NEURAL INFORMATION PROCESSING SYSTEMS

RClicks: Realistic Click Simulation for Benchmarking Interactive Segmentation

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https://emb-ai.github.io/rclicks-project/

Interactive segmentation (IS)

Goal: to obtain high-quality pixel-level masks with limited user interaction

*Among various types of user input, **clicks** are the most common*

Interactive segmentation example using Segment Anything Model (SAM)

IS evaluation

1. Evaluation requires user inputs, gathering real-user data is impractical

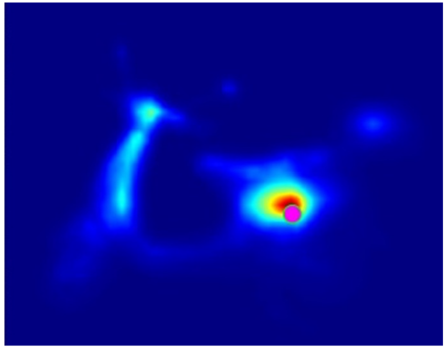
2. IS quality is assessed with a **baseline** clicking strategy: clicks are put in the center of the largest erroneous area

3. IS method might be **overfitted** for **baseline** clicks

4. To evaluate IS methods in a realistic way we propose a user **clickability model**

Real-users clicks

clicks simulated by **clickability model** and **baseline** click

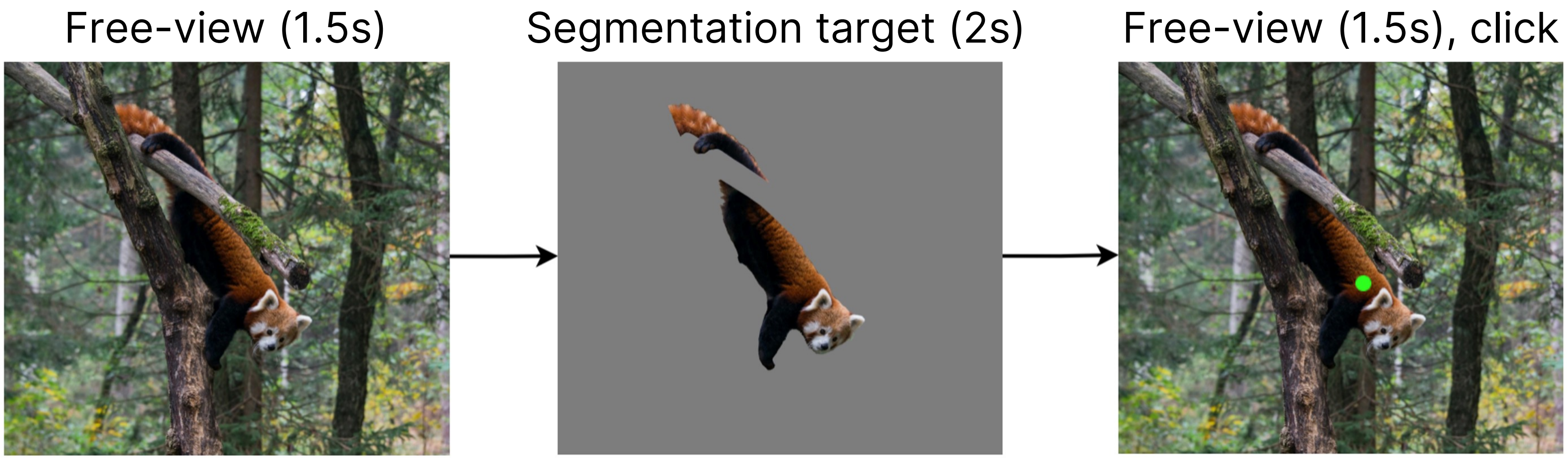


clicks distribution predicted by **clickability model**

Contributions

- Multi–round interaction dataset of **475 544 clicks**
- Novel **clickability model** for realistic click simulation
- RClicks — a **benchmark** for measurement of **real–world** annotation time and robustness of IS methods
- **Difficulty score** for IS instances on first real clicks

Data collection procedure



Data collection procedure

Users' click data

Our dataset is **based on** GrabCut, Berkeley, DAVIS, COCO-MVal, and TETRIS

To obtain error masks **for the subsequent rounds**, we applied SAM, SimpleClick, RITM, and synthetic distortions

We collected a dataset of clicks **both on PC** and **mobile devices**

Dataset	First #	Subseq. #	Sum #
GrabCut	2 395	3 427	5 822
Berkeley	4 859	6 937	11 796
DAVIS	16 975	23 687	40 662
COCO-MV	38 097	53 926	92 023
TETRIS	123 023	202 218	325 241
All	185 349	290 195	475 544

Number of collected clicks for each dataset in interaction rounds

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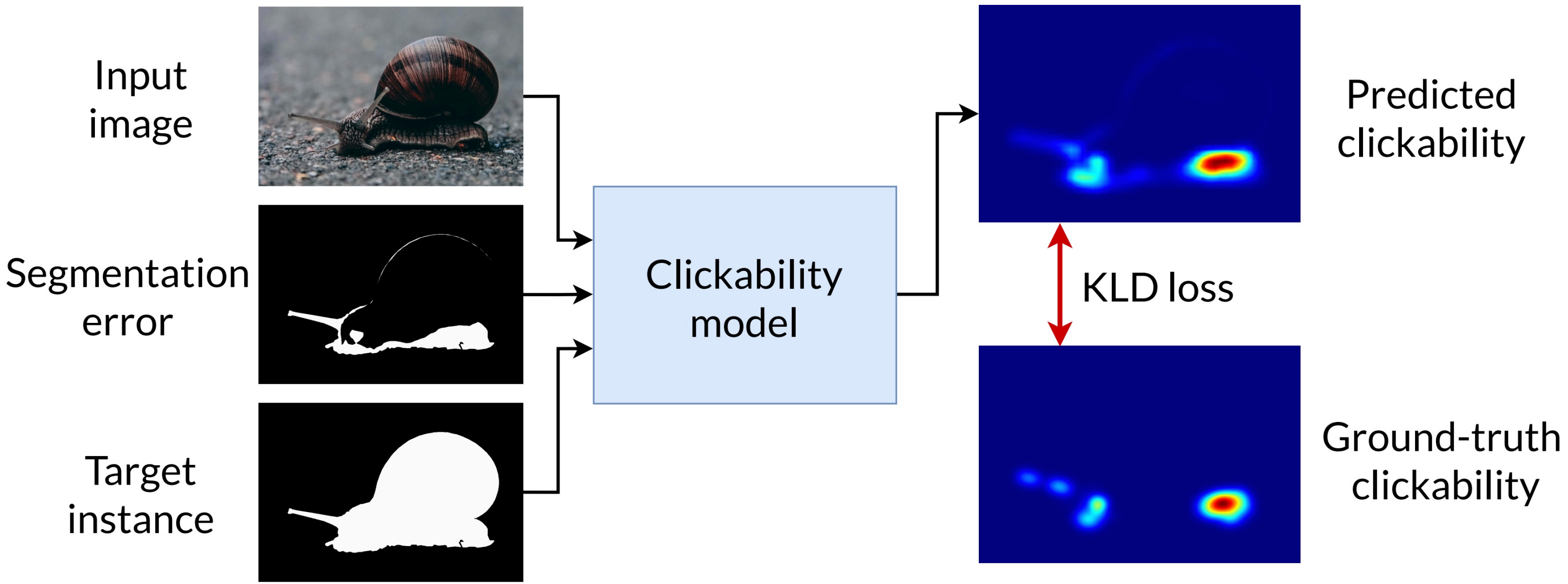
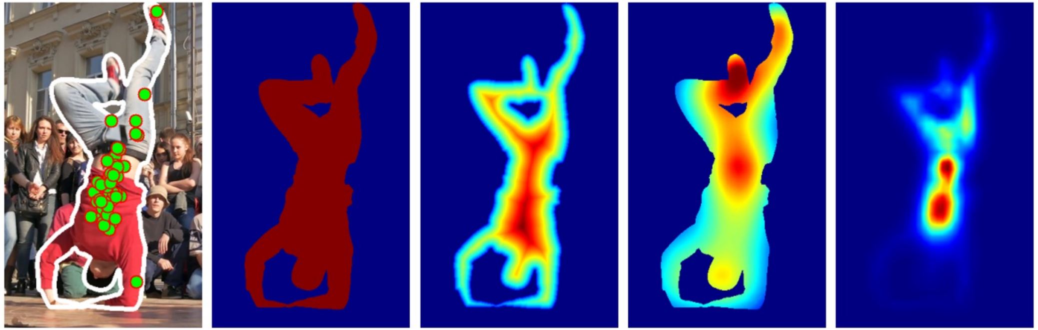
Clickability model



Proposed clickability prediction pipeline

Clickability model



(a) Clicks (b) UD (c) DT (d) SM (e) Ours

Examples of **considered clickability models**:

(a) visualizes target object (white contour) and ground-truth clicks (green points)

(b) - (d) depict uniform distribution (UD), distance transform (DT), and saliency map (SM) respectively

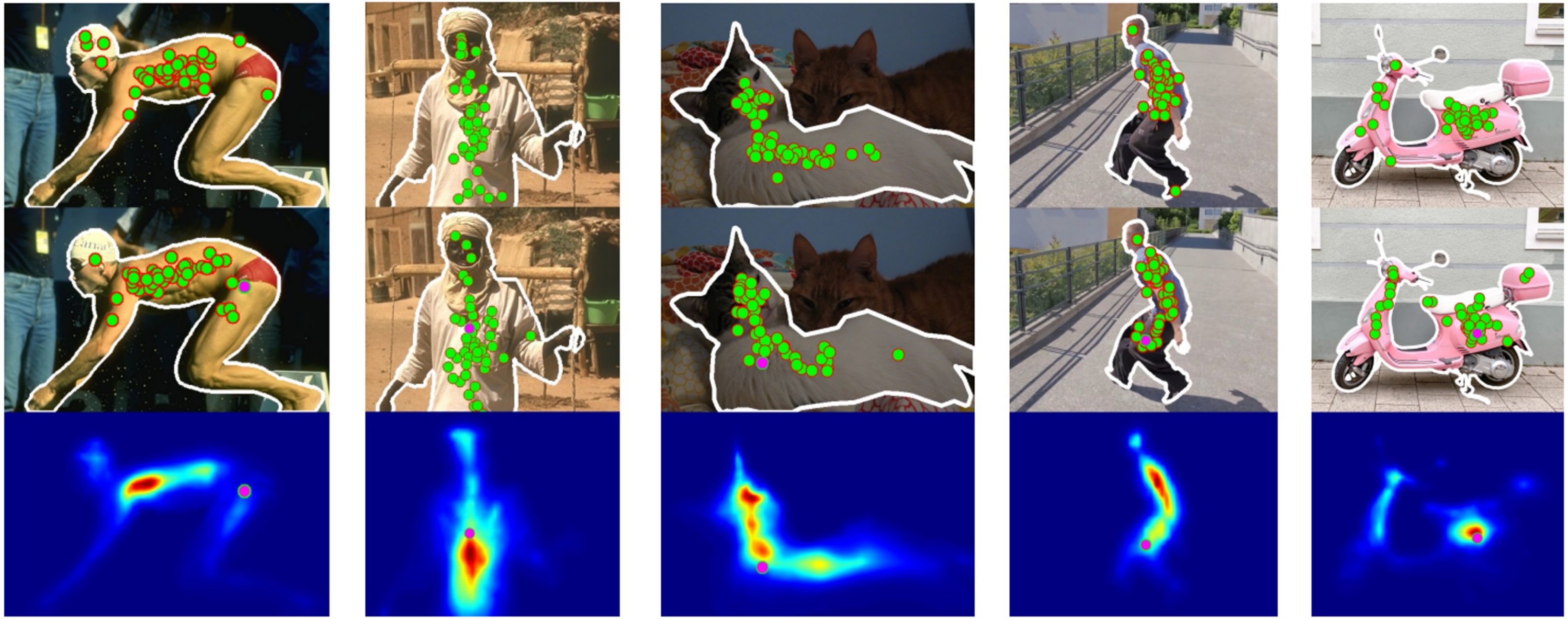
(e) - our predicted clickability map

Evaluation of various clickability models on real-user clicks of TETRIS validation part

Our approach **outperforms** existing clicking strategies in terms of the proximity of samples to real-user clicks

Model	KS $\uparrow$	$PL_1 \downarrow$	WD $\downarrow$	NSS $\uparrow$	PDE $\uparrow$
UD	0.10	0.57	0.17	3.99	1.36E-05
DT	0.14	0.52	0.16	6.45	2.76E-05
SM	0.13	0.51	0.15	4.79	1.83E-05
Ours	**0.55**	**0.40**	**0.08**	**9.11**	**4.69E-05**

Qualitative example



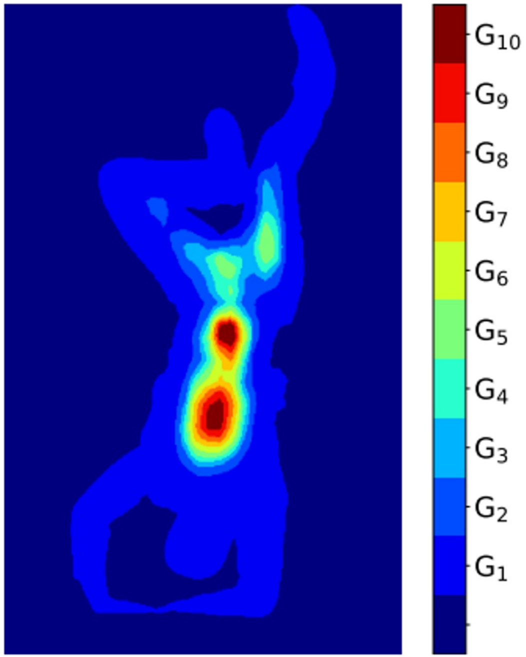
(a) GrabCut (b) Berkeley (c) COCO-MVal (d) DAVIS (e) TETRIS

Examples of real and predicted users' clicks and clickability map

RClicks benchmark

Using **Clicking Groups**, we propose the following objective IS robustness metrics:

- **Sample NoC** — mean and standard deviation of clicks (max 20) needed to achieve 90% IoU averaged across clicking groups (G_1 – G_{10})
- **ΔSB** — relative increase in Sample NoC compared to a baseline strategy
- **ΔGR** — relative increase in annotation time between G_1 and G_{10} clicking groups



Spatial distribution of **Clicking Groups** for the instance

Evaluation results

Method	Backbone	Data	DAVIS NoC$_{20}$@90 Sample (±std)	DAVIS ΔSB (+%)	DAVIS ΔGR (+%)	COCO–MVal NoC$_{20}$@90 Sample (±std)	COCO–MVal ΔSB (+%)	COCO–MVal ΔGR (+%)	TETRIS NoC$_{20}$@90 Sample (±std)	TETRIS ΔSB (+%)	TETRIS ΔGR (+%)
GPCIS	RN50	C+L	6.44±0.85	16.88	53.65	4.74±1.31	26.43	79.00	3.87±0.79	19.55	56.43
RITM	HR18	C+L	6.23±0.67	6.92	16.13	3.71±0.78	10.27	20.22	3.69±0.52	7.02	13.95
	HR18-IT	C+L	6.15±0.83	11.37	31.14	3.22±0.83	15.84	37.01	3.48±0.60	11.59	23.99
	HR32-IT	C+L	5.90±0.89	18.34	51.07	3.24±0.83	15.50	37.31	3.44±0.65	17.47	30.69
AdaptClick	ViT-B	C+L	4.97±0.40	8.60	15.14	2.93±0.58	9.44	19.75	2.62±0.37	6.99	12.94
SimpleClick	ViT-B	C+L	5.32±0.54	9.05	26.33	3.07±0.70	11.72	23.60	2.73±0.41	8.86	16.64
	ViT-L	C+L	5.03±0.42	8.71	16.67	2.67±0.56	8.05	20.88	*2.46±0.35*	7.11	10.01
	ViT-H	C+L	5.00±0.42	*7.06*	12.29	**2.57±0.54**	6.14	17.65	2.36±0.33	6.94	10.83
CFR-ICL	ViT-H	C+L	*4.53±0.46*	9.32	18.47	*2.70±0.63*	9.58	24.13	**2.12±0.34**	8.76	14.33
SAM	ViT-B	SA-1B	5.30±0.53	8.26	*11.27*	4.91±0.79	9.88	15.73	3.04±0.51	11.17	10.06
	ViT-L	SA-1B	5.21±0.41	8.82	11.59	4.81±0.63	8.89	14.97	2.60±0.40	8.11	7.08
	ViT-H	SA-1B	5.42±0.49	8.00	15.02	5.14±0.68	7.63	15.61	2.66±0.38	**5.95**	8.50
SAM-HQ	ViT-L	SA-1B	5.19±0.48	8.58	15.69	5.05±0.74	9.64	13.50	2.81±0.51	11.02	7.69
	ViT-H	SA-1B	5.16±0.44	8.15	18.36	4.97±0.68	7.71	*12.36*	2.75±0.41	*6.78*	7.95
SAM 2	Hiera-T	SA-V	4.65±0.28	**4.86**	**7.46**	3.86±0.64	7.79	13.14	3.11±0.50	9.45	3.57
	Hiera-B+	SA-V	4.67±0.33	8.49	15.86	3.75±0.61	*7.44*	12.67	3.02±0.47	9.51	*4.79*
	Hiera-L	SA-V	*4.61±0.29*	9.51	13.28	3.84±0.62	9.12	12.35	2.83±0.41	7.46	*4.10*
	Hiera-H	SA-V	**4.39±0.23**	7.55	10.03	3.42±0.51	**6.12**	**9.34**	2.74±0.38	6.51	4.87
SAM 2.1	Hiera-T	SA-V	4.67±0.32	7.08	8.99	3.91±0.68	8.45	*11.88*	3.11±0.50	9.75	**3.35**
	Hiera-B+	SA-V	4.63±0.32	9.72	14.30	3.76±0.62	8.16	12.35	3.04±0.49	9.59	4.70
	Hiera-L	SA-V	4.67±0.32	11.75	15.39	3.88±0.62	7.47	11.95	2.87±0.43	8.35	4.51
	Hiera-H	SA-V	4.44±0.25	10.35	*9.48*	3.51±0.52	*6.78*	9.91	2.81±0.39	7.41	4.50

Evaluation results of state-of-the-art interactive segmentation methods

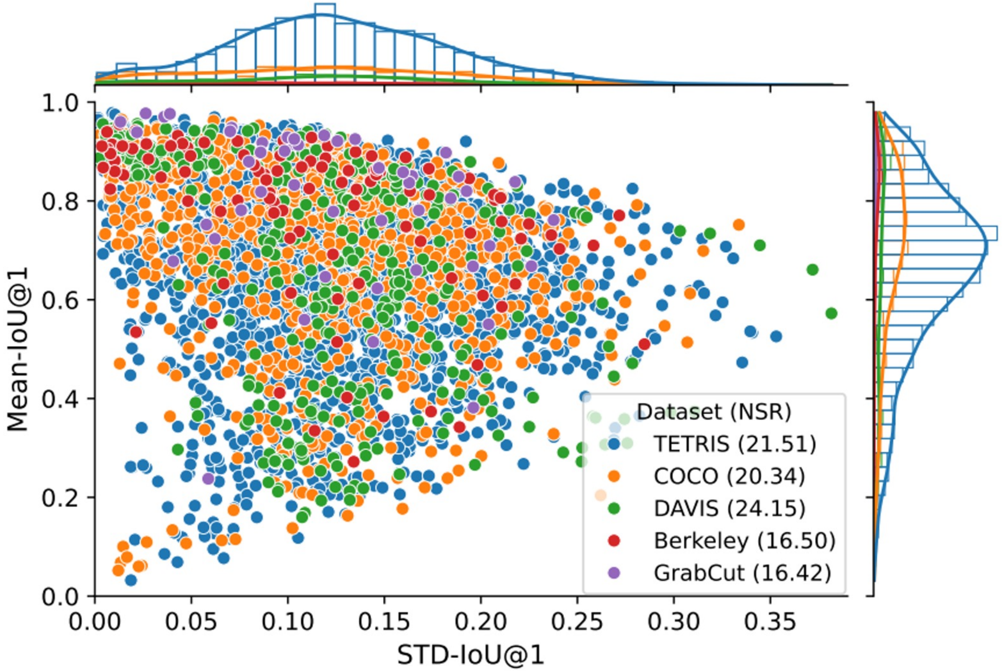
According to **Sample NoC** and **ΔGR** values, the best annotation time is achieved by SAM 2, CFR-ICL and SimpleClick, while the two latter methods are less robust compared to SAM-like methods

Datasets' difficulty

Scatter plot of the mean vs. standard deviation (STD) of IoU for the first real-users clicks

Difficulty score for every dataset — Noise to Signal Ratio (NSR). The higher score means the harder dataset for annotation:

$$\textbf{NSR} = \frac{\textbf{STD of IoU}}{\textbf{Mean of IoU}}$$



Main findings

Baseline strategy underestimates the real-world **annotation time** from **5% up to 29%**

Currently there is **NO segmentation method** that is optimal in terms of both performance and robustness on all datasets

DAVIS, with its 24.15 NSR, stands as the **hardest** dataset for annotation

Annotation time of users from different clicking groups varies from **3% up to 79%**