Assistive Technologies

05-499/899 Fall 2024

Celebrating Accessibility

https://cmu-05-499.github.io

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Administrivia

- Check the permissions on your slides and videos for HW1. If we can't access them, you get a zero!
- Readings posted on Canvas/Announcements.

Partner Organizations for Projects

1. Western PA School for Blind Children: Learning Adventures for the Visual Impaired (Adult Day Program) – Oakland
2. The University School – Shadyside
3. SocialWise VR
4. ITI Assistive Technologies
5. Aspiritech
6. Olitsky Career Readiness Program at CMU
7. CMU Libraries

Assistive Technology

Any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities

- Wikipedia

Access Technology

Access Technology refers to technologies originally designed to assist people with disabilities, which have now evolved to benefit all users by providing accessibility features.

- Lazar, Goldstein, and Taylor 2015

Ramps

Elevators and Lifts

Glasses

According to glasses.com, the first pair of glasses as we know them for correcting vision were invented sometime around the 13th century in Italy.

Vision/ Low Vision

Braille

Refreshable Braille Displays

BRaille Note Takers

White Cane

Guide Dogs

Tactile Signs and Graphics

GPS Navigation Tools

Text to Speech

Screen Readers

Alternative Text

Optical Character Recognition

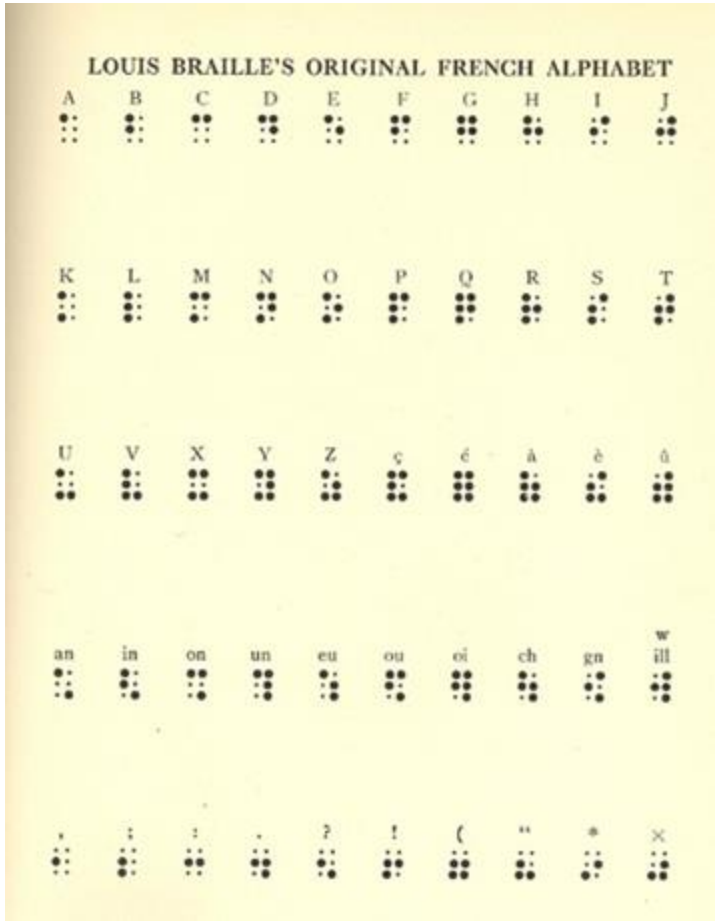
Screen Magnification and Zooming

Braille

Braille Code invented by Louis Braille in the 1800s. French Alphabet.

Uniform Braille code not adopted in English-Speaking countries until 1932

Embossed dots. 6 or 8 dot cells



Refreshable Braille Displays

Braille displays provide access to information on a computer screen by electronically raising and lowering different combinations of pins in braille cells

Many have about 40 cells

Braille Note Takers

More Similar to a Personal Digital Assistant

Read/write files, emails, music, basic web browsing

Humanware BrailleNote Touch

White Cane

People have been using sticks to aid walking for thousands of years.

White cane invented in the early 1900s.

Very lightweight, multiple tips.

Guide Dogs / Seeing Eye Dogs

- 150,000 years ago domesticated dogs
- First training of dogs to assist blind people late 1700s
- 1920-1930s we see guide dog schools in the UK

Tactile Signs and Graphics

GPS Navigation Tools

1980s military applications

~1996 when GPS becomes available for civilians

Connecting to Mapping Software and Applications

Discussion of Readings

- Discussion Leader: Riya Mody

1. History of the white cane
2. User Interface of a Homepage Reader

Text to Speech

Uses Synthesized voices to generate audio or speech output of text on the screen

Screen Readers

Reads the words on the screen

Keystroke to move to next area

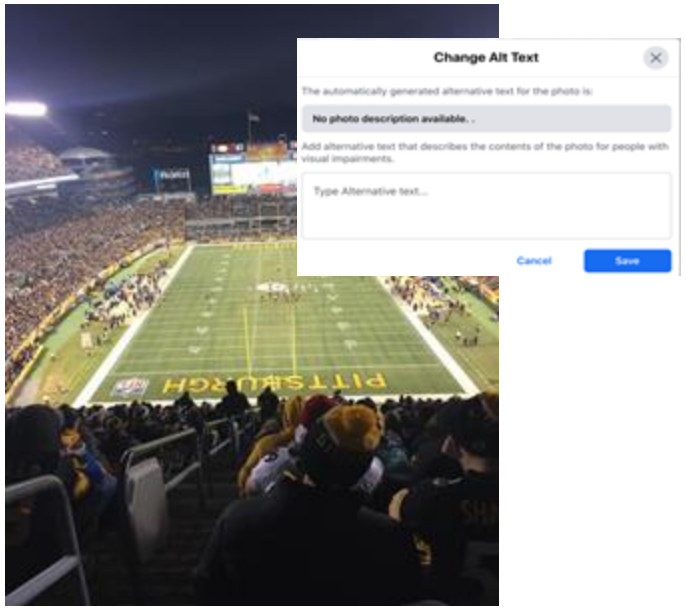
Blind people can operate them amazingly quickly

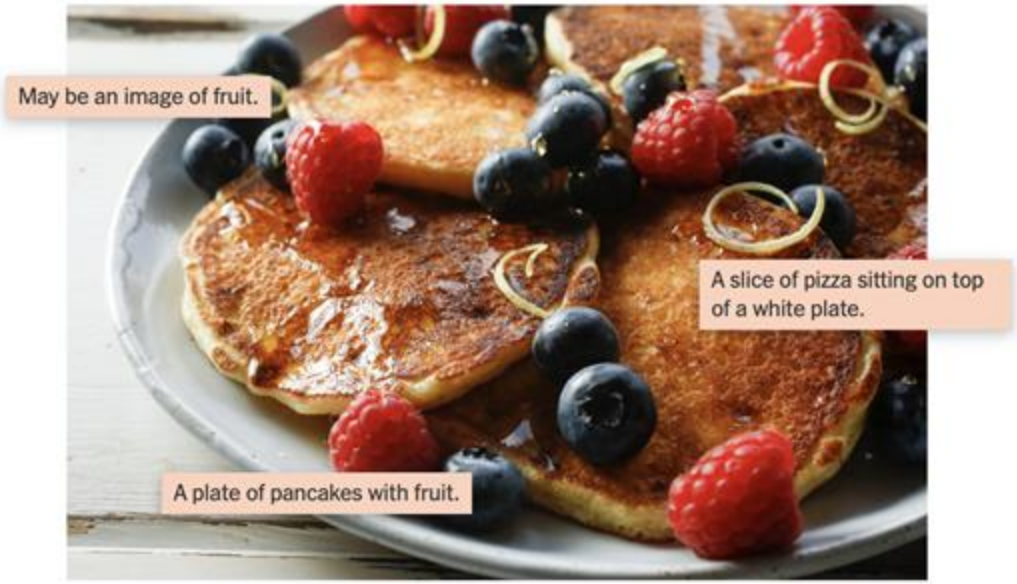
Examples of Screen Readers:

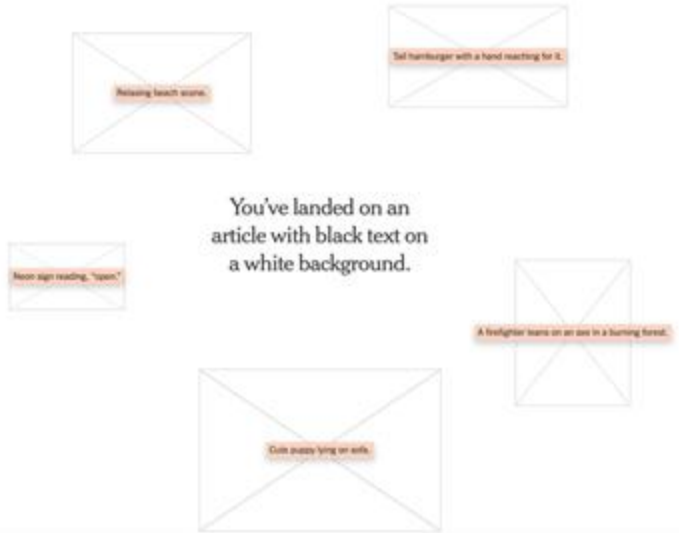
JAWS, NVDA, VoiceOver, TalkBack

Alternative Text

Alternative text provides a way to add text descriptions to image elements







Optical Character Recognition (OCR)

Extracts information from handwritten or printed text.

OCR software can automatically extract data from printed documents, saving money and time for processing them.

Screen Magnification and Zooming

Screen magnification apps are used by individuals with low vision. These apps take a computer or mobile device's visual output and enlarge it to allow for easier and more detailed viewing.

Digital, works on software layer, relieves eye fatigue, good posture, maintain good viewing distance from screen.

VizWiz

VizWiz

StateLens

StateLens: A Reverse Engineering Solution for Making Existing Dynamic Touchscreens Accessible

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ABSTRACT
Blind people frequently encounter inaccessible dynamic touchscreens in their everyday lives that are difficult, frustrating, and often impossible to use independently. Touchscreens are often the only way to control everything from coffee machines and payment terminals, to subway ticket machines and in-flight entertainment systems. Interacting with dynamic touchscreens is difficult non-visually because the visual user interfaces change, interactions often occur over multiple different screens, and it is easy to accidentally trigger interface actions while exploring the screen. To solve these problems, we introduce *StateLens* — a three-part reverse engineering solution that makes existing dynamic touchscreens accessible. First, StateLens reverse engineers the underlying state diagrams of existing interfaces using point-of-view videos found online or taken by users using a hybrid crowd-computer vision pipeline. Second, using the state diagrams, StateLens automatically generates conversational agents to guide blind users through specifying the

Figure 1. StateLens is a system that enables blind users to interact with touchscreen devices in the real world by (i) reverse engineering a structured model of the underlying interface, and (ii) using the model to provide interactive conversational and audio guidance to the user about how to use it. A set of 3D-printed accessories enable capacitive touchscreens to be used non-visually by preventing accidental touches on the interface.

CaneTroller

Enabling People with Visual Impairments to Navigate Virtual Reality with a Haptic and Auditory Cane Simulation

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Figure 1. (A) A blind user wearing the gear for our VR evaluation, including a VR headset and *Canetroller*, our haptic VR controller. (B) The mechanical elements of *Canetroller*. (C) Overlays of the virtual scene atop the real scene show how the virtual cane extends past the tip of the Canetroller device and can interact with the virtual trash bin. (D) The use of Canetroller to navigate a virtual street crossing: the inset shows the physical environment, while the rendered image shows the corresponding virtual scene. Note that users did not have any visual feedback when using our VR system. The renderings are shown here for clarity.

ABSTRACT

Traditional virtual reality (VR) mainly focuses on visual feedback, which is not accessible for people with visual impairments. We created *Canetroller*, a haptic cane controller that simulates white cane interactions, enabling people with visual impairments to navigate a virtual environment by transferring their cane skills into the virtual world. Canetroller provides three types of feedback: (1) physical resistance generated by a wearable programmable brake mechanism that physically impedes the controller when the virtual cane comes in contact with a virtual object; (2) vibrotactile feedback that simulates the vibrations when a cane hits an object or touches and drags across various surfaces; and (3) spatial 3D auditory feedback simulating the sound of real-world cane interactions. We designed indoor and outdoor VR scenes to evaluate the effectiveness of our controller. Our study showed that Canetroller was a promising tool that enabled visually impaired participants to navigate different virtual spaces. We discuss potential applications supported by Canetroller ranging from entertainment to mobility training.

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Author Keywords

Virtual reality; white cane; blindness; visual impairments; haptic feedback; auditory feedback; mobility.

ACM Classification Keywords

H.5.1. Information interfaces and presentation: Multimedia Information Systems. K.4.2. Computers and Society: Assistive technologies for persons with disabilities.

INTRODUCTION

Virtual reality (VR) technologies are maturing quickly and have been widely applied to different fields by researchers and designers, such as entertainment [6,81], education [32,34], and social activities [62]. Researchers have recognized VR's potential in accessibility and developed various VR systems for training and rehabilitation for people with different disabilities [25], such as dyslexia [17,21], stroke [14,33], and ADHD [1,34].

While presenting great potential in a variety of use cases, current VR solutions rely mainly on realistic visual feedback to provide an immersive experience to sighted people, for whom the visual sense is dominant [38]. Most VR applications are not accessible for people with visual impairments (VIPs), preventing them from benefiting from this important class of emerging technologies [28].

Some prior research has explored VR experiences for VIPs. However, they either generated pure auditory virtual reality that has limited capability in describing the shape or specific layout of a virtual space [28,36], or provided

Hearing

Speech to text, speech recognition, ASL recognition, video conference.

Speech Recognition

- First speech recognition system from Bell Labs in 1952.
  - “Audrey” could recognize spoken numbers.
- Based on acoustics, linguistics: could recognize 1000 words by 1970s.
- Big leap in 1980s with Hidden Markov Models.
  - “Every time I fire a linguist, the performance of the system goes up.” - Fred Jelinek (IBM)
- Massive improvement in mid 2010s with deep learning
  - Word error rate dropped below 5% (better than people!)

ASL Recognition

System that translates between sign language and English.

Lots of research systems that can recognize some nouns from some ways of signing.

However, no viable systems exist, but some startups are really trying:

OmniBridge, SignAll

Deaf community: Please do not attempt this without us. You're being audist.

Video Conferencing

TTY relay services for text communications but no support for ASL

2-way video call as early as 1930

1990s first desktop video conferencing

2000s begin smartphone based video calls

Participation Activity

Pair up with a neighbor.
Write your names on a piece of paper.

Discuss these questions:

- Which ones of these have you ever used?
- What did you use them for?
- How well did they work for you?
- For what disabilities would you recommend their use?

Share with the class.
Turn in your paper before you leave.

Physical Mobility and Motor

Crutches and Braces
Grips and Reachers
Wheelchairs
Adaptive Inputs / Switches
Scanning Interfaces
Eye Gaze
Brain Computer Interfaces (BCI)
Remote Controlled Devices
Telepresence Robots

Crutches and Braces

Grips / Reachers

Wheelchairs (Manual, Powered)

Wheelchairs (Sports)

Basketball/Tennis

Rugby

Adaptive Inputs/Input Modification

Mechanical

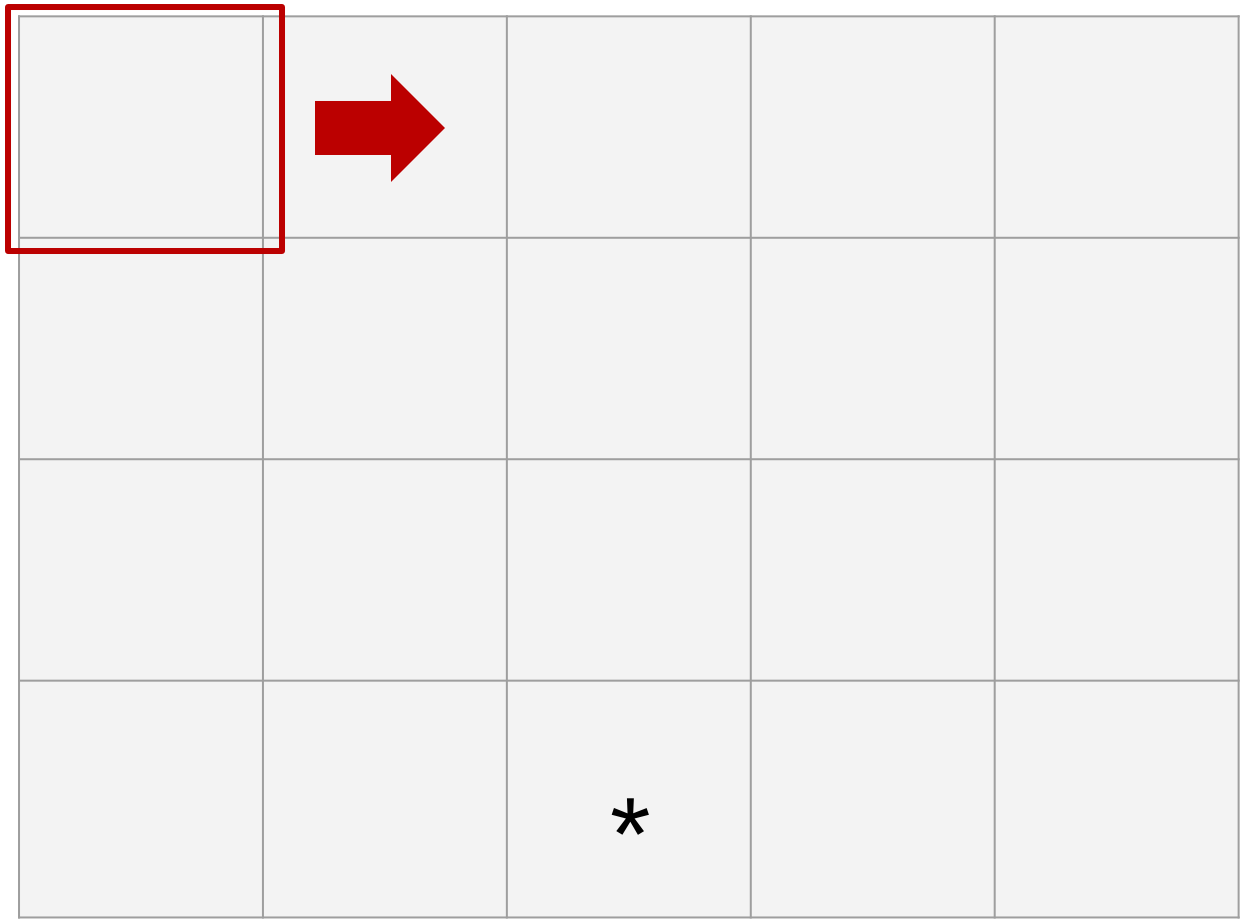
Proximity and Pneumatic

Scanning Interfaces

Automatic

Stepped

Inverse Scanning



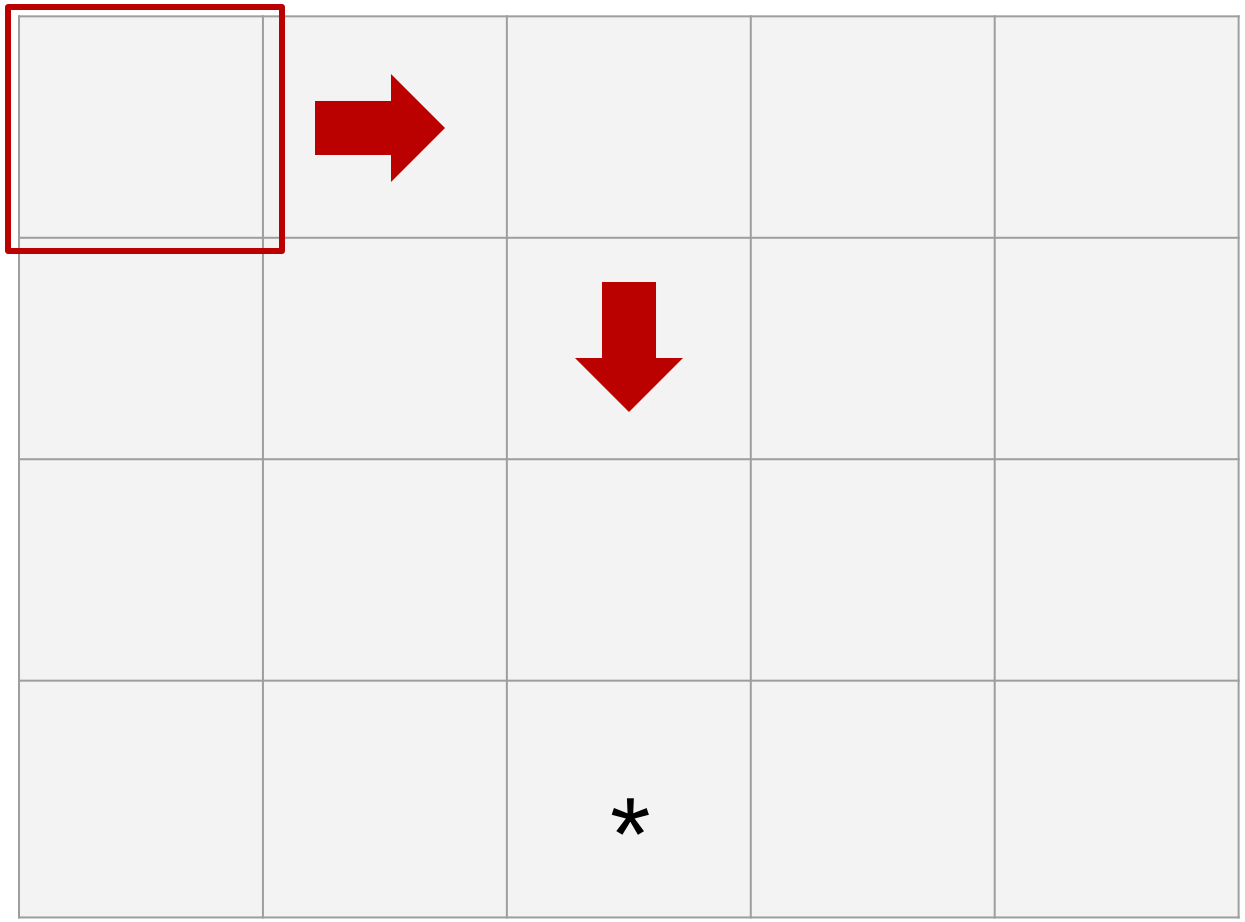
Scanning Interfaces

Automatic

Stepped

Inverse Scanning

Directed Scanning



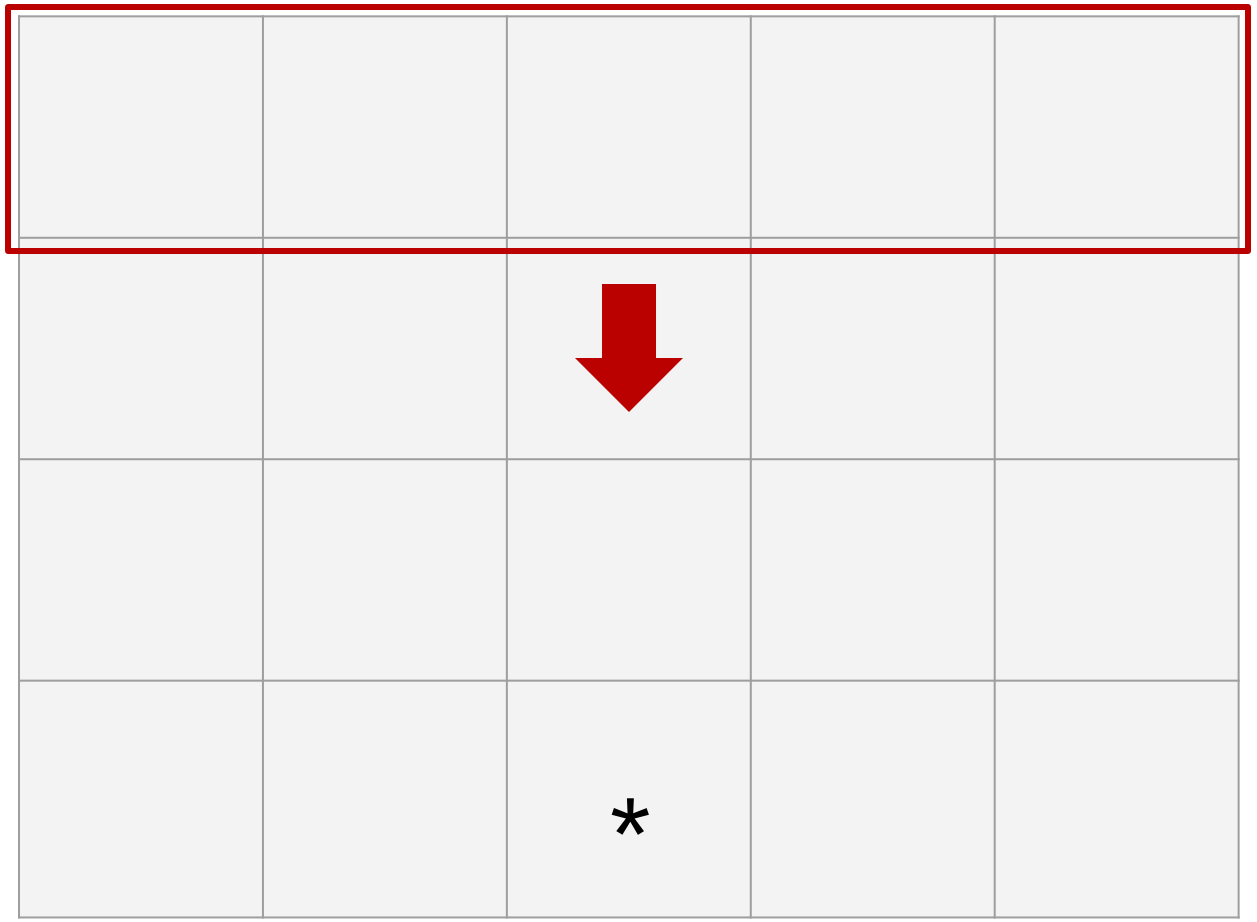
Scanning Interfaces - By Group

Automatic

Stepped

Inverse Scanning

Directed Scanning



Scanning Interfaces

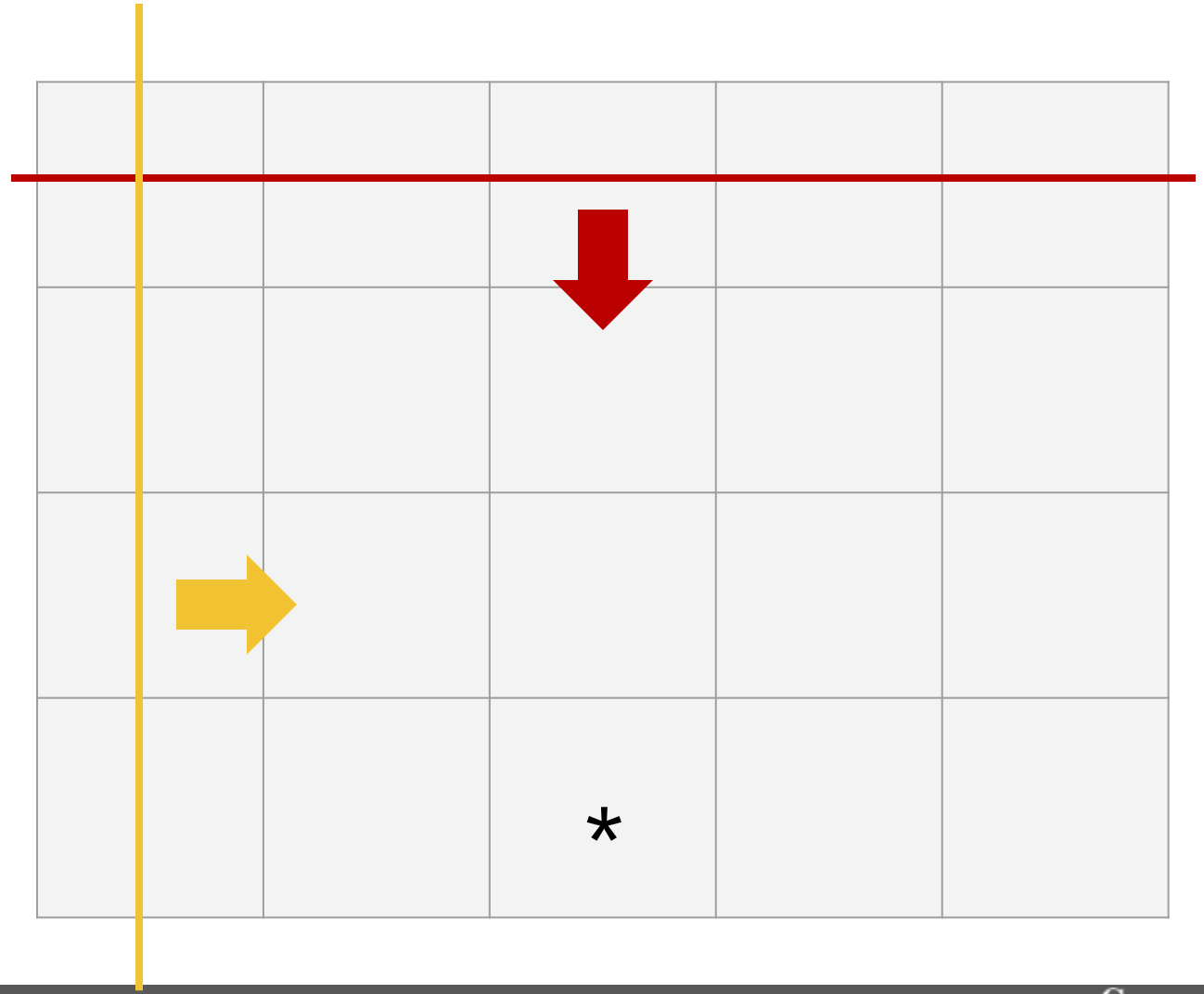
Automatic

Stepped

Inverse Scanning

Directed Scanning

Cartesian Scanning



All together

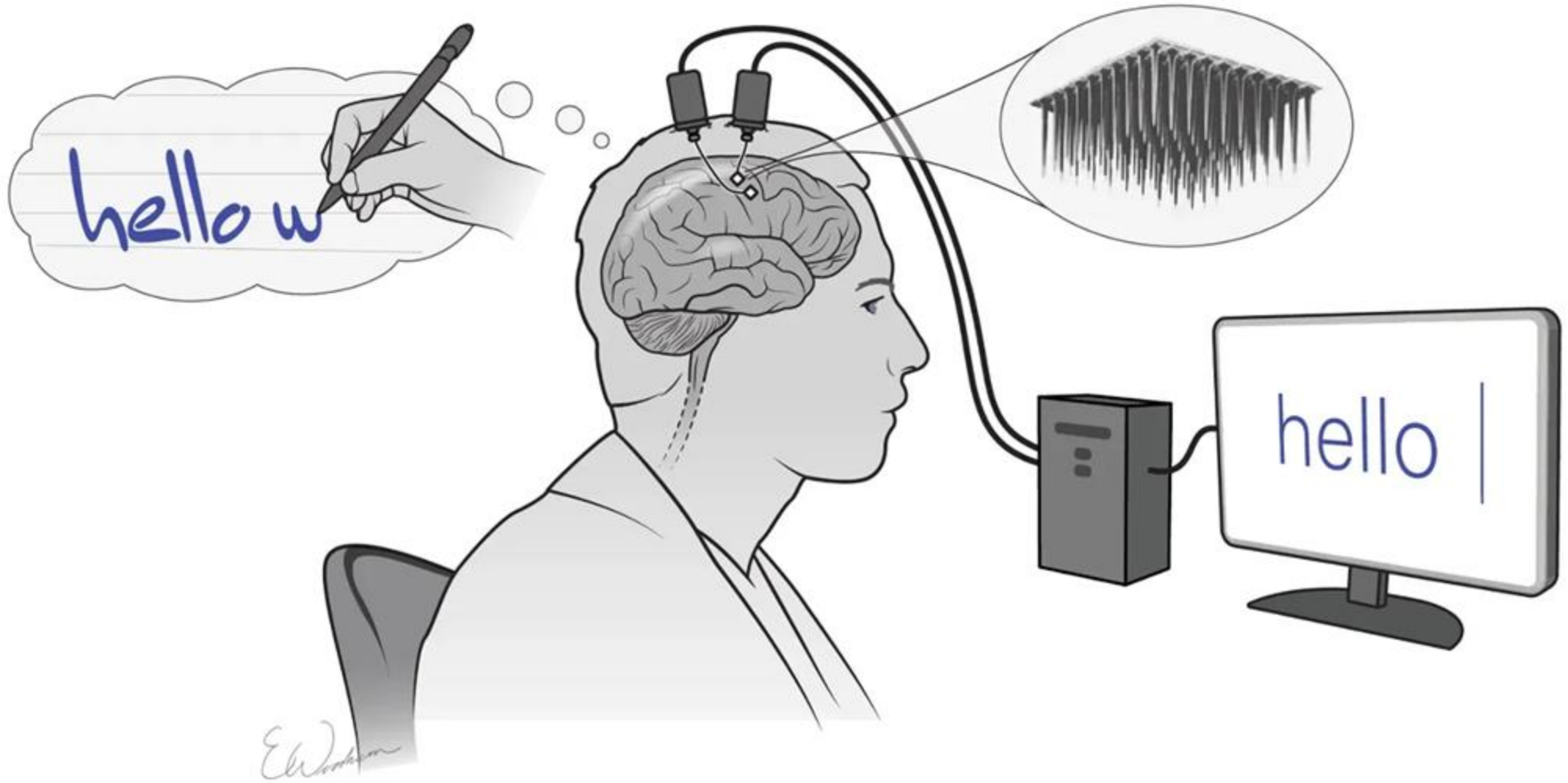
Gaze Recognition

Shoots IR at your pupils and detects the position of the reflected light.

“Remote” eye trackers sit away from the head and must also do head tracking.

Watch out for the Midas Effect when using gaze for control.

Brain-Computer Interfaces



Remote Controlled Devices

Telepresence Robots

Allow you to remotely “be there” and travel around a physical space and interact with people via video call