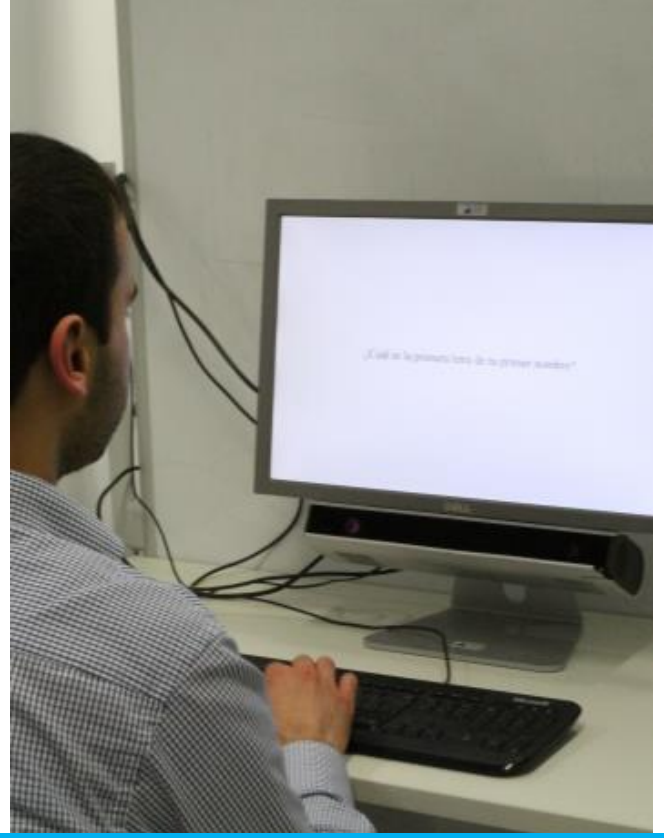

Image by Tschneidr (CC BY-SA)

Eye Gaze Interaction

Learning Goals

- Understand …
  - how gaze interaction works
  - what parameters can be measured from the eye
  - The Midas touch problem and implications for user interfaces
- Know …
  - what fixations, saccades, and smooth pursuit are
  - different types of gaze interaction and be able to give examples
  - about different applications of gaze interaction

The eyes show where you look

- Eye gaze is linked to seeing
- By looking at someone you can see what they look at
- What can we observe?
  - Fast eye movement (saccades) between objects of interest
  - Fixations on objects of interest
  - Following moving objects with gaze (smooth pursuits)
- Pupil dilation
  - Responds to light (a lot)
  - To cognitive load (a little)

Eye Movements

Person reading slowly

Gaze tracking

- What to meaure?
  - Gaze position/movement of the eye
  - Position/movement of the head
  - Relationship to the real world
- Typical API
  - Koordinates (x, y) in the world image as stream (e.g. 100 Hz)
  - Pupil dilation value (d)

Eye Tracker

- **Eye tracking glasses**:
  - Camera that looks at the users eyes
  - Camera that looks towards the environment
  - Mapping of the gaze position to a position in the real world (this is calibrated)
- Stationary eye tracker
  - Camera looking at the users face
  - Estimate gaze position
  - Estimate head position (or hold the head still)
  - Mapping of the gaze position to a position in the real world (this is calibrated)

Tobii Technology (CC BY)
https://commons.wikimedia.org/wiki/File:Tobii_Glasses_2_Eye_Tracker_Wearable_System_Tobii_I.jpg

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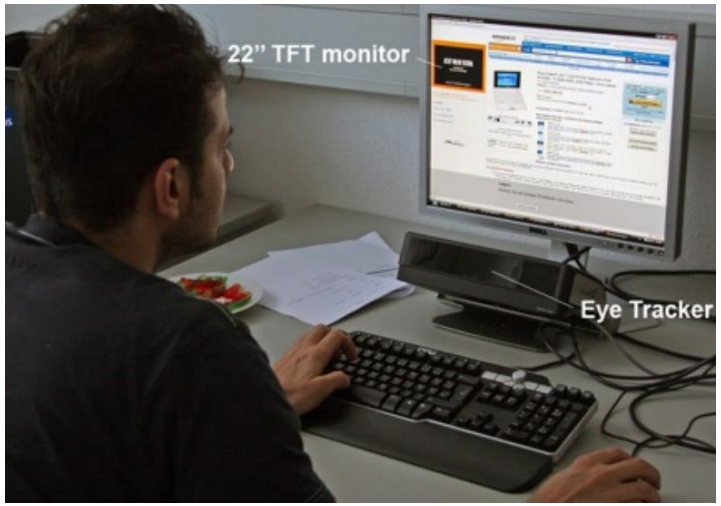
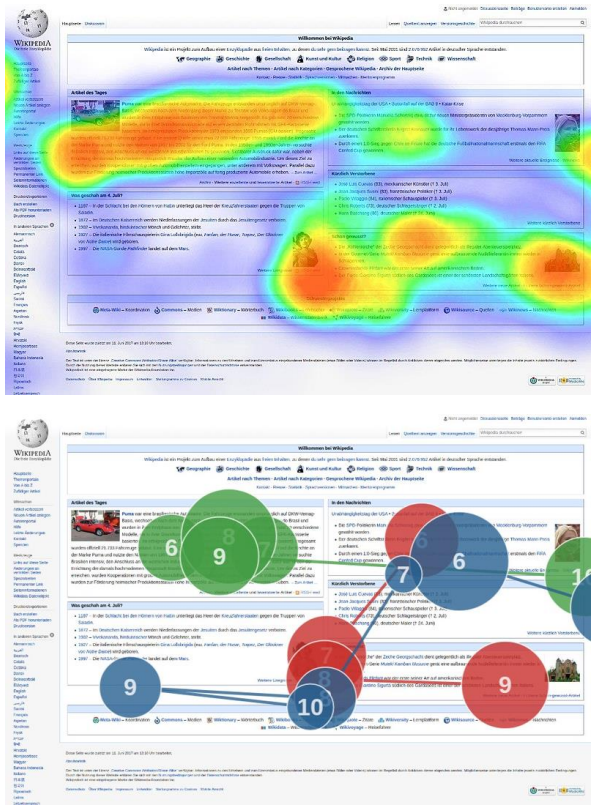


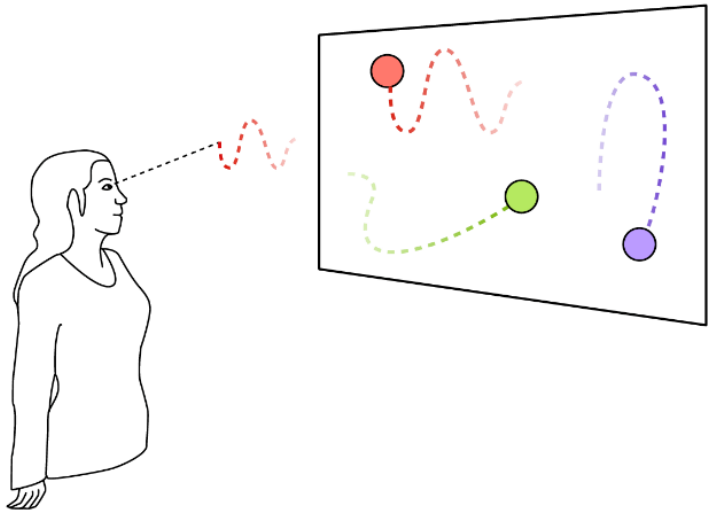
Gaze interaction

- **Fixations:** Use gaze to fixate a target
  - Select this after a certain time (dwell time), e.g. 2 second
  - Select this when a button is pressed
  - Requires calibration
- Smooth Pursuit: Use gaze to follow an objects
  - Several moving objects are presented on the screen
  - Follow with the case on of these objects
  - The object that is followed is selected
  - Can be done without calibration
- Gaze Gestures
  - Simple gaze gestures: Look right, look down
  - Complex gesture: look along a path / an outline
  - Can be done without calibration



Images by Tschneidr (CC BY-SA)

Gaze interaction



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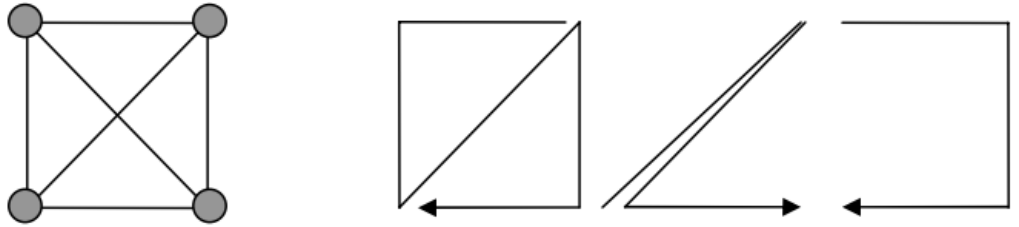
Gaze interaction



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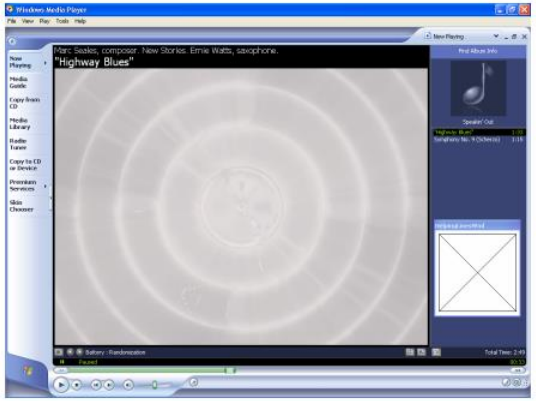

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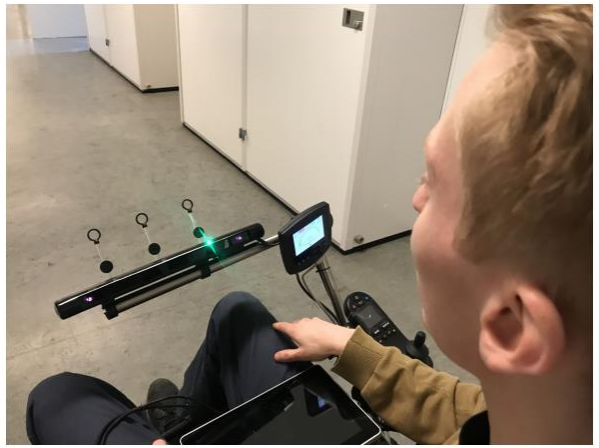
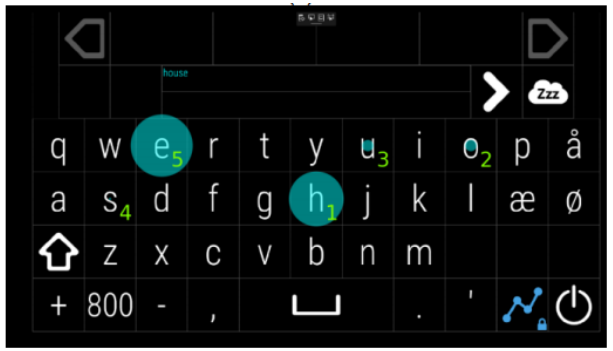
Gaze interaction Application

- **Accessibility**
  (typically fixations and dwell time)
  - Use case as alternative input
  - Operate buttons or menues
  - Gaze type
- Analytics
  - Understand what people look at
  - Usability research, market research
- Display adaptation
  - Automatically scroll when at the end of a display page
  - Marker on screen for faster resume
  - Pause media, when the user is not looking
- Image cropping
  - Crop based on where people look





Jacopo M. Araujo, Guangtao Zhang, John Paulin Paulin Hansen, and Sadasivan Puthusserypady. 2020. Exploring Eye-Gaze Wheelchair Control. In ACM Symposium on Eye Tracking Research and Applications (ETRA '20 Adjunct). Association for Computing Machinery, New York, NY, USA, Article 16, 1–8. DOI:https://doi.org/10.1145/3379157.3388933
Tanya Bafna. 2018. Gaze Typing using Multi-key Selection Technique. In Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '18). Association for Computing Machinery, New York, NY, USA, 477–479. DOI:https://doi.org/10.1145/3234695.3240992

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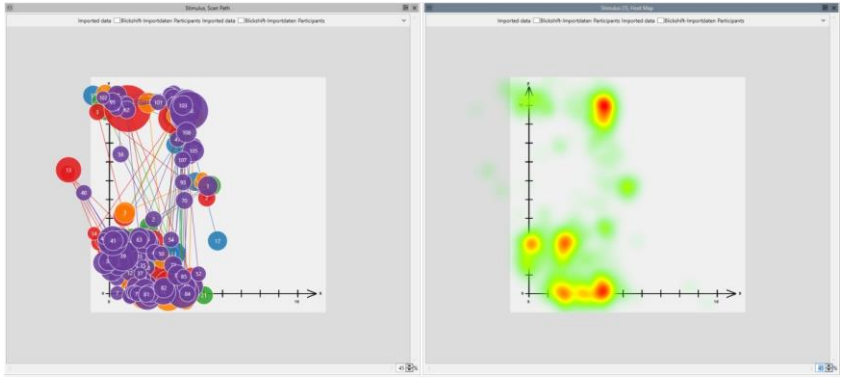

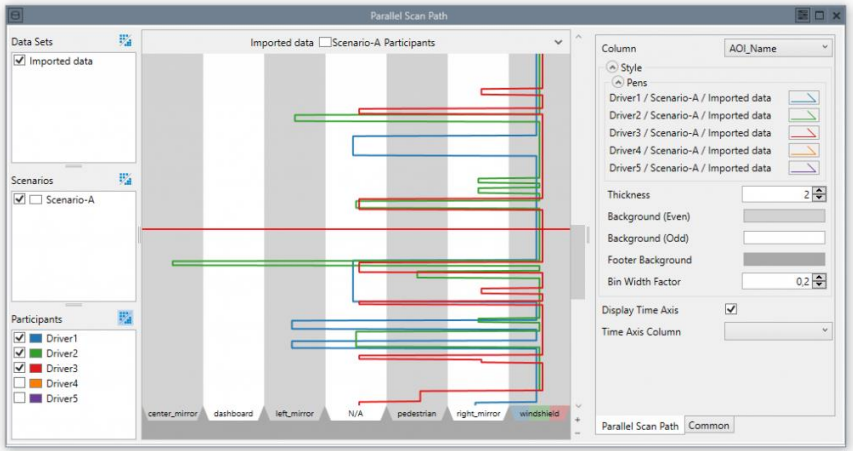

Photos from: https://www.blickshift.com/products-services/blickshift-analytics/

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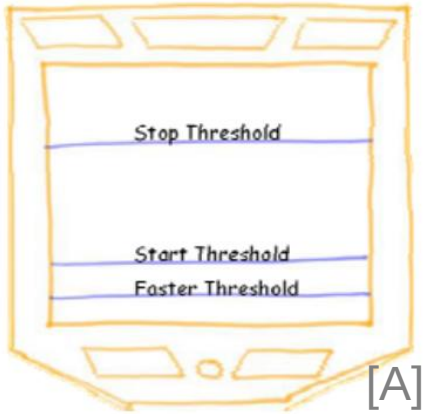
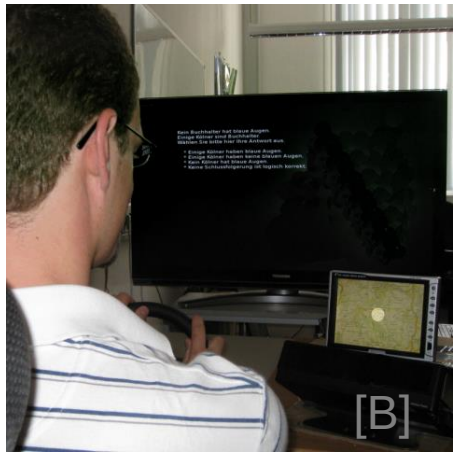


[A]


[B]

[A] Kumar, M., Winograd, T., & Paepcke, A. (2007, April). Gaze-enhanced scrolling techniques. In CHI'07 Extended Abstracts on Human Factors in Computing Systems (pp. 2531-2536).
[B] Kern, D., Marshall, P., & Schmidt, A. (2010, April). Gazemarks: gaze-based visual placeholders to ease attention switching. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 2093-2102).

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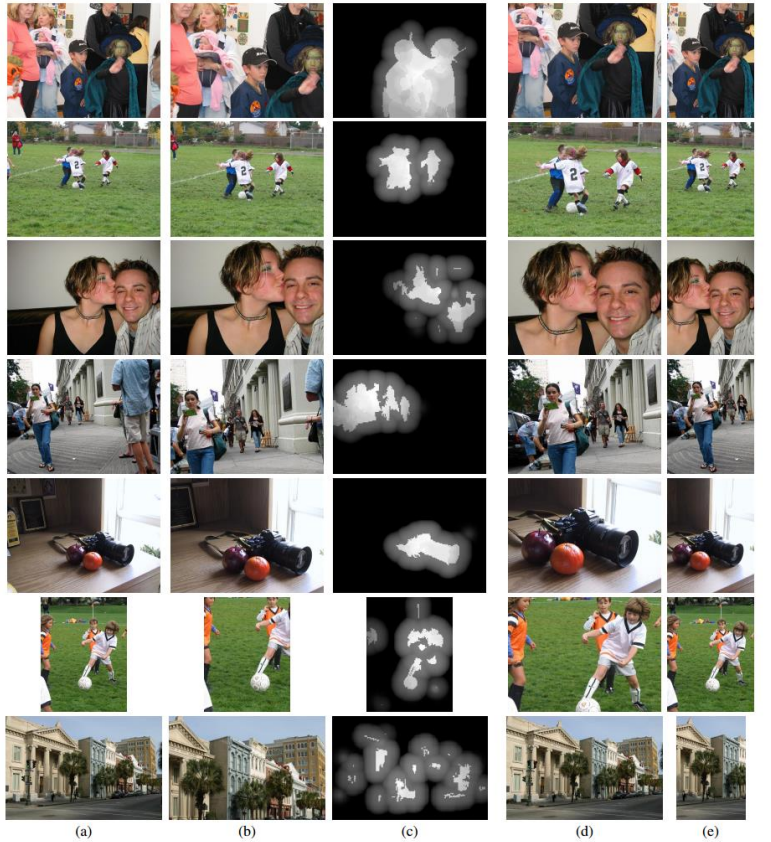
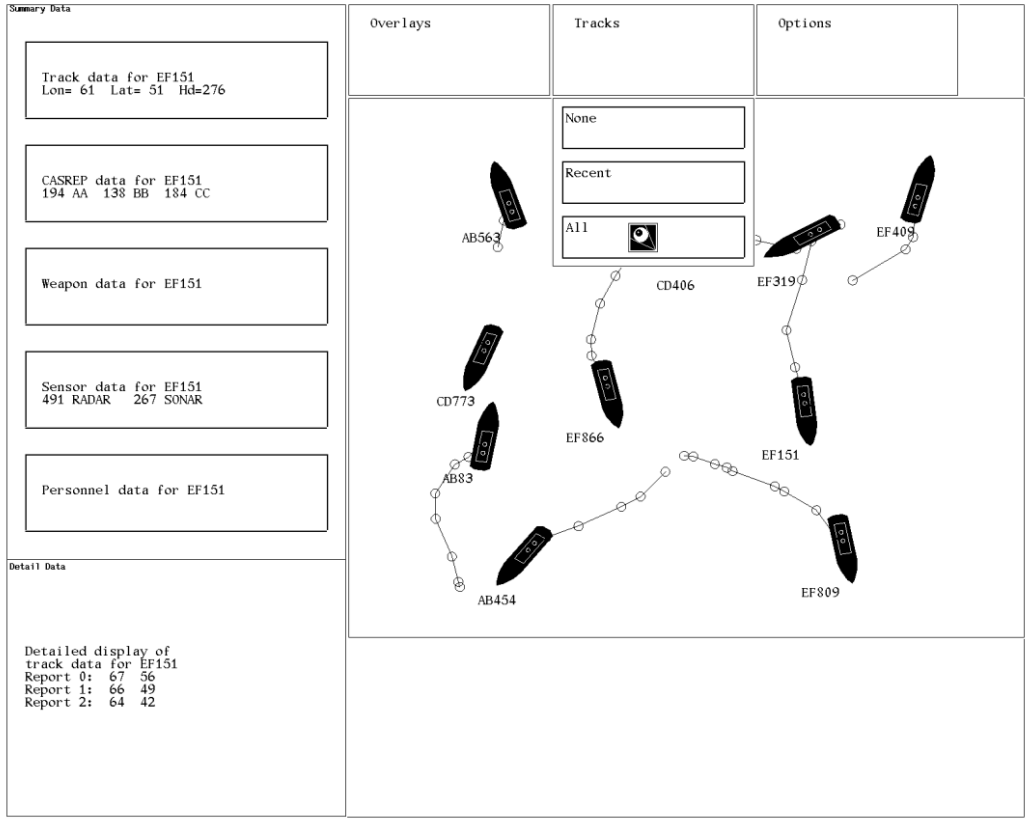


Figure 6. Results for a set of representative images. (a) Original image; (b) fully automatic crop [Suh et al. 2003]; (c) gaze-based content map; (d,e) gaze-based crops to horizontal and vertical aspect ratios.

Santella, Anthony, Maneesh Agrawala, Doug DeCarlo, David Salesin, and Michael Cohen. "Gaze-based interaction for semi-automatic photo cropping." In *Proceedings of the SIGCHI conference on Human Factors in computing systems*, pp. 771-780. ACM, 2006.

Early Work on Eye-Tracking for HCI

- Object Selection
- Continuous Attribute Display
- Moving an Object
- Eye-controlled Scrolling Text
- Menu Commands



Jacob, Robert JK. "Eye tracking in advanced interface design." Virtual environments and advanced interface design (1995): 258-288.
Jacob, R. J. (1991). The use of eye movements in human-computer interaction techniques: what you look at is what you get. ACM Transactions on Information Systems (TOIS), 9(2), 152-169.

Midas Touch Problem

Fundamental Issue of Gaze Interaction

"The most naive approach to **using eye position as an input** might be to use it as a direct substitute for a mouse: changes in the user's line of gaze would cause the mouse cursor to move. **This is an unworkable (and annoying)** approach, because people are not accustomed to operating devices just by moving their eyes. They expect to be able to look at an item without having the look "mean" something. Normal **visual perception requires that the eyes move** about…[…]

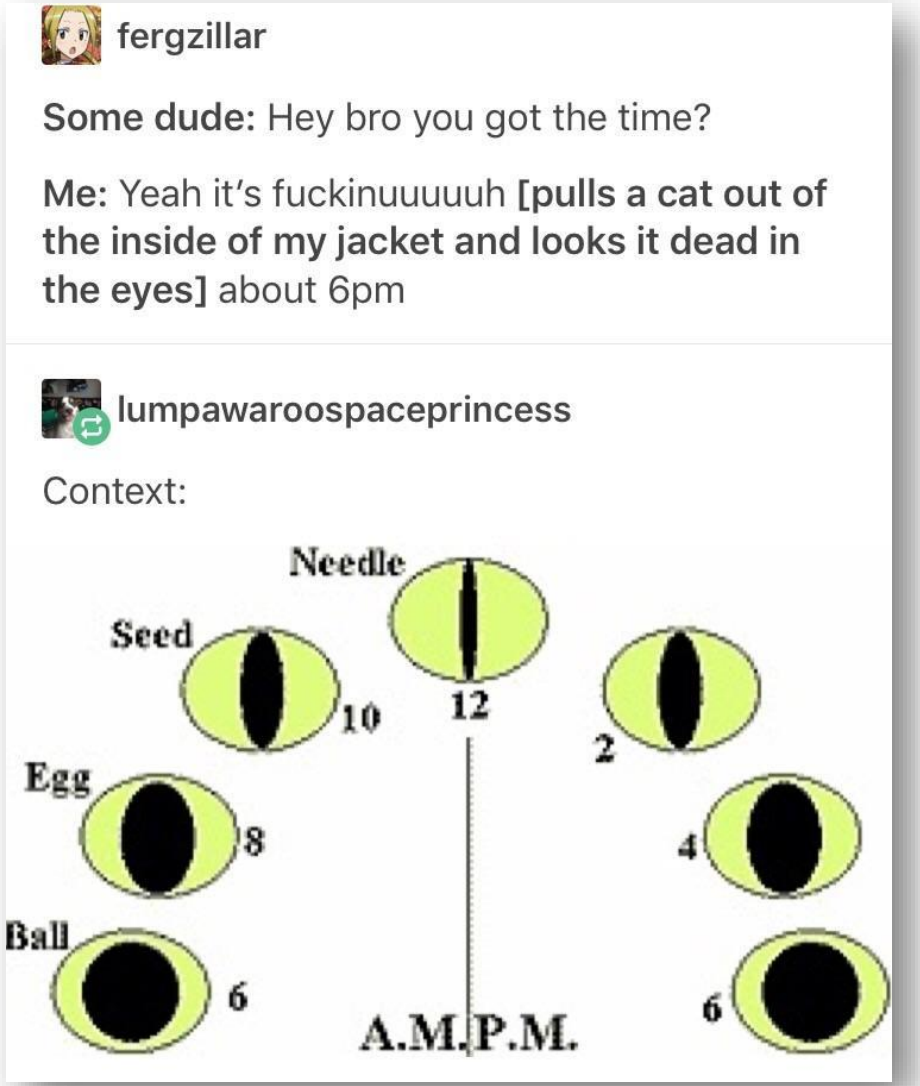
Before long, though, it becomes like the **Midas Touch. Everywhere you look, another command is activated**; you cannot look anywhere without issuing a command. […]

The challenge in building a useful eye tracker interface is to avoid this Midas Touch problem. Ideally, the interface **should act on the user's eye input** when he wants it to **and let him just look around** when that's what he wants, but the two cases are impossible to distinguish in general."

Jacob, R. J. (1991). The use of eye movements in human-computer interaction techniques: what you look at is what you get. *ACM Transactions on Information Systems (TOIS)*, *9*(2), 152-169.

Pupil size

What does it tell us?



https://www.reddit.com/r/tumblr/comments/8cm6om/got_the_time/

Pupil size

Light and cognitive load

- Acts as the aperture of the eye
- Pupil size change with the light level
  - bright – smaller pupil – smaller opening
    - less light to the eye
  - Dark – wider pupil – larger opening
    - more light to the eye
- Mental workload will also impact pupil size
  - If the light is constant, and the task is
    - Difficult: wider pupil
    - Easy: smaller pupil

	Light (large impact)		Task (small impact)	
	low	high	difficult	easy
Pupil diameter	↗	↘	↗	↘

Model: $PD = PD_{light} + PD_{task}$

$PD_{task} = PD - PD_{light}$

Estimate: $mental\ workload \approx f(PD_{task})$

Bastian Pfleging, Drea K. Fekety, Albrecht Schmidt, and Andrew L. Kun. 2016. A Model Relating Pupil Diameter to Mental Workload and Lighting Conditions. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16). Association for Computing Machinery, New York, NY, USA, 5776–5788. DOI:https://doi.org/10.1145/2858036.2858117

Did you understand this block?

Can you answer these questions?

- What information will a gaze tracker provide?
- What are basic measures we can take from the eye for interaction?
- What is the advantage of using smooth pursuit instead of fixations in an interface?
- What is the Midas touch problem? What are common solutions?
- Give examples for gaze interaction user interfaces?
- Give examples of applications of gaze tracking?
- What can pupil size tell you?

References

- Jacob, Robert JK. "Eye tracking in advanced interface design." Virtual environments and advanced interface design (1995): 258-288.
- Jacob, R. J. (1991). The use of eye movements in human-computer interaction techniques: what you look at is what you get. ACM Transactions on Information Systems (TOIS), 9(2), 152-169.
- Mélodie Vidal, Andreas Bulling, and Hans Gellersen. 2013. Pursuits: spontaneous interaction with displays based on smooth pursuit eye movement and moving targets. In Proceedings of the 2013 ACM international joint conference on Pervasive and ubiquitous computing (UbiComp '13). ACM, New York, NY, USA, 439-448.
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- Jakob Karolus, Paweł W. Wozniak, Lewis L. Chuang, and Albrecht Schmidt. 2017. Robust Gaze Features for Enabling Language Proficiency Awareness. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17). Association for Computing Machinery, New York, NY, USA, 2998–3010. DOI:https://doi.org/10.1145/3025453.3025601
- Jacopo M. Araujo, Guangtao Zhang, John Paulin Paulin Hansen, and Sadasivan Puthusserypady. 2020. Exploring Eye-Gaze Wheelchair Control. In ACM Symposium on Eye Tracking Research and Applications (ETRA '20 Adjunct). Association for Computing Machinery, New York, NY, USA, Article 16, 1–8. DOI:https://doi.org/10.1145/3379157.3388933
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- Bastian Pfleging, Drea K. Fekety, Albrecht Schmidt, and Andrew L. Kun. 2016. A Model Relating Pupil Diameter to Mental Workload and Lighting Conditions. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16). Association for Computing Machinery, New York, NY, USA, 5776–5788. DOI:https://doi.org/10.1145/2858036.2858117
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- Florian Alt, Alireza Sahami Shirazi, Albrecht Schmidt, and Julian Mennenöh. 2012. Increasing the user's attention on the web: using implicit interaction based on gaze behavior to tailor content. In Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design (NordiCHI '12). Association for Computing Machinery, New York, NY, USA, 544–553. DOI:https://doi.org/10.1145/2399016.2399099

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