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Generative One-shot Camouflage Instance Segmentation

Thanh-Danh Nguyen[1,2], Vinh-Tiep Nguyen†[1,2], and Tam V. Nguyen[3]
[1]University of Information Technology, Ho Chi Minh City, Vietnam,
[2]Vietnam National University, Ho Chi Minh City, Vietnam, [3]University of Dayton, Dayton, OH 45469, United States
{danhnt, tiepnv}@uit.edu.vn, tamnguyen@udayton.edu, †corresponding author

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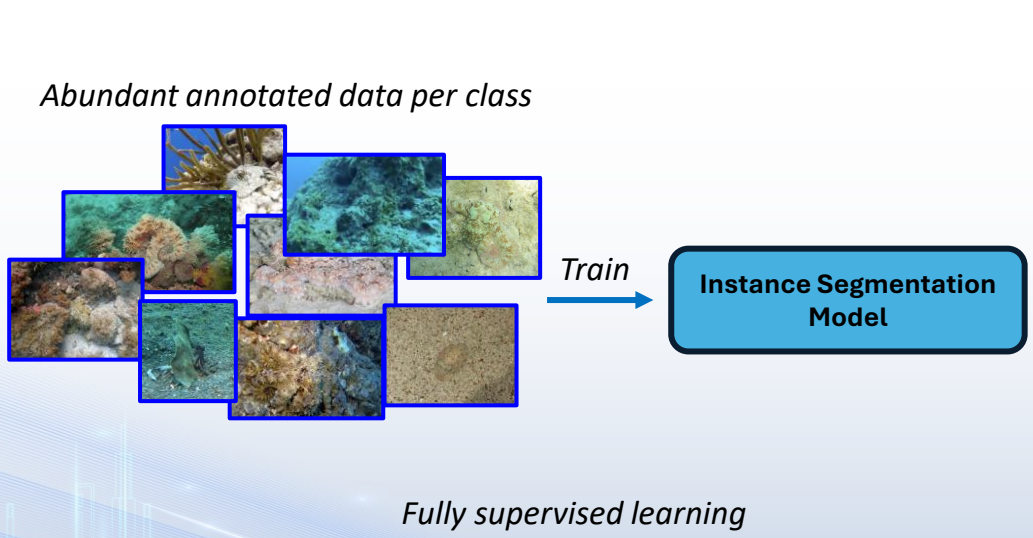
1. Introduction

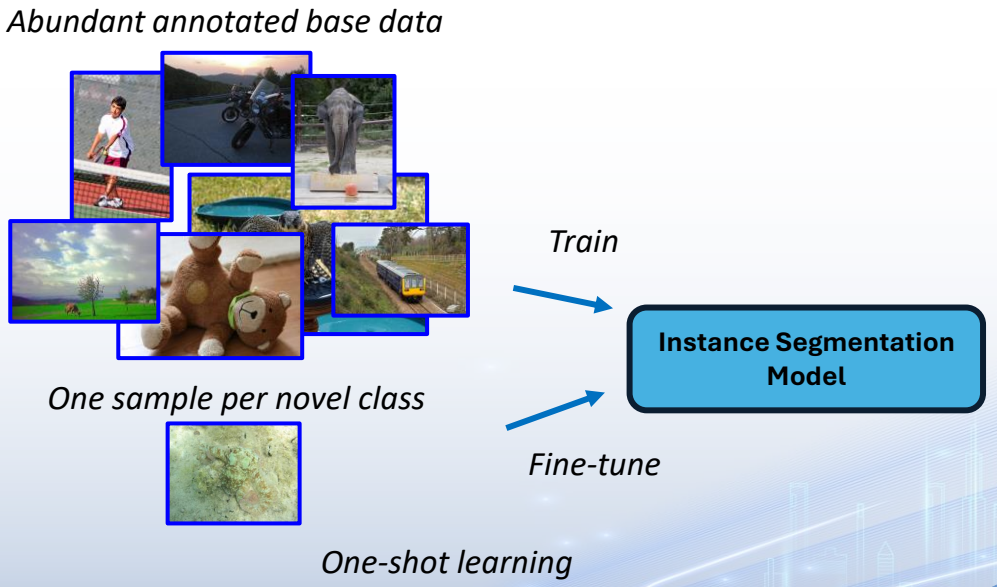
- **"Camouflage"** is **a defense mechanism** that animals use to **conceal their appearance** by blending in with their environment
- **Applications:** search-and-rescue work, wild species discovery and preservation, medical diagnostic, etc.

Exemplary camouflaged samples extracted from CAMO-FS dataset

1. Introduction

- **One-shot Camouflage Instance Segmentation (One-shot CIS)** is formulated as a two-stage training task:
  - **Base training phase** on abundant annotated data of *general domain*
  - **Novel fine-tuning phase** on **one-shot sample** of *novel domain*





1. Introduction

Focused challenge: high-performance methods require training on large annotated datasets, which are costly and impractical to collect in camouflage scenarios

Contribution: we propose **Generative One-shot Camouflage Instance Segmentation**, dubbed **CAMO-GenOS**

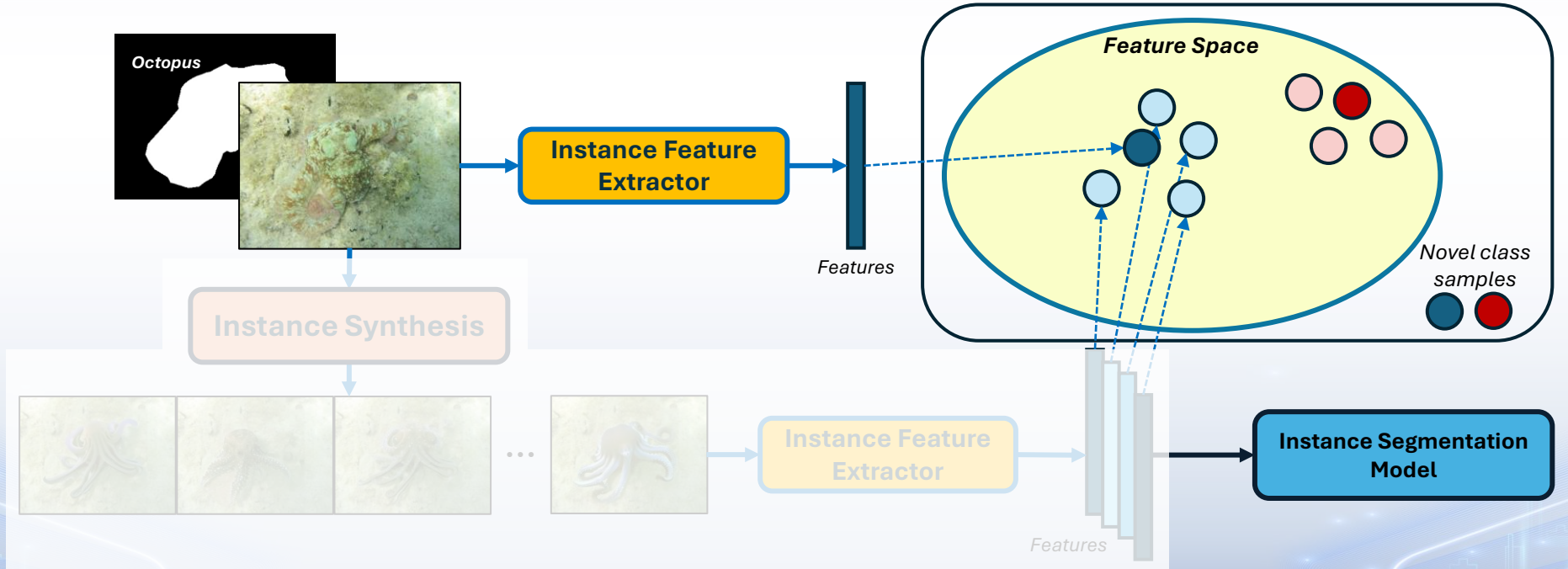


Fig. Our CAMO-GenOS Concept Idea Presentation

2. Related work

- **Image Segmentation Research**
- **Camouflage Instance Segmentation**
- **Multi-conditional Image Synthesis in Low-shot CIS**
- **Few-shot Camouflaged Datasets for Instance Segmentation**

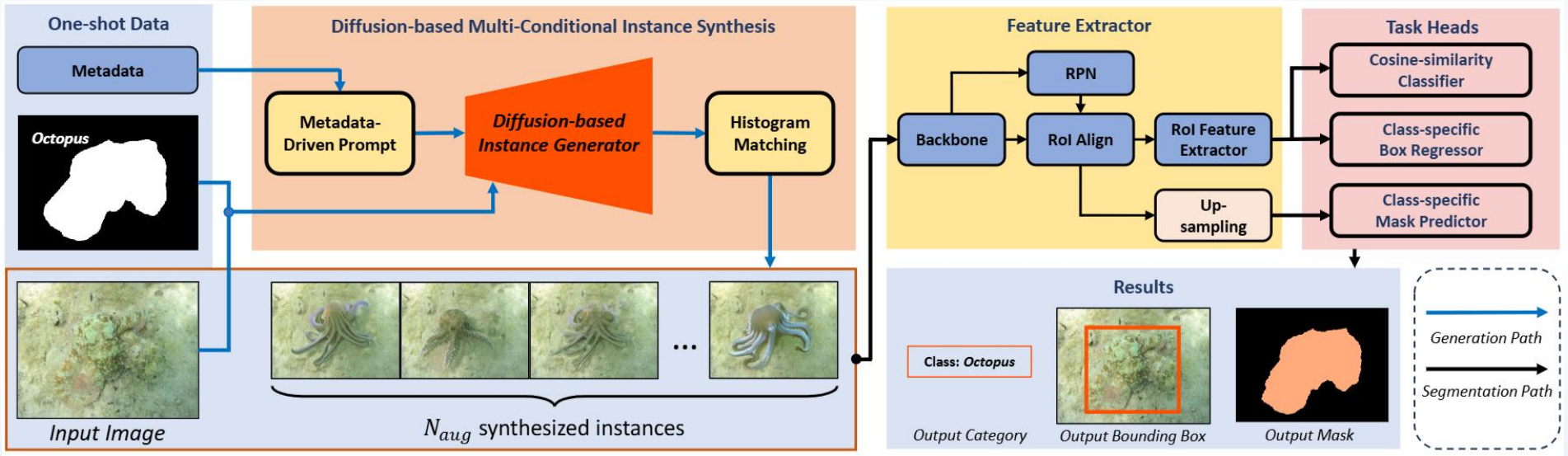
Dataset	Year	Venue	Type	#Annot. Camo. Img.	#Meta-Cat.	#Obj. Cat.	Bbox. GT	Obj. Mask GT	Ins. Mask GT	Few-shot
CamouflagedAnimals	2016	ECCV	Video	181	-	6	×	✓	✓	×
MoCA	2020	ACCV	Video	7,617	-	67	✓	×	×	×
CHAMELEON	2018	-	Image	76	-	-	×	✓	×	×
CAMO	2019	CVIU	Image	1,250	2	8	×	✓	×	×
COD	2020	CVPR	Image	5,066	5	69	✓	✓	✓	×
NC4K	2021	CVPR	Image	4,121	5	69	✓	✓	✓	×
CAMO++	2022	TIP	Image	2,695	10	47	✓	✓	✓	×
CAMO-FS	2024	IEEE ACCESS	Image	2,852	10	47	✓	✓	✓	✓

Tab. Comparison among camouflage datasets (w/o non-camouflaged images)

3. Method

CAMO-GenOS has 2 main components: ▶ Diffusion-based Multi-Conditional Instance Synthesis

▶ One-shot Instance Segmentation Pipeline

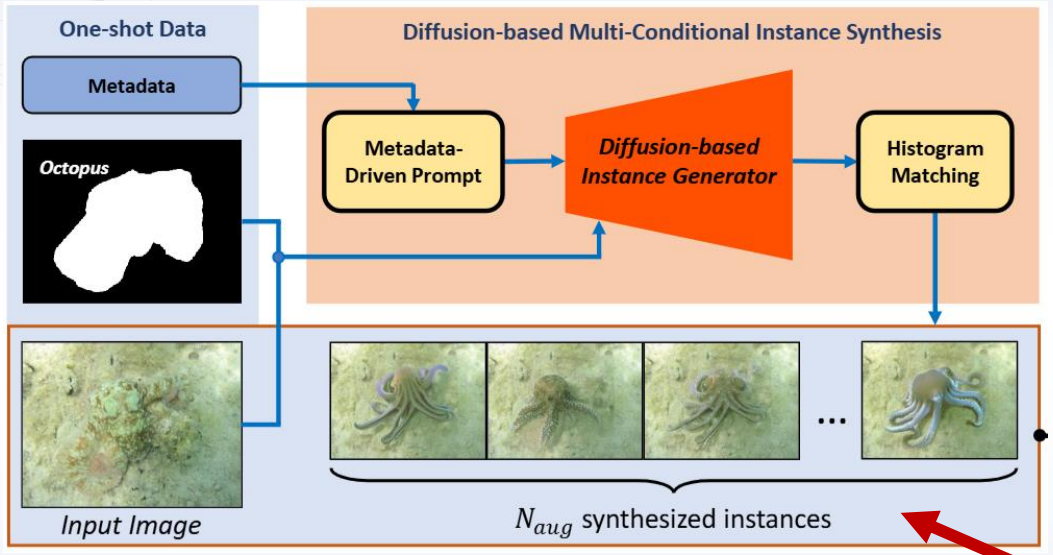


Overview of our CAMO-GenOS framework leveraging generative models to enhance one-shot camouflage instance segmentation

CAMO-GenOS employs the Diffusion-based Multi-Conditional Instance Synthesis to enhance the diversity of camouflage instances to boost the One-shot CIS performance

3. Method

Diffusion-based Multi-Conditional Instance Synthesis

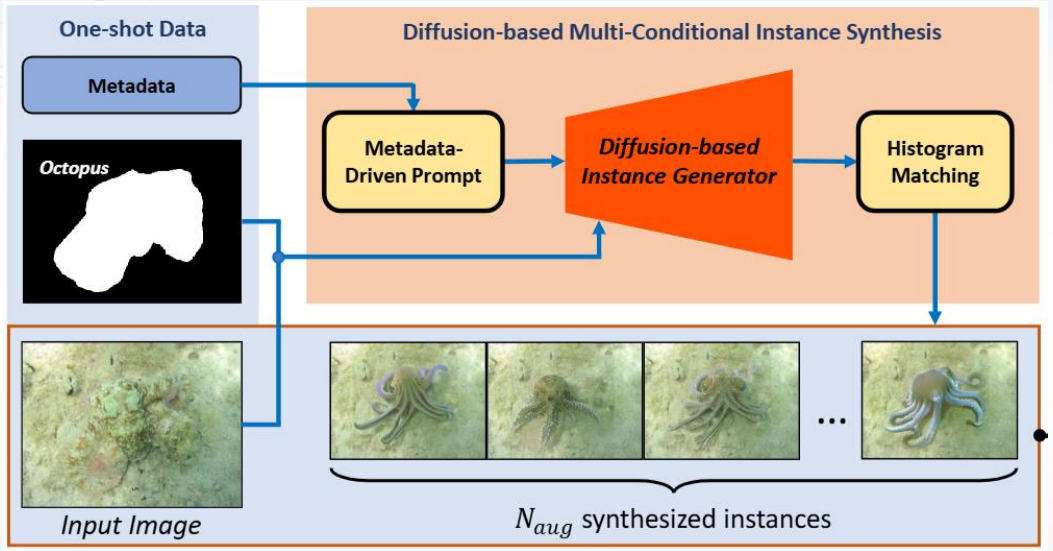


Focus: Diffusion-based Multi-Conditional Instance Synthesis

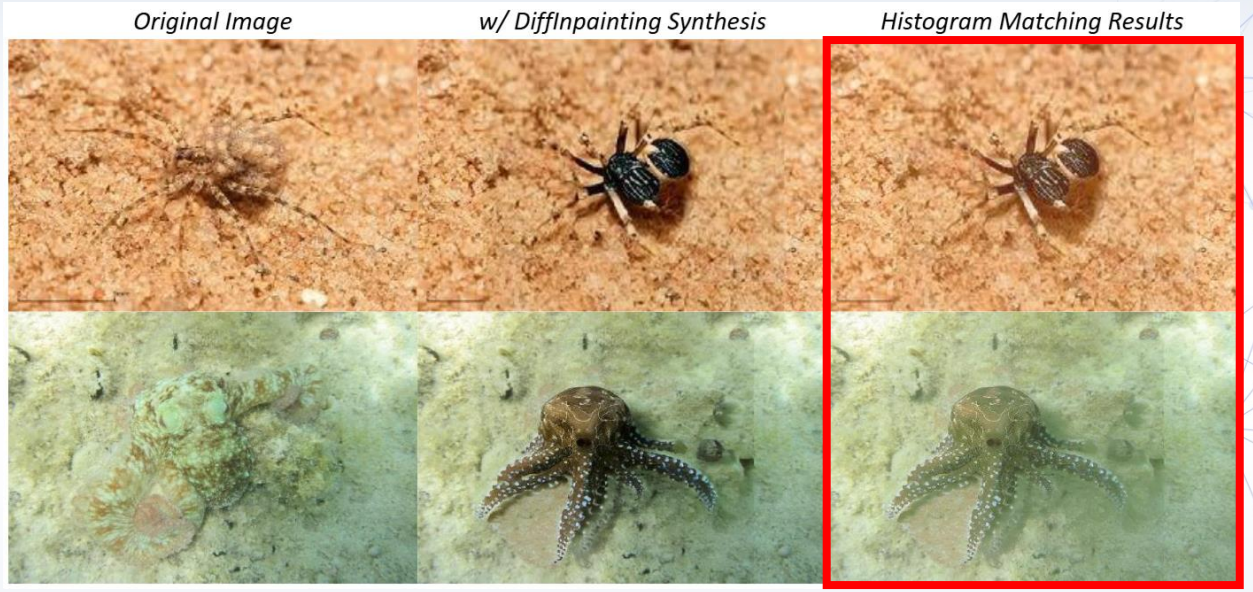
- Inspired by **InstSynth**[21,46], CAMO-GenOS synthesizes N_{aug} samples from multiple conditions:
  - A referenced query image $I_q \in C_{novel}$,
  - A ground truth mask M_q,
  - A guided text prompt P_q
- **Metadata-Driven Conditional Text Prompt**: *"a photo of a/an [size] [meta-class] [instance class]"*
- The synthesized instances are post-processed with the **Histogram Matching** technique

3. Method

Diffusion-based Multi-Conditional Instance Synthesis



Focus: Diffusion-based Multi-Conditional Instance Synthesis

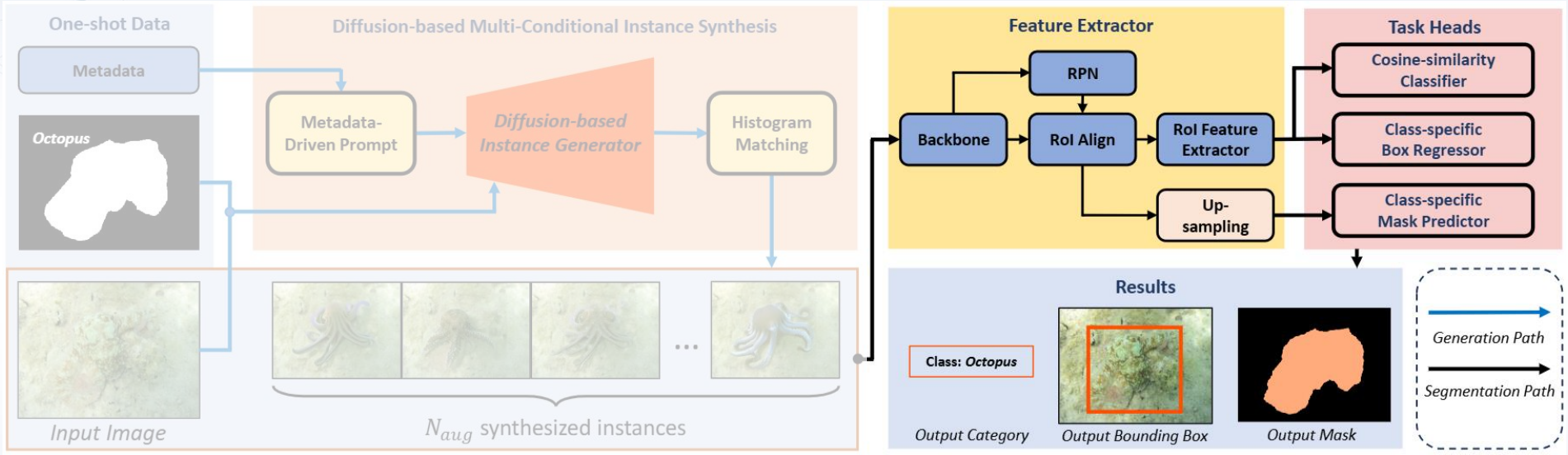


Exemplary histogram matching results on the synthesized instances

- **Histogram Matching Post-processing** adjusts the synthesized pixel intensity to match the original image

3. Method

One-shot Instance Segmentation Pipeline



Focus: One-shot Instance Segmentation Pipeline

- Following FS-CDIS[7] and iMTFA[11], our **CAMO-GenOS** formulates the **one-shot CIS** task with:
  - **Base training phase**: on **80** COCO classes
  - **Novel fine-tuning phase**: on **47** CAMO-FS classes

4. Experiments

- **Pioneer** in **one-shot learning** on **camouflage instance segmentation** domain
- Our **CAMO-GenOS improves over the SoTA FS-CDIS**[7] thanks to the generative approach in both tasks on CAMO-FS benchmark

Tab. State-of-the-art comparison on CAMO-FS dataset. The chosen backbones are COCO-80 FPN-ResNet-101.

		Instance Segmentation										
Method	**Synthesis Base**	**nAP**		**nAP50**	**nAP75**	**nAPs**	**nAPm**	**nAPl**	**nAR1**	**nAR10**	**nARs**	**nARm**	**nARl**
Mask-RCNN [28]		2.99		5.73	3.26	20.68	3.06	2.74	12.45	13.81	21.85	8.34	13.74
iMTFA [11]		3.66		5.37	4.09	22.42	4.35	2.01	11.30	13.58	25.97	12.96	12.53
iFS-RCNN [10]		4.27		5.98	4.75	21.57	5.71	4.87	11.70	13.51	23.35	11.75	14.28
FS-CDIS [7]		4.46	-	7.34	4.84	25.50	5.60	3.48	14.77	17.26	27.20	13.51	17.11
CAMO-GenOS (ours)	BlendedDiff [19]	4.80	+0.34	7.79	5.37	28.59	5.67	3.32	17.85	19.53	29.00	13.45	20.65
	DiffInpainting [17]	4.91	+0.45	7.84	5.47	26.54	5.06	4.02	17.18	18.72	27.70	9.75	19.23
	GLIGEN [18]	4.74	+0.28	7.53	5.31	28.10	4.79	5.28	17.65	19.38	29.33	12.29	20.42
		Object Detection											
Method	**Synthesis Base**	**nAP**		**nAP50**	**nAP75**	**nAPs**	**nAPm**	**nAPl**	**nAR1**	**nAR10**	**nARs**	**nARm**	**nARl**
Mask-RCNN [28]		3.74		6.15	4.33	26.60	5.95	4.37	16.83	18.44	27.57	11.85	19.66
iMTFA [11]		2.93		5.86	2.20	20.95	4.18	2.03	9.25	10.84	21.74	11.49	8.77
iFS-RCNN [10]		3.79		5.92	4.46	20.95	5.17	4.55	10.04	11.67	21.15	10.60	13.01
FS-CDIS [7]		3.88	-	7.71	3.21	22.38	6.40	3.32	12.66	14.85	22.67	11.89	15.36
CAMO-GenOS (ours)	BlendedDiff [19]	4.90	+1.02	8.09	4.78	29.12	7.49	3.61	17.70	19.34	29.13	15.24	20.42
	DiffInpainting [17]	5.00	+1.12	8.33	5.26	27.90	6.57	4.05	18.04	19.60	28.20	9.67	20.51
	GLIGEN [18]	4.83	+0.95	7.94	4.85	29.23	6.28	3.97	18.46	20.59	29.64	12.92	21.81

**The increased values in blue are compared to the SoTA baseline FS-CDIS [7].*

4. Experiments – Ablation study

Tab. Ablation study of our CAMO-GenOS on multiple generation-based methods evaluated on CAMO-FS

Method	Instance Segmentation nAP		nAP50	nAP75	Object Detection nAP		nAP50	nAP75
FS-CDIS [7]	4.46		7.34	4.84	3.88		7.71	3.21
+ ITL	4.55		7.52	4.94	3.99		7.92	3.47
+ IMS	3.94		7.44	3.64	4.01		8.05	3.44
+ Both	4.10		7.40	4.15	3.99		7.82	3.40
CAMO-GenOS (ours)								
w/ BlendedDiff [19]	4.80	+0.34	7.79	5.37	4.90	+1.02	8.09	4.78
+ ITL	5.16	+0.61	8.25	5.73	4.97	+0.98	8.54	5.08
+ IMS	4.19	+0.25	7.98	4.54	4.75	+0.74	8.38	5.16
+ Both	4.25	+0.15	7.36	4.71	4.79	+0.80	7.71	4.52
w/ DiffInpainting [17]	4.91	+0.45	7.84	5.47	5.00	+1.12	8.33	5.26
+ ITL	4.80	+0.25	7.90	5.32	4.97	+0.98	8.29	4.61
+ IMS	4.04	+0.10	7.21	4.34	4.68	+0.69	7.84	4.84
+ Both	4.29	+0.19	7.30	4.60	4.70	+0.71	7.83	4.86
w/ GLIGEN [18]	4.74	+0.28	7.53	5.31	4.83	+0.95	7.94	4.85
+ ITL	5.30	+0.75	8.26	6.02	5.23	+1.24	8.63	5.61
+ IMS	4.39	+0.45	7.28	4.86	4.52	+0.51	7.87	4.52
+ Both	4.33	+0.23	7.28	4.74	4.75	+0.76	7.62	5.52

**The increased values in blue are compared to the SoTA baseline FS-CDIS [7] with the corresponding ITL, IMS, and both of them.*

- Different diffusion-based instance synthesis methods **stably increase the nAP** of the baselines on both tasks
- **Instance triplet loss** (ITL, built on top of FS-CDIS) yields better contribution to the final nAP

5. Conclusion

In this work:

- We proposed **CAMO-GenOS –** a **pioneer framework** addressing **one-shot camouflage instance segmentation** utilizing a **generative approach** to enrich the training samples
- Experimental results proves our SOTA results among the surveyed methods on CAMO-FS benchmark

In the future:

- Generalize our proposals to the general domain
- Automate the multiple conditional image generation procedure

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