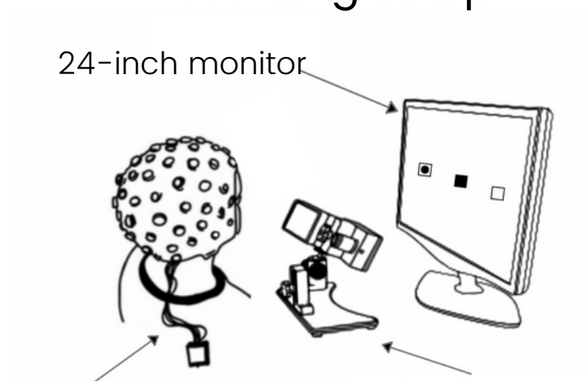
EEGEyeNet: a Simultaneous Electroencephalography and Eye-tracking Dataset and Benchmark for Eye Movement Prediction

Ard Kastrati 1, Martyna Beata Płomecka 2, Damian Pascual 1, Lukas Wolf 1, Victor Gillioz 1, Roger Wattenhofer 1, Nicolas Langer 2
1: ETH Zurich, Department of Electrical Engineering, Distributed Computing Group
2: University of Zurich, Department of Psychology, Methods of Plasticity Research

Recording Setup



Published Dataset

Simultaneously recorded EEG + Eye-Tracking

~3 million fixations and saccades

3 paradigms requiring different cognitive load

High variety of eye movements

356 Participants 20-80yo
(largest dataset of this kind)

Published Benchmark

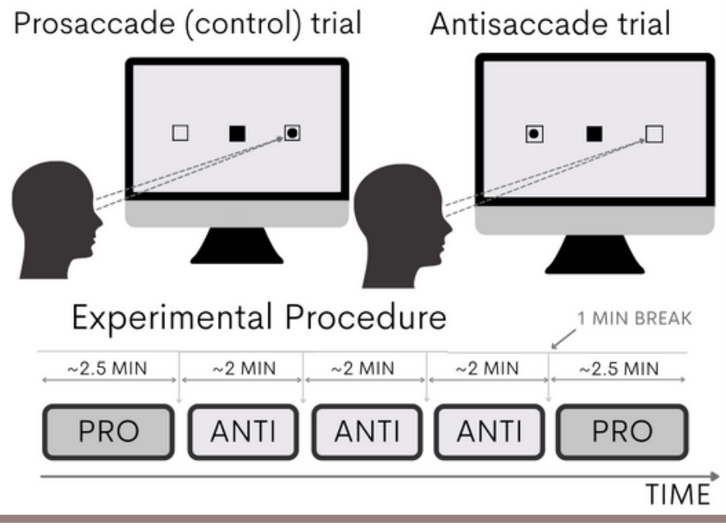
Baselines:
- classical machine learning models
- neural networks.

- Left-right,
- Angle-amplitude,
- Absolute position

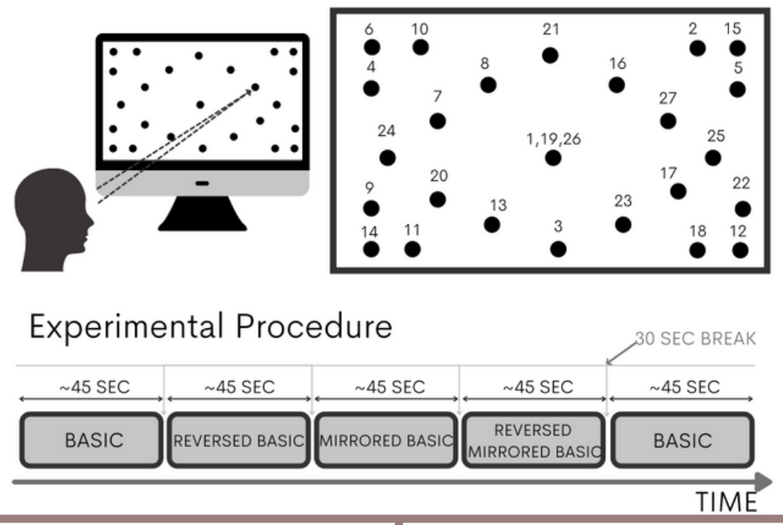
3 different tasks with increasing difficulty

Experimental paradigms

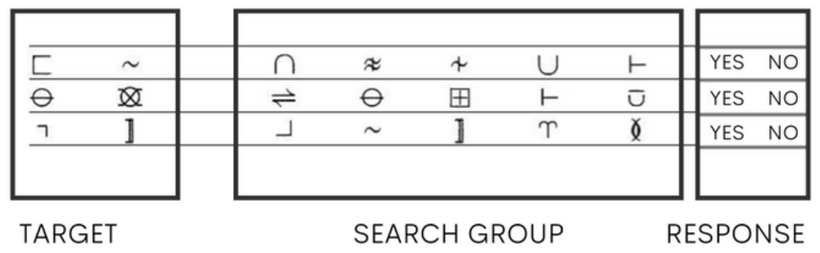
ANTISACCADE PARADIGM



LARGE GRID PARADIGM



VISUAL SYMBOL SEARCH PARADIGM



120 SECONDS, NO BREAKS,
MAX 60 TRIALS (ROWS)

Benchmark

TASKS

Left-right | Angle-Amplitude | Abs. Position

Dataset	# Participants Total	Train	Validation	Test	# Samples Total	Train	Validation	Test
Left-Right	329	229	50	50	30842	21042	4980	4820
Angle/Amplitude	27	19	4	4	17830	12275	2836	2719
Abs. Position	27	19	4	4	21464	14706	3277	3481

Overview of EEGEyeNet Dataset

Paradigm	Preproc.	# Fixations	# Saccades	# Blinks	Total time
Pro- Antisac.	min	357115	358384	56179	38 h
	max	358587	359856	57991	38 h 6 mins
Large Grid	min	68075	68245	11108	7 h 52min
	max	69013	69185	11237	7 h 58 min
VSS	min	43384	43443	971	1 h 29 min
	max	43279	43339	945	1 h 28 min
Total	min	468574	470072	68258	47 h 21 min
	max	470879	472380	70173	47 h 33 min

Benchmark Results

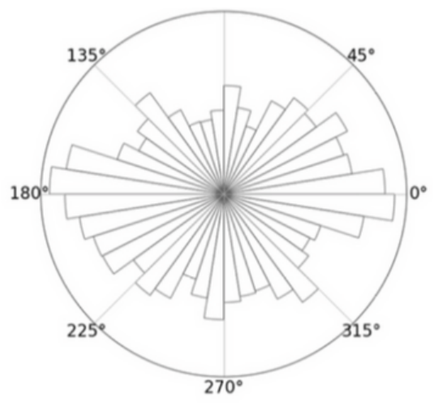
Model	Left-Right Accuracy	Angle/Amplitude Angle RMSE	Angle/Amplitude Amp. RMSE	Abs. Position RMSE
KNN	90.7 ±0	1.26 ±0	59.3 ±0	119.7 ±0
GaussianNB	87.7 ±0	-	-	-
LinearSVC	92.0 ±0	-	-	-
RBF SVC/SVR	89.4 ±0	1.88 ±0	75.9 ±0	123 ±0
Linear Regression	-	1.39 ±0	64.6 ±0	118.3 ±0
Ridge Regression	-	1.39 ±0	64.2 ±0	118.2 ±0
Lasso Regression	-	1.38 ±0	63.9 ±0	118 ±0
Elastic Net	-	1.38 ±0	63.6 ±0	118.1 ±0
Random Forest	96.5 ±0	1.09 ±0.01	59.8 ±0.1	116.7 ±0.1
Gradient Boost	97.3 ±0.1	1.11 ±0.01	60 ±0.1	117 ±0.1
AdaBoost	96.3 ±0	1.43 ±0.01	65 ±0.1	119.4 ±0.1
XGBoost	97.9 ±0	1.11 ±0	61.3 ±0	118 ±0
CNN	98.3 ±0.5	**0.33** ±0.05	32 ±3.6	**70.2** ±1.1
PyramidalCNN	98.5 ±0.2	0.34 ±0.04	**30.7** ±1	73.6 ±1.9
EEGNet	98.6 ±0.1	0.70 ±0.08	46 ±5.2	81.7 ±1.0
InceptionTime	97.9 ±1.1	0.44 ±0.16	43.6 ±21.85	70.8 ±0.8
Xception	**98.8** ±0.1	0.47 ±0.28	32.2 ±1.9	78.7 ±1.6
Naive Baseline	52.3	1.90	74.7	123.3

Mean and standard deviation of 5 runs of the considered models on the three benchmark tasks. Angle is measured in radians, Amplitude and Absolute Position in mm.

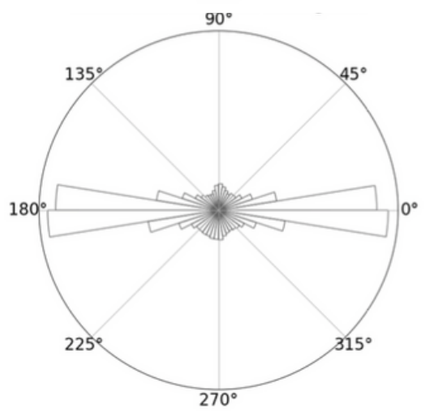
Our evaluation reveals that deep learning models are superior to other statistical techniques in estimating gaze position from EEG data. Although this is not surprising, given the complexity of the task and the larger expressive capacity of neural networks, it confirms that EEGEyeNet is a valuable resource for developing large neural models. We expect that future work will surpass our scores advancing EEG-based eye tracking.

Distribution of the saccade angle

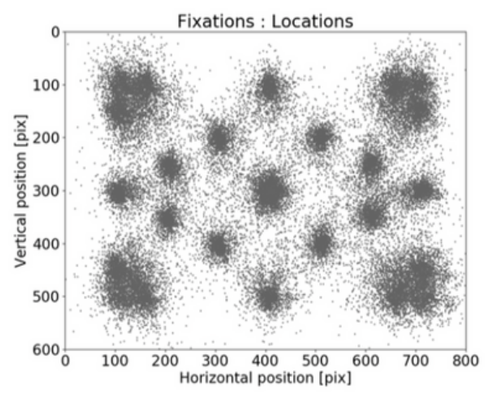
Angle, Amplitude, Absolute position tasks:

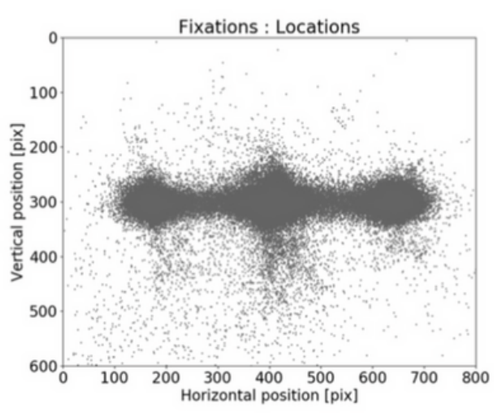


Left-Right task:



Distribution of the fixation positions





www.eegeye.net

Contact us:
akastrati@ethz.ch,
martyna.plomecka@uzh.ch