Delving into Shape-aware Zero-shot Semantic Segmentation

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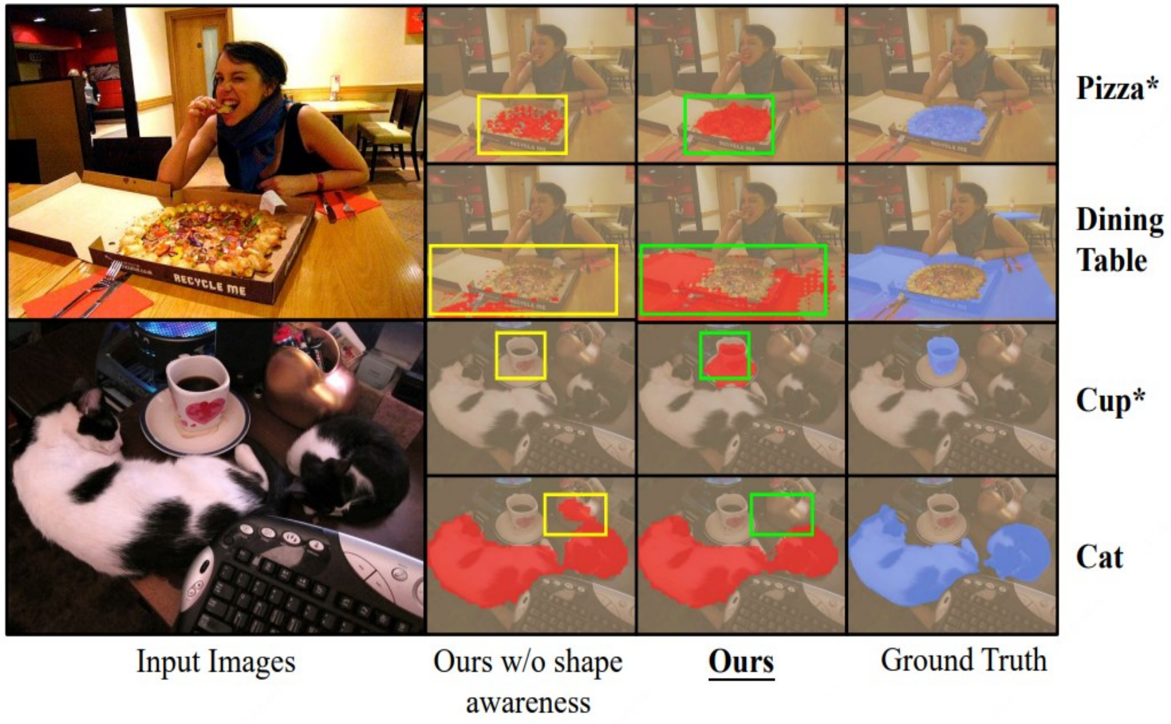
Content

Introduction

Problems:



- In real-world, unknown objects may appear, hence there is a need to learn and achieve dense predictions for unknown object categories from limited samples.
- Dense prediction task requires not only accurate semantic understanding but also fine shape delineation.
- However, existing vision-language models are trained with image-level language descriptions.

Introduction

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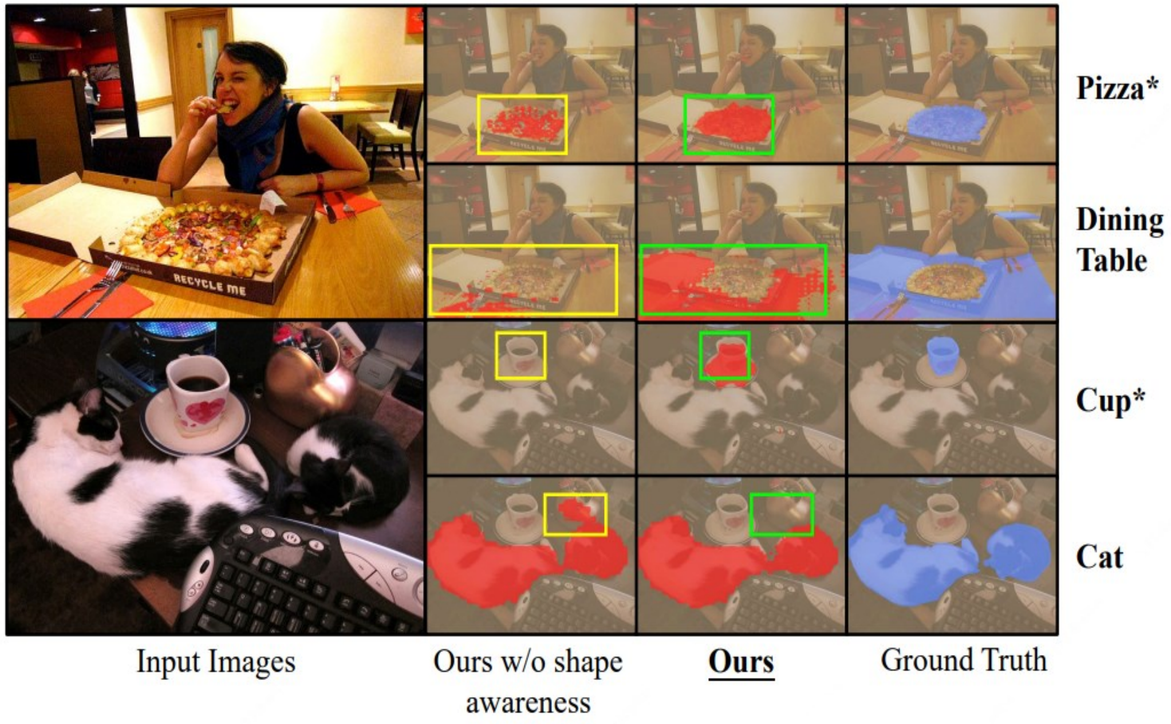
Solutions:



- Leverage the eigen vectors of Laplacian matrices constructed with self-supervised pixelwise features to promote shape-awareness.

- Propose to jointly optimizing a boundary segment constraint that aligns both the boundary of predicted semantic regions and the ground truth regions.

Method

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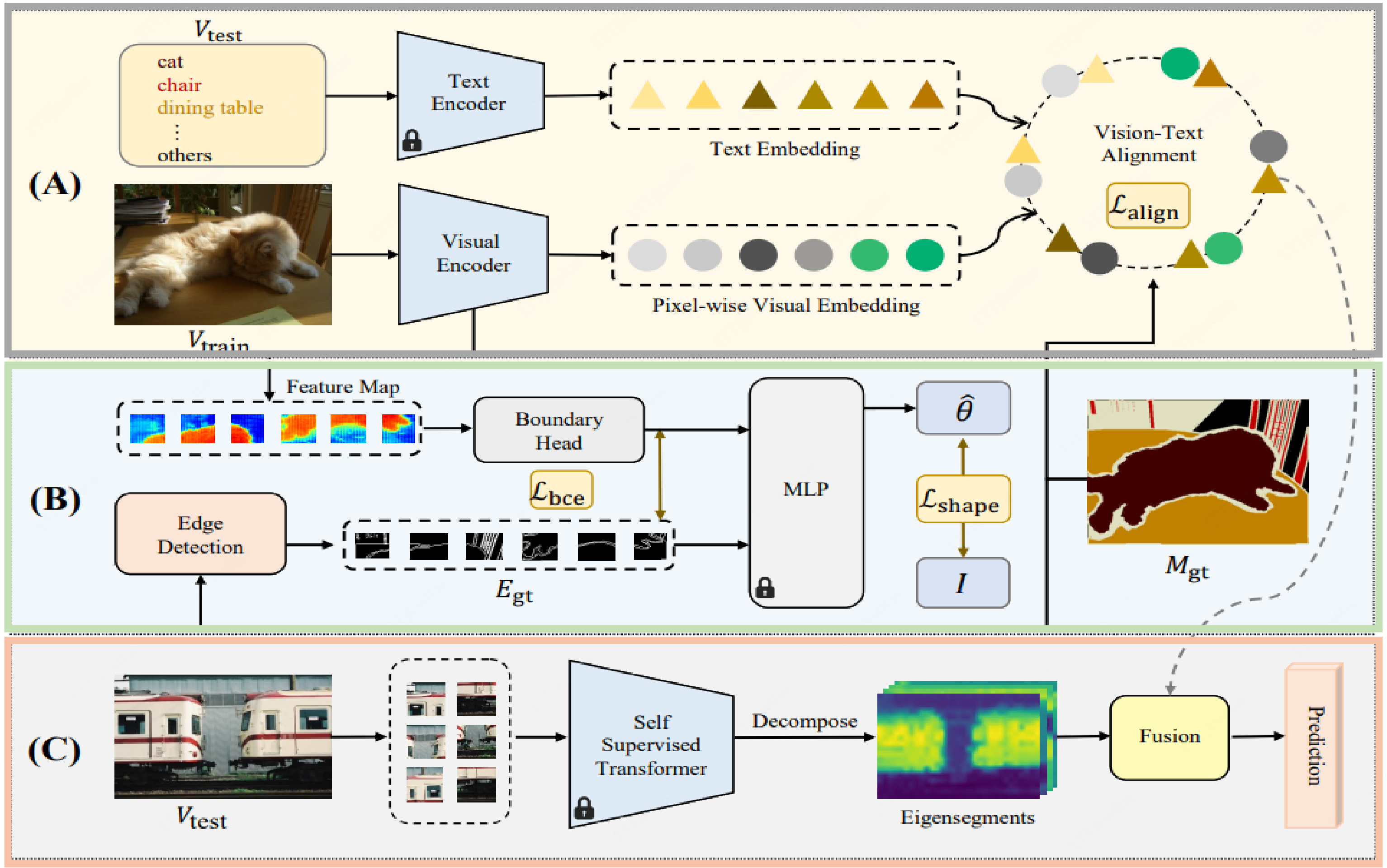

Overall architecture

Experiment

Our results on PASCAL-5^i and COCO-20^i datasets

Method	Backbone	Setting	PASCAL-5^i 5^0	5^1	5^2	5^3	mIoU	FBIoU	COCO-20^i 20^0	20^1	20^2	20^3	mIoU	FBIoU
FWB [38]	ResNet	1-shot	51.3	64.5	56.7	52.2	56.2	–	17.0	18.0	21.0	28.9	21.2	–
DAN [52]	ResNet	1-shot	54.7	68.6	57.8	51.6	58.2	71.9	–	–	–	–	24.4	62.3
PFENet [51]	ResNet	1-shot	60.5	69.4	54.4	55.9	60.1	72.9	36.8	41.8	38.7	36.7	38.5	63.0
HSNet [37]	ResNet	1-shot	67.3	72.3	62.0	63.1	66.2	77.6	37.2	44.1	42.4	41.3	41.2	69.1
SPNet [54]	ResNet	zero-shot	23.8	17.0	14.1	18.3	18.3	44.3	–	–	–	–	–	–
ZS3Net [4]	ResNet	zero-shot	40.8	39.4	39.3	33.6	38.3	57.7	18.8	20.1	24.8	20.5	21.1	55.1
LSeg [25]	ResNet	zero-shot	52.8	53.8	44.4	38.5	47.4	64.1	22.1	25.1	24.9	21.6	23.4	57.9
Ours	DRN	zero-shot	**57.3**	**60.3**	**58.4**	**45.9**	**55.5**	**66.4**	**34.2**	**36.5**	**34.6**	**35.6**	**35.2**	**58.4**
LSeg [25]	ViT-L	zero-shot	61.3	63.6	43.1	41.0	52.3	67.6	28.1	27.5	30.0	23.2	27.2	**59.9**
Ours	ViT-L	zero-shot	**62.7**	**64.3**	**60.6**	**50.2**	**59.4**	**69.0**	**33.8**	**38.1**	**34.4**	**35.0**	**35.3**	58.2

The cross dataset results

Model	Backbone	external dataset	target dataset	PASCAL-5^i
LSeg	ViT-L	✗	✓(seen classes)	52.3
SPNet	ResNet	✗	✓(seen classes)	18.3
ZS3Net	ResNet	✗	✓(seen classes)	38.3
LSeg	ResNet	✗	✓(seen classes)	47.4
LSeg+	ResNet	COCO	✗	59.0
OpenSeg [14]	ResNet	COCO	✗	60.0
Ours	DRN	COCO	✗	**62.7**

Experiment

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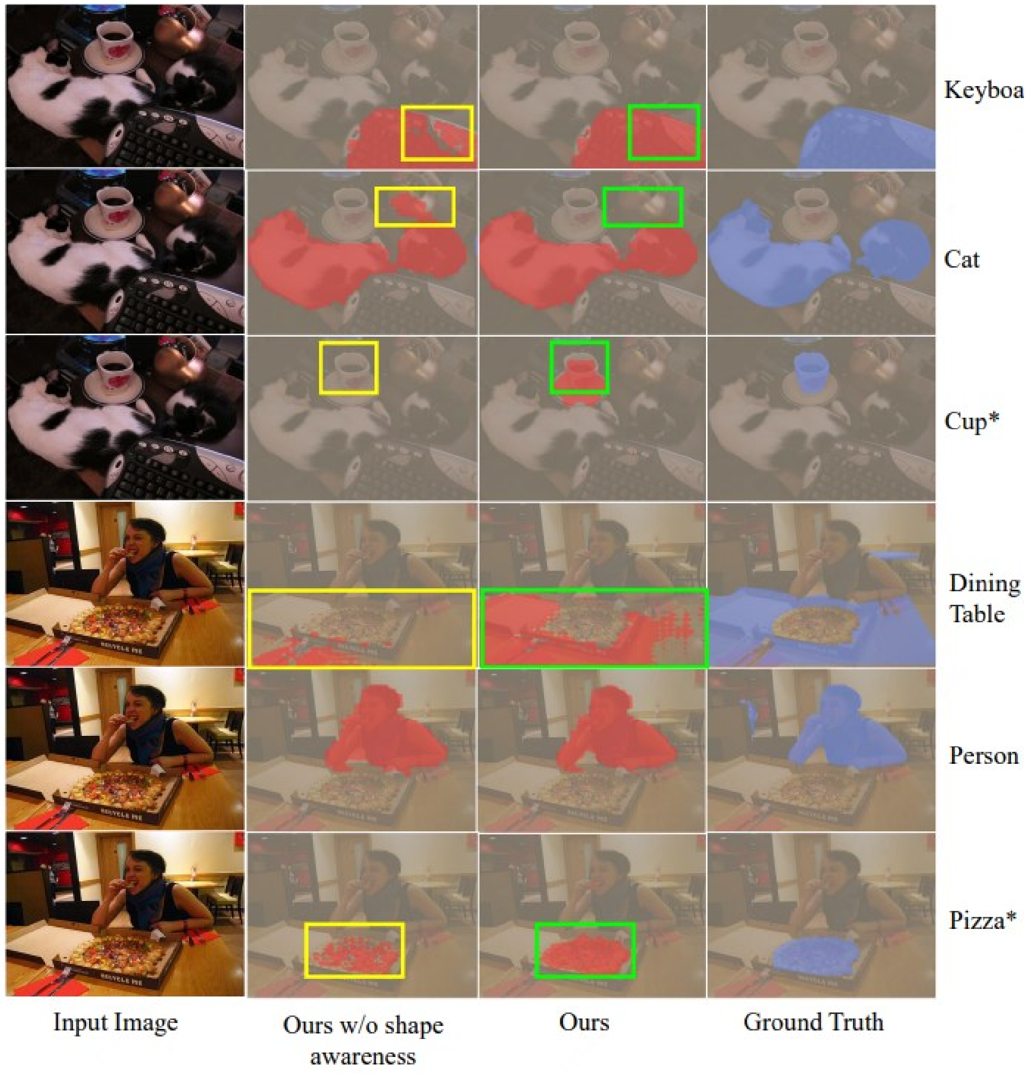
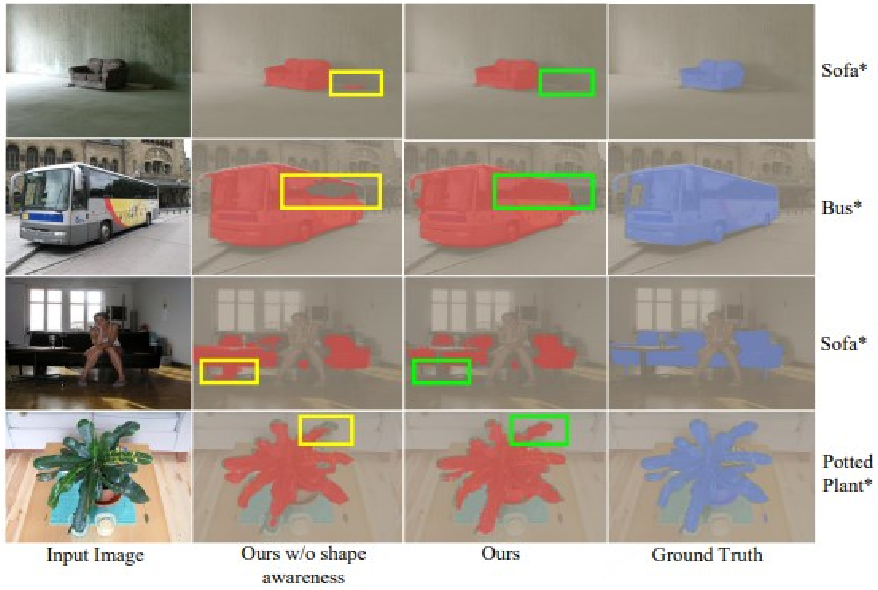
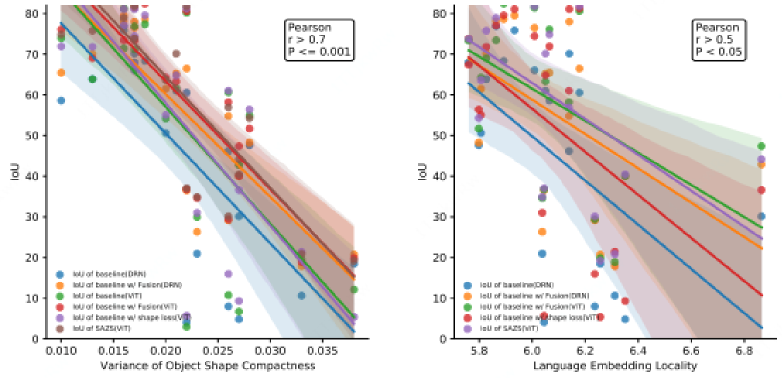


Our results on COCO-20^i dataset



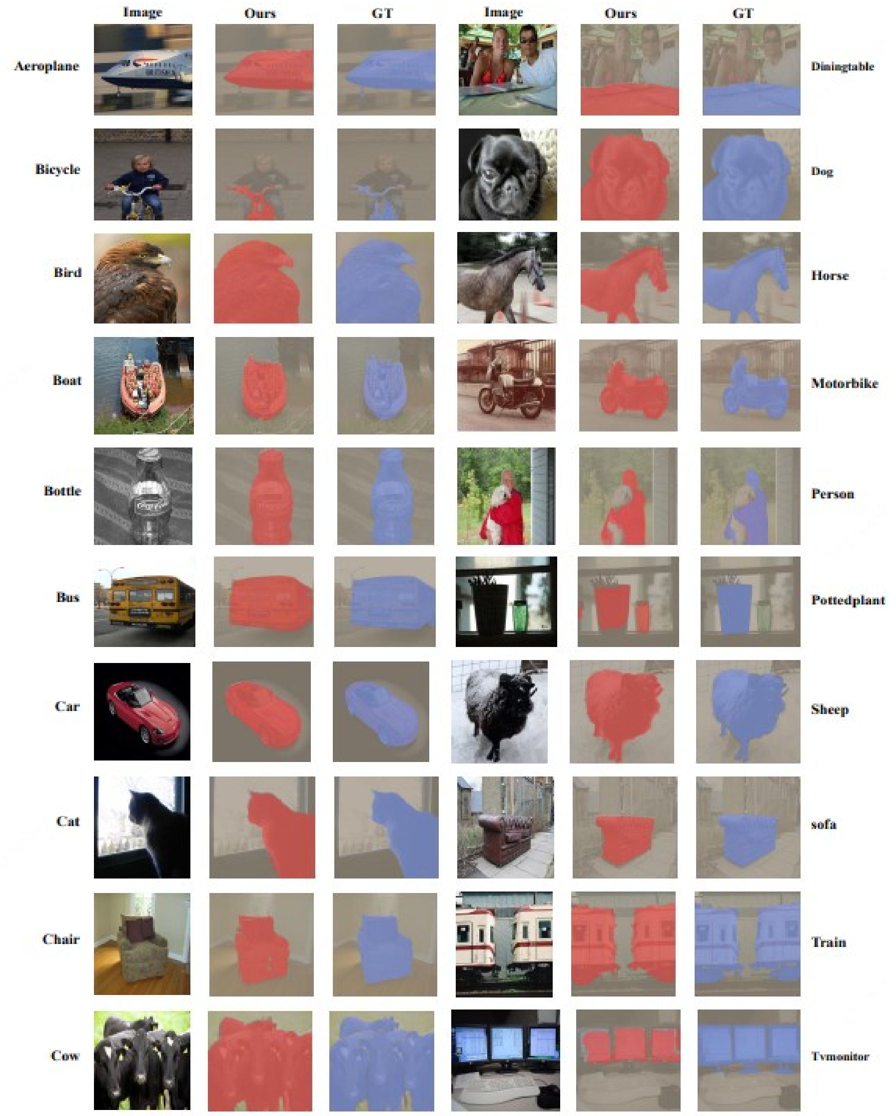
Our results on PASCAL-5^i dataset



Correlation of CO variance and mean language embedding locality on IoU

Experiment

Our results on COCO-20^{i} dataset



Our results on PASCAL-5^{i} dataset

Experiment

Ablation study on COCO-20^i (ViT backbone)

Model	Fusion	$\mathcal{L}_{shape}$	20^0	20^1	20^2	20^3	mIoU
SAZS	✓	✓	**34.2**	36.5	**34.6**	**35.6**	**35.2**
SAZS	✓		33.7	**38.2**	33.4	35.5	35.2
SAZS		✓	28.4	27.6	25.4	25.1	26.6
SAZS			24.2	28.5	24.4	23.3	25.1
LSeg [25]			22.1	25.1	24.9	21.6	23.4

Ablation study on PASCAL-5^i (ViT backbone)

Model	Fusion	$\mathcal{L}_{shape}$	5^0	5^1	5^2	5^3	mIoU
SAZS	✓	✓	62.7	**64.3**	**60.6**	**50.2**	**59.4**
SAZS	✓		**63.1**	62.4	59.0	49.2	58.4
SAZS		✓	59.7	63.4	44.3	42.2	52.4
SAZS			59.2	61.9	43.8	41.9	51.7
LSeg [25]			61.3	63.6	43.1	41.0	52.3

Ablation study on COCO-20^i (DRN backbone)

Model	Fusion	$\mathcal{L}_{shape}$	20^0	20^1	20^2	20^3	mIoU
SAZS	✓	✓	**33.8**	38.1	**34.4**	**35.0**	**35.3**
SAZS	✓		33.3	**39.0**	33.9	32.7	34.7
SAZS		✓	30.0	30.4	27.5	28.5	29.1
SAZS			26.3	32.0	26.2	26.2	27.7
LSeg [25]			28.1	27.5	30.0	23.2	27.2

Impact of Z_{shape} and Z_{sem} of fusion module

Model	external dataset	Z_{shape}	Z_{sem}	PASCAL-5^i
SAZS	COCO			58.4
SAZS	COCO	✓		58.6
SAZS	COCO		✓	62.7

Conslusion

Our contributions:

- We propose a novel methodology for shape-aware zero-shot semantic segmentation models from language supervision, named SAZS, and set new state-of-the-art performance on PASCAL and COCO datasets.
- We propose to leverage the eigen vectors of Laplacian matrices constructed with self-supervised pixelwise features to promote shape-awareness.
- We propose to jointly optimizing a boundary segment constraint that aligns both the boundary of predicted semantic regions and the ground truth regions while narrowing the visual-language embedding space.
- We draw several interesting and conclusive observations: the benefits of promoting shape-awareness highly relates to objects' compactness and language embedding locality.