Unlocking Attributes’ Contribution to Successful Camouflage: A Combined Textual and Visual Analysis Strategy

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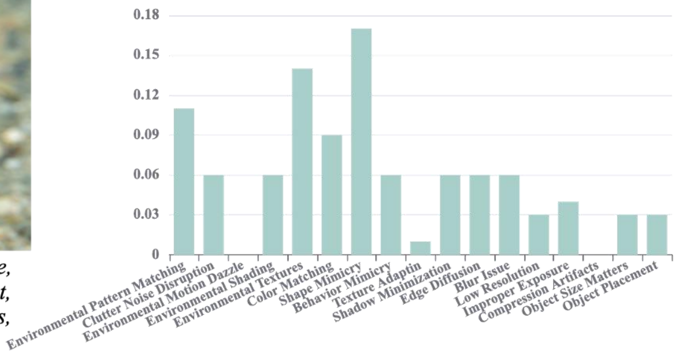
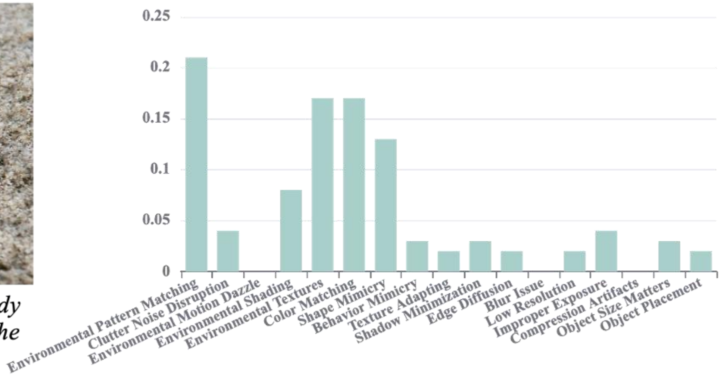
The image displays a creature resembling algae, integrating seamlessly with the marine environment, exhibiting an intricate structure of appendages, positioned against a blurry ocean floor background.



The image shows a crab camouflaged against a sandy background. Its color and texture blend with the surrounding sand, making it difficult to distinguish.



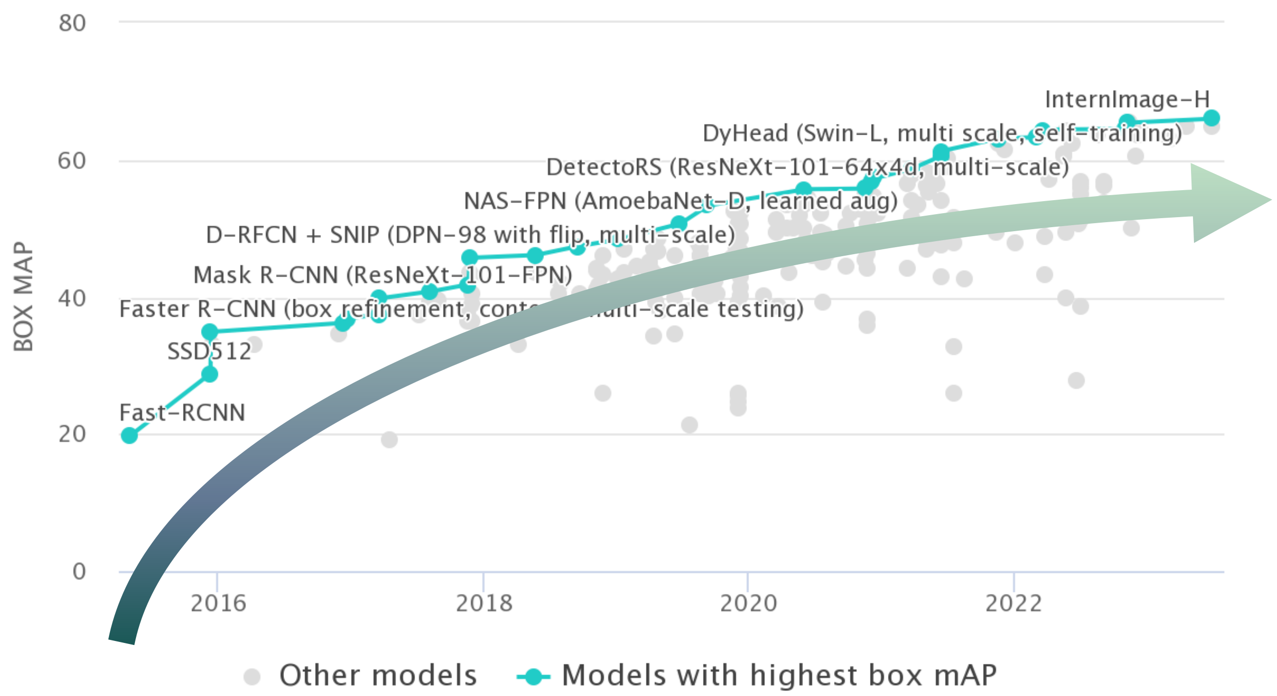
Repo: https://github.com/lyu-yx/ACUMEN

Paper: https://arxiv.org/abs/2408.12086

1. Introduction

1.1 Problem Statement

General detection/segmentation algorithms presented slowing of performance lift.
Main reason: have troubles when object feature become less representative or camouflaged by themselves.



Performance drop example:
- mis-classification
- false detection
- Missing detection

1. Introduction

1.2 Related Works

- Approaches based on hand-crafted features and deep learning methods have achieved astonishing performance in **visual modalities**.

- However, the combined use of **textual and visual modalities** to **enhance performance and understanding of camouflage patterns** has not yet been explored.

1.3 Our Solution

- We commence by **collecting a dataset** enriched with image descriptions and attribute contributions. Subsequently, we construct a **bifurcated multimodal framework** that merges textual and visual analyses seamlessly.

2. Motivation

1. From cognitive science point of view, merging **textual and visual** information synergistically boosts cognitive understanding[1-2].

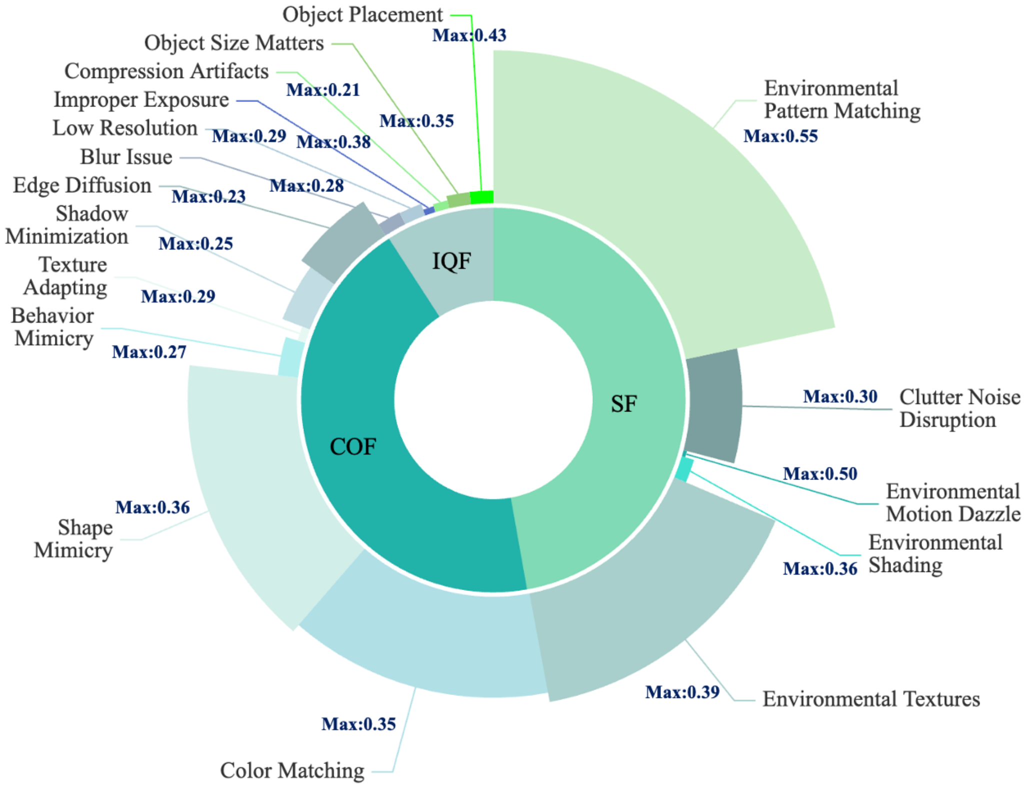
2. Evolutionary biology highlights the significance of camouflage pattern creation (by prey) and its identification (by predators) in evolutionary progress, underlining the necessity to analyze camouflage from both **granular attribute insights (designing)** and a wider **object detection (breaking)** standpoint.

- Environmental Pattern Matching;
- Color Matching;
- Shading.

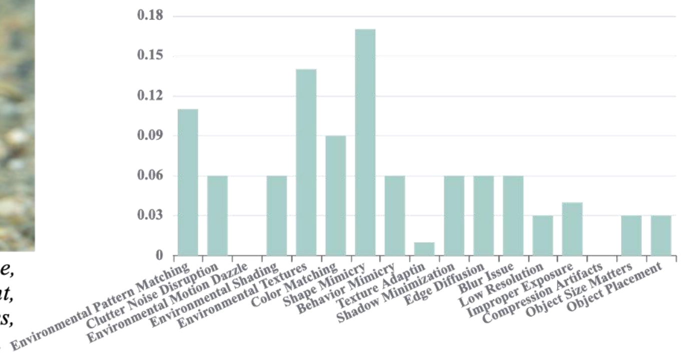
- Shape Mimicry;
- Environmental Textures;
- Color Matching.

[1] Mayer, R.E.: Multimedia learning. In: Psychology of learning and motivation, vol. 41, pp. 85–139 (2002)
[2] Paivio, A.: Imagery and verbal processes. Psychology Press (2013)

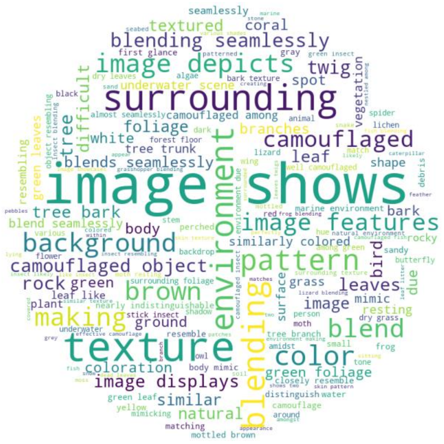
3. COD-TAX Dataset



The image displays a creature resembling algae, integrating seamlessly with the marine environment, exhibiting an intricate structure of appendages, positioned against a blurry ocean floor background.



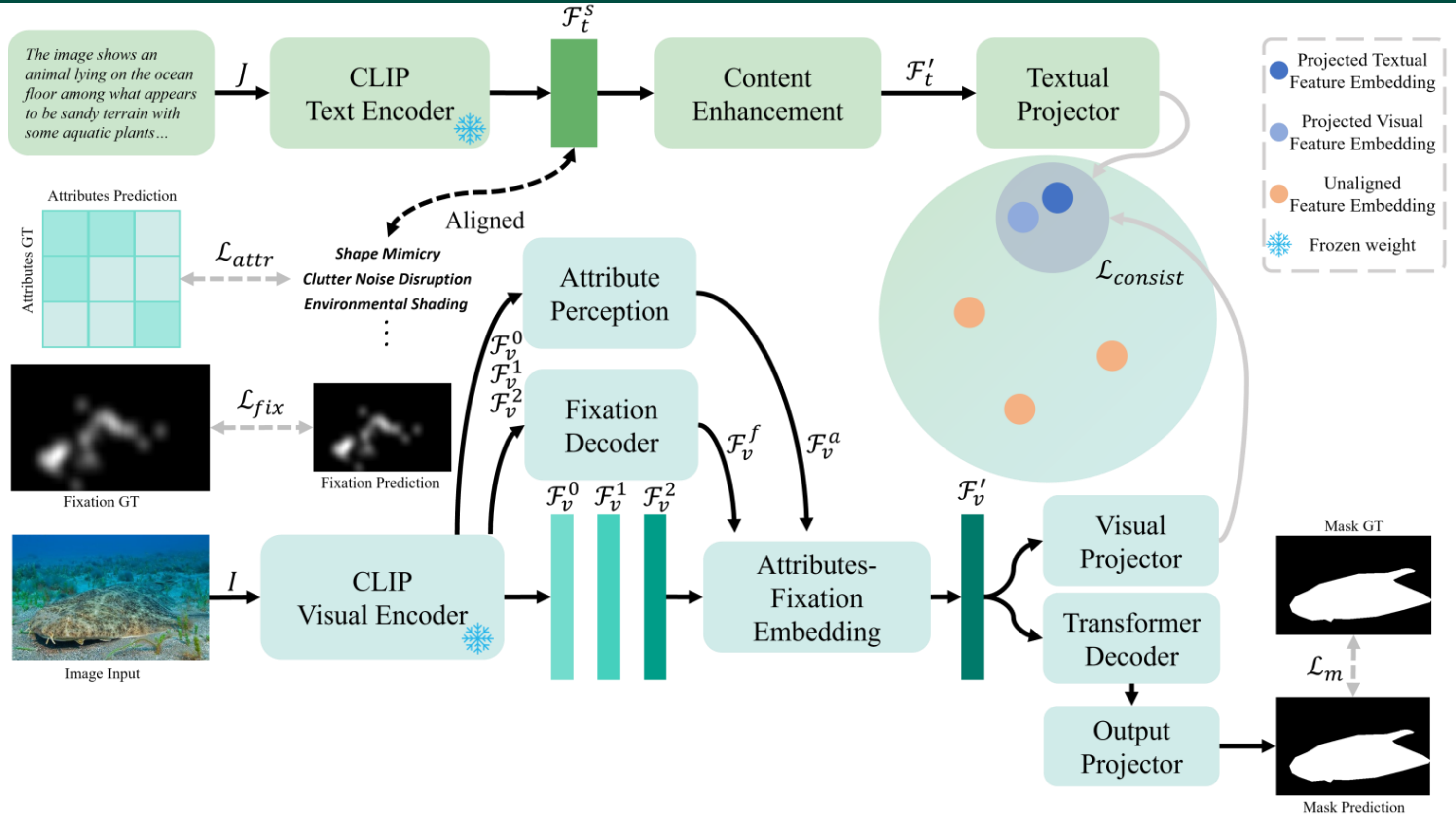
Surrounding Factors (5 sub attr), Camouflaged Object-Self Reasons (6 sub attr), and Imaging Quality Reasons (6 sub attr). 17 attributes in total.



- The range of maximum values extends from 0.21 to 0.55.
- The average values fluctuate between 0.004 and 0.21.
- Average description length of 26.52 words.

All the descriptions and attributions are generated by GPT-4V first and finetuned by more than 30 volunteers.

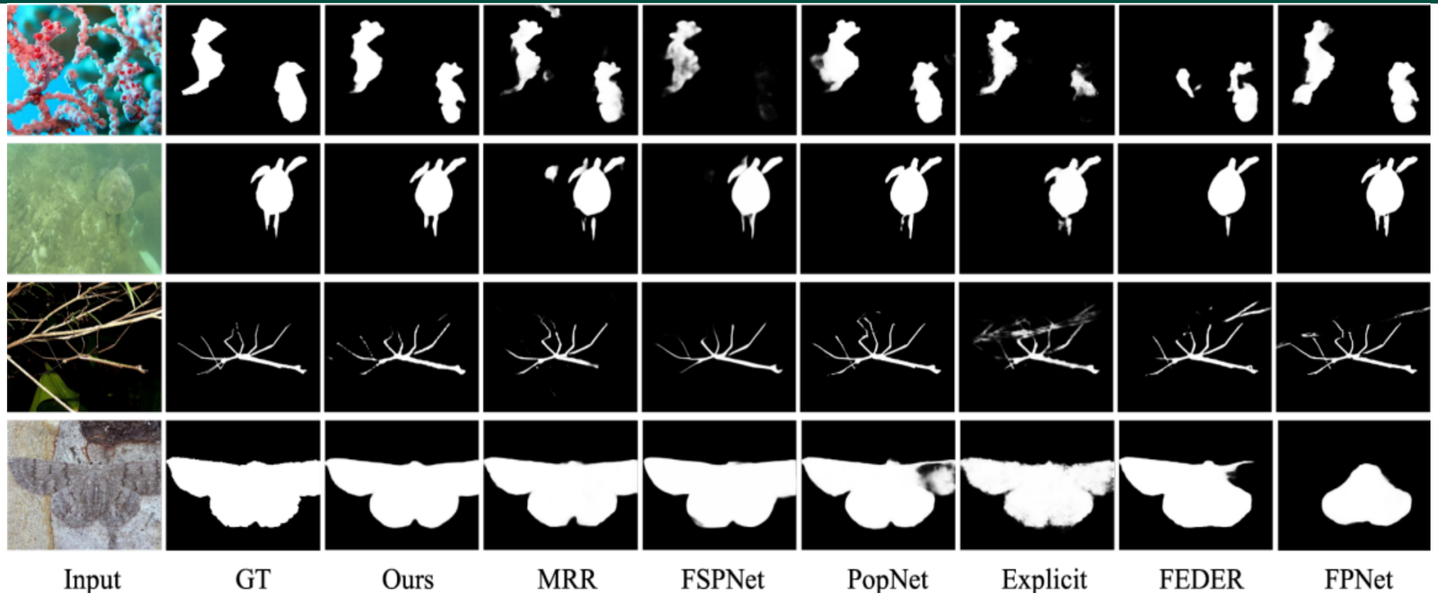
4. Network Overall



ACUMAN presented a dual-branch architecture, consisting of a **textual branch (in green)** and a **visual branch (in cyan)**.

During the inference, **the textual branch is omitted** to eliminate dependency on LVLMs like GPT4, thereby making the inference process solely reliant on visual cues.

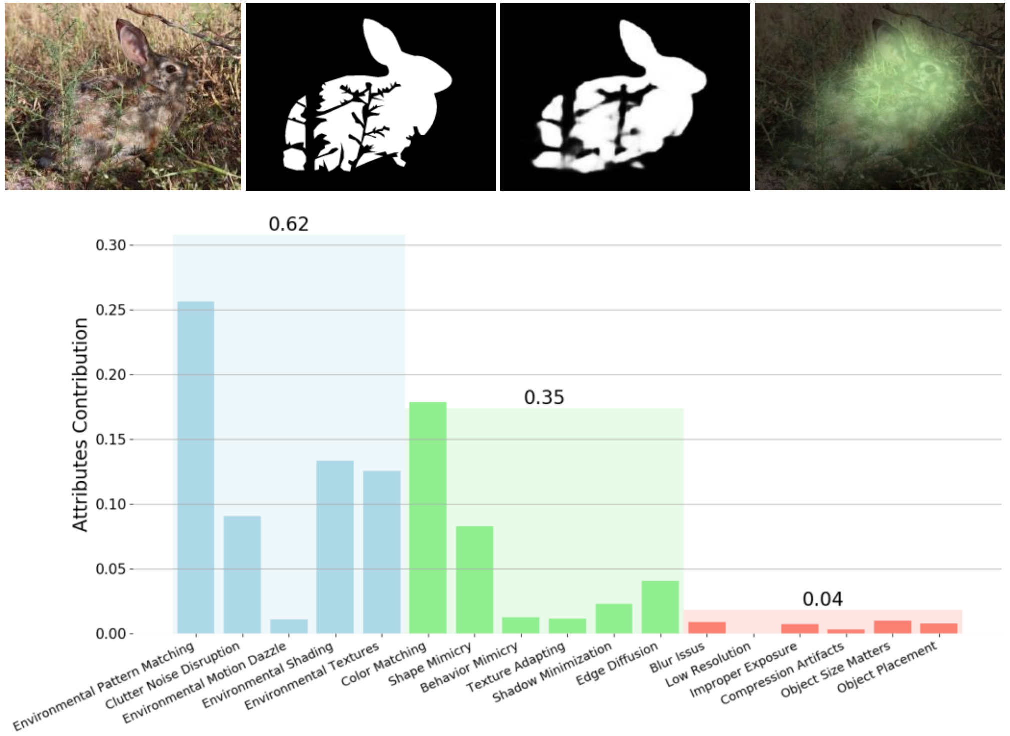
5. Results

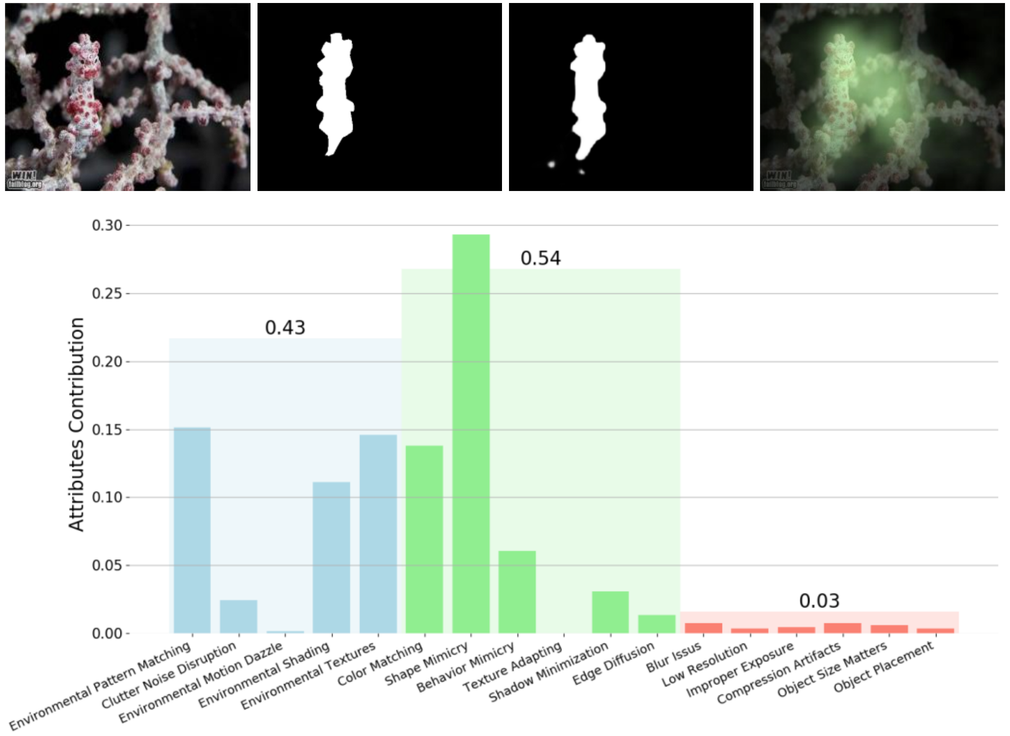


Methods	Publication	Size	CAMO				COD10K				NC4K			
			$S_\alpha \uparrow$	$E_\phi \uparrow$	$F_\beta^\omega \uparrow$	$M \downarrow$	$S_\alpha \uparrow$	$E_\phi \uparrow$	$F_\beta^\omega \uparrow$	$M \downarrow$	$S_\alpha \uparrow$	$E_\phi \uparrow$	$F_\beta^\omega \uparrow$	$M \downarrow$
PopNet [47]	ICCV_{2023}	512^2	0.806	0.859*	0.744*	0.073	0.827	0.910*	0.757*	0.031	0.852	0.909*	0.802*	0.043
CFANet [52]	ICME_{2023}	416^2	0.815	0.876	0.761	0.073	0.834	0.905	0.730	0.031	0.848	0.906	0.791	0.046
MFFN [54]	WACV_{2023}	384^2	†	†	†	†	0.846	0.897*	0.745	0.028	0.856	0.902*	0.791	0.042
FEDER [12]	CVPR_{2023}	384^2	0.807	0.873	0.738*	0.069	0.823	0.900	0.716*	0.032	0.846	0.905	0.789*	0.045
Explicit [26]	CVPR_{2023}	352^2	0.846	0.895	0.777	0.059	0.843	0.907	0.742	0.029	†	†	†	†
FSPNet [18]	CVPR_{2023}	384^2	0.856	0.899	0.799	0.050	0.851	0.895	0.735	0.026	**0.879**	0.915	0.816	**0.035**
MRR-Net [49]	TNNLS_{2023}	384^2	0.826	0.880	0.759*	0.070	0.835	0.901	0.720*	0.032	0.857	0.906	0.786*	0.044
FPNet [4]	ACM MM_{2023}	512^2	0.852	0.905	0.806	0.056	0.850	0.913	0.748	0.029	†	†	†	†
LSR+[2] [28]	TCSVT_{2023}	384^2	0.854	0.924	†	0.049	0.847	0.924	†	0.028	0.870	0.924	†	0.036
Ours	-	336^2	**0.886**	**0.939**	**0.850**	**0.039**	**0.852**	**0.930**	**0.761**	**0.026**	0.874	**0.932**	**0.826**	0.036

5. Results

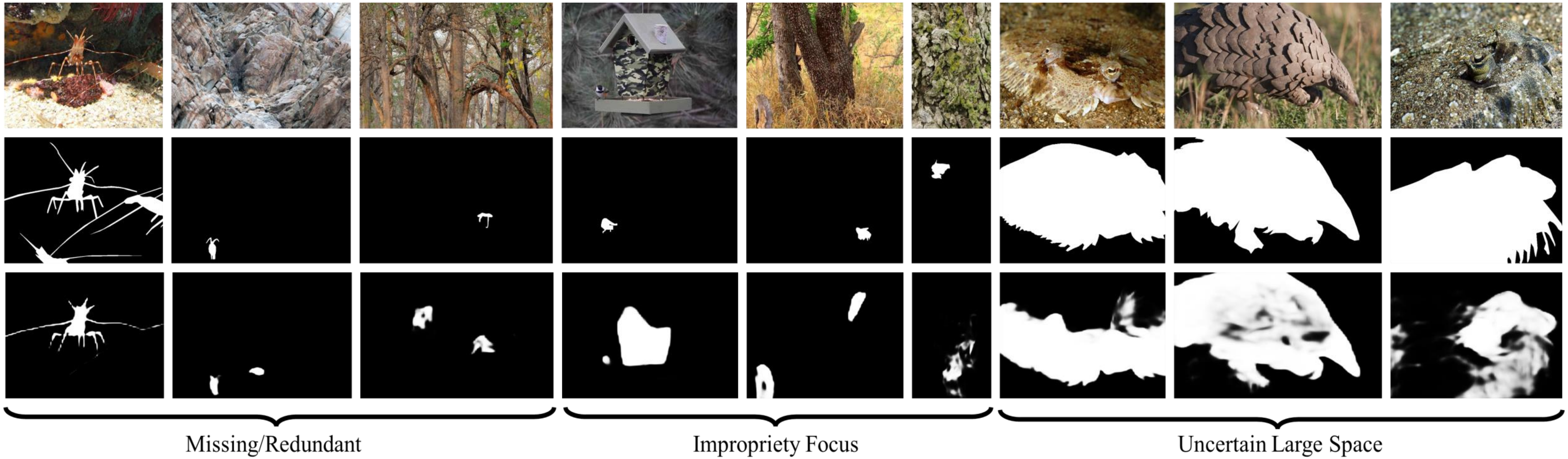
Intermediate Results:





5. Results

Failure Cases:



6. Conclusion & Future Works

- Presented a study on the role of **camouflage attributes** in determining the effectiveness of camouflage patterns, alongside the introduction of the COD-TAX dataset for comprehensive analysis.
- We also introduce the **ACUMEN framework**, which uniquely integrates textual and visual data for enhancing COS performance.

- For future works, we aim to refine our investigation by **assessing the camouflage level**, introducing metrics for quantifying camouflage patterns and identifying their primary influencing factors.
- In terms of broad applicability, we are eager to investigate **additional downstream applications** pertinent to COS.

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