Supplementary Material: Webly Supervised Learning of Convolutional Networks

Anonymous ICCV submission

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In the supplementary material we include:

1. Additional results on PASCAL VOC for ablation analysis.
2. Scene classification results.
3. Diagnosis results for webly supervised object detection using [4].
4. Lists of objects, scenes and attributes.

1. Additional Results on PASCAL VOC

For ablation analysis, we provide more results on the PASCAL VOC 2007 detection challenge. Please refer to Table 1 for comparison. The newly added results are shown at the bottom rows. Following the notation in the paper, "NFT" means before fine-tuning, and "FT" means after fine-tuning (100K iterations with a step size of 20K). We add three pairs of new results:

GoogleO-CI "CI" stands for "Cleaned Images". This network is obtained by fine-tuning GoogleO on the images obtained by our object localization algorithm (described in Section 3.3). Here, the entire image is regarded as clean if at least one object is found inside it. However, the extra location information (bounding box) is not used - the input is still the full image.

GoogleO-CB "CB" stands for "Cleaned images with Bounding boxes". Similar to GoogleO-CI, the network is fine-tuned on the cleaned images. However, instead of using the entire image, the image patches cropped by the discovered bounding boxes are fed into the network. Both GoogleO-CI and Google-CB were fine-tuned for 200K iterations, with the learning rate reduced every 40K iterations.

IN-GoogleA To see if more data can help the performance, we fine-tuned the ImageNet pretrained network [3] to all the images downloaded from Google. The fine-tuning was performed for 400K iterations, reducing learning rate every 80K iterations.

Somewhat to our surprise, we found the extra clean-up step does not help improving the detection performance. In fact, the average precision dropped for most of the categories, regardless of whether the bounding box information is used or not. We suspect one reason lies in the size of the data: after the object localization step, the number of images was cut in more than a half ($\sim$0.67M compared to $\sim$1.5M). Also better algorithms can be devised for cleaning up web images.

On the other hand, fine-tuning ImageNet pretrained model to Google images gives slightly better result than training from scratch. However, further investigation is still needed here since IN-GoogleA has seen more images (ImageNet 1M) than GoogleA.

2. Scene Classification

To further demonstrate the usage of CNN features directly learned from the web, we also conducted a set of scene classification experiments on the MIT Indoor-67 dataset [5]. For each image, we simply computed the $fc7$ feature vector, which has 4096 dimensions. We did not use any data augmentation or spatial pooling technique, with the only pre-processing step normalizing the feature vector to unit ℓ_2 length [6]. The default SVM parameters (C=1) were fixed throughout the experiments.

Table 2 summarizes the results on the default train/test split. We can see our web based CNNs achieved very competetive performances: all the three networks achieved an accuracy at least on par with ImageNet pretrained models. Fine-tuning on hard images enhanced the features, but adding scene-related categories gave a huge boost to 66.5 (comparable to the CNN trained on Places database [9], 68.2). This indicates CNN features learned directly from the web are indeed generic.

Moreover, since we can get semantic labels (*e.g.* actions) other than objects or scenes from the web for free, webly supervised CNN bears a great potential to perform well on many relevant tasks - and the cost is just as low as providing a category list to query for that domain.

VOC 2007 test	aero	bike	bird	boat	bottle	bus	car	cat	chair	cow	table	dog	horse	mbike	person	plant	sheep	sofa	train	tv	**mAP**
ImageNet-NFT [3]	57.6	57.9	38.5	31.8	23.7	51.2	58.9	51.4	20.0	50.5	40.9	46.0	51.6	55.9	43.3	23.3	48.1	35.3	51.0	57.4	44.7
GoogleO-NFT	57.1	59.9	35.4	30.5	21.9	53.9	59.5	40.7	18.6	43.3	37.5	41.9	49.6	57.7	38.4	22.8	45.2	37.1	48.0	54.5	42.7
GoogleA-NFT	54.9	58.2	35.7	30.7	22.0	54.5	59.9	44.7	19.9	41.0	34.5	40.1	46.8	56.2	40.0	22.2	45.8	36.3	47.5	54.2	42.3
Flickr-NFT	55.3	61.9	39.1	29.5	24.8	55.1	62.7	43.5	22.7	49.3	36.6	42.7	48.9	59.7	41.2	25.4	47.7	41.9	48.8	56.8	44.7
VOC-Scratch [1]	49.9	60.6	24.7	23.7	20.3	52.5	64.8	32.9	20.4	43.5	34.2	29.9	49.0	60.4	47.5	28.0	42.3	28.6	51.2	50.0	40.7
ImageNet-FT [3]	64.2	**69.7**	**50.0**	**41.9**	**32.0**	62.6	71.0	**60.7**	**32.7**	58.5	46.5	**56.1**	60.6	66.8	54.2	31.5	52.8	48.9	57.9	**64.7**	**54.2**
GoogleO-FT	65.0	68.1	45.2	37.0	29.6	65.4	73.8	54.0	30.4	57.8	48.7	51.9	**64.1**	64.7	54.0	**32.0**	54.9	44.5	57.0	64.0	53.1
GoogleA-NFT	64.2	68.3	42.7	38.7	26.5	65.1	72.4	50.7	28.5	**60.9**	**48.8**	51.2	60.2	65.5	54.5	31.1	50.5	**48.5**	56.3	60.3	52.3
Flickr-FT	63.7	68.5	46.2	36.4	30.2	**68.4**	**73.9**	56.9	31.4	59.1	46.7	52.4	61.5	**69.2**	53.6	31.6	53.8	44.5	58.1	59.6	53.3
GoogleO-CB-NFT	56.8	56.5	33.8	27.5	22.7	51.3	55.1	41.0	15.6	42.3	31.0	37.7	46.8	55.2	38.8	23.0	41.5	30.4	48.1	51.2	40.3
GoogleO-CB-FT	**67.2**	**69.7**	45.9	36.5	31.7	64.9	**73.9**	54.2	30.4	59.9	43.6	49.6	59.1	66.3	52.7	30.6	52.3	42.5	59.6	62.4	52.7
GoogleO-CI-NFT	55.7	57.1	33.6	27.4	22.6	55.6	57.3	39.3	17.6	39.7	35.0	35.5	46.9	57.0	39.5	21.0	43.1	31.1	49.4	52.1	40.8
GoogleO-CI-FT	63.2	67.0	41.2	34.7	30.7	66.7	73.1	56.5	30.2	58.0	44.6	50.4	57.1	67.4	52.6	31.2	53.1	41.9	**60.1**	61.9	52.1
IN-GoogleA-NFT	55.0	60.2	39.5	33.4	23.8	58.7	60.6	48.6	23.2	44.9	35.8	44.1	50.3	60.1	42.9	23.9	49.0	39.8	49.7	54.4	44.9
IN-GoogleA-FT	64.6	**69.7**	44.1	34.8	28.4	66.1	72.1	56.2	30.7	57.0	45.8	50.4	61.9	66.5	**54.8**	31.7	**58.0**	43.0	56.8	62.9	52.8

Table 1. Additional Results on VOC-2007 (PASCAL data used).

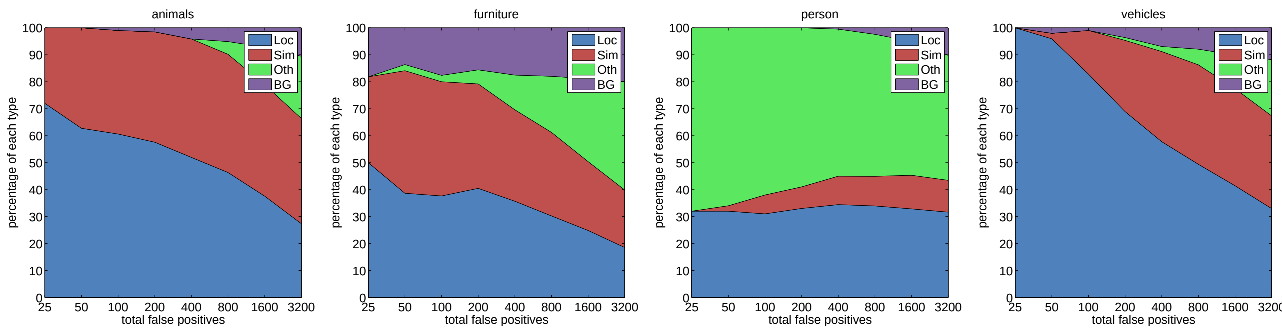

Figure 1. Diagnosis analysis using [4] for better understanding of the failure modes of our webly supervised pipeline. Please see top false positives in Figure 2 and 3.

Indoor-67	**Accuracy**
ImageNet [9]	56.8
OverFeat [6]	58.4
GoogleO	58.1
GoogleA	**66.5**
Flickr	59.2

Table 2. Scene Classification Results on MIT Indoor-67 Dataset.

3. Diagnosis for Webly Supervised Object Detection

The final analysis comes from the nice tool developed in [4]. We would like to see what is the failure modes of our webly supervised object detection (when no PASCAL VOC train data is present). We took the results from our best model (Flickr-C) and fed them for diagnosis. Figure 1, 2 and 3 highlight some of the interesting observations we found. Hopefully these findings can offer more insights about how the web based detectors are performing and what are the possible directions to go for better performance.

Firstly, localization error accounts for a lot of false positives. Since Google Image Search results do not contain location information, the background is inevitably included when the detector is trained (*e.g.* aeroplane, dining table). Moreover, multiple objects can occur in the image, and the algorithm has no clue that they should be treated as separate pieces (*e.g.* bottle). Since our CNN representation is directly trained on full images, it is also learned to be invariant to such variations. All these factors caused serious localization issues.

Second, we did observe some interesting semantic drift between PASCAL categories and Google categories. For example, bicycle can also mean motorcycle on Google. Careful disambiguation of different senses for a polysemous word is needed here. Also note that our person detector is severely confused with cars, we suspect it is because "caprice" was added as a related category and it can also mean a car (chevy caprice). How to handle such issues is a fascinating future research topic by itself.

Finally, there is massive confusion within animal categories (*e.g.* horse *vs.* cow). We believe it is mainly caused by the domain shifting between Google Images and PASCAL images. Adding Flickr data can benefit this case (only Google images are used to train our detectors).

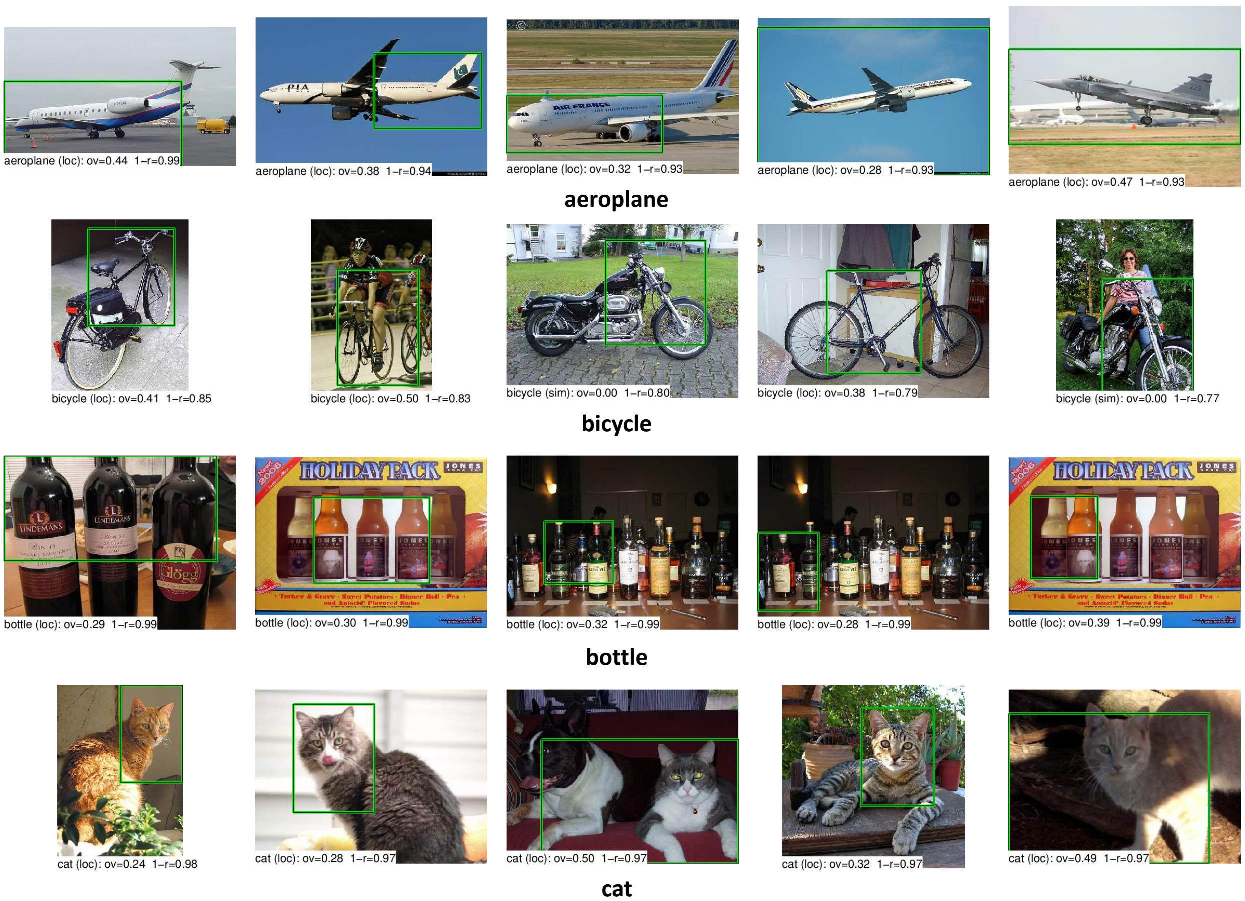

Figure 2. Top false positives for selected categories on PASCAL VOC 2007 detection with Flickr-C. From top down: aeroplane, bicycle, bottle, cat.

4. Lists of Concepts

4.1. Lists for Network Training

We obtained three lists of categories from ImageNet Challenge [7], SUN database [8] and NEIL knowledge base [2].

ImageNet syn-sets are transformed to its surface forms by just taking the first explanation. Most of them are focusing on object categories. To better assist querying and reducing noise, we remove the suffix (usually correspond to attributes, *e.g*. indoor/outdoor) of the SUN categories. These two lists are augmented by the categories listed on NEIL knowledge base, which are better suited as query words. We also used NEIL's list of attributes.

In total we have 2,240 objects and 89 attributes to train the GoogleO net focusing on objects.

1950 car, abacus, abaya, aberdonia, abs, academic gown, ac car, accordion, achiridae, acorn, acorn squash, acoustic guitar, acropolis, actor, actress, acura, acura mdx, adidas ball, admiral, aeron, affenpinscher, afghan hound, african chameleon, african crocodile, african elephant, african grey, african grey parrot, african hunting dog, agama, agaric, agile, agra fort, aholehole, airbus 330, airbus 340, airbus a320, airbus a330, airbus a380, air conditioner, aircraft, aircraft carrier, airedale, air hockey, airliner, airplane, airplane nose, airship, airsoft gun, aisle, ak 47, akg, alarm, albacore, albatross, albert einstein, ale, alfa alfetta, alfa romeo, alfa romeo quadrifoglio, alfredo, alice cooper, alienware x17, allegra versace, alligator, alligator gar, alligator lizard, aloo gobi, aloo tikki, alp, alpaca, altar, alto saxophone, amber, ambulance, amc, american airlines, american alligator, american black bear, american chameleon, american coot, american egret, american limousine, american lobster, american organ, american rambler, american staffordshire terrier, amphibian, ana ivanovic, analog clock, anchor, andre agassi, andrew garfield, android, anemone fish, angel, angelfish, angkor, angora, ant, antelope, antlers, apartment, apiary, appenzeller, apple, apple chip, apple dumpling, apple fruit, apron, arabian camel, arch shape, arctic fox, armadillo, armchair, arroz con pollo, artesia, arthropod crab, artichoke, articulated bus, ashcan, asian elephant, asparagus, asparagus soup, assault rifle, aston martin, aston martin db9, aston martin zagato, astrovette, atom bomb, atos, atv trailer, audi a6, audi a8, audi avant, australian terrier, autobot, avant, avenger, avocado, awl, axe, axolotl, baboon, baby, bachelor, backboard, backgammon, backhoe, backpack, bacon, badger, badminton, bagel, bagpipe, bagpipe chanter, bagre, baguette, bakery, balance beam, bald eagle, balloon, ballplayer, ballpoint, bamboo pipe, banana, banana boat, banana cream, band aid, banded gecko, banjo, banjolele, bannister, banyan, barack obama, barbell, barber chair,

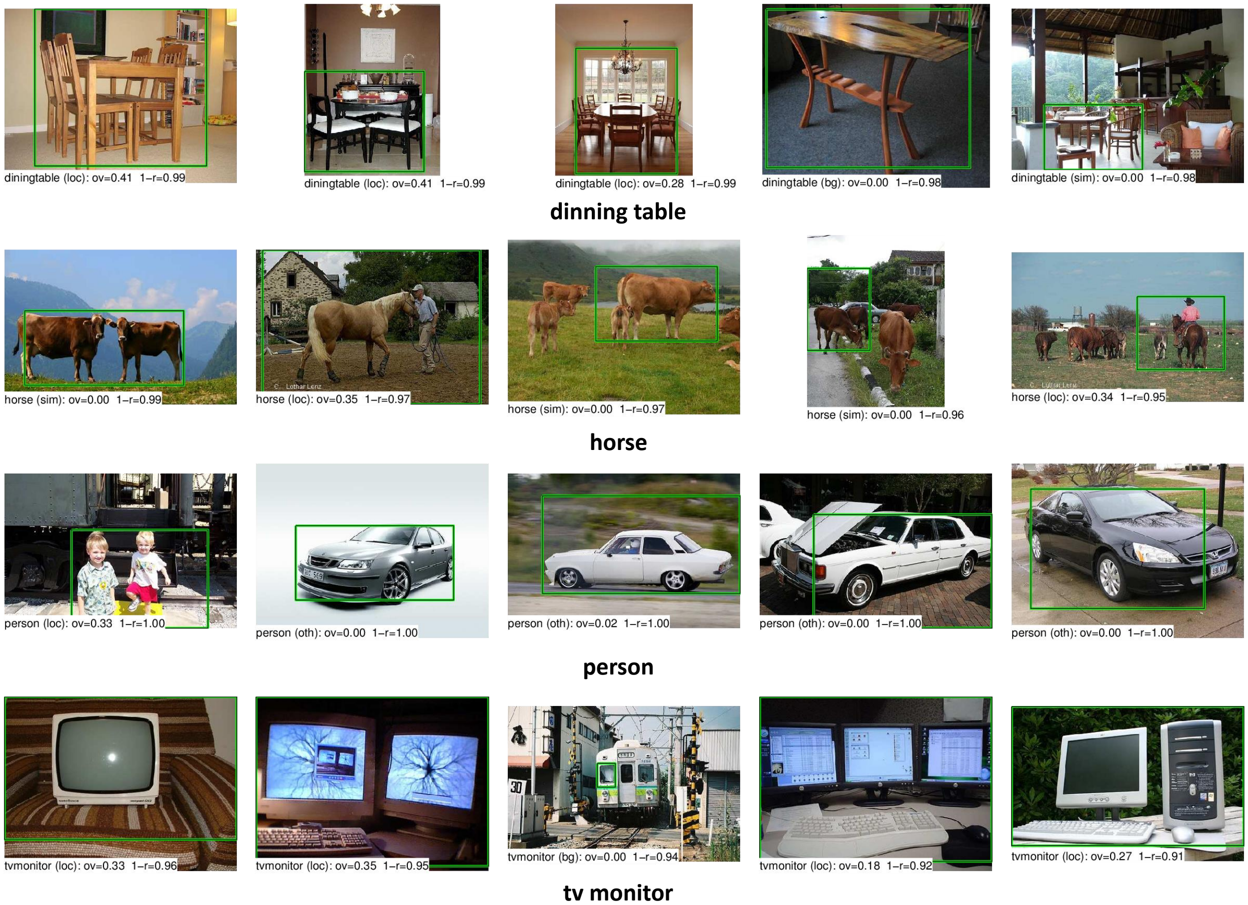

Figure 3. Top false positives for selected categories on PASCAL VOC 2007 detection with Flickr-C. From top down: dining table, horse, person, tv monitor.

barbershop, barge, baritone horn, barn, barndoor skate, barn spider, barometer, barracouta, barracuda, barrel, barrow, baseball, baseball bat, basenji, basketball, basketball net, basking shark, bass, bass clarinet, basset, bass harmonica, bassinet, bassoon, bass sax, bat, bathing cap, bath towel, bathtub, batman, baya fruta, baya weaver, bayon temple, bb gun, beach wagon, beacon, beagle, beak, beaker, bean, bear, bearskin, beaver, bed, bedford, bedlington terrier, bee, bee eater, beef stroganoff, beer, beer bottle, beer glass, beignet, belair, bell, bellagio fountain, bell cote, bell pepper, bench, benq gh600, bentley, bentley gt, bernese, bernese mountain dog, beyerdynamic, bib, bible, bicycle, bicycle built for two, bicycle rack, big ben, bigeye thresher, bighorn, bikini, bill gates, binder, binoculars, biplane, bird, birdhouse, bison, bittern, black, black and gold garden spider, black and tan coonhound, black bream, black footed ferret, black grouse, blackmoor, black rice, black snook, black stork, black swan, black widow, bladefish, blenheim spaniel, bleu cheese dressing, blind shark, blizzard, bloodhound, blouse, blt, blue, blue acara, bluefish, blue groper, bluetick, bmw 320, bmw d3, bmw isetta, bmw m67, bmx, boa constrictor, boar, boathouse, bobsled, boeing dreamliner, bolero, bolete, bolo tie, bolwell, bomb, bone flute, bonfire, bongo drum, bonnet, booby, book, bookcase, book jacket, bookshelf, bookshop, boombox, boomerang, border collie, border terrier, borscht, borzoi, bosch, bosch product, bosch tools, bose, bose qc15, bossa nova, boston bull, boston celtics, boston terrier, bottlecap, bouldering, bourdon, bouvier des flandres, bow, bowl, bowling ball, bow tie, boxer, box turtle, boy, bra, brabancon griffon, bracelet, brain coral, brambling, brass, brass choir, brassiere, brassy minnow, bread, breakwater, bream, breastplate, briard, brick, brick texture, bridge, bristol blenheim, brittany spaniel, broadbill, broadbill fish, broccoli, bronco nagurski, broom, broth, brown, brown bear, bruce banner, brussel sprout, bsa, bubble, bucket, buckeye, buckle, buick, buick enclave, buick encore, building, bulbul, bull, bulletproof vest, bullet train, bullfrog, bull mastiff, burger, burrito, bus, bustard, butcher shop, butterfly, butterflyfish, butterfly perch, butternut squash, c3po, cab, cabbage, cabbage butterfly, cabriolet, cadillac, cadillac cts, cadillac elmiraj, cairn, calculator, caldron, california golden trout, camaro, camera, camionnette, camry hybrid, candied yam, candle, cannelloni, cannon, cannondale, canoe, can opener, cap, capital bikeshare, cappuccino, caprice, capuchin, car, caramel corn, carbonara, cardigan, cardoon, carisma, car mirror, carousel, carpenter kit, carrot puree, carrot raisin salad, cart, carton, car wheel, cash machine, casio edifice, cassette, cassette player, castle, cat, catamaran, caterpillar equipment, cathedral, cathedral of santiago de compostela, catwoman, cauliflower, cavefish, cd, cd player, celery, cello, cellphone, cellular telephone, centipede, cereal bar, cessna aircraft, chai, chain, chainlink fence, chain mail, chainsaw, chain saw, chain texture, challah, chambered nautilus, chamomile, chana dal, chandelier, changgo, chapati, charlie chaplin, charlie hunnam, check texture, cheese, cheeseburger, cheese fondue, cheetah, cherokee 4wd, cherokee rose, cherry, cherry pie, chery cross eastar, chesapeake bay retriever, chess, chest, chevrolet chevelle, chevrolet denali, chevrolet epica, chevrolet nomad, chevrolet panther, chevrolet syclone, chevy nova, chicago bulls, chickadee, chiffonier, chihuahua, chime, chimpanzee, china cabinet, chisel, chiton, chocolate, chocolate sauce, chopsticks, chow, christmas stocking, christ redeemer, chromatic harmonica, chrysler concorde, chrysler jeep, chrysler vision, chubby, church, cicada, cinderella, cinema, cinnamon stick, circular saw, citroen, citroen picasso, citroen projet, citroen saxo, citroen sm, clam, clawhammer, cleaver, cliff, cliff dwelling, cloak, clock, clog, closet, cloud, clouds, cloudy weather, clownfish, clown knife, clubman, club wagon, clumber, cluttered, c max, coach, coach bus, coach purse, coat, cock, cocker spaniel, cockroach, cocktail shaker, coconut rice, coffee maker, coffee mug, coffeepot, coho, coil, cold scenery, collie, colobus, colosseum, combination lock, comet, comic book, commode, commodore sv6, common iguana, common newt, computer keyboard, computer mouse, concert percussion, conch, cone shape, confectionery, conga drum, congrio, congrio dorado, consomme, container ship, convertible, cooker, cooktop, cooper, coral fungus, coral grouper, coral reef, cordless drill, cordless phone, corkscrew, corn, cornet, corolla, corsa, corvette, coucal, couch, cougar, countryman, coupe, cow, cowboy, cowboy boot, cowboy hat, cowpea, coyote, cpu, cracker, cradle, crane, crane fly, crash cymbal, crash helmet, crate, crayfish, crib, cricket, cricket ball, crock pot, crocodile, croissant, crooked, croquet ball, crossover, crossword puzzle, crowded, crumpet, crutch, cuatros, cube shape, cucumber, cuirass, cup, cupboard, cupcake, curly coated retriever, curtain, custard apple, cyan, cylinder shape, dacia, dacia renault logan, daewoo, daewoo prince, daihatsu, daihatsu charmant, daihatsu duster, daimler, daimler db18, daimler superv8, daisy, dalmatian, dam, damselfish, damselfly, dandie dinmont, dandylion, dan tam, daph, dark knight, darth vader, datsun, datsun maxima, datsun pickup, datsun pulsar, datsun sentra, datsun stanza, david beckham, decanter, decepticon, deer, delta, delta airlines, dentist chair, desert eagle, desk, desktop computer, deville, dhokla, dhol, dhole, dial telephone, diamondback, diamond shape, diaper, digital clock, digital watch, dingo, dining set, dining table, dinosaur, dior, dirt bike, dishrag, dishwasher, disk brake, doberman, dobro, doby, dock, doctor, doctor who, dodge, dodge dakota, dodge durango, dodge fargo, dodge route van, dodge sprinter van, dodge suburban, dog, dogsled, dome, dongxiao, donkervoort, donkey kong, donkey shrek, door handle, doormat, dori, dots, double decker, dough, doumbek, dove, dowitcher, downbeat, dragon, dragonfly, drake, drawer, drill, drilling platform, drum, drums percussion, drumstick, dry, dryer, dry van, dubai tower, duck, duetto, dugong, dumbbell, dump truck, dung beetle, dungeness crab, duryea motor wagon, dutch oven, dwyane wade, eagle, eagle jaguar, ear, earbud, earphone, earth, earthstar, easel, echidna, ed sheeran, eel, eft, eggnog, eggplant, eggplant parmigiana, egyptian cat, eiffel tower, elantra, electrical outlet, electric fan, electric guitar, electric locomotive, electric ray, elephant, elevator, ender wiggin, english foxhound, english setter, english springer, entertainment center, entlebucher, envelope, eraser, eskimo dog, espresso, espresso maker, estuary cod, estuary perch, european fire salamander, european gallinule, ewer, excavator, expedition, explorer sport, eye, f16, f18, face, face powder, falcon, false albacore, fan, farming, farro, faucet, feather boa, feather texture, fence, fern, ferrari, ferrari 400i, ferris wheel, festiva, fiat, fiat abarth, fiat campagnola, fiat dino, fiat doblo, fiat siena albea, fiddler crab, fig, fighter plane, figure skater, file, finger, fingerling potato, fipple flute, fire, fireboat, fire engine, fire extinguisher, fire screen, fish, flag, flagpole, flamingo, flank steak, flash bulb, flatbed, flat coated retriever, flatworm, fleetwood, flower, flowerpot, flute, fly, flyingfish, flying squirrel, foggy weather, folding chair, foliage, food truck, football, football helmet, ford ranger, ford windstar, fork, forkbeard, forklift, fountain, fountain pen, four poster, four string banjo, fox, fox squirrel, fpv, fpv rc, freezer, freight car, french bulldog, french horn, french loaf, frida kahlo, fried egg, fried onion, frijoles, frilled lizard, frisbee, frog, fruehauf, fruit desserts, fryer, frying pan, fur coat, furry texture, fusion hybrid, gar, garage, garbage truck, garden spider, garlic, garlic soup, garter snake, gasmask, gas pump, gateway arch, gazelle, gene bangert, george lucas, german shepherd, german short haired pointer, geyser, giant defy, giant panda, giant schnauzer, gibbon, gila monster, giraffe, girl, glasses, glove, glowlight tetra, gmc denali, goal post, goat, goblet, goggle eye fish, go kart, gold, golden gate, golden retriever, goldfinch, goldfish, golf ball, golfcart, golf putter, golf trolley, gondola, gong, goonch, goose, gordon setter, gorilla, gourd, gown, grado, grandeur, grand piano, granny smith, grape, grasshopper, grass texture, gray, graysby, great dane, greater swiss mountain dog, great grey owl, great pyrenees, great white shark, green, green chili, greenhouse, green lizard, green mamba, green snake, grenache, gretsch, grey fox, greyhound, greyhound bus, grey whale, grigio telesto, grille, grocery store, groenendael, groom, ground beetle, guacamole, guenon, guillotine, guinea pig, guitar, gulf sturgeon, gumpert apollo, gypsy moth, gyromitra, hacksaw, hair, hair blower, hairbrush, hair dryer, hair slide, hair spray, half track, hamburger patty, hamburger soup, ham hock, hammer, hammered dulcimer, hammerhead, hamper, hamster, hand, handbag, hand blender, hand blower, handgun, hand held computer, handkerchief, handrail, handycam, hard boiled egg, hard disc, hard disk, hardyhead, hare, harmonica, harp, hartebeest, harvester, harvestman, hat, hatchback, hatchet, hay, head cabbage, headlight, headphone, headset, helicopter, helmet, hen, hen of the woods, hermit crab, hero cycles, hifiman, high heel, hiker, hilsa, hino ranger, hip, hippo, hippopotami, hippopotamus, hob, hockey puck, hockey stick, hog, hognose snake, holden calais, holden rodeo, holster, home theater, honda accord, honda aerodeck, honda atv, honda cbr, honda city zx, honda civic, honda cr85r, honda cross tour, honda cross tourer, honda fcx clarity, honda hsc, honda incentives, honda mclaren, honda nsx, honda pilot, honda prelude, honda rvf, honda smx, honda stream, honda vfr, honda vtr, honeycomb, hook, hoopskirt, horizontal bar, horizontal cylinder, horizontal lines, hornbill, horned viper, horse, horse cart, hotdog, hot pepper, hot pot, hottentot, hourglass, house finch, howler monkey, hsv gts, huevos rancheros, hula hoop, hulk, hummer, hummingbird, hunting horn, hurdy gurdy, hyena, hyundai, ibex, ibizan hound, ibm mainframe, ice bear, ice cream, ice lolly, ice texture, idakka, igor andreev, imac, impala, indian cobra, indian elephant, indigo bunting, indoor, indri, inifiniti, international s120, ipad, ip camera, iphone, ipod, iridescent shark, irish bagpipe, irish setter, irish terrier, irish water spaniel, irish wolfhound, iron, ironman, isaac newton, isopod, isuzu, isuzu axiom, isuzu dmax, italian greyhound, jacamar, jack crevalle, jacket, jackfruit, jackfruits, jack o' lantern, jaguar, jaguar car, jaguar daimler, japanese spaniel, jar, jasmine, jay, jean, jeans, jeep, jeepster, jeep wrangler, jellyfish, jennair, jensen healey, jersey, jewelfish, jigsaw puzzle, jinrikisha, joe, joker, joystick, jug, juggler, juice, junco, jupiter, kakapo, kart, katana, katy perry, kayak, keeshond, kelpie, kenworth t2000, kerry blue terrier, kettle, kettle corn, key, keyboard, kia amanti, kia venga, kilka, killer whale, kilt, kimono, kindle, kindle fire, kinect, king crab, king penguin, king snake, kitchen blender, kitchen sponge, kite, kit fox, kiwi fruit, knee pad, knife, knifejaw, knot, koala, kobuz, kofta, koheru, komodo dragon, komondor, kpanlogo, krill, kungfu, kuvasz, lab coat, labrador retriever, lacewing, lada 2107, laddle, laddoo, ladle, ladybug, lakeland terrier, lakeside, lamborghini, lamp, lampshade, lancia, lancia flaminia, landing gear, land rover, langur, lantern, lantra, laptop, lawn mower, leaf beetle, leafhopper, leaning tower, leatherback turtle, lebron james, lefse, leg, lemon, lens cap, lentil salad, leonard pope, leonberg, leopard, leopard grouper, leopard shark, lesser panda, letter opener, lexus, lexus gs450h, lexus gs hybrid, lhasa, library, lifeboat, lighter, limo, limousine, limpkin, lincoln, lincoln car, lincoln cosmopolitan, lincoln navigator, liner, lion, lionel messi, lionfish, lipstick, little blue heron, lizard, llama, loaf, loafer, locomotive, loggerhead, logging truck, logitech g15, longboard, longfin mako, long horned beetle, longnose skate, looxcie, lorikeet, loris, los angeles lakers, lotion, lotus eclat, loudspeaker, loupe, lufthansa plane, lumbermill, lungfish, lycaenid, lychee, lynx, m50, macaque, macaw, macbook air, macbook pro, mackerel tuna, madagascar cat, magenta, magentis, magnetic compass, magpie, mailbag, mailbox, maillot, malamute, malibu, malinois, mallard, maltese dog, man, manefish, mango dressing, manhole cover, manjur, manta ray, mantel, mantis, maraca, marat safin, marimba, marimbula, mariner hybrid, mario, marjoram, marmoset, marmot, mars, mars rover, maserati gransport, maserati merak, maserati quattroporte, mashed potato, mask, matchstick, maypole, mazda, mazda kazamai, mazda mps, mazda scrum, mazda senku, mazdaspeed, maze, measuring cup, meat loaf, medicine ball, medicine chest, meerkat, megalith, megamouth, melon, menu, menudo, mercedes benz, mercedes cla, mercury, mercury truck, mesclun, mexican hairless, mey, miami heat, michael jordan, michelin, michelin man, mickey mantel, mickey mouse, microphone, microwave, microwave oven, military uniform, milk, milk can, milk shark, mini, miniature donkey, miniature pinscher, miniature poodle, miniature schnauzer, minibus, mini cabrio, mini cooper, minigun, miniskirt, minivan, mink, mirage sedan, mirror, missile, mitsubishi, mitsubishi bravo, mitsubishi lancer, mitsubishi vii, mitsubishi viii, mitten, mixer, mixing bowl, mixr, mobile home, mobius strip, model t, modem, modern, mola mola, monarch, monastery, mongoose, monitor, monkey, monkfish, moonfish, moped, morgan, mortar, mortarboard, mosque, mosquito, mosquito net, motocompo, motorboat, motor scooter, mountain bike, mountainous, mountain sucker, mountain tent, mouse, mousetrap, moussaka, mouth, moving van, mud turtle, muffin, mulan, mullet snapper, mushroom, musical clock, musket, muzzle, mysterious, nail, nannygai, napkin, narrow, natural, nautilus, navigator, navy destroyer, neck brace, necklace, needlefish, nematode, neptune, newfoundland, news anchor, nexus 4, ngoni, night snake, nikola tesla, nikon d3100, nikon d600, nikon d90, nile tilapia, nilgai, nintendo 64, nipple, nissan altima, nissan auto, nissan clipper, nissan condor, nissan diesel, nissan gtir, nissan versa, norfolk terrier, northern snakehead, norwegian elkhound, norwich terrier, nose, notebook, nova, oat bran, oatmeal, obelisk, oboe, ocarina, octavina, odometer, office chair, oil filter, okra, old english sheepdog, oldsmobile, onion, opel ascona, opel astra, opel astra gtc, opel vauxhall signum, open area, opera house, opirus, optima, optimus prime, orange, orangutan, oreo, organ, oscilloscope, ostrich, otter, otterhound, oud, outdoor, oven, overpass, overskirt, ox, oxcart, oxen, ox plough, oxygen mask, oyster, oystercatcher, packard patrician, packet, pacman, paddle, paddlewheel, padlock, paintbrush, pajama, palace, pan, pancake, panchax, panpipe, pantaleon, panther, papad, paper, paper towel, papillon, parachute, parallel bars, parasol, parfait, park bench, parking meter, parmesan roll, parsley, parsley potato, partridge, passenger car, pastry, patas, patio, pay phone, pc, pea, peach, peacock, pear, pedestal, pedestrian, pedicab, pekinese, pele, pelican, pembroke, pen, pencil box, pencil sharpener, penguin, pepper, perfume, perodua kelisa, perodua myvi, persian cat, person, pesto pasta, petri dish, peugeot bipper, peugeot coupe, peugeot van, pharmacist, photocopier, photo frame, piano, pick, pickelhaube, picket fence, pickup, pier, pig, pigeon, pigfish, piggy bank, pillar, pill bottle, pillow, pineapple, ping pong ball, pink, pinwheel, pipe, pirate, pistol, pitcher, pittsburgh steelers, pizza, pizza roll, plaid, plain, plane, planer, planetarium, plastic bag, plate, plate rack, platter, platypus, play dough, playstation, plover, plow, plum, plunger, plymouth, plymouth challenger, plymouth conquest, pocket bike, podium, polaroid camera, pole, polecat, police van, polo ball, pomegranate, pomeranian, poncho, pontiac aztek, pool ball, pool table, pop bottle, popcorn ball, porcupine, porsche boxster, porsche carrera, porsche cayenne, pot, potala palace, potato, potato chips, potpie, potter wheel, power drill, power saw, power tools, prairie chicken, prayer rug, praying mantid, pretzel, princeps, printer, prison, proboscis monkey, projectile, projector, promontory, protein bar, proton, proton arena, proton perdana, ptarmigan, puck, puffer, pug, pumpkin, punching bag, purple, purse, pylon, pyramid, quail, quarter window motor, quattroporte, queue, quill, quilt, r2d2, rabbit, racer, racket, radiator, radio, radio telescope, railing, rain barrel, rainy weather, rajma, ram, rapeseed, rasna, rayban, razor, recreational vehicle, rectangular shape, recycle bin, red, red backed sandpiper, redbone, red bream, red breasted merganser, red devil, redfish, red fox, red piranha, redshank, red wine, red wolf, reel, reflex camera, refrigerator, regal tang, remote control, renault grand modus, renault megane, renault megane cabriolet, renault megane scenic, renault samsung, repinique, rer, restaurant, revolver, rhino, rhinoceros beetle, rhodesian ridgeback, rifle, ringlet, ringneck snake, river lamprey, road roller, roadster, roaster, robin, robot, rock beauty, rock crab, rockets, rockfish, rocking chair, rock python, roller coaster, rolling pin, rolls royce, rolls royce cloud, ronaldinho, rondador, rooster, rotisserie, rottweiler, round shape, rover, rover mgf, royal stewart tartan, rubber duck, rubber eraser, ruddy turnstone, ruffed grouse, rug, rugby ball, rugged scene, rule, ruler, running shoe, running water, rural, rx 8, saab, saab 97x, safe, safety pin, sailboat, saint bernard, salad, saleen s7, salmon, salmon bites, saltshaker, saluki, samoyed, samsung galaxy, sandal, sandbar, sandglass, santa claus, santro, sarangi, saron, sarong, saturn, sausage ball, sax, saxophone, scabbard, scacciapensieri, scaglietti, scale, scalpel, scandal, scanner, scarf, schipperke, school bus, schooner, scion, scissor, scone, scooter, scoreboard, scorpion, scotch terrier, scottish deerhound, screen, screw, screwdriver, scuba diver, sea anemone, sea cucumber, seadoo, sea eel, seagull, seahorse, sea lion, sealyham terrier, seashell, seashore, sea slug, sea snake, sea spider, seat belt, seat exeo, sea urchin, sedan, sennheiser, sewing machine, shanny, shanz, shark, shed, sheep, shelf, shetland sheepdog, shield, shih tzu, shime daiko, shingles, shiny texture, ship, shirt, shoe, shoe shop, shofar, shoji, shopping basket, shopping cart, shotgun, shoulder pad, shovel, shovelnose, shower cap, shower curtain, shrubbery, shubunkin, shuttlecock, siamang, siamese cat, siberian husky, siberian tiger, sidewinder, siena cathedral, sieve, sild, silky terrier, silver, silver seatrout, sink, skateboard, skeleton, ski, skil, ski mask, skin texture, skoda forman, sks, skunk, sky, sleeping bag, slide rule, sliding door, slimy sculpin, slipper, slot, sloth bear, slr, slug, sma c31, smallie, smart car, smoke, snail, snailfish, snake, snakehead, snorkel, snow leopard, snowmobile, snowplow, snowy weather, soap dispenser, soccer ball, soccer net, sock, sofa, softball bat, soft coated wheaten terrier, solar dish, soldering iron, solo oboe, sombrero, sonata, sony cybershot, sorrel, soup, soup bowl, space bar, space heater, space rover, space shuttle, spadefish, spaghetti bolognaise, spaghetti squash, sparling, sparrow, spatula, speckled, speedboat, sphinx, spider, spiderman, spider monkey, spider web, spigola, spindle, spiny lobster, sponge, spoon, spoonbill, sports car, sportsperson, sportster, spotlight, spotted salamander, sprinkler, square shape, squash ball, squash casserole, squirrel, squirrel monkey, ss 90, ssangyong rodius stavic, staffordshire bullterrier, stage, stair, standard poodle, standard schnauzer, stapler, star, starbucks, starfish, statue, statue of liberty, steam engine, steam locomotive, steam whistle, steel arch bridge, steel drum, steep, stephansdom, stereo, sterling rover, stethoscope, steve jobs, stick, still water, stingray, stinkhorn, stockpot, stole, stone, stonehenge, stone wall, stool, stopwatch, stove, strainer, strawberry, streetcar, street sign, stretcher, stripe texture, stroganoff, strumstick, studio couch, stupa, sturgeon, subaru 1000, subaru liberty, subaru outback, subaru trezia, submarine, suburban, subway, subway train, sugar, suit, sukiyaki, sulphur butterfly, sulphur crested cockatoo, sun, sunbeam alpine, sun bear, sundial, sunflower, sunglass, sunglasses, sunny weather, sun perch, sunscreen, supercar, superman, supernova, supersonic jet, surgeonfish, suspension bridge, sussex spaniel, suv, suzuki forenza, suzuki forenza wagon, suzuki freewind, suzuki fronte, swab, swan, sweatshirt, swimming trunks, swing, switch, sword, sxt neon, syclone, symmetrical, syringe, tabby, table, table lamp, tabor drum, tahoe, tailed frog, taj mahal, tam tam, tank, tape measure, tape player, taphon, tarabuka, tarantula, tart, tartan, tarte tatin, tarwhine, tasmanian devil, tata nano, tattoo, tautog, taxi, teacup, teapot, teddy, teeth, telehandler, telephone, telescope, television, tempo vidal, tench, tennis ball, tennis racket, terrapin, tesla, tesla tower, tgv, thatch, theater curtain, the bean, theremin, thimble, thornback ray, threadfish, three toed sloth, thresher, throne, thunder snake, tibetan mastiff, tibetan terrier, tick, tiger, tiger beetle, tiger cat, tiger shark, tiger woods, tile roof, timber wolf, tinfoil barb, tire, titanic, titi, tmx, toaster, tobacco shop, tobu cycle, toilet seat, toilet tissue, tomato, torch, tortilla, tortilla chip, tostadas, totem pole, toucan, tovshuur, towel, tower, tower bridge, tow truck, toy, toyota alphard hybrid, toyota auris hybrid, toyota belta yaris, toyota camry, toyota hiace, toyota minivan, toyota mr2, toyota prius, toyota quantum, toyota regius, toyota sienna, toyota sienna van, toyota spyder, toyota supra, toyota tarlet, toyota yaris, toy poodle, toyshop, toy terrier, tractor, traffic light, trailer, trailer truck, train, tram, tramontana, transformer, trash bin, tray, tree, tree frog, tree stump, trench coat, tribe, triceratops, tricycle, trifle, trilobite, trimaran, tripod, triumphal arch, trolleybus, trombone, trout, truck, truck rig, tub, tub gurnard, tumbler, tuna, tupan, turkey, turnstile, turquoise, turtle, tusker, tv, typewriter keyboard, uhu fish, uilleann pipe, ukulele, ultraman, umbrella, unicycle, upright, upright piano, uranus, urban, urn, utensil, vacuum, vacuum truck, valley, van, vase, vault, vauxhall adam, vauxhall astra, vauxhall astravan, vauxhall corsa, vauxhall vectra, vegetable tempura, velvet, vending machine, venus, vera zvonareva, verrophon, vertical, vertical cylinder, vertical lines, vestment, viaduct, vice tool, vicuna, vijay singh, villu, vine snake, vintage guitar, violet, violin, viper, viper snake, vizsla, voca, volcano, volkswagen, volkswagen beetle, volkswagen polo, volleyball, volvo bus, vor indicator, vulture, waffle iron, wagon, walker hound, walking stick, wall, wallaby, wall clock, wallet, wardrobe, warm scenery, warplane, warthog, washbasin, washer, washing machine, watch, water bottle, waterbuck, water buffalo, water jug, water ouzel, water snake, water tower, wave, waverunner, weakfish, weasel, web site, weevil, weimaraner, welsh springer spaniel, west highland white terrier, whale, wheel, whippet, whiptail, whisk, whiskey jug, whistle, white, whitefish, white stork, white wolf, whiting, wide, wig, wild boar, window, window screen, window shade, windshield, windsor tie, wine, wine bottle, wing, wire, wire haired fox terrier, wiry, wobbegong, wok, wolf, wolf spider, wolpertinger, woman, wombat, wooden legs, wooden spoon, wood rabbit, wool, worm fence, wreck, xindi, yamaha, yawl, yellow, yellow clorox bottle, yellowfin bream, yellow lady slipper, yellow tail, yellow tail fish, yoda, yorkshire terrier, yurt, zebra, zebra shark, zia syed, zinedine zidane, zopf, zucchini.

Later we found around $1/4$ of the 2000+ categories are related to vehicles (aeroplane, bicycle, boat, bus, car, motorcycle, train), with a lot of them being specific car models. Therefore, this list is heavily skewed to vehicles.

To train the GoogleA net, the following list of scene categories are also included:

abbey, access road, afghanistan, agra, air base, airfield, airlock, airplane cabin, airport, airport entrance, airport terminal, airport ticket counter, alaska, alcove, alley, alliance bank stadium, ameriquest field, amphitheater, amsterdam, amusement arcade, amusement park, anechoic chamber, angel stadium, apartment building, apple store, apse, aquarium, aquatic theater, aqueduct, arcade, arch, archaelogical excavation, archive, argentina, arlington stadium, armory, army base, arrival gate, art gallery, artificial lake, artists loft, art school, art studio, ashbourne, assembly line, astrodome, athens, athletic field, atlanta fulton county stadium, atrium home, atrium public, attic, att park, auditorium, auto factory, auto mechanics, auto racing paddock, auto showroom, autozone park, aylesbury, backstage, backstairs, badlands, badminton court, baggage claim, bakery kitchen, bakery shop, balcony, baldwin park, ballpark, ball pit, ballroom, bamboo forest, bank, bank vault, banquet hall, baptistry, bar, barbershop, barn, barndoor, barnyard, barrack, baseball diamond, baseball field, baseball stadium, basement, basilica, basketball arena, basketball court, bathhouse, bathroom, batters box, batting cage, battlement, bayou, bazaar, beach, beach house, beauty salon, bedchamber, bedroom, beer garden, beer hall, beijing, belfry, bell foundry, berlin, berth, berth deck, betting shop, bicycle racks, bindery, biology laboratory, bistro, bleachers, bloomingdale, boardwalk, boat cargo deck, boat deck, boathouse, bog, bolivia, bollywood, bologna, bomb shelter, bookbindery, bookstore, booth, botanical garden, bowling alley, bow window, boxing ring, box seat, braves field, brazil, breakroom, brewery, brickyard, bridge, building complex, building facade, bullpen, bullring, burial chamber, busch memorial stadium, bus depot, bus interior, bus shelter, bus station, butchers shop, butte, cabana, cabin, cafeteria, call center, camden stadium, camden yards, campsite, campus, canal natural, canal urban, candlestick park, candy store, canteen, canyon, caravansary, car dealership, cardroom, cargo port, car interior, carport, carrousel, casino, castle, catacomb, cathedral, catwalk, cavern, cemetery, cessna aircraft interior, chalet, chaparral, chapel, chase field, checkout counter, cheese factory, chemical plant, chemistry lab, chicken coop, chicken farm, childs room, choir loft, church, circus tent, cisco field, citibank park, citizens bank park, city, city of palms park, classroom, clean room, cliff, cloakroom booth, cloakroom room, clock tower, cloister, closet, clothing store, coast, coast road, cockpit, coffee shop, colt stadium, comerica park, computer room, conference center, conference hall, conference room, confessional, construction site, control room, control tower, convenience store, coors field, corn field, corolla interior, corral, corridor, cottage, cottage garden, county stadium, courthouse, courtroom, courtyard, covered bridge, cracker jack stadium, crawl space, creek, crevasse, crosley field, crosswalk, cubicle library, cubicle office, cybercafe, dacha, dairy, dam, dance school, darkroom, day care center, delicatessen, dell diamond, dentists office, department store, departure lounge, desert road, desert sand, desert vegetation, diner, dinette home, dinette vehicle, dining car, dining hall, dining room, dirt track, disch falk field, discotheque, distillery, ditch, dock, dodger stadium, dolmen, dolphins stadium, donjon, doorway, dorm room, downtown, drainage ditch, dressing room, dress shop, drill rig, driveway, driving range, drugstore, dry dock, dubai, dugout, dunn tire park, dutchess stadium, earth fissure, ebbets field, edison field, editing room, egypt, electrical room, electrical substation, elevated catwalk, elevator door, elevator interior, elevator lobby, elevator shaft, embankment, embassy, engine room, entrance hall, equestrian, escalator, escarpment, estuary, excavation, exhibition hall, exposition park, fabric store, factory, fairway, farm, fastfood restaurant, fence, fenway park, ferryboat, ferryboat cargo deck, ferryboat passenger deck, field cultivated, field road, field wild, fire escape, fire station, firing range, fish farm, fishmarket, fishpond, fitting room, fjord, flea market, flight of stairs, floating dry dock, flood, florist shop, fly bridge, food court, football arena, football field, football stadium, forbes field, forest broadleaf, forest fire, forest needleleaf, forest path, forest road, formal garden, fort, fortress, foundry, fountain, freeway, freight elevator, frontier field, funeral chapel, funeral home, furnace room, galley, game room, gangplank, garage, garbage dump, gas station, gasworks, gate, gatehouse, gazebo, general store, geodesic dome, ghost town, gift shop, glacier, glade, golf course, gorge, granary, great american ball park, great hall, greengrocery, greenhouse, grotto, guardhouse, gulch, gun deck, gun store, gymnasium, hacienda, hallway, handball court, hangar, harbor, hardware store, hatchery, hatchway, hat shop, hayfield, hayloft, hearth, heath, hedge maze, hedgerow, heliport, herb garden, hhh metrodome, hi corbett field, highway, hill, hilltop park, hiram bithorn stadium, hockey arena, home office, home theater, hoodoo, hospital, hospital room, hotel, hotel room, hot spring, hot tub, house, hubert humphrey metrodome, hummingbird centre, hunting lodge, hut, iceberg, ice cream parlor, ice floe, ice shelf, ice skating rink, igloo, imaret, incinerator, industrial area, industrial park, inn, interior savings centre, invesco field, irrigation ditch, islet, jacobs field, jacuzzi, jail, jail cell, japanese garden, jarry park, jetty, jewelry shop, joss house, junk pile, junkyard, jury box, kansas city municipal stadium, kart track, kasbah, kauffman stadium, kennel, keyspan park, kindergarden, kiosk, kitchen, kitchenette, korea, lab, labyrinth, lagoon, lake, lake olmstead stadium, landfill, landing deck, las vegas, laundromat, lava flow, lavatory, lawn, league park, lean-to, lecture room, legends field, legislative chamber, levee, library, lido deck, lift bridge, lighthouse, limousine interior, liquor store, living room, loading dock, lobby, lock chamber, locker room, loft, london, lookout station, los angeles coliseum, louisiana superdome, lumberyard, machine shop, maldives, manhole, mansion, manufactured home, market, marsh, martial arts gym, mastaba, maternity ward, mausoleum, mcafee coliseum, medina, memorial stadium, menhir, mesa, mess hall, metrodome, metropolitan stadium, mezzanine, military hospital, military hut, military tent, mill, miller park, mine, mineshaft, mini golf course, minute maid park, mission, moat dry, moat water, mobile home, monastery, moon bounce, moor, morgue, mosque, motel, mountain, mountain path, mountain road, movie theater, mudflat, museum, music store, music studio, n3com park, nationals ballpark, nationals park, natural history museum, naval base, network associates coliseum, newsroom, newsstand, new yankee stadium, new york, niagara falls, nightclub, norway, nuclear power plant, nunnery, nursery, nursing home, oakland alameda county coliseum, oakland coliseum, oasis, oast house, observatory, ocean, office, office building, office cubicles, oilfield land, oilfield offshore, oil refinery, oilrig, old kent park, operating room, optician, orchard, orchestra pit, organ loft, orlop deck, ossuary, outcropping, outhouse, overpass, oyster bar, oyster farm, pac bell park, packaging plant, pagoda, palace, palace hall, palisade, pantry, paper mill, parade ground, paris, park, parking garage, parking lot, parlor, particle accelerator, party tent, pasture, patio, pavilion, pawnshop, pedestrian overpass, penalty box, performance arena, performance stadium, perfume shop, petco park, pet shop, pharmacy, phoenix municipal stadium, phone booth, physics laboratory, piano store, picnic area, pier, pig farm, pilothouse, pisa, pitchers mound, pittsburgh, pizzeria, plane cargo deck, planetarium, plantation house, playground, playroom, plaza, pnc park, podium, police station, polo grounds, pond, pontoon bridge, pool room, poop deck, porch, portico, portrait studio, postern, power plant, print shop, priory, progress energy park, progressive field, promenade, promenade deck, pub, pulpit, pump room, putting green, quadrangle, qualcomm stadium, quay, quicksand, quonset hut, racecourse, raceway, raft, railroad track, railway yard, rainforest, ramp, ranch, ranch house, reading room, reception, recreation room, rectory, recycling plant, refectory, repair shop, residential neighborhood, resort, rest area, restaurant, restaurant kitchen, restaurant patio, restroom, revolving door, rfk stadium, rice paddy, richmond county bank ballpark, riding arena, river, road cut, rock arch, rodeo arena, roller skating rink, rolling mill, rome, roof, roof garden, root cellar, rope bridge, rosenblatt stadium, roundabout, roundhouse, rubble, ruin, runway, russ chandler stadium, sacristy, safeco field, salt plain, sandbar, sandbox, sand trap, san francisco, sauna, savanna, sawmill, schoolhouse, schoolyard, science museum, scottsdale stadium, scriptorium, sea cliff, seals stadium, seawall, security check point, server room, sewer, sewing room, shea stadium, shed, shipping room, shipyard, shoe shop, shopfront, shopping mall, shower, shower room, shrine, signal box, sinkhole, skate park, ski jump, ski lodge, ski resort, ski slope, sky, skydome, skyscraper, skywalk, slum, snowfield, snowy mountain, soccer arena, soccer field, soccer stadium, spa massage room, spa mineral bath, spillway, sporting goods store, squash court, stable, stadium, stage, staircase, starting gate, steam plant, steel mill, stilt house water, stone circle, storage room, storeroom food, storm cellar, street, strip mall, strip mine, student residence, submarine interior, subway interior, subway station, subway station entrance, subway station platform, sun deck, sun life stadium, supermarket, surprise stadium, sushi bar, swamp, swimming hole, swimming pool, sydney, synagogue, taiga, target field, taxistand, taxiway, tea garden, tearoom, teashop, television room, television studio, tempe diablo stadium, temple, tennis court, tent, terrace farm, textile mill, theater, three rivers stadium, thriftshop, throne room, tibet, ticket booth, ticket window, tiger stadium, tobacco shop, tollbooth, toll plaza, topiary garden, tower, town house, toyshop, track, trading floor, trailer park, train depot, train interior, train railway, train station, train station, train station platform, tree farm, tree house, trench, trestle bridge, tropicana field, tucson electric park, tundra, tunnel, tunnel car, tunnel rail, turkish bath, turner field, underwater coral reef, underwater ice, underwater kelp forest, underwater ocean, underwater pool, underwater wreck, us cellular arena, utility room, utility tunnel, valley, van interior, vegetable garden, velodrome, venice, ventilation shaft, veranda, vestry, veterinarians office, viaduct, videostore, village, vineyard, volcano, volleyball court, voting booth, waiting room, walk in freezer, warehouse, washhouse, watchtower, waterfall, waterfall frozen, waterfall plunge, watering hole, water mill, water park, water tower, water treatment plant, wave, weighbridge, wendelstein, wet bar, wharf, wheat field, whispering gallery, widows walk, wig shop, wind farm, windmill, window seat, wine cellar, winery, winners circle, witness stand, woodland, workroom, workshop, wrestling ring, wrigley field, yankee stadium, yard, youth hostel, zen garden, ziggurat, zoo.

4.2. List for Category Expansion

For category expansion (Section 3.3), we used more categories for each of the 20 PASCAL VOC classes. Since our list is skewed toward vehicles, some categories (*e.g.* bottle, horse) did not receive any augmented category after semantic verification.

aeroplane aircraft, fighter plane, cessna aircraft, plane, airplane, airliner, supersonic jet, warplane, f16, boeing dreamliner, airbus 340, biplane, lufthansa plane, airbus a320, airbus a380, airbus a330, airbus 330, delta airlines, american airlines.

bicycle hero cycles, cannondale, bicycle built for two, bmx, mountain bike, giant defy.

bird lorikeet, indigo bunting, goldfinch, bee eater, hummingbird, toucan, broadbill, macaw, sparrow, chickadee, red backed sandpiper, magpie, baya weaver, pigeon, dove, house finch, brambling, eagle, seagull, seagull, spoonbill, bald eagle, water ouzel, plover, jacamar, peacock, junco, hornbill, vulture, coucal, white stork, swan, african grey, quail, partridge, bittern.

boat ship, container ship, schooner, sailboat, navy destroyer, catamaran, aircraft carrier, titanic, speedboat, trimaran, motorboat, barge, fireboat, lifeboat, gondola, canoe, yawl, kayak.

bottle *NA*

bus school bus, double decker, articulated bus, coach bus, volvo bus, trolleybus, minibus, greyhound bus.

car sports car, supercar, lamborghini, mazda, smart car, ferrari, hatchback, roadster, corvette, toyota prius, tesla, convertible, camaro, porsche carrera, hyundai, saleen s7, buick, lincoln car, nissan auto, coupe, dodge, audi a8, fusion hybrid, sedan, viper, mitsubishi, plymouth, scion, 1950 car, inifiniti, ac car, honda hsc, honda nsx, mazda senku, rover, c max, nissan versa, acura, cabriolet, toyota supra, jaguar car, bmw 320, grigio telesto, chevrolet panther, citroen projet, fiat abarth, audi a6, vauxhall corsa, porsche boxster, toyota spyder, plymouth challenger, gumpert apollo, suv, mazdaspeed, crossover, honda incentives, fiat, kia venga, citroen, lancia, datsun.

cat tabby, persian cat, angora, siamese cat, tiger cat, egyptian cat, lynx.

chair armchair, rocking chair, throne, bench, stool, folding chair, office chair, aeron, barber chair, dentist chair.

cow bull, oxen, ox, water buffalo.

dining table table, desk.

dog golden retriever, labrador retriever, german shepherd, eskimo dog, maltese dog, beagle, pug, pomeranian, samoyed, siberian husky, staffordshire bullterrier, english foxhound, malinois, chihuahua, malamute, toy terrier, vizsla, shetland sheepdog, american staffordshire terrier, border collie, west highland white terrier, collie, boxer, kelpie, dalmatian, rottweiler, saint bernard, papillon, flat coated retriever, walker hound, brittany spaniel, greater swiss mountain dog, bull mastiff, chow, miniature poodle, cocker spaniel, toy poodle, rhodesian ridgeback, saluki, basset, greyhound, great pyrenees, welsh springer spaniel, lakeland terrier, basenji, miniature pinscher, japanese spaniel, kuvasz.

horse *NA*

motorcycle motor scooter, yamaha, tmx, bsa, m50, dirt bike, honda vtr, honda cr85r, honda cross tourer, sportster, honda cbr.

person woman, actor, actress, man, girl, face, boy, bachelor, katy perry, andre agassi, barack obama, andrew garfield, baby, caprice, ender wiggin, sportsperson.

potted plant fern, parsley.

sheep goat.

sofa couch, studio couch.

train bullet train, electric locomotive, locomotive, steam locomotive, steam engine, tgv, rer, subway train, passenger car, tram.

tv monitor tv, television, monitor, screen, imac.

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