

## LaSO: Label-Set Operations networks for multi-label few-shot learning

### Supplementary Material

Here we present some more visual examples of LaSO networks results. We apply the LaSO networks trained on 64 MS-COCO categories to images from MS-COCO validation set (unseen during training). As in figure 4 of the paper, we use retrieval to visualize the synthesized feature vectors as the image with the closest feature vector in the validation set. We demonstrate results obtained using the learned LaSO operation, the analytic LaSO variant, and also (for reference) retrieval using the inputs to the operation, self excluded. We demonstrate example results for using LaSO to perform the label set intersection  $A \cap B$  (Figure 1), union  $A \cup B$  (Figure 2), subtraction  $A \setminus B$  (Figure 3), and hybrid  $A \setminus (B \cap C)$  (Figure 4) operations.

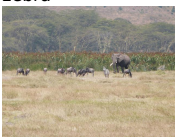



















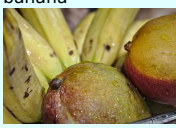

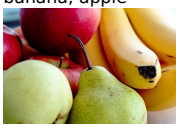



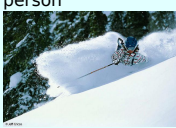


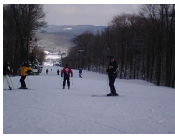









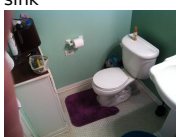


image A	image B	learned $A \cap B$	analytic $A \cap B$	retrieval A	retrieval B
cow, elephant, zebra 	person, elephant 	elephant 	person, elephant 	bird, elephant 	person, dog, elephant 
bicycle, car, fire hydrant 	person, truck, fire hydrant 	fire hydrant 	truck 	person, car, fire hydrant 	car, truck, surfboard 
bowl, broccoli, dining table 	spoon, broccoli 	broccoli 	fork, knife, carrot, dining table 	broccoli, carrot 	pizza, cell phone, oven 
bowl, banana, apple 	person, banana, potted plant 	banana 	person, bottle, knife, spoon, bowl, banana 	banana, apple 	person, banana 
person, bear 	person, backpack, skis 	person 	bear 	bear 	person, skis, snowboard 
person, car, stop sign 	truck, stop sign 	stop sign 	person, stop sign, handbag 	person, car, frisbee 	car, stop sign 
cat, toilet 	toilet, sink 	toilet 	bottle, toilet, sink 	cat, toilet 	toilet, sink 

Figure 1. Examples of label set intersection  $A \cap B$  operation results using LaSO and alternatives. Learned LaSO result is framed in cyan box. True labels of the images are shown above them. ‘Retrieval A’ and ‘retrieval B’ are provided for reference and depict the nearest neighbors to the corresponding operation input images in feature space.

















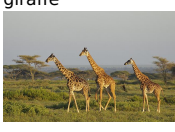




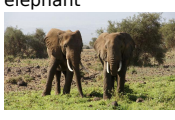


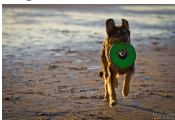









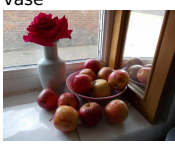


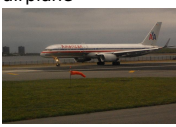
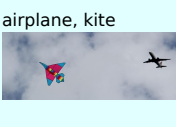



<u>image A</u>	<u>image B</u>	<u>learned <math>A \cup B</math></u>	<u>analytic <math>A \cup B</math></u>	<u>retrieval A</u>	<u>retrieval B</u>
toilet, sink 	person, toilet 	person, toilet, sink 	toilet, sink 	toilet, sink 	person, toilet, potted plant 
broccoli, carrot 	bowl, broccoli 	bowl, broccoli, carrot 	person, broccoli 	broccoli, carrot 	broccoli 
giraffe 	person, zebra 	person, zebra, giraffe 	zebra, giraffe 	giraffe 	person, zebra, chair 
elephant 	bird 	bird, elephant 	elephant 	elephant 	bird 
dog, frisbee 	person, frisbee 	person, dog, frisbee 	dog, frisbee 	dog, frisbee 	person, frisbee 
apple 	banana, apple, orange 	banana, apple, orange 	banana, apple 	bowl, apple, vase 	banana, apple 
kite 	airplane 	airplane, kite 	airplane 	person, sports ball, kite 	person, airplane 

Figure 2. Examples of label set union  $A \cup B$  operation results using LaSO and alternatives. Learned LaSO result is framed in cyan box. True labels of the images are shown above them. ‘Retrieval A’ and ‘retrieval B’ are provided for reference and depict the nearest neighbors to the corresponding operation input images in feature space.



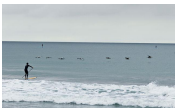


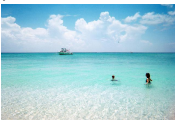







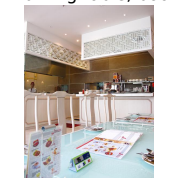




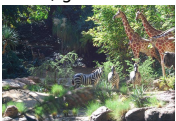

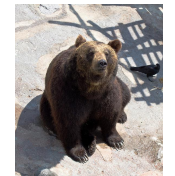

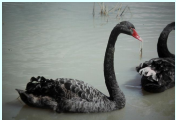


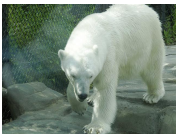







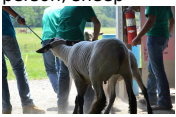






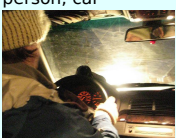



<u>image A</u>	<u>image B</u>	<u>learned <math>A \setminus B</math></u>	<u>analytic <math>A \setminus B</math></u>	<u>retrieval A</u>	<u>retrieval B</u>
person, bird, surfboard 	bird 	person, surfboard 	person, boat 	person, boat, surfboard 	bird 
person, bird, donut 	donut, dining table, vase 	person, bird 	bird 	person, surfboard 	person, bottle, fork, knife, spoon, chair, dining table, book 
zebra, giraffe 	zebra 	giraffe 	bear 	zebra, giraffe 	zebra 
bird, bear 	bear 	bird 	bear 	bear 	bear 
bird, zebra, giraffe 	giraffe 	bird, zebra 	bird 	zebra, giraffe 	giraffe 
dog, sheep 	person, sheep 	dog 	sheep 	dog, sheep 	person, horse 
person, car, donut 	donut 	person, car 	person, bicycle, bench, handbag, bottle, sandwich 	person, donut 	knife, donut 

Figure 3. Examples of label set subtraction  $A \setminus B$  operation results using LaSO and alternatives. Learned LaSO result is framed in cyan box. True labels of the images are shown above them. ‘Retrieval A’ and ‘retrieval B’ are provided for reference and depict the nearest neighbors to the corresponding operation input images in feature space.






































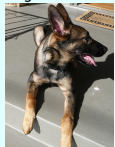



















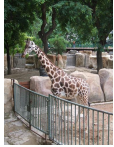
image A	image B	image C	learned $A \setminus (B \cap C)$	analytic $A \setminus (B \cap C)$	retrieval A	retrieval B	retrieval C
person, dog, sheep 	person, car, sheep 	person, sheep 	dog 	person, dog, sheep 	person, dog, sheep 	person, car, bench, baseball bat, baseball glove, chair 	person, bench, baseball bat, baseball glove 
person, backpack, tie, suitcase 	person, tie, bottle, cup 	person, tie 	backpack, suitcase 	person, bench, suitcase 	person, backpack, suitcase, chair, cell phone 	person, tie 	person, tie 
bird, kite 	person, kite 	person, bicycle, kite 	bird 	kite 	person, kite 	person, kite 	person, car, chair, scissors 
bird, bear 	bear 	bear 	bird 	bear 	bear 	bird, bear 	bear 
dog, sheep 	person, dog, sheep 	sheep 	dog 	sheep 	dog, sheep 	person, dog, sheep, suitcase, chair, dining table 	sheep 
person, frisbee 	person, handbag, frisbee, bottle 	dog, frisbee 	person 	person, frisbee 	person, frisbee 	person, sports ball, baseball bat 	dog, frisbee 
zebra, giraffe 	person, giraffe, handbag, carrot 	zebra, giraffe 	zebra 	boat, bird 	zebra, giraffe 	person, giraffe, handbag, carrot 	person, giraffe 

Figure 4. Examples of label set hybrid  $A \setminus (B \cap C)$  operation results using LaSO and alternatives. Learned LaSO result is framed in cyan box. True labels of the images are shown above them. ‘Retrieval A’, ‘retrieval B’, and ‘retrieval C’ are provided for reference and depict the nearest neighbors to the corresponding operation input images in feature space.