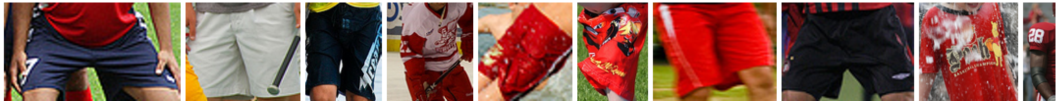
1 Supplementary Material

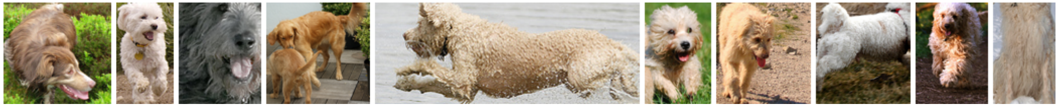
1.1 Triplet Retrieval: More Examples

These are extended results of Figure 5 in the paper. We fix a depedency triplet and retrieve the image fragments that have the highest score with the triplet. These are sorted from left to right in decreasing score.

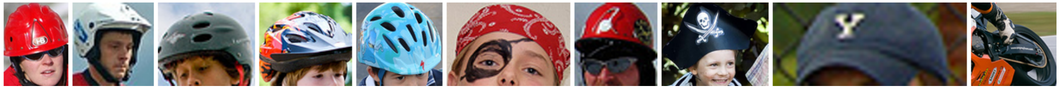
(AMOD, red, shorts)



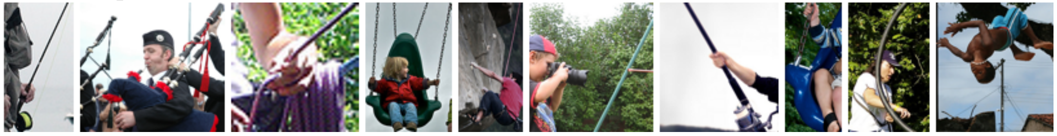
(AMOD, blond, dog)



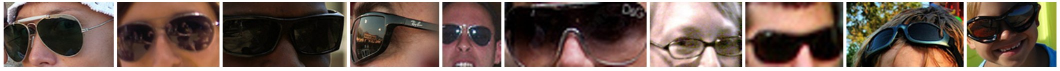
(DET, a, helmet)



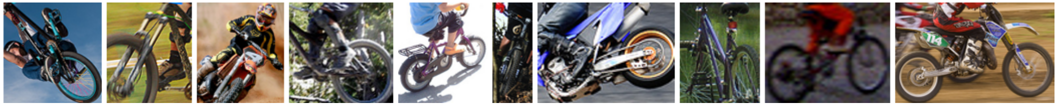
(DET, a, rope)



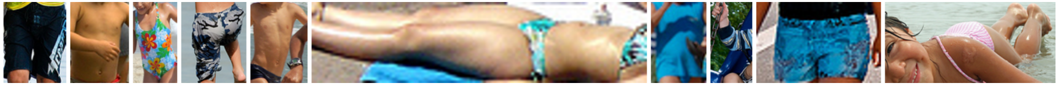
(DOBJ, sunglasses, wearing)



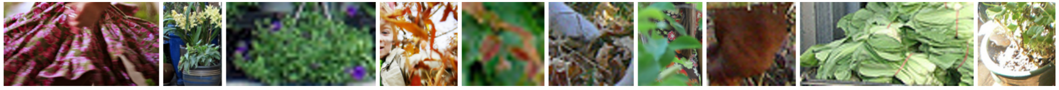
(NN, bike, rider)



(NN, swimming, trunks)

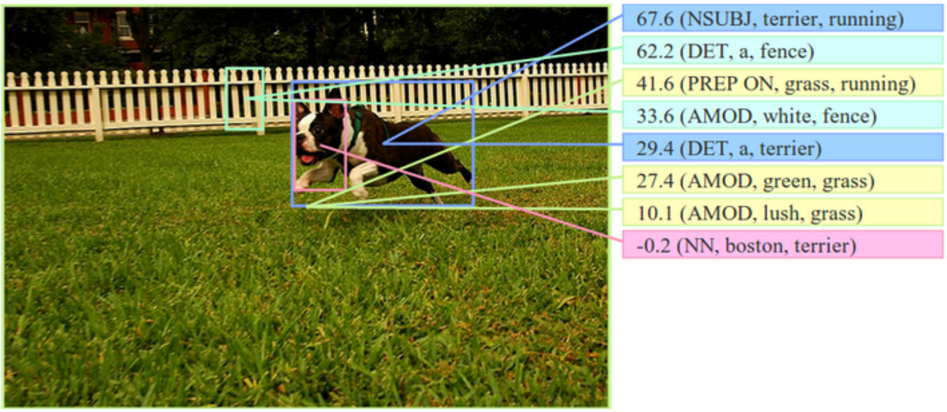


(PREP OF, flowers, bucket)

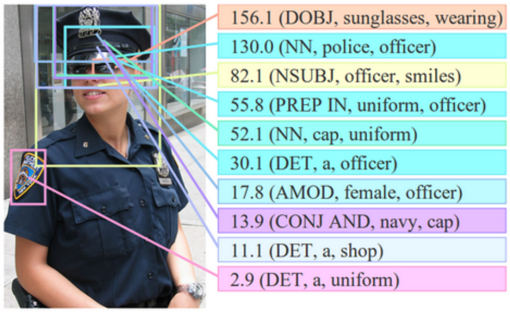


1.2 Image Annotation: More Examples

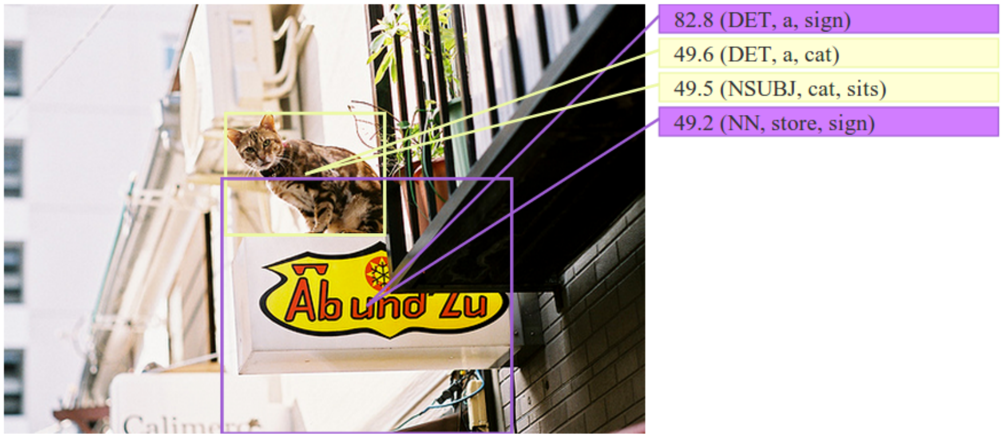
These are more examples of the results shown in Figure 4 in the paper. We fix an image and retrieve the top 5 most compatible sentences (shown below each image). The fragments of the top sentence are visualized next to the image and connected to the image fragment that they have the highest score with.


67.6 (NSUBJ, terrier, running)
62.2 (DET, a, fence)
41.6 (PREP ON, grass, running)
33.6 (AMOD, white, fence)
29.4 (DET, a, terrier)
27.4 (AMOD, green, grass)
10.1 (AMOD, lush, grass)
-0.2 (NN, boston, terrier)

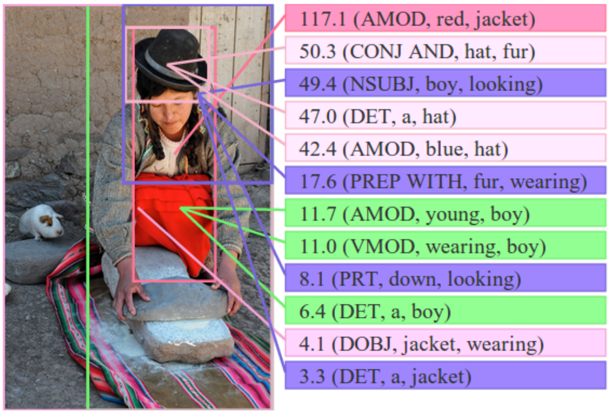
1. A Boston Terrier is running on lush green grass in front of a white fence.
2. A German shepherd is showing its teeth as it growls at another German shepherd.
3. A dog runs on the green grass near a wooden fence.
4. A black and white dog is running in a grassy garden surrounded by a white fence.
5. A small dog jumps over a striped gate.


156.1 (DOBJ, sunglasses, wearing)
130.0 (NN, police, officer)
82.1 (NSUBJ, officer, smiles)
55.8 (PREP IN, uniform, officer)
52.1 (NN, cap, uniform)
30.1 (DET, a, officer)
17.8 (AMOD, female, officer)
13.9 (CONJ AND, navy, cap)
11.1 (DET, a, shop)
2.9 (DET, a, uniform)

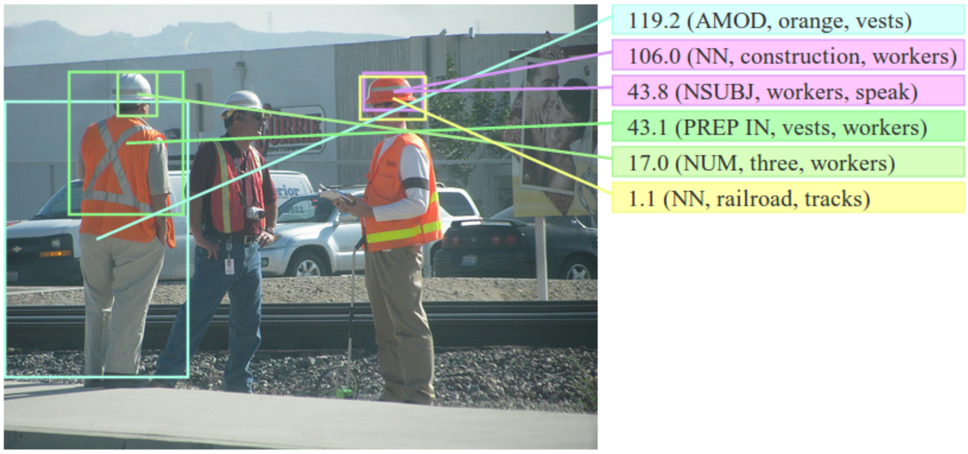
1. A female police officer in a cap and navy uniform smiles while wearing sunglasses outside of a shop.
2. A female police officer, wearing an officer's hat and sunglasses, stands in uniform in front of a window-lined street block.
3. An african American police officer and woman stand at the front of a bus.
4. A child is wearing a blue knitted hat.
5. A police woman smiling and wearing sunglasses and a hat.



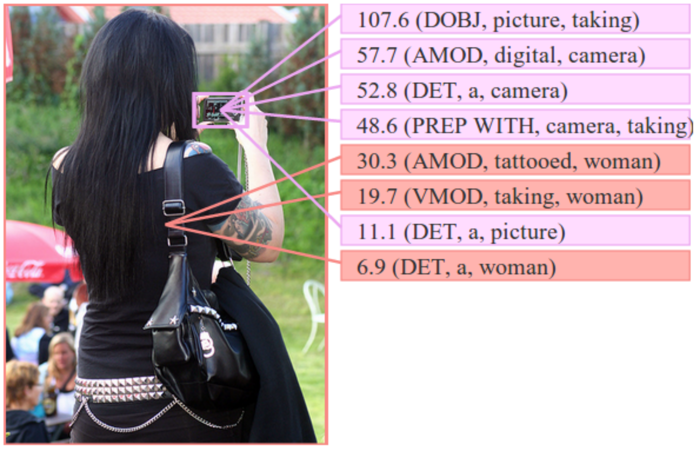
1. A cat sits on top of a store sign.
2. Man looking out the window of a train.
3. A cat sits upon a business sign.
4. A cat is sitting atop a sign on the side of a building.
5. Man standing at a counter in a convenience store with a woman on the other side of the counter wearing a white shirt looking at him very expectantly.


117.1 (AMOD, red, jacket)
50.3 (CONJ AND, hat, fur)
49.4 (NSUBJ, boy, looking)
47.0 (DET, a, hat)
42.4 (AMOD, blue, hat)
17.6 (PREP WITH, fur, wearing)
11.7 (AMOD, young, boy)
11.0 (VMOD, wearing, boy)
8.1 (PRT, down, looking)
6.4 (DET, a, boy)
4.1 (DOBJ, jacket, wearing)
3.3 (DET, a, jacket)

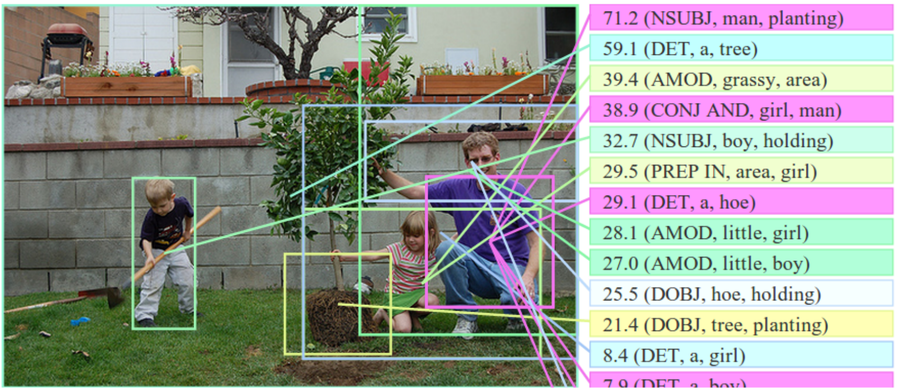
1. A young boy or girl wearing a red jacket with fur and a blue hat is looking down.
2. A young African american boy with red pants standing in front of a house.
3. Two boys wearing red jackets are digging shovels into the dirt, the smaller boy in the yellow boots has a mohawk.
4. A little boy dressed in red pants is standing in the street.
5. Little boy in red pants, no shirt, picking his teeth.


119.2 (AMOD, orange, vests)
106.0 (NN, construction, workers)
43.8 (NSUBJ, workers, speak)
43.1 (PREP IN, vests, workers)
17.0 (NUM, three, workers)
1.1 (NN, railroad, tracks)

1. Three construction workers in orange vests speak to one another in front of railroad tracks.
2. Construction worker in orange vest and white hard hat with a shovel.
3. Several construction workers with orange safety vests are digging into the ground.
4. Construction workers in orange and yellow vests with jeans work on a street.
5. Construction workers picketing against PM Construction Services.

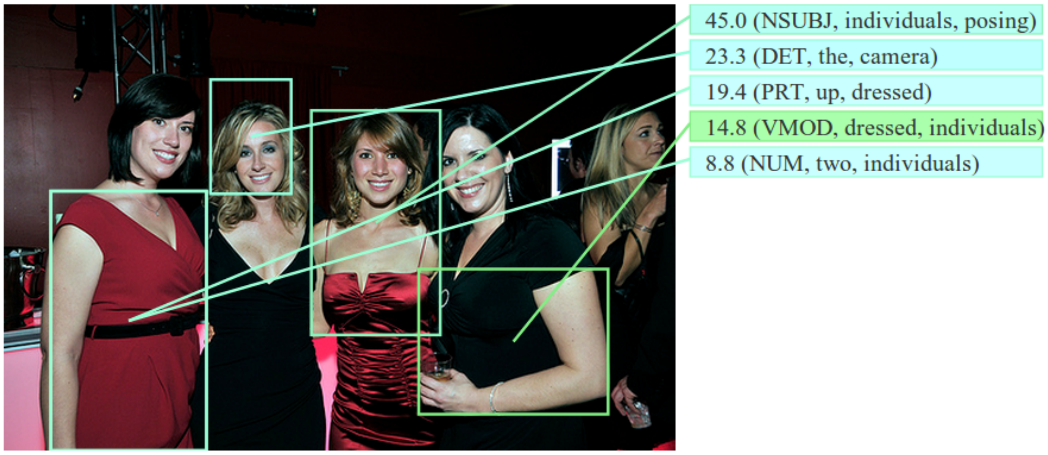

107.6 (DOBJ, picture, taking)
57.7 (AMOD, digital, camera)
52.8 (DET, a, camera)
48.6 (PREP WITH, camera, taking)
30.3 (AMOD, tattooed, woman)
19.7 (VMOD, taking, woman)
11.1 (DET, a, picture)
6.9 (DET, a, woman)

1. A tattooed woman taking a picture with a digital camera.
2. Somebody took a photo of a girl with long black hair taking a photo.
3. A woman with a camera on a tripod is smiling for another camera.
4. A woman dressed in black with a tattoo on her right arm is taking a picture with her camera.
5. People enjoying a festival while having drinks and taking pictures on the cellphone.


71.2 (NSUBJ, man, planting)
59.1 (DET, a, tree)
39.4 (AMOD, grassy, area)
38.9 (CONJ AND, girl, man)
32.7 (NSUBJ, boy, holding)
29.5 (PREP IN, area, girl)
29.1 (DET, a, hoe)
28.1 (AMOD, little, girl)
27.0 (AMOD, little, boy)
25.5 (DOBJ, hoe, holding)
21.4 (DOBJ, tree, planting)
8.4 (DET, a, girl)
7.9 (DET, a, boy)

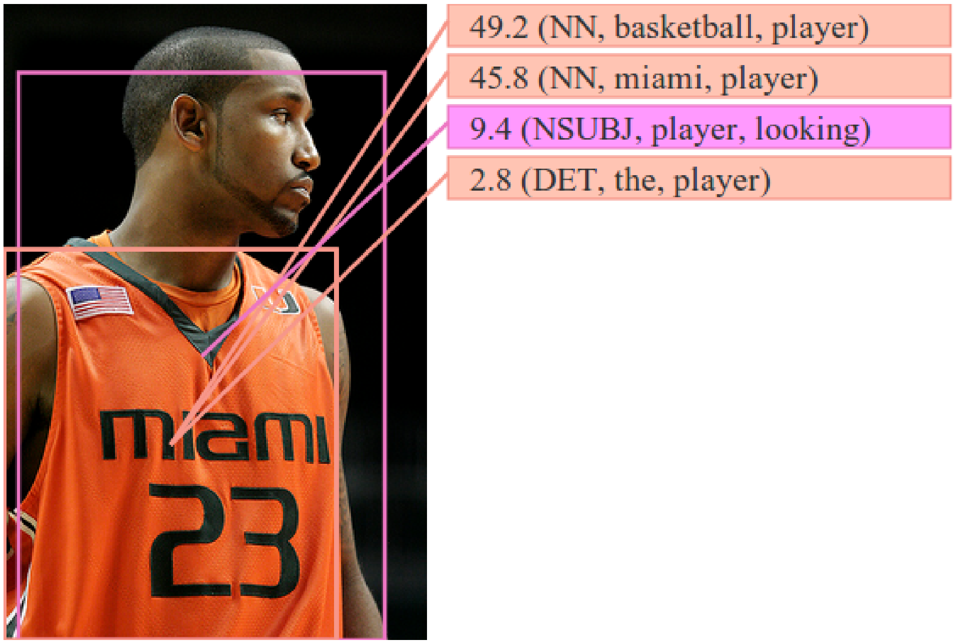
1. A man and a little girl in a grassy area are planting a tree while a little boy off to the side is holding a hoe.
2. A father-figure and two children outside their home doing yard work such as using a hoe on the grass and planting a tree.
3. Three little children in a grassy yard running towards the camera.
4. A man and two children are planting a tree.
5. A woman is playing with two children on a seesaw in a playground.

An issue with sentences as shown in this example is that the model does not reason about numbers and it is not natural to align triplets such as (NUM, two, individuals) to a detection. Also note the highly confident detection of camera on a person's face. These mistakes are due to people often describing frontal faces of people as ”looking into the camera”.


45.0 (NSUBJ, individuals, posing)
23.3 (DET, the, camera)
19.4 (PRT, up, dressed)
14.8 (VMOD, dressed, individuals)
8.8 (NUM, two, individuals)

1. Two individuals dressed up like animals are posing for the camera .
2. Four girls in evening attire pose for a picture .
3. two girls dress up for halloween .
4. Two girls wearing goth trendy clothing while one looks back at the camera .
5. four girls in evening wear are posing for a photograph .

For the image below, we note that there are 18 mentions of “Miami” in the training set.

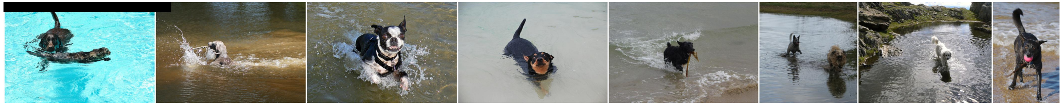


1. The Miami basketball player is looking .
2. A man in a Miami basketball uniform looking to the right
3. A girl with a nose ring , earring , and Mohawk .
4. A Miami basketball player dribbles by an Arizona State player .
5. A Miami basketball player looks off in the distance .

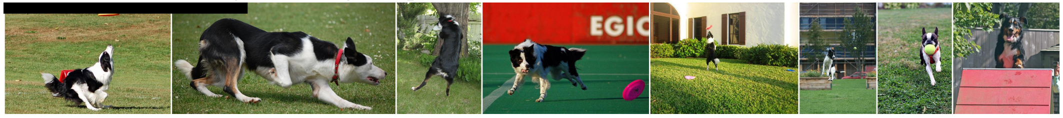
1.3 Image Search: Examples

In this experiment on Flickr8K test set we fix a sentence and retrieve the most compatible images. The images are ranked from left to right in decreasing confidence.

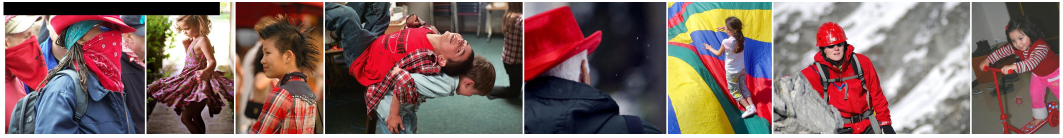
A black dog with brown on his face is swimming .



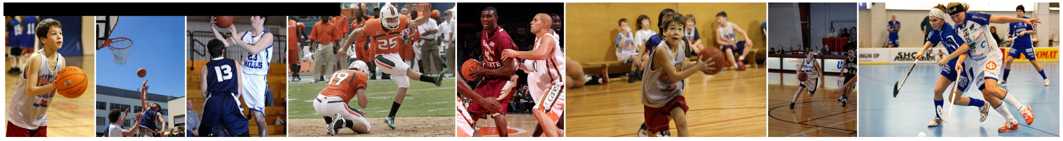
A black and white dog is looking at a pink Frisbee on a court .



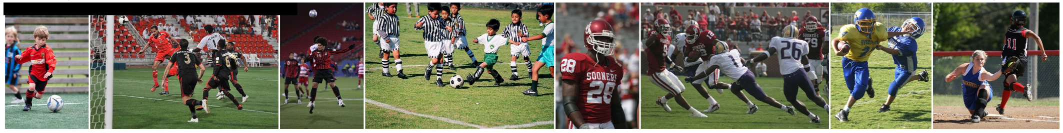
A girl in a red jacket , surrounded by people .



The boy in the white jersey is dribbling the orange Wizards basketball .

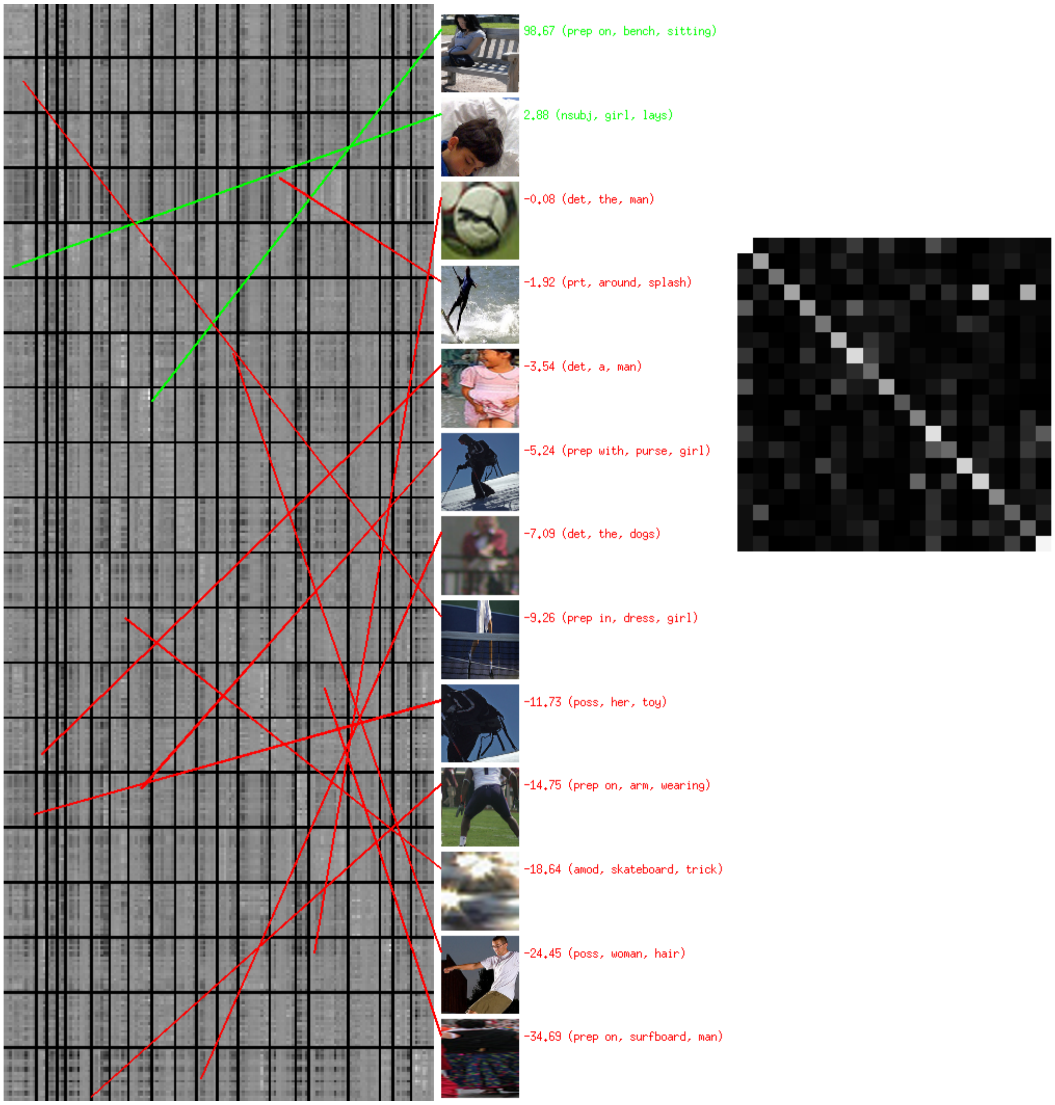


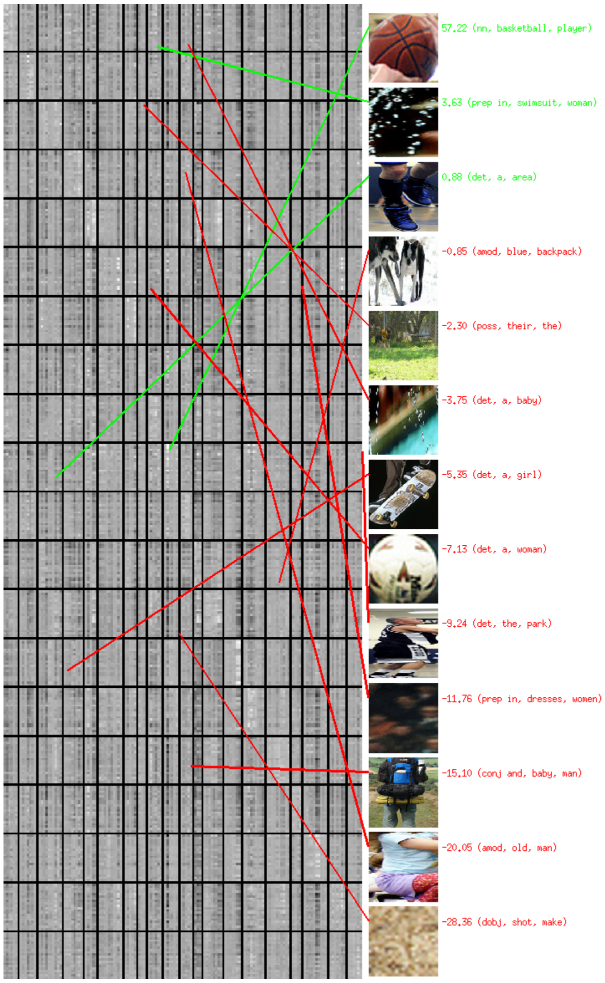
The person in the red and black uniform has a ball above her head .
(one of the current limitations is that the model does not reason about relative positions of objects)



1.4 Score Matrix Visualization

We visualize some real examples of Figure 3 in the paper. Left: The raw fragment scores. Right: image-sentence scores for the batch of 20 images and sentences, once accumulated from fragment scores along blocks. The black grid lines delineate the boundaries between images and sentences. The red and green lines and images on side zoom in on particular examples of image-sentence fragment pairs from the matrix. Green indicates score greater than 0, red less than 0.




57.22 (nn, basketball, player)
3.63 (prep in, swimsuit, woman)
0.88 (det, a, area)
-0.85 (amod, blue, backpack)
-2.30 (poss, their, the)
-3.75 (det, a, baby)
-5.35 (det, a, girl)
-7.13 (det, a, woman)
-9.24 (det, the, park)
-11.76 (prep in, dresses, women)
-15.10 (conj and, baby, man)
-20.05 (amod, old, man)
-28.36 (dobj, shot, make)