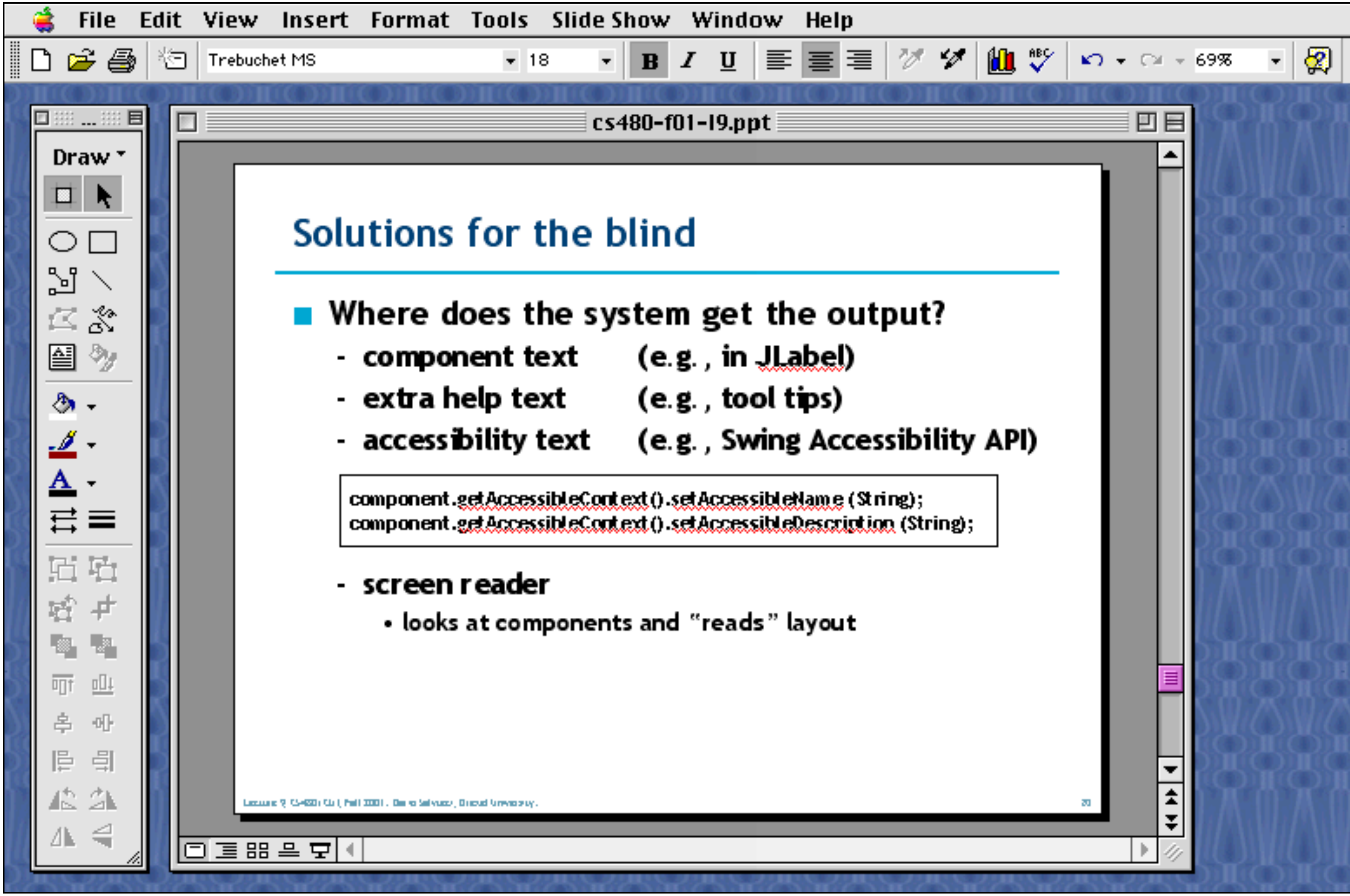
Solutions for the blind

- IBM Home Page Reader
  - screen reader for web pages
  - basic commands:

Spacebar	→	Begins reading from the current position on the page.
Control key	→	Stops speaking.
Left Arrow	→	Reads the previous paragraph.
Down Arrow	→	Repeats the current paragraph.
Right Arrow	→	Reads the next paragraph.
Home key	→	Moves back to the top of the page, and reads the first paragraph.
Tab key	→	Reads the next link. Links are spoken with a female voice.
Enter key	→	Activates a link, and opens a new page.
Alt key	→	Moves to the main HPR menu. Press Alt again to move back to where you were.
Ctrl + O	→	Provides a place to type the address of a Web page to open.

Exercise: Screen Reader

- The user wants to italicize every occurrence of "e.g." on the slide they're creating.
  - see next slide for the screen
- What commands can the user give the system to do this task?
- How can the computer give the user information and respond to commands?
- Think about this for a minute...


File Edit View Insert Format Tools Slide Show Window Help
Trebuchet MS
18
69%
Draw
cs480-f01-19.ppt
Solutions for the blind
Where does the system get the output?
- component text (e.g., in JLabel)
- extra help text (e.g., tool tips)
- accessibility text (e.g., Swing Accessibility API)
component.getAccessibleContext().setAccessibleName(String);
component.getAccessibleContext().setAccessibleDescription(String);
- screen reader
• looks at components and "reads" layout

Solutions for the blind

- Where does the system get the output?
  - component text (e.g., in labels)
  - extra help text (e.g., tool tips)
  - accessibility text (e.g., Swing Accessibility API)

```
component.getAccessibleContext().setAccessibleName (String);
component.getAccessibleContext().setAccessibleDescription (String);
```

  - screen reader
    - looks at components and "reads" layout

Hearing impairment

- One of the most common disabilities
  - 15 million Americans have some impairment
  - 2 million are deaf
- Important for GUI user?
  - typically not central, at least nowadays
  - but applications are becoming more multimodal…
    - e.g., video conferencing?

Addressing hearing impairment

- Well-known device for hearing impaired:
  TDD (Telecommunications Device for the Deaf)
  - transmit typed text directly to other person
  - for interaction with voice phone users, messages go through messaging center — a real person
    - yikes… privacy? intonation?
    - can also synthesize speech

Addressing hearing impairment

- Sign language recognition
  - user wears gloves, or signs in front of a wearable camera
  - system observe American Sign Language gestures
  - infer desired input
  - how do they do it?

  - to date, there still seem to be no commercial options — this is a hard problem

Cognitive impairment

- In some ways, a much deeper problem than the other impairments we've mentioned
  - affects more than just input / output
- Types of cognitive impairments
  - memory: trouble retrieving needed information
  - perception: trouble attending / discriminating (of course, related to visual / aural impairment)
  - problem solving: trouble recognizing problems, maintaining current goals, implementing solutions
  - concepts: trouble generalizing, learning

Addressing cognitive impairment

- Keep things simple!
- Recommendations include
  - simplify language, everywhere
  - provide multiple levels of help whenever possible
  - use consistent displays and procedures
- Use as a "cognitive prosthesis"
  - computer helps address impairments
  - e.g., reminders to take medication

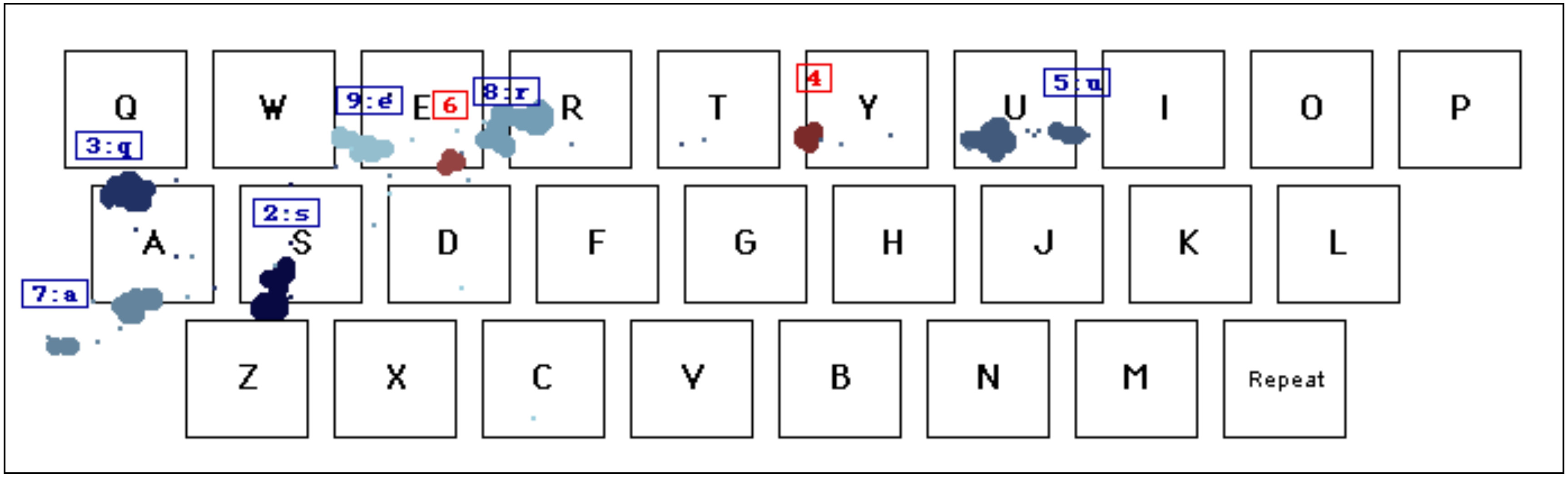
Language impairment

- Could go hand-in-hand with cognitive impairment
- But could also arise from language variability
  - foreign-born users
- There are sort-of solutions, like Google Translate
- Again, keep things simple

Speech impairment

- Also a common impairment
- Like language, closely related to the individual (such as native language)
- Like hearing, not essential to today's GUIs

Eye-gaze input



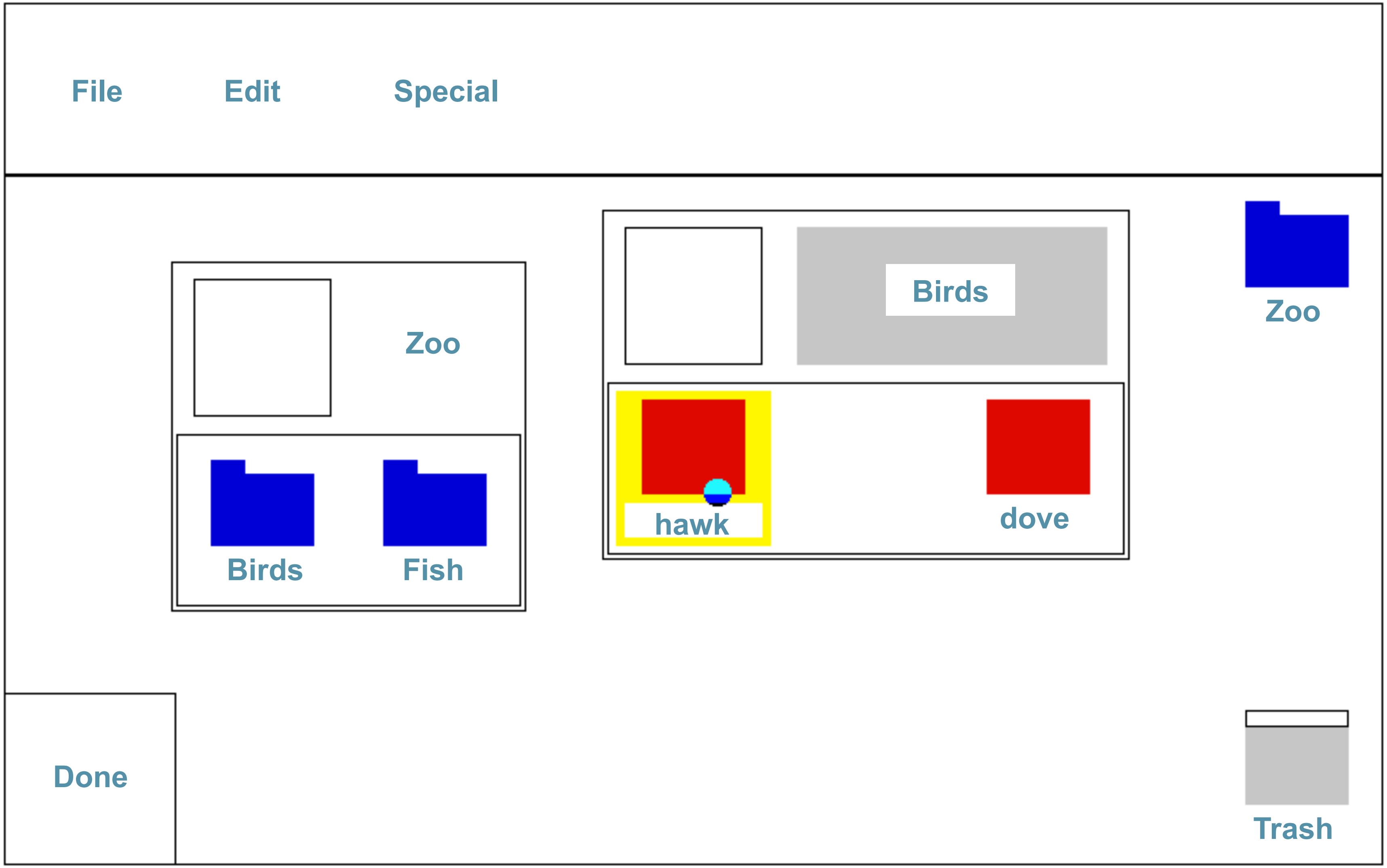
HC"Eye"

- Human --> machine communication...
  - Keyboard, mouse
  - Speech, handwriting, gestures
  - Poking (CRL Kiosk), tickling (Tickle-Me Elmo)!
- Gaze-based interfaces
  - Users control the interface using gaze/eye movements
  - Typical focus on disabled users
  - Gaze is often the only (or at least primary) input

Gaze-Added Interfaces (GAIs)

- Users control the interface using gaze and/or other inputs
- Gaze added to basic/existing input instead of replacing it
- Users can…
  - employ only basic inputs
  - employ only gaze input
  - employ any combination of basic / gaze

Case Study: IGO



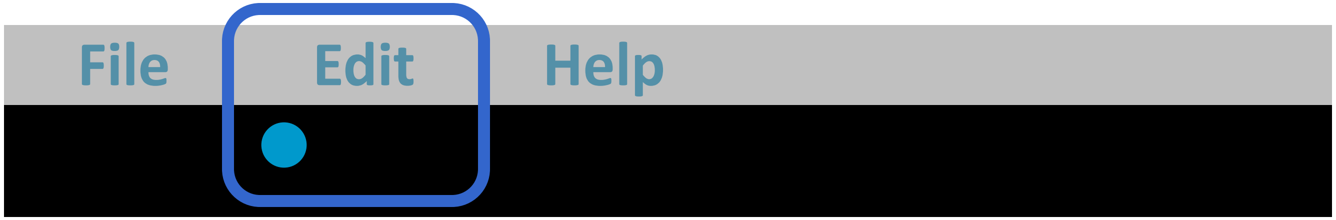
Gaze-Added Input

- Gaze focus: background highlight

- Gaze button: (keyboard) key
- Gaze control analogous to mouse
  - click for select
  - double-click for open
  - hold for drag

Intelligent Interpretation

- All GBIs must interpret gaze – i.e., assign gaze to intended object

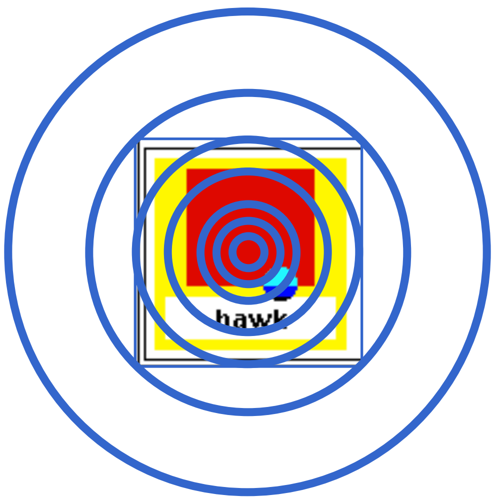


- Standard interpretation
  - assign gaze to underneath / nearest object
- Intelligent interpretation
  - assign gaze to most likely object
  - use probabilistic model of behavior

Intelligent Interpretation

- Find object that maximizes
  Pr (gaze|object) • Pr (object|history)

Gaussian distribution of gaze location <*x*,*y*> around object center

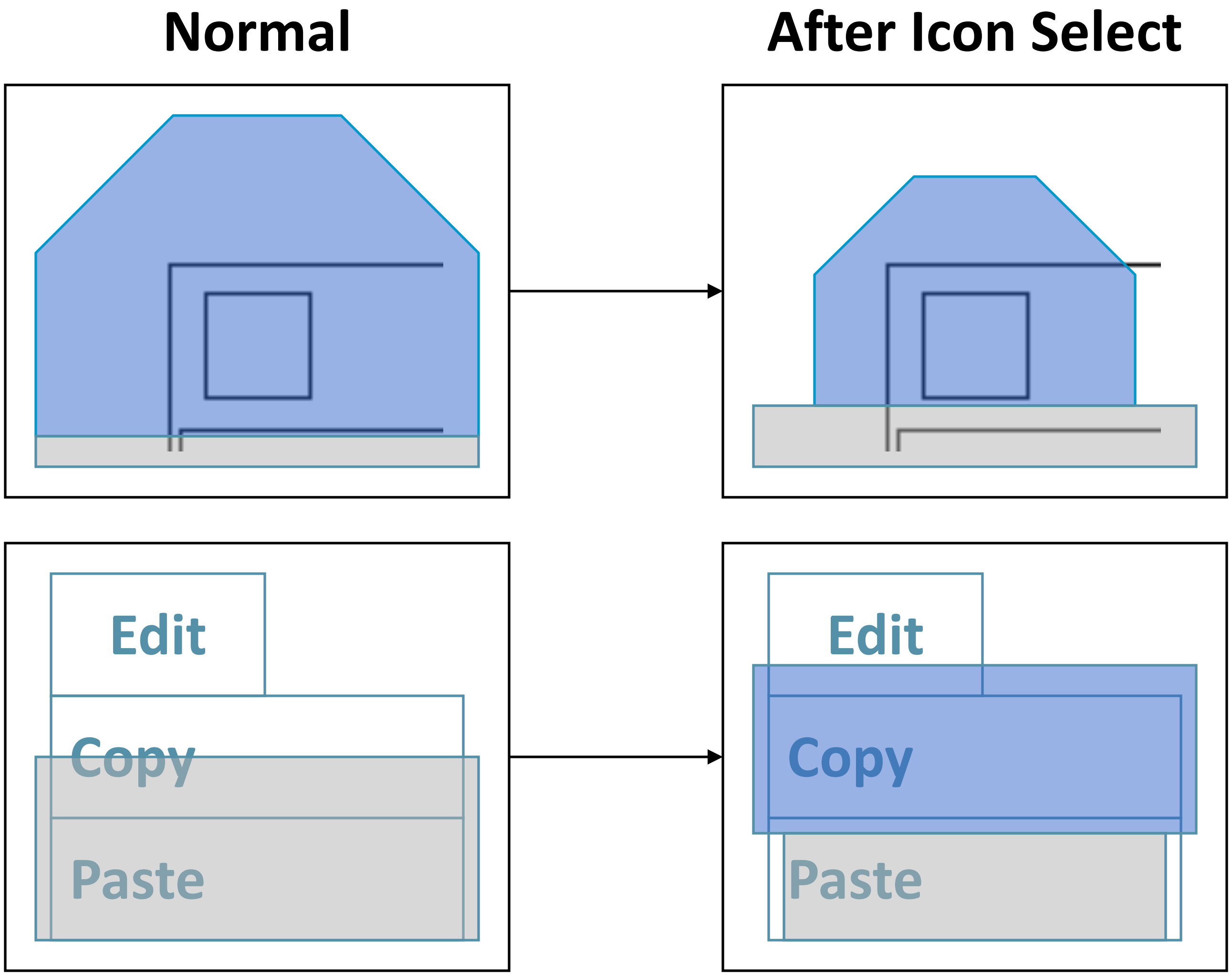


Distribution of object probabilities given some action history

File	Edit	Help
.20	.40	.10

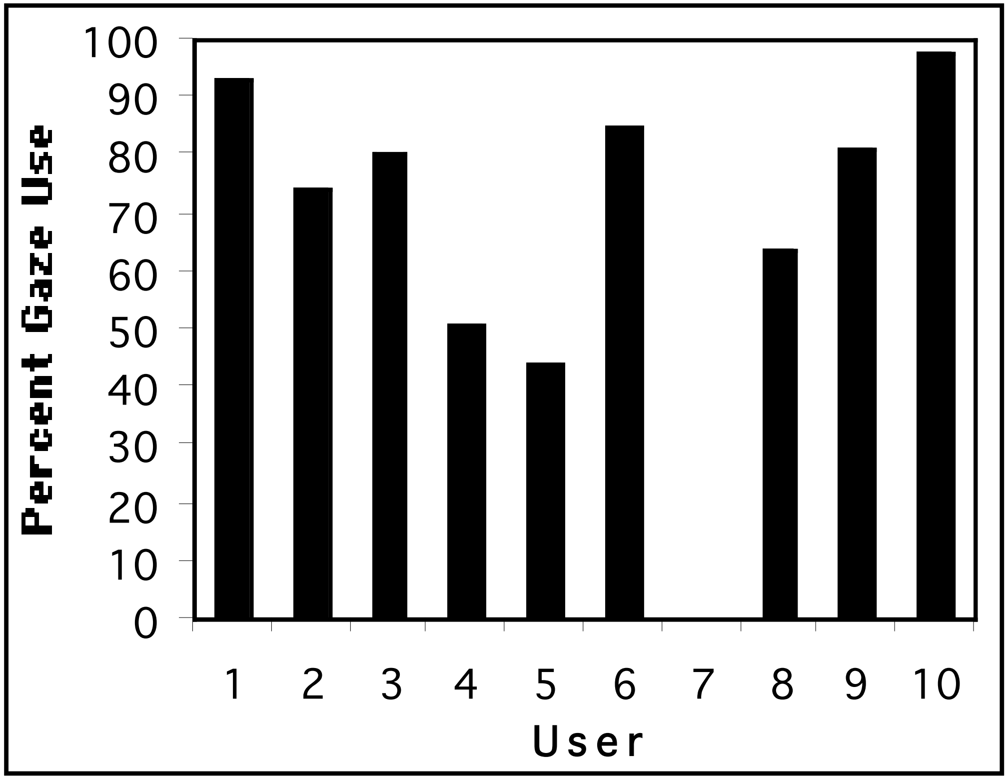
.30

Intelligent Interpretation



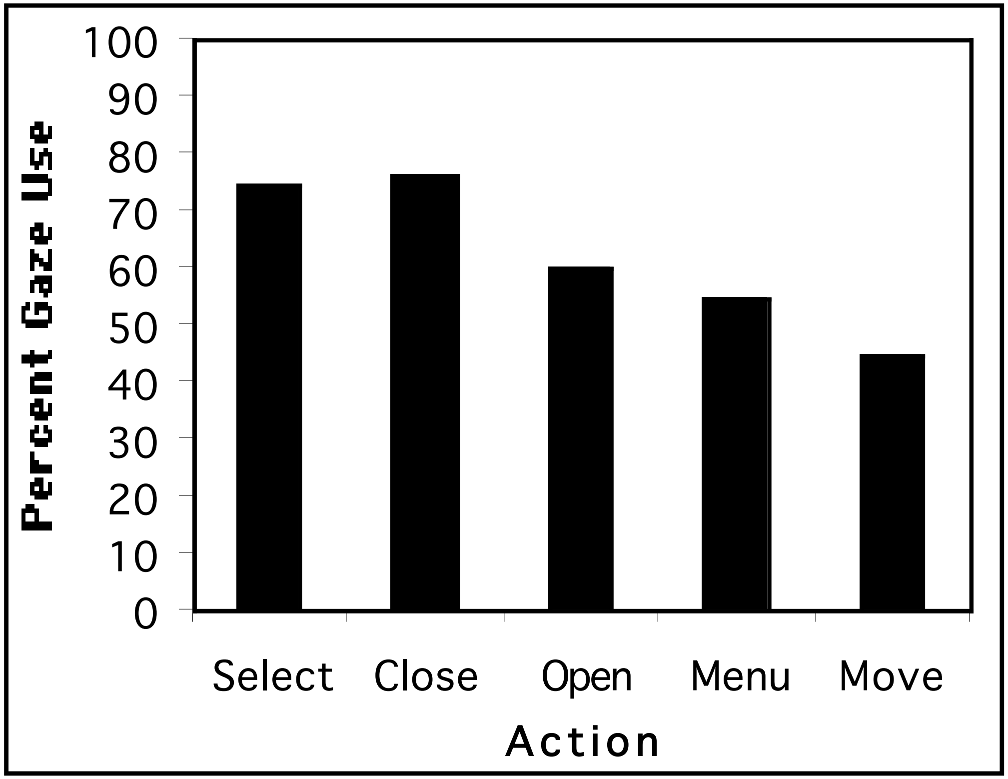
Free Stage Gaze Use

- Overall gaze use = 67%
- Correlated to (gaze–mouse) times (R=.70)



Gaze Use by Action Type

- Less complex actions –> more gaze use



Lessons Learned

- Gaze nicely complements other inputs
  - users quickly adapt to gaze input
  - users successfully interleave gaze, mouse
- Common difficulties
  - "leave before click"
  - gaze dragging
  - handling two "cursors"
- Intelligent interpretation helps
  - eye trackers will improve,
    but variability will remain
  - better eye tracking –> greater usability