

Eye-Tracking Methodology

Author: Bálint Szabó

E-mail: szabobalint@erg.bme.hu



Budapest University of Technology and Economics
Department of Ergonomics and Psychology

Ergonomics 2019

The human eye

Eye tracking

History

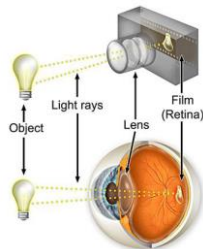
Case studies

Practice

Vision and the human eye

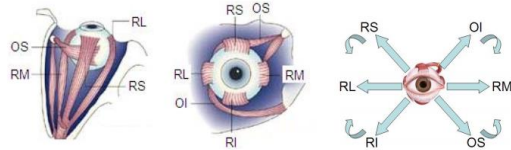
The eye is the organ which gives us the sense of light, allowing us to observe and learn more about the surrounding world than we do with any of the four senses.

Like a camera, the eye is able to refract light and produce a focused image that can stimulate neural responses and enable the ability to see.



Eye muscles

- Rectus Lateral (moves the eye outward, away from the nose)
- Rectus Medial (moves the eye inward, toward to the nose)
- Rectus Superior (moves the eye upward and slightly outward)
- Rectus Inferior (moves the eye downward and slightly inward)
- Oblique Superior (moves the eye inward and downward)
- Oblique Inferior (moves the eye outward and upward)



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Eye movements

- Enable the visual system to acquire information
- Accomplished mostly through unconscious scanning eye movements
- Purpose: to fixate objects (foveal region)
- Eyes move all the time (even during sleep)
- Several different movement types, such as
 - Pursuit
 - Tremor
 - Rotation
 - Drift

•But the most interesting types are

Fixation

Saccade



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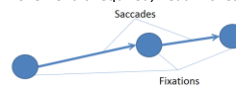
Basic eye movement types

Fixation

- Eye is a (relatively) still and "fixated" to the certain point (reading a single word)
- All the information from the scene is (mainly) acquired during fixation
- Duration varies from 120-1000 ms, typically 200-600 ms
- Interspersed with saccades

Saccades

- "Jumps" which connect fixations
- Very rapid (duration is typically only 40-120 ms)
- Very fast (up to 600 °/s) and therefore the vision system is suppressed
- Ballistic (the end point of saccade cannot be changed during the movement)
- If larger than 30 degree movement is required, head moves along with eyes



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Reading process

DANS, RÖN OCH JAGPROJEKT

På jakt efter ungdomars kroppsspråk och den synkretiska dansen, en sammansättning av olika kulturers dans, har jag i mitt fältarbete under hösten rörfång på olika arenor inom skolans värld. Nordiska, afrikanska, syd- och östeuropiska ungdomar gör sina röster höra genom sång, musik, skrik, skrat och gestaltar danser och uttryck med hjälp av kroppsspråk och dans.

Den individuella esteten framträder i kläder, frisyer och symboliska tecken som förstärker ungdomarnas "jagprojele" där också den egna stilen i kroppspråkerna spelar en betydande roll i identitetsprövningen. Utpehalsrummet fungerar som offentlig arena där ungdomarna spelar upp sina performanceliknande kroppsspråk.



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The human eye
Eye tracking
 History
 Case studies
 Practice

Eye Tracking

Eye tracking is a technique whereby an individual's eye movements are measured so that the researcher knows both where a person is looking at any given time and the sequence in which the person's eyes are shifting from one location to another.

An **eye tracker** is a device for measuring eye positions and eye movement.

Field of application:

- Basic research (vision and reading)
- Marketing research
- Web and software ergonomics
- General product development
- Assistive technology

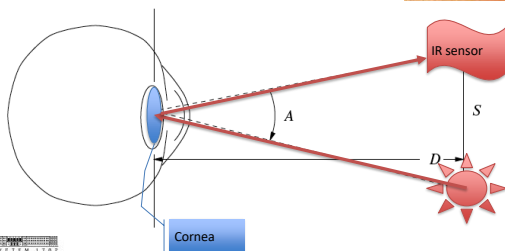
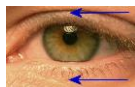


Eye tracking devices



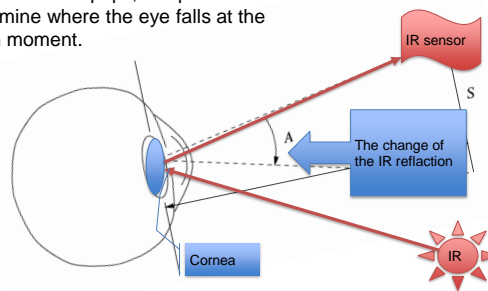
Operating principle I.

Infrared light
Detecting cornea reflection
Identify pupil

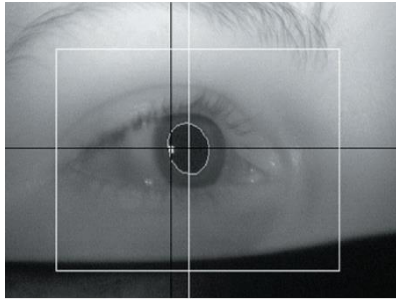


Operating principle II.

Based on the position changes of the cornea and the pupil, it is possible to determine where the eye falls at the given moment.

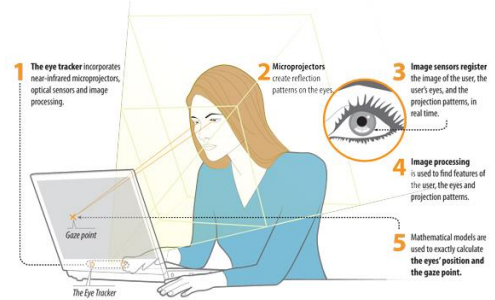


It looks like this



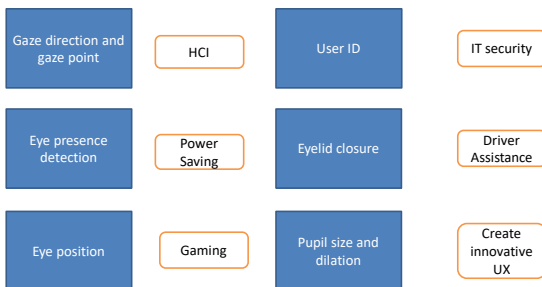
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The complete system



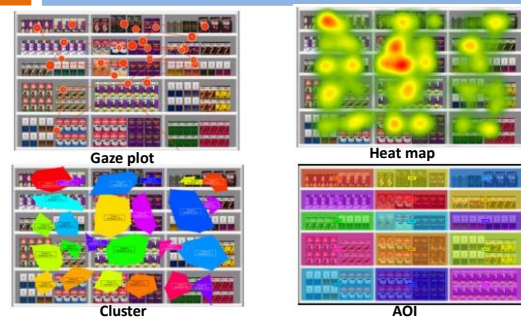
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What can be tracked and why?



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Visualizing and analyzing eye movement data



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Scan Path



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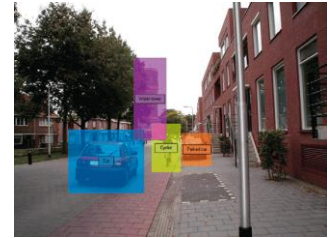
AOI analysis

If you are interested in specific areas you are able to get quantitative data!

Most important indicators:

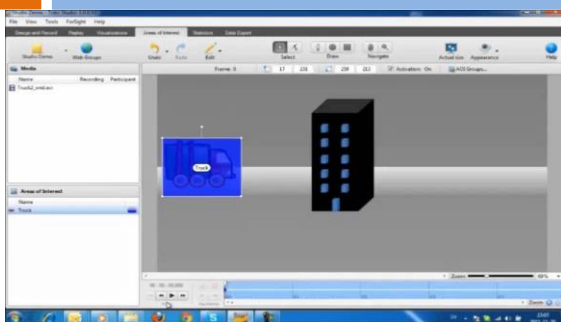
- Time to first fixation
- Number of fixations
- Visit count

You are able to determine dynamic AOI!



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Dynamic AOI



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History of Eye Tracking

1800s: Direct observation

1898: *Delaberre* - Mechanical lever

1901: *Dodge and Cline*

- Photographing movements (reflection of a light source from the cornea)
- Remained a standard method for 50 years
- The method required the head to be kept as still as possible
 - 1920: *Buswell* (reading aloud – 1935 recorded eye movements while looking at pictures)
 - 1932: *Butsch* (eye movements during copy typing)
 - 1943: *Weaver* (eye movements of pianists)
 - 1950: *Ratliff and Riggs* (modest amount of head movement allowed)

1962: *Mackworth and Thomas*

- They used a camera mounted on the head which simultaneously filmed the view ahead and the corneal reflection.
- Heavy, not particularly accurate, only 2° visual angle



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Electro-oculography (EOG)

Basic fact:

Electrostatic field exists when eyes rotate.

Recording technique:

By recording small differences in the skin potential around the eye, the position of the eye can be estimated.

Disadvantage:

- This technique does not require the clear view of the eye
- It requires the close contact of electrodes to the user



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Video-based technology

1980s: Video cameras had become much smaller and lighter

- number of commercial eye trackers began to become available
- they were usually based on pupil position
- illuminating the eye with infrared light to produce a 'white' pupil which can be tracked electronically
- variant of this devices tracks the iris rather than the pupil

Main categories:

- **head-mounted systems**
- **non-intrusive systems**

Subcategories:

- ambient
- infrared (NIR)



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Case study I.

- **Professional:** Wooden toy trading
- **Main goal:** Increase the user experience of the webshop
- 9 usability tasks to investigate the conformance of registration and the online shopping process; navigation on the website and the menu; how easy to find products etc.
- 3 lay and 3 experienced user

User	Age	Whole execution time [min:sec]
Test	23	25:47
Experienced_1	25	20:33
Experienced_2	26	28:05
Experienced_3	27	18:40
Lay_1	57	31:42
Lay_2	58	42:42
Lay_3	37	26:14

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Case study I.

Warning message



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Case study I.

Feedback system message



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Case study I.

Registration

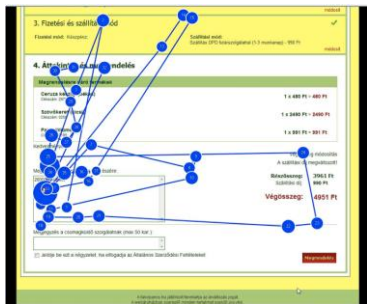


User	Time to first fixation [sec]	Fixation length [sec]	Observation length [sec]	Observation count	Time to click [sec]
Test	8.27	0.85	1.33	3	11.75
Experienced_1	N/A	N/A	N/A	N/A	11.23
Experienced_2	0.91	0.07	0.34	2	8.37
Experienced_3	N/A	N/A	N/A	N/A	6.33
Lay_1	N/A	N/A	N/A	N/A	N/A
Lay_2	9.7	0.07	0.38	5	24.31
Lay_3	4.47	0.15	0.39	2	66.31

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Case study I.

Message to the delivery system



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Case study I.

Message to the delivery system - Solution



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Case study II.

Ticket buying process



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Case study III.

Edit



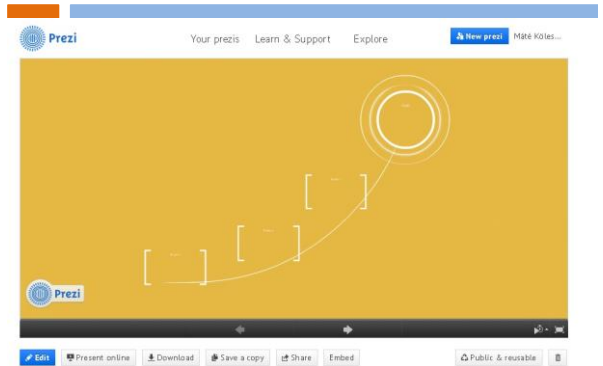
Case study III.

Share



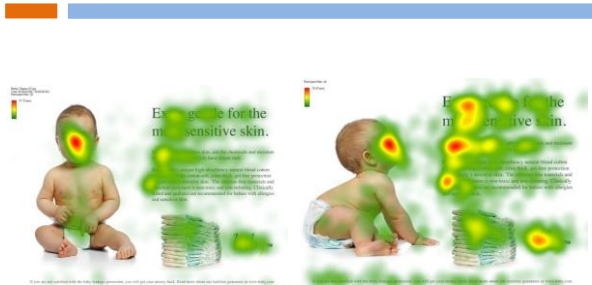
Case study III.

Solution



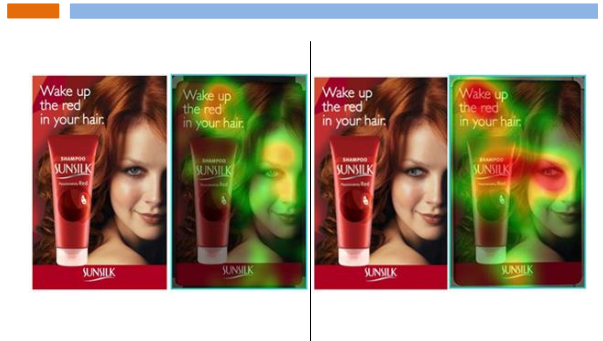
Case study IV.

Guiding the user



Case study V.

Guiding the user



Case study VII.



Case study VIII.

Driving behaviour study

Case study IX.

Flying simulator



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Case study X.

First task

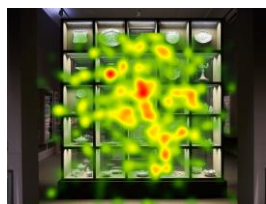


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Case study X.

Results

Heatmap



Defining AOI



Based on the heatmap: B2, B3, C2, C3, C4 and D4 parts are the most important

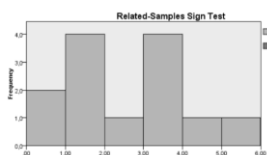
Case study X.

Visit count results for selected AOI areas

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
001	1	1	1	N/A	N/A	2	2	2	2	2	2	2	2	2	2
002	2	2	2	N/A	N/A	2	2	2	2	2	2	2	2	2	2
003	3	3	3	N/A	N/A	2	2	2	2	2	2	2	2	2	2
004	4	4	4	N/A	N/A	2	2	2	2	2	2	2	2	2	2
005	5	5	5	N/A	N/A	2	2	2	2	2	2	2	2	2	2
006	6	6	6	N/A	N/A	2	2	2	2	2	2	2	2	2	2
007	7	7	7	N/A	N/A	2	2	2	2	2	2	2	2	2	2
008	8	8	8	N/A	N/A	2	2	2	2	2	2	2	2	2	2
009	9	9	9	N/A	N/A	2	2	2	2	2	2	2	2	2	2
010	10	10	10	N/A	N/A	2	2	2	2	2	2	2	2	2	2
011	11	11	11	N/A	N/A	2	2	2	2	2	2	2	2	2	2
012	12	12	12	N/A	N/A	2	2	2	2	2	2	2	2	2	2
013	13	13	13	N/A	N/A	2	2	2	2	2	2	2	2	2	2
014	14	14	14	N/A	N/A	2	2	2	2	2	2	2	2	2	2
015	15	15	15	N/A	N/A	2	2	2	2	2	2	2	2	2	2
016	16	16	16	N/A	N/A	2	2	2	2	2	2	2	2	2	2
017	17	17	17	N/A	N/A	2	2	2	2	2	2	2	2	2	2
018	18	18	18	N/A	N/A	2	2	2	2	2	2	2	2	2	2
019	19	19	19	N/A	N/A	2	2	2	2	2	2	2	2	2	2
020	20	20	20	N/A	N/A	2	2	2	2	2	2	2	2	2	2
021	21	21	21	N/A	N/A	2	2	2	2	2	2	2	2	2	2
022	22	22	22	N/A	N/A	2	2	2	2	2	2	2	2	2	2
023	23	23	23	N/A	N/A	2	2	2	2	2	2	2	2	2	2
024	24	24	24	N/A	N/A	2	2	2	2	2	2	2	2	2	2
025	25	25	25	N/A	N/A	2	2	2	2	2	2	2	2	2	2
026	26	26	26	N/A	N/A	2	2	2	2	2	2	2	2	2	2
027	27	27	27	N/A	N/A	2	2	2	2	2	2	2	2	2	2
028	28	28	28	N/A	N/A	2	2	2	2	2	2	2	2	2	2
029	29	29	29	N/A	N/A	2	2	2	2	2	2	2	2	2	2
030	30	30	30	N/A	N/A	2	2	2	2	2	2	2	2	2	2

Case study X.

Wilcoxon test results



Total N	13
Test Statistic	13,000
Standard Error	1,803
Standardized Test Statistic	3,328
Asymptotic Sig. (2-sided test)	,001
Exact Sig. (2-sided test)	,000

- ATT: Mean of visit counts for the forgoing AOI areas.
- The median of ATT is significantly higher than median of NATT (Z=13, p=0.001).
- It can be also demonstrated statistically that B2, B3, C2, C3, C4 and D4 parts are the most important

Case study X.

Second task

Kor	Nem	Bejárásidő [perc:mp]	Sorozat					Figyelmesítés	Információ olvasás [mp]	Információ olvasás [db]	
			1.	2.	3.	4.	5.				
1	43	N	26:05:00	K	V	K	Z	1	331	34	
2	47	N	18:50	Z	K	V		1	66	11	
3	N/A	N	10:15	K	V	K	Z	0	9	2	
4	53	N	18:04	K	V	K	Z	1	2	2	
5	32	N	15:07	K	V	Z		1	81	6	
6	27	N	2:01	K	V	K	Z	0	0	0	
7	31	N	7:36	K	V	Z		0	16	7	
8	37	F	14:01	K	V	K	Z	0	39	10	
9	61	N	20:39	Z	K	V	K	Z	0	172	23
10	70	F	10:33	V	K			1	65	11	
11	36	N	12:49	Z	K	V		0	44	13	
12	42	N	15:05	Z	K	V		1	117	17	
13	46	F	12:59	K	V	Z	K	0	13	6	
14	33	N	13:23	Z	K	V	K	Z	0	26	9
15	46	F	16:13	K	V			1	0	0	



Case study X.

Fixation durations



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Case study XI.

Psychology of sports



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