Privacy-Aware Eye Tracking Using Differential Privacy [Supplementary Material]

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With eye tracking being increasingly integrated into virtual and augmented reality (VR/AR) head-mounted displays, preserving users' privacy is an ever more important, yet under-explored, topic in the eye tracking community. We report a large-scale online survey (N=124) on privacy aspects of eye tracking that provides the first comprehensive account of with whom, for which services, and to what extent users are willing to share their gaze data. Using these insights, we design a privacy-aware VR interface that uses differential privacy, which we evaluate on a new 20-participant dataset for two privacy sensitive tasks: We show that our method can prevent user re-identification and protect gender information while maintaining high performance for gaze-based document type classification. Our results highlight the privacy challenges particular to gaze data and demonstrate that differential privacy is a potential means to address them. Thus, this paper lays important foundations for future research on privacy-aware gaze interfaces.

This supplementary document provides survey results of users' privacy concerns in eye tracking, corresponding significance and skewness tests, the full list of questions and results of our online survey as well as a list of all extracted eye movement features.

CCS Concepts: • **Security and privacy → Human and societal aspects of security and privacy**; • **Human-centered computing → Human computer interaction (HCI)**;

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1   SURVEY RESULTS

We conducted a large-scale online survey to shed light on users' privacy concerns related to eye tracking technology and the information that can be inferred from eye movement data. We advertised our survey on social platforms (Facebook, WeChat) and local mailing lists for study announcements. The survey opened with general questions about eye tracking and VR technologies; continued with questions about future use and applications, data sharing and privacy (especially regarding with whom users are willing to share their data); and concluded with questions about the participants' willingness to share different eye movement representations. Participants answered each question on a 7-point Likert scale (1: Strongly disagree to 7: Strongly agree). To simplify the analysis, we merged scores 1 to 3 to "Disagree" and 5 to 7 to "Agree". At the end we asked for demographic information and offered a raffle.

1.1   Services and Attributes

Services

	Diseases Detection	Natural VR Interaction	Visual Search Target Detection	User Interface Interaction	Understandable Website Content	Reading Skill Improvement	Learning Skill Improvement	Stress Level Monitoring	Interest Identification	Activity Recognition	Shopping Assistance
1-3 - Disagree:	13.71	24.19	41.94	26.61	50.81	20.16	16.13	19.35	73.39	50.81	79.03
4 - Neither agree nor disagree:	5.65	4.84	8.87	5.65	11.29	9.68	8.06	11.29	8.06	12.10	4.84
5-7 - Agree:	80.65	70.97	49.19	67.74	37.90	70.16	75.81	69.35	18.55	37.10	16.13

Private Attributes

	Sexual Preference	Gender	Age	Mood and Emotions	Race	Identity
1-3 - Disagree:	74.19	51.61	41.13	44.35	65.32	78.23
4 - Neither agree nor disagree:	6.45	7.26	12.10	12.10	8.87	4.03
5-7 - Agree:	19.35	41.13	46.77	43.55	25.81	17.74

Fig. 1. Survey results (Services and Attributes): With which services would you agree to share your eye tracking data (Services)?; Would you agree to private attributes being inferred by these services (Private Attributes)?

1.2   Whom and Where

Sharing

	Eye Tracking Data
1-3 - Disagree:	41.13
4 - Neither agree nor disagree:	12.90
5-7 - Agree:	45.97

Owner

	Governmental Agency (non-health)	Governmental Health Authority	Local Company	International Company	Private Company (user's country)	Private Company (foreign country)	User Himself (home cloud)	Company Internal Use (intranet)	Research Institute
1-3 - Disagree:	62.90	37.10	61.29	63.71	60.48	73.39	14.52	56.45	8.06
4 - Neither agree nor disagree:	5.65	8.06	16.13	12.90	17.74	17.74	5.65	16.13	11.29
5-7 - Agree:	31.45	54.84	22.58	23.39	21.77	8.87	79.84	27.42	80.65

Environment

	Public	Private	Constrained
1-3 - Disagree:	63.71	58.06	32.26
4 - Neither agree nor disagree:	9.68	16.94	13.71
5-7 - Agree:	26.61	25.00	54.03

Application

	In Exchange for Benefits	VR/AR
1-3 - Disagree:	63.71	32.26
4 - Neither agree nor disagree:	11.29	16.13
5-7 - Agree:	25.00	51.61

Fig. 2. Survey results (Whom and Where): Would you agree to share your eye tracking data in general (Sharing); with whom (Owner); where (Environment); in exchange for benefits or for VR/AR usage (Application)?

1.3   Data Representation

No Modification

	Raw	Temporal Statistics	Appearance Statistics	Fixation Statistics	Fixation Points on Surface	Scan Path on Surface	Saccade Statistics	Gaze Plot	Scan Path Statistics	Heatmaps	Areas of Interest	Aggregated Features
1-3 - Disagree:	16.94	13.71	14.52	25.00	40.32	39.52	20.97	31.45	17.74	32.26	29.84	17.74
4 - Neither agree nor disagree:	16.13	14.52	9.68	16.13	15.32	15.32	13.71	14.52	19.35	12.90	12.10	16.13
5-7 - Agree:	66.94	71.77	75.81	58.87	44.35	45.16	65.32	54.03	62.90	54.84	58.06	66.13

Modified Representation (Anonymised)

	Raw	Temporal Statistics	Appearance Statistics	Fixation Statistics	Fixation Points on Surface	Scan Path on Surface	Saccade Statistics	Gaze Plot	Scan Path Statistics	Heatmaps	Areas of Interest	Aggregated Features
1-3 - Disagree:	8.87	8.87	7.26	11.29	16.94	16.13	13.71	15.32	13.71	13.71	13.71	12.90
4 - Neither agree nor disagree:	5.65	4.84	8.06	8.06	8.87	7.26	5.65	7.26	7.26	7.26	8.87	6.45
5-7 - Agree:	85.48	86.29	84.68	80.65	74.19	76.61	80.65	77.42	79.03	79.03	77.42	80.65

Fig. 3. Survey results (Data Representations): What kind of data representation would you agree to share (No Modification), and does this behaviour change if the data is anonymised prior to sharing (Anonymised)?

2 STATISTICAL TESTS

The following tables correspond to the Figures 1, 2, and 3. We found nearly all answers for the provided questions to be significantly different from equal distribution tested with Pearson's chi-squared test ($p < 0.001$, dof = 6). Additionally, we calculated the skewness and observed that the majority of questions show a significant difference to the corresponding normal distribution ($p < 0.1$).

2.1 Statistical tests corresponding to Figure 1

	Services												Private Attributes					
	Diseases Detection	Natural VR Interaction	Visual Search Target Detection	User Interface Interaction	Understandable Website Content	Reading Skill Improvement	Learning Skill Improvement	Stress Level Monitoring	Interest Identification	Activity Recognition	Shopping Assistance		Sexual Preference	Gender	Age	Mood and Emotions	Race	Identity
chi-squared	91.19	54.84	25.48	43.1	24.92	55.63	68.84	40.73	73.58	19.5	114.9		138.39	51.0	32.48	28.87	74.15	189.31
p-value	1.7e-17	5.0e-10	2.8e-4	1.1e-7	3.5e-4	3.5e-10	7.1e-13	3.3e-7	7.5e-14	3.4e-3	1.9e-22		2.2e-27	3.0e-9	1.3e-5	6.4e-5	5.8e-14	3.6e-38
z-score skew	-4.64	-3.07	-0.94	-3.15	0.54	-3.39	-4.05	-3.03	3.45	0.79	4.28		4.31	0.71	-1.04	-0.35	2.99	4.79
p-value skew	3.5e-6	2.1e-3	0.35	1.6e-3	0.59	7.0e-4	5.0e-5	2.5e-3	5.5e-4	0.43	1.9e-5		1.6e-5	0.48	0.30	0.72	2.8e-3	1.7e-6

2.2 Statistical tests corresponding to Figure 2

|	Sharing		Owner										Environment				Application	
	Eye Tracking Data		Governmental Agency (non-health)	Governmental Health Authority	Local Company	International Company	Private Company (user's country)	Private Company (foreign country)	User Himself (home cloud)	Company Internal Use (intranet)	Research Institute		Public	Private	Constrained		In Exchange for Benefits	VR/AR
chi-squared	26.73		44.79	22.89	43.1	55.97	61.39	77.42	72.0	26.16	88.94		39.03	30.0	31.81		40.5	32.26
p-value	1.6e-4		5.2e-8	8.4e-4	1.1e-7	3.0e-10	2.4e-11	1.2e-14	1.6e-13	2.1e-4	5.0e-17		7.1e-7	4.0e-5	1.8e-5		3.6e-7	1.5e-5
z-score skew	-0.97		1.59	-1.53	1.5	1.8	1.76	2.06	-4.58	1.55	-4.95		2.1	1.7	-1.97		2.55	-1.99
p-value skew	0.33		0.11	0.13	0.13	0.07	0.08	0.04	4.7e-6	0.12	7.5e-7		0.04	0.09	0.05		0.01	0.05

2.3 Statistical tests corresponding to Figure 3

|	No Modification												Modified Representation (Anonymised)											
	Raw	Temporal Statistics	Appearance Statistics	Fixation Statistics	Fixation Points on Surface	Scan Path on Surface	Saccade Statistics	Gaze Plot	Scan Path Statistics	Heatmaps	Areas of Interest	Aggregated Features	Raw	Temporal Statistics	Appearance Statistics	Fixation Statistics	Fixation Points on Surface	Scan Path on Surface	Saccade Statistics	Gaze Plot	Scan Path Statistics	Heatmaps	Areas of Interest	Aggregated Features
chi-squared	41.74	57.1	63.76	29.77	13.85	9.79	40.05	21.76	48.52	19.61	26.16	49.31	95.26	96.61	91.08	74.71	51.45	58.68	75.84	61.39	68.5	68.16	62.74	73.24
p-value	2.1e-7	1.8e-10	7.7e-12	4.3e-5	3.1e-2	1.3e-1	4.5e-7	1.3e-3	9.3e-9	3.2e-3	2.1e-4	6.5e-9	2.4e-18	1.3e-18	1.8e-17	4.4e-14	2.4e-9	8.4e-11	2.6e-14	2.4e-11	8.3e-13	9.7e-13	1.3e-11	8.8e-14
z-score skew	-3.25	-3.78	-3.98	-2.13	-0.78	-0.9	-2.98	-1.87	-2.9	-1.84	-2.12	-3.5	-4.8	-4.45	-4.28	-4.44	-3.82	-3.91	-3.77	-4.0	-4.24	-4.14	-3.98	-4.5
p-value skew	1.1e-3	1.6e-4	7.0e-5	0.03	0.44	0.37	2.9e-3	0.06	3.7e-3	0.07	0.03	4.7e-4	1.6e-6	8.6e-6	1.9e-5	9.1e-6	1.3e-4	9.4e-5	1.6e-4	6.4e-5	2.2e-5	3.4e-5	6.9e-5	6.6e-6

3 SURVEY EVALUATION

3.1 Eye Tracking and Virtual Reality (VR) Technologies

3.1.1 I am familiar with eye tracking technology.
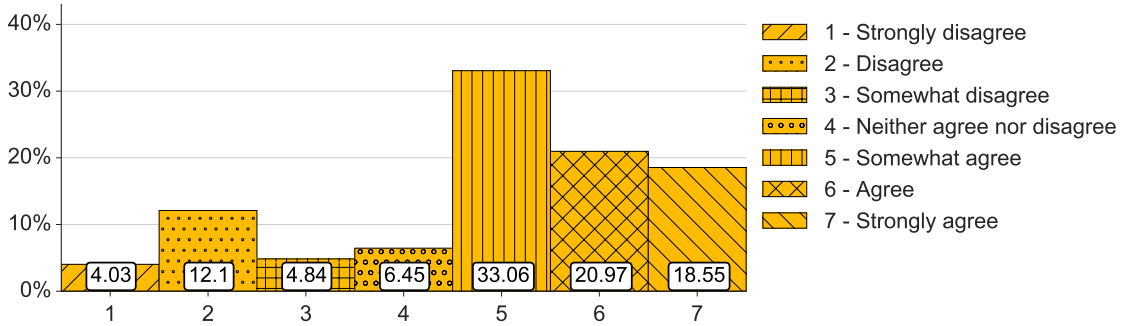
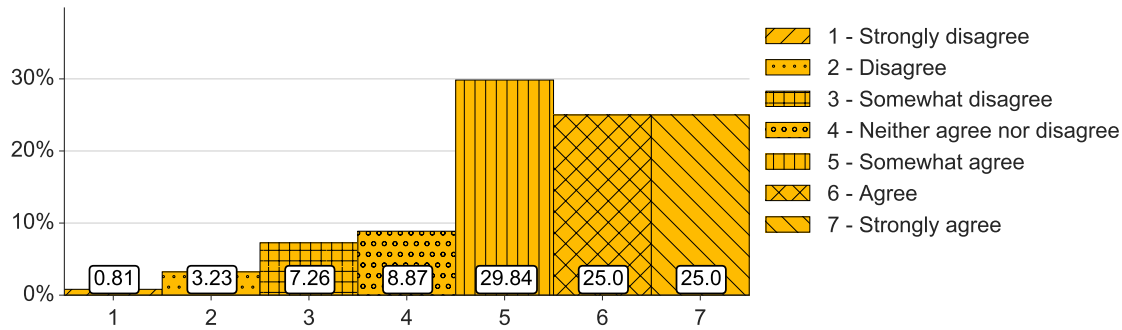### 3.1.2 How many eye tracking applications or experiments have you used or participated?
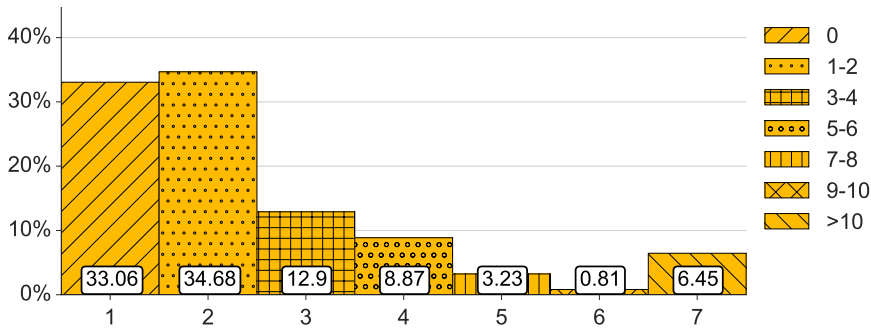
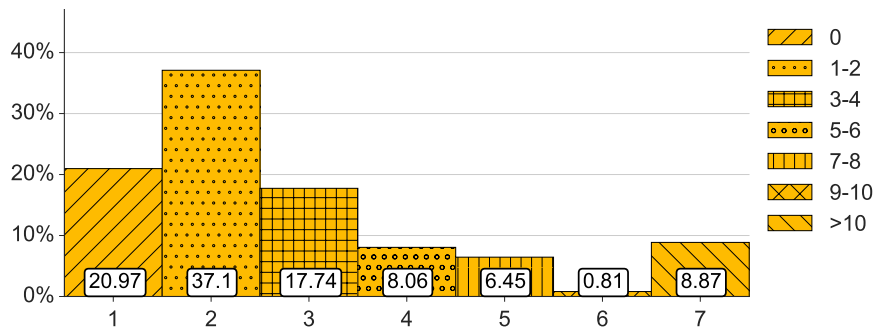### 3.1.3 I am concerned about eye tracking technology in terms of ...

	1)	2)	3)	4)
1 - Strongly disagree:	6.45	6.45	6.45	0.81
2 - Disagree:	16.94	20.97	12.90	5.65
3 - Somewhat disagree:	14.52	10.48	8.87	4.84
4 - Neither agree nor disagree:	16.13	15.32	13.71	8.87
5 - Somewhat agree:	21.77	24.19	21.77	20.97
6 - Agree:	17.74	15.32	26.61	25.81
7 - Strongly agree:	6.45	7.26	9.68	33.06

1) social acceptability
   (e.g.: How I am perceived by other people?)
2) mental comfortability
   (e.g.: increase/decrease mental workload)
3) physical comfortability
   (e.g.: increase/decrease physical workload)
4) privacy

3.1.4   I am familiar with virtual reality (VR) and augmented reality (AR) technology.

▨	1 - Strongly disagree
⋯	2 - Disagree
⊞	3 - Somewhat disagree
⊙	4 - Neither agree nor disagree
⊞	5 - Somewhat agree
⊠	6 - Agree
▨	7 - Strongly agree

Values: 0.81, 3.23, 7.26, 8.87, 29.84, 25.0, 25.0

3.1.5   How many VR applications or experiments have you used or participated?

▨	0
⋯	1-2
⊞	3-4
⊙	5-6
⊞	7-8
⊠	9-10
▨	>10

Values: 20.97, 37.1, 17.74, 8.06, 6.45, 0.81, 8.87

3.1.6   I am concerned about VR technology in terms of ...

	1)	2)	3)	4)
1 - Strongly disagree:	8.87	8.06	4.03	4.03
2 - Disagree:	20.16	8.87	3.23	16.13
3 - Somewhat disagree:	12.90	7.26	5.65	12.10
4 - Neither agree nor disagree:	17.74	12.90	10.48	14.52
5 - Somewhat agree:	21.77	26.61	28.23	17.74
6 - Agree:	14.52	25.00	34.68	18.55
7 - Strongly agree:	4.03	11.29	13.71	16.94

1) social acceptability
   (e.g.: How I am perceived by other people?)
2) mental comfortability
   (e.g.: increase/decrease mental workload)
3) physical comfortability
   (e.g.: increase/decrease physical workload)
4) privacy

3.2 Future Use of Eye Tracking Data

3.2.1 Would you agree to share eye tracking data ...

	1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)
1 - Strongly disagree:	1.61	3.23	8.87	7.26	11.29	3.23	3.23	3.23	35.48	16.13	44.35
2 - Disagree:	4.84	11.29	15.32	8.06	24.19	10.48	5.65	9.68	24.19	22.58	20.97
3 - Somewhat disagree:	7.26	9.68	17.74	11.29	15.32	6.45	7.26	6.45	13.71	12.10	13.71
4 - Neither agree nor disagree:	5.65	4.84	8.87	5.65	11.29	9.68	8.06	11.29	8.06	12.10	4.84
5 - Somewhat agree:	15.32	29.03	20.16	21.77	16.13	26.61	26.61	26.61	12.10	20.97	10.48
6 - Agree:	32.26	27.42	24.19	30.65	19.35	30.65	33.06	22.58	5.65	11.29	4.84
7 - Strongly agree:	33.06	14.52	4.84	15.32	2.42	12.90	16.13	20.16	0.81	4.84	0.81

1) for early detection of mental and psychological disease like dementia or Parkinson?
2) to enable hands-free interaction with displays and in virtual realty? You could type letters or select a button by gaze interaction or interact with items or persons in VR more naturally.
3) to identify the target of your visual search to provide information about the target you are looking at (e.g. the name of a person, information about a product, etc.)?
4) to improve interactions with user interfaces and devices, e.g. to make them more intuitive or faster?
5) to allow apps and websites to provide content easy to understand?
6) to analyse reading ability and propose methods to improve your reading skills or to change reading material in terms of appearance (enlarging text, highlighting current line)?
7) to analyse and improve your learning skills?
8) monitor your stress level and to provide early-stage healthcare intervention?
9) to identify your interests, e.g. what you like or dislike, and guide you like a shopping assistance, or to steer advertisement?
10) to identify activity specific patterns which could be used for activity tracking, lifelogging or self-quantifying, (e.g. reading, watching TV, playing a video game, computer work, etc.)?
11) to analyse your shopping behaviour on websites or within shopping malls to improve product placement?

3.2.2 Would you agree to share eye tracking data to identify your ... for a better service (e.g. entertainment, news, business, education, etc.)?

	1)	2)	3)	4)	5)	6)
1 - Strongly disagree:	49.19	31.45	20.97	25.81	37.90	55.65
2 - Disagree:	18.55	15.32	12.10	10.48	20.97	17.74
3 - Somewhat disagree:	6.45	4.84	8.06	8.06	6.45	4.84
4 - Neither agree nor disagree:	6.45	7.26	12.10	12.10	8.87	4.03
5 - Somewhat agree:	4.84	16.13	16.94	20.16	8.06	8.06
6 - Agree:	12.10	20.97	26.61	18.55	14.52	9.68
7 - Strongly agree:	2.42	4.03	3.23	4.84	3.23	0.00

1) sexual preferences
2) gender
3) age
4) mood and emotions
5) race
6) identity

3.3 Sharing Eye Tracking Data
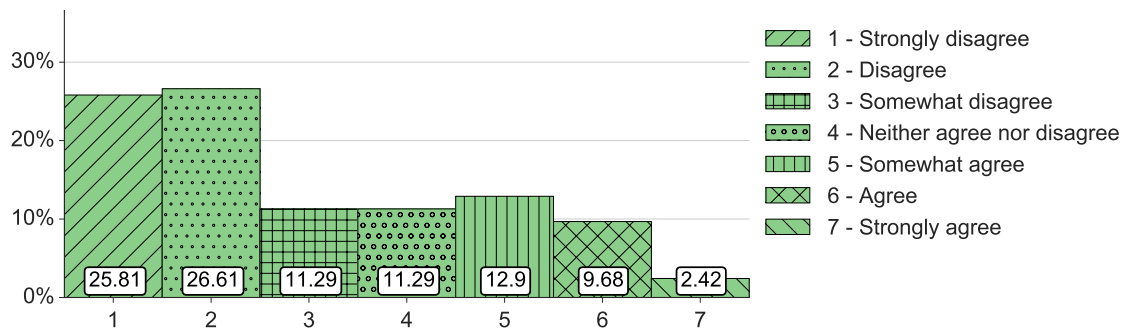
3.3.1 Would you share your eye tracking data?
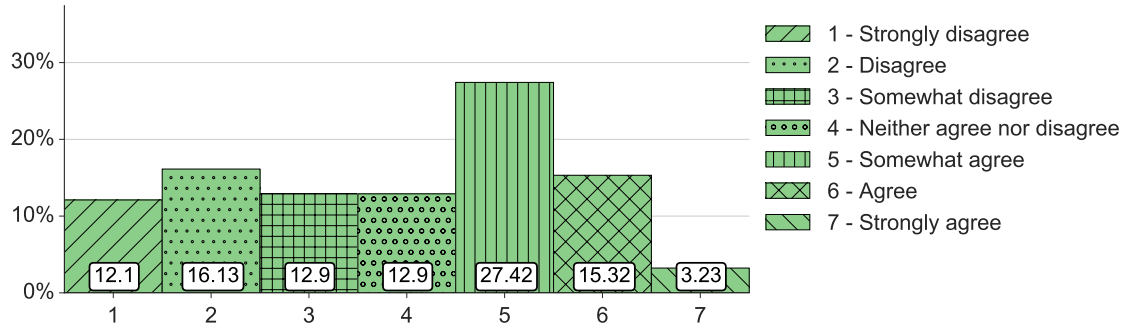
3.3.2 In general, I would trust a manufacturer and I am willing to share my eye tracking data if it is operated/owned by ...

	1)	2)	3)	4)	5)	6)	7)	8)	9)
1 - Strongly disagree:	25.00	12.10	21.77	31.45	25.81	33.06	4.03	26.61	3.23
2 - Disagree:	21.77	14.52	25.00	18.55	27.42	23.39	6.45	16.94	0.81
3 - Somewhat disagree:	16.13	10.48	14.52	13.71	7.26	16.94	4.03	12.90	4.03
4 - Neither agree nor disagree:	5.65	8.06	16.13	12.90	17.74	17.74	5.65	16.13	11.29
5 - Somewhat agree:	21.77	24.19	18.55	19.35	18.55	8.87	22.58	13.71	18.55
6 - Agree:	8.87	22.58	3.23	3.23	2.42	0.00	29.84	10.48	34.68
7 - Strongly agree:	0.81	8.06	0.81	0.81	0.81	0.00	27.42	3.23	27.42

1) a governmental agency (non-health related).
2) a governmental health authority (e.g., city, state/province, federal/national).
3) a recognized local company.
4) a recognized international company.

5) a recognized private company in user's country.
6) a recognized private company in foreign country.
7) the user himself (home cloud).
8) company internal use (intranet).
9) research institute.

3.3.3 Would you share your eye tracking data in exchange for benefits like shopping assistance, activity logging, etc.?

3.3.4   Would you share your eye tracking data if the data was collected in ...
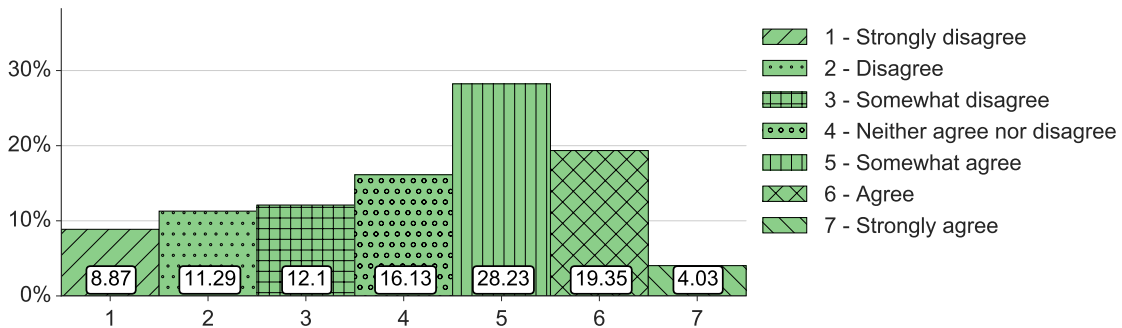
	1)	2)	3)
1 - Strongly disagree:	25.81	22.58	7.26
2 - Disagree:	24.19	23.39	12.10
3 - Somewhat disagree:	13.71	12.10	12.90
4 - Neither agree nor disagree:	9.68	16.94	13.71
5 - Somewhat agree:	15.32	13.71	26.61
6 - Agree:	10.48	9.68	22.58
7 - Strongly agree:	0.81	1.61	4.84

1) public, e.g. train station or park?
2) a private environment, e.g. office or home?
3) constrained environments (e.g. a specific room or place)?

3.3.5   Would you share eye tracking data if the data was collected in one of the following places?

	1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)
1 - Strongly disagree:	29.03	25.81	25.00	23.39	16.13	60.48	29.84	12.10	32.26	33.06	34.68
2 - Disagree:	25.00	25.00	22.58	20.97	20.97	19.35	26.61	15.32	19.35	20.97	20.97
3 - Somewhat disagree:	9.68	20.97	14.52	8.06	7.26	9.68	10.48	12.10	10.48	10.48	8.87
4 - Neither agree nor disagree:	5.65	8.06	9.68	14.52	13.71	4.84	8.06	11.29	10.48	9.68	6.45
5 - Somewhat agree:	20.16	11.29	14.52	17.74	20.16	1.61	12.90	18.55	14.52	12.90	12.10
6 - Agree:	8.06	8.06	12.10	10.48	15.32	3.23	10.48	19.35	11.29	10.48	14.52
7 - Strongly agree:	2.42	0.81	1.61	4.84	6.45	0.81	1.61	11.29	1.61	2.42	2.42

1) department store
2) friend's home
3) public transport
4) home
5) library
6) restroom
7) workplace
8) car
9) lobby (e.g. hotel)
10) cafe
11) street

3.3.6   Would you share your eye tracking data if the data was collected in VR or AR?.

Legend:
- 1 - Strongly disagree
- 2 - Disagree
- 3 - Somewhat disagree
- 4 - Neither agree nor disagree
- 5 - Somewhat agree
- 6 - Agree
- 7 - Strongly agree

Bar values: 1: 8.87, 2: 11.29, 3: 12.1, 4: 16.13, 5: 28.23, 6: 19.35, 7: 4.03

3.3.7 *Would you share your eye tracking data if the data was collected ...*

	1)	2)
1 - Strongly disagree:	12.90	13.71
2 - Disagree:	20.16	17.74
3 - Somewhat disagree:	9.68	16.13
4 - Neither agree nor disagree:	25.00	23.39
5 - Somewhat agree:	16.13	16.13
6 - Agree:	12.10	11.29
7 - Strongly agree:	4.03	1.61

1) indoor?
2) outdoor?

3.3.8 *Would you share eye tracking data if the collected data was recorded in the ...*

	1)	2)	3)	4)	5)
1 - Strongly disagree:	9.68	8.06	8.06	10.48	14.52
2 - Disagree:	23.39	21.77	21.77	24.19	26.61
3 - Somewhat disagree:	7.26	5.65	4.03	6.45	11.29
4 - Neither agree nor disagree:	31.45	30.65	33.87	34.68	29.03
5 - Somewhat agree:	12.90	17.74	16.94	10.48	12.90
6 - Agree:	11.29	12.10	11.29	10.48	4.84
7 - Strongly agree:	4.03	4.03	4.03	3.23	0.81

1) morning?
2) noon?
3) afternoon?
4) evening?
5) night?

3.3.9 *Would you share eye tracking data if the recording duration was restricted to one of the following options?*

	1)	2)	3)	4)	5)	6)	7)	8)	9)
1 - Strongly disagree:	1.61	10.48	14.52	22.58	8.06	17.74	18.55	20.16	44.35
2 - Disagree:	7.26	17.74	20.97	30.65	8.06	23.39	23.39	29.84	25.00
3 - Somewhat disagree:	5.65	23.39	12.90	12.90	12.10	20.16	12.90	12.10	16.13
4 - Neither agree nor disagree:	9.68	7.26	16.94	10.48	16.13	12.10	20.16	18.55	5.65
5 - Somewhat agree:	29.03	29.03	18.55	12.90	21.77	11.29	14.52	8.87	5.65
6 - Agree:	33.87	10.48	10.48	8.06	20.16	11.29	7.26	4.84	2.42
7 - Strongly agree:	12.90	1.61	5.65	2.42	13.71	4.03	3.23	5.65	0.81

1) for a specific application with user allowance
2) automatic data recording if eye tracking data is necessary for usage
3) selected hours per day
4) during work time (at work)
5) for personal use
6) during free time
7) during work days
8) during weekend
9) whole day recording

3.3.10 Would you share eye tracking data if the collected data was saved for ...

	1)	2)	3)	4)	5)	6)	7)	8)
1 - Strongly disagree:	4.84	46.77	13.71	18.55	29.03	37.90	43.55	62.90
2 - Disagree:	6.45	23.39	13.71	18.55	20.16	24.19	22.58	16.13
3 - Somewhat disagree:	10.48	8.06	13.71	12.90	13.71	8.06	12.10	8.06
4 - Neither agree nor disagree:	12.10	9.68	20.16	20.97	12.90	12.90	9.68	7.26
5 - Somewhat agree:	35.48	8.87	20.16	14.52	15.32	10.48	7.26	5.65
6 - Agree:	20.16	3.23	14.52	10.48	7.26	5.65	4.03	0.00
7 - Strongly agree:	10.48	0.00	4.03	4.03	1.61	0.81	0.81	0.00

1) application specific purpose
   (e.g. direct application feedback,
   VR interaction and gaming, etc)?
2) an unspecified amount of time?
3) a day?
4) a week?
5) a month?
6) a half year?
7) a year?
8) forever?

3.3.11 Would you share eye tracking data if the data was collected during one of the following emotions?

	1)	2)	3)	4)	5)	6)	7)	8)
1 - Strongly disagree:	14.52	15.32	15.32	11.29	11.29	16.13	13.71	14.52
2 - Disagree:	21.77	20.97	23.39	14.52	12.90	20.16	16.94	13.71
3 - Somewhat disagree:	8.87	6.45	12.10	5.65	4.03	6.45	3.23	4.03
4 - Neither agree nor disagree:	22.58	25.00	23.39	21.77	24.19	25.81	25.81	25.81
5 - Somewhat agree:	14.52	13.71	12.10	23.39	24.19	15.32	18.55	19.35
6 - Agree:	16.13	16.94	12.10	17.74	17.74	15.32	16.94	16.94
7 - Strongly agree:	1.61	1.61	1.61	5.65	5.65	0.81	4.84	5.65

1) fear
2) anger
3) sadness
4) joy
5) surprise
6) disgust
7) trust
8) anticipation

3.3.12 Would you share eye tracking data if it was collected to run an application of the following categories?

	1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)	12)	13)	14)
1 - Strongly disagree:	22.58	17.74	8.06	20.97	12.90	21.77	24.19	25.00	15.32	19.35	13.71	9.68	21.77	3.23
2 - Disagree:	18.55	19.35	11.29	21.77	14.52	20.97	29.84	25.00	12.10	20.16	13.71	5.65	22.58	1.61
3 - Somewhat disagree:	17.74	20.97	11.29	20.16	11.29	14.52	18.55	15.32	8.06	14.52	12.10	6.45	11.29	3.23
4 - Neither agree nor disagree:	13.71	12.10	10.48	13.71	12.90	13.71	8.87	15.32	12.90	15.32	17.74	8.87	17.74	5.65
5 - Somewhat agree:	20.16	16.94	25.81	16.13	25.81	17.74	10.48	11.29	32.26	16.13	17.74	22.58	12.90	15.32
6 - Agree:	7.26	11.29	22.58	5.65	18.55	8.87	6.45	7.26	14.52	11.29	20.97	33.06	11.29	34.68
7 - Strongly agree:	0.00	1.61	10.48	1.61	4.03	2.42	1.61	0.81	4.84	3.23	4.03	13.71	2.42	36.29

1) utilities (e.g. taxi app, bank app, etc.)
2) entertainment (e.g. streaming, chatting, watching videos, etc.)
3) games (e.g. VR)
4) news
5) productivity
6) lifestyle
7) social networking
8) business
9) education/parenting
10) travel
11) book
12) health/medical and fitness
13) food and drink
14) research (anonymised data storage)

3.3.13 Would you share eye tracking data if it was collected during one of the following activities?

	1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)	12)	13)	14)
1 - Strongly disagree:	20.97	20.16	11.29	12.90	20.16	25.81	9.68	17.74	8.87	28.23	19.35	20.97	22.58	22.58
2 - Disagree:	26.61	19.35	9.68	13.71	21.77	14.52	7.26	19.35	7.26	13.71	16.94	15.32	17.74	15.32
3 - Somewhat disagree:	14.52	11.29	9.68	8.87	16.13	21.77	7.26	11.29	9.68	8.87	9.68	13.71	9.68	12.90
4 - Neither agree nor disagree:	11.29	9.68	12.90	12.10	11.29	15.32	16.13	19.35	15.32	32.26	16.13	16.13	15.32	13.71
5 - Somewhat agree:	15.32	22.58	29.84	27.42	16.13	12.90	29.84	16.94	25.81	8.06	18.55	18.55	16.13	19.35
6 - Agree:	9.68	13.71	19.35	18.55	11.29	8.06	24.19	12.10	25.00	7.26	13.71	11.29	14.52	9.68
7 - Strongly agree:	1.61	3.23	7.26	6.45	3.23	1.61	5.65	3.23	8.06	1.61	5.65	4.03	4.03	6.45

1) office work
2) computer work
3) reading
4) writing
5) browsing
6) social interaction
7) gaming
8) eating, drinking
9) driving
10) smoking
11) walking
12) mobile phone interaction
13) watching TV
14) concentrated work

3.3.14   Would you share eye tracking data if it was collected while you are interacting with one of the following devices?

	1)	2)	3)	4)	5)	6)
1 - Strongly disagree:	12.90	12.90	16.13	12.90	9.68	16.94
2 - Disagree:	16.13	16.13	16.13	17.74	8.06	15.32
3 - Somewhat disagree:	8.87	8.87	8.87	8.06	8.06	8.06
4 - Neither agree nor disagree:	12.90	14.52	15.32	16.94	12.10	18.55
5 - Somewhat agree:	25.81	25.00	25.00	24.19	29.84	19.35
6 - Agree:	16.13	16.13	14.52	15.32	24.19	16.94
7 - Strongly agree:	7.26	6.45	4.03	4.84	8.06	4.84

1) desktop computer   4) tablet
2) laptop   5) book
3) mobile phone   6) TV

3.3.15   Would you share eye tracking data if the data is collected while you are interacting with one of the following persons?

	1)	2)	3)	4)	5)	6)
1 - Strongly disagree:	27.42	28.23	14.52	23.39	23.39	32.26
2 - Disagree:	20.16	20.97	8.87	16.13	22.58	20.97
3 - Somewhat disagree:	10.48	12.10	10.48	10.48	8.06	10.48
4 - Neither agree nor disagree:	7.26	11.29	12.10	19.35	15.32	15.32
5 - Somewhat agree:	18.55	13.71	29.84	18.55	16.13	8.87
6 - Agree:	12.10	10.48	16.13	8.87	9.68	7.26
7 - Strongly agree:	4.03	3.23	8.06	3.23	4.84	4.84

1) friends   4) foreigners/strangers
2) relatives   5) working colleagues
3) pets   6) boss

3.3.16   Would you share eye tracking data if the kind of recorded was restricted to ...

	1)	2)	3)	4)	5)	6)
1 - Strongly disagree:	6.45	19.35	16.13	19.35	17.74	22.58
2 - Disagree:	10.48	12.90	12.90	16.13	16.13	16.13
3 - Somewhat disagree:	10.48	16.94	12.10	13.71	9.68	12.10
4 - Neither agree nor disagree:	12.10	16.13	17.74	16.13	16.13	17.74
5 - Somewhat agree:	26.61	20.97	21.77	18.55	17.74	16.94
6 - Agree:	28.23	11.29	15.32	11.29	18.55	11.29
7 - Strongly agree:	5.65	2.42	4.03	4.84	4.03	3.23

1) gaze or pupil behaviour?   4) gaze or pupil behaviour + scene video content?

2) scene video content?   5) gaze or pupil behaviour + eye video content?

3) eye video content?   6) gaze or pupil behaviour + scene video content + eye video content?

3.3.17   Suppose you want to create an anonymous online identity in order to share your eye tracking data. Would you "hide" the following ADDITIONAL personal information?

	1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)	12)	13)	14)	15)	16)	17)
1 - Strongly disagree:	3.2	4.0	4.0	4.0	3.2	4.0	4.8	4.8	6.5	5.7	3.2	3.2	5.7	6.5	8.9	13.7	6.5
2 - Disagree:	5.7	2.4	0.8	0.8	8.9	7.3	9.7	11.3	8.9	5.7	5.7	3.2	8.1	20.2	14.5	20.2	13.7
3 - Somewhat disagree:	5.7	2.4	2.4	2.4	6.5	8.1	16.9	19.4	16.1	14.5	4.0	3.2	13.7	14.5	12.9	19.4	15.3
4 - Neither agree nor disagree:	5.7	3.2	3.2	2.4	10.5	15.3	18.6	16.9	12.9	13.7	8.9	2.4	13.7	15.3	16.1	14.5	12.9
5 - Somewhat agree:	8.1	9.7	6.5	3.2	10.5	12.1	13.7	16.1	10.5	8.9	6.5	4.0	10.5	9.7	7.3	8.1	6.5
6 - Agree:	27.4	24.2	27.4	26.6	22.6	18.6	12.1	9.7	18.6	18.6	20.2	23.4	20.2	14.5	12.9	6.5	12.9
7 - Strongly agree:	44.4	54.0	55.6	60.5	37.9	34.7	24.2	21.8	26.6	33.1	51.6	60.5	28.2	19.4	27.4	17.7	32.3

1) first name

2) last name

3) identifiable profile picture

4) residential address

5) city where I live

6) occupation and employment information

7) hobbies

8) interests

9) current location information (e.g., kitchen, public transport, office)

10) my health condition(s)

11) email address

12) phone number

13) age and date of birth

14) gender

15) race

16) eye color

17) iris image

3.4   Eye Tracking Data Representations

3.4.1   Would you agree to share eye tracking data which consists of ...

	1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)	12)
1 - Strongly disagree:	4.03	3.23	3.23	3.23	11.29	15.32	4.84	9.68	5.65	8.87	8.06	5.65
2 - Disagree:	7.26	7.26	8.06	12.10	14.52	10.48	9.68	13.71	8.06	12.10	13.71	8.87
3 - Somewhat disagree:	5.65	3.23	3.23	9.68	14.52	13.71	6.45	8.06	4.03	11.29	8.06	3.23
4 - Neither agree nor disagree:	16.13	14.52	9.68	16.13	15.32	15.32	13.71	14.52	19.35	12.90	12.10	16.13
5 - Somewhat agree:	22.58	25.00	29.03	20.16	20.16	17.74	27.42	22.58	31.45	22.58	25.00	22.58
6 - Agree:	27.42	29.84	28.23	26.61	19.35	20.16	25.00	23.39	18.55	23.39	23.39	30.65
7 - Strongly agree:	16.94	16.94	18.55	12.10	4.84	7.26	12.90	8.06	12.90	8.87	9.68	12.90

1) the raw x and y gaze or pupil position over time?

2) statistics of steady (fixations) and dynamic (saccades) state of the eyes (when fixations and saccades take place)?

3) statistics of steady (fixations) and dynamic (saccades) state of the eyes (how often fixations and saccades appear in a given time range)?

4) statistics of eye tracking data which describe the number of fixations, fixation duration as well as their spatial distribution on public displays, computer monitors, or in VR environment?

5) fixation points on public displays, computer monitors, or in VR environment?

6) scan path information, the concatenation of gaze movements on public displays, computer monitors, or in VR environment?

7) scan path statistics, e.g. whether after a gaze movement to left is followed by a movement upwards, on public displays, computer monitors, or in VR environment?

8) fixations with duration and scan path information (Gaze Plot), the concatenation of gaze movements and fixational behaviour, on public displays, computer monitors, or in VR environment?

9) fixations with duration and scan path information statistics, e.g. whether after a gaze movement to left is followed by a movement upwards and how long the following fixation lasts, on public displays, computer monitors, or in VR environment?

10) heatmaps, user's gaze distribution on public displays, computer monitors, or in VR environment?

11) statistics of gaze distribution on areas of interests (AOIs) on public displays, computer monitors, or in VR environment?

12) aggregated features, given as so-called feature vectors, where each entry of such a vector describe a feature of user's behaviour like average blinking rate, fixation duration, ratio of saccadic movements, etc. within a given time window?

3.4.2   Imagine your eye tracking data could be modified so that it is anonymous, i.e. indistinguishable from that of another user. Would you agree to share ...

	1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)	12)
1 - Strongly disagree:	1.61	0.81	0.81	2.42	4.03	3.23	0.81	3.23	2.42	3.23	2.42	3.23
2 - Disagree:	2.42	3.23	3.23	4.03	5.65	7.26	6.45	5.65	5.65	4.84	6.45	4.84
3 - Somewhat disagree:	4.84	4.84	3.23	4.84	7.26	5.65	6.45	6.45	5.65	5.65	4.84	4.84
4 - Neither agree nor disagree:	5.65	4.84	8.06	8.06	8.87	7.26	5.65	7.26	7.26	7.26	8.87	6.45
5 - Somewhat agree:	25.00	28.23	27.42	24.19	22.58	25.81	29.03	25.81	23.39	27.42	25.00	25.00
6 - Agree:	32.26	29.84	29.03	28.23	25.81	25.00	23.39	25.00	28.23	23.39	25.00	27.42
7 - Strongly agree:	28.23	28.23	28.23	28.23	25.81	25.81	28.23	26.61	27.42	28.23	27.42	28.23

1) the raw x and y gaze or pupil position over time?
2) statistics of steady (fixations) and dynamic (saccades) state of the eyes (when fixations and saccades take place)?
3) statistics of steady (fixations) and dynamic (saccades) state of the eyes (how often fixations and saccades appear in a given time range)?
4) statistics of eye tracking data which describe the number of fixations, fixation duration as well as their spatial distribution on public displays, computer monitors, or in VR environment?
5) fixation points on public displays, computer monitors, or in VR environment?
6) scan path information, the concatenation of gaze movements on public displays, computer monitors, or in VR environment?
7) scan path statistics, e.g. whether after a gaze movement to left is followed by a movement upwards, on public displays, computer monitors, or in VR environment?
8) fixations with duration and scan path information (Gaze Plot), the concatenation of gaze movements and fixational behaviour, on public displays, computer monitors, or in VR environment?
9) fixations with duration and scan path information statistics, e.g. whether after a gaze movement to left is followed by a movement upwards and how long the following fixation lasts, on public displays, computer monitors, or in VR environment?
10) heatmaps, user's gaze distribution on public displays, computer monitors, or in VR environment?
11) statistics of gaze distribution on areas of interests (AOIs) on public displays, computer monitors, or in VR environment?
12) aggregated features, given as so-called feature vectors, where each entry of such a vector describe a feature of user's behaviour like average blinking rate, fixation duration, ratio of saccadic movements, etc. within a given time window?

3.4.3　Would you agree to share scene video information of public displays, computer monitors, or in VR environment which consists of ...

	1)	2)	3)	4)	5)	6)
1 - Strongly disagree:	10.48	8.87	8.06	4.84	4.84	8.06
2 - Disagree:	16.94	15.32	14.52	16.13	16.13	16.13
3 - Somewhat disagree:	21.77	13.71	14.52	13.71	12.90	11.29
4 - Neither agree nor disagree:	16.94	20.16	16.94	17.74	17.74	14.52
5 - Somewhat agree:	19.35	23.39	25.81	25.81	25.81	28.23
6 - Agree:	12.10	15.32	16.94	16.94	19.35	17.74
7 - Strongly agree:	2.42	3.23	3.23	4.84	3.23	4.03

1) the scene content during a whole eye tracking recording?
2) single frame from each fixation?
3) gaze stripes, sequence of image frame from each fixation?
4) tiny image patches around the gaze position during a whole eye tracking recording?
5) tiny image patches around the gaze position from each fixation?
6) the whole scene video but with blurred out surrounding and clear object of interest?

3.4.4　Would you agree to share eye video information recorded from eye tracking camera which consists of ...

	1)	2)	3)
1 - Strongly disagree:	17.74	14.52	6.45
2 - Disagree:	20.16	18.55	15.32
3 - Somewhat disagree:	19.35	11.29	8.06
4 - Neither agree nor disagree:	11.29	10.48	10.48
5 - Somewhat agree:	13.71	20.97	22.58
6 - Agree:	13.71	16.13	27.42
7 - Strongly agree:	4.03	8.06	9.68

1) the whole eye video with visible iris and surrounding facial expressions?
2) share the whole eye video with visible iris but blurred surrounding facial expressions?
3) the whole eye video but only showing the pupil centre without iris or facial expressions?

4 EYE MOVEMENT FEATURE EXTRACTION

Table 1 summarises the features that we extracted from fixations, saccades, blinks, pupil diameter, and a user's scan paths. Similar to [Bulling et al. 2011], each saccade is encoded as a character forming words of length n (wordbook). We extracted these features on a sliding window of 30 seconds (step size of 0.5 seconds).

Fixation (8)	rate, mean, max, var of durations, mean/var of var pupil position within one fixation
Saccades (12)	rate/ratio of (small/large/right/left) saccades, mean, max, variance of amplitudes
Combined (1)	ratio saccades to fixations
Wordbooks (24)	number of non-zero entries, max and min entries, and their difference for n-grams with n <= 4
Blinks (3)	rate, mean/var blink duration
Pupil Diameter (4)	mean/var of mean/var during fixations

Table 1. We extracted 52 eye movement features to describe a user's eye movement behaviour. The number of features per category is given in parentheses.

REFERENCES

Andreas Bulling, Jamie A. Ward, Hans Gellersen, and Gerhard Tröster. 2011. Eye Movement Analysis for Activity Recognition Using Electrooculography. *IEEE Transactions on Pattern Analysis and Machine Intelligence* 33, 4 (2011), 741–753. https://doi.org/10.1109/TPAMI.2010.86