

# Supplementary Material for: Multi-Class Hinge Loss for Conditional GANs

Ilya Kavalero  
University of Maryland, College Park  
ilyak@umd.edu

Wojciech Czaja  
University of Maryland, College Park  
czaja@umd.edu

Rama Chellappa  
Johns Hopkins University, Baltimore  
rchella4@jhu.edu

## 1. Source Code

Our MHGAN and baseline implementations are based on the Self-Attention GAN [4] available on github [1]. Our code is available at <https://github.com/ilyakava/gan>.

## 2. Additional details on our SSL GANs

Figure 1 shows how labelled and unlabelled data flow through our ACAN and MHGAN networks during semi-supervised learning. In Figure 1a is a projection discrimination network with an auxiliary classifier added. Figure 1b shows that for unlabeled data, the role of  $y$  is substituted with the pseudolabel  $\tilde{y}_{C(x)}$ , and the classification loss is not trained.

Figure 2 shows that the best FID over time was more quickly achieved by MHGAN-SSL for 1 million iterations, though the performance is not as impressive as in the fully supervised case.

## 3. Imagenet-64

We also evaluated MHGAN on a smaller scale dataset of Imagenet at resolution  $64 \times 64$ . The conclusions from these experiments are the same but more muted compared to Imagenet at  $128 \times 128$ . Figures 3a and 3b show that MHGAN improves the FID and IS scores over SAGAN and ACGAN baselines, and in table 1 are FID and IS numbers calculated over 50k images, and the Intra-FID comparison of SAGAN versus MHGAN which shows that diversity stayed the same between the two models.

Method	Imagenet 64x64	
	IS	FID
Real data	56.67	
Baseline 1M	19.60	15.49
MHGAN 1M	<b>22.16</b>	<b>13.29</b>

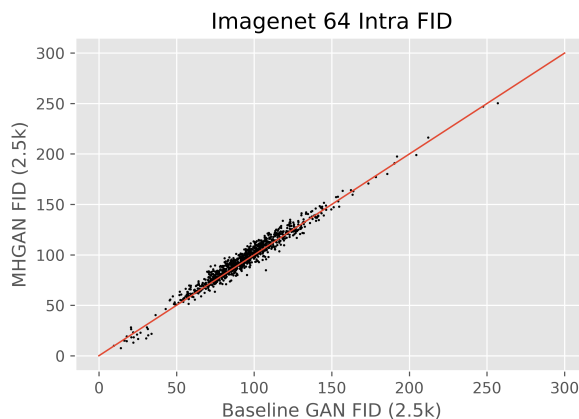


Table 1: Inception Scores and FIDs (50k) for supervised image generation on Imagenet  $64 \times 64$ . Though the margin of improvement is not as great as for Imagenet  $128 \times 128$ , adding the auxiliary MHGAN loss proves fruitful. Diversity is maintained at the same level (it improved in Imagenet  $128 \times 128$ ).

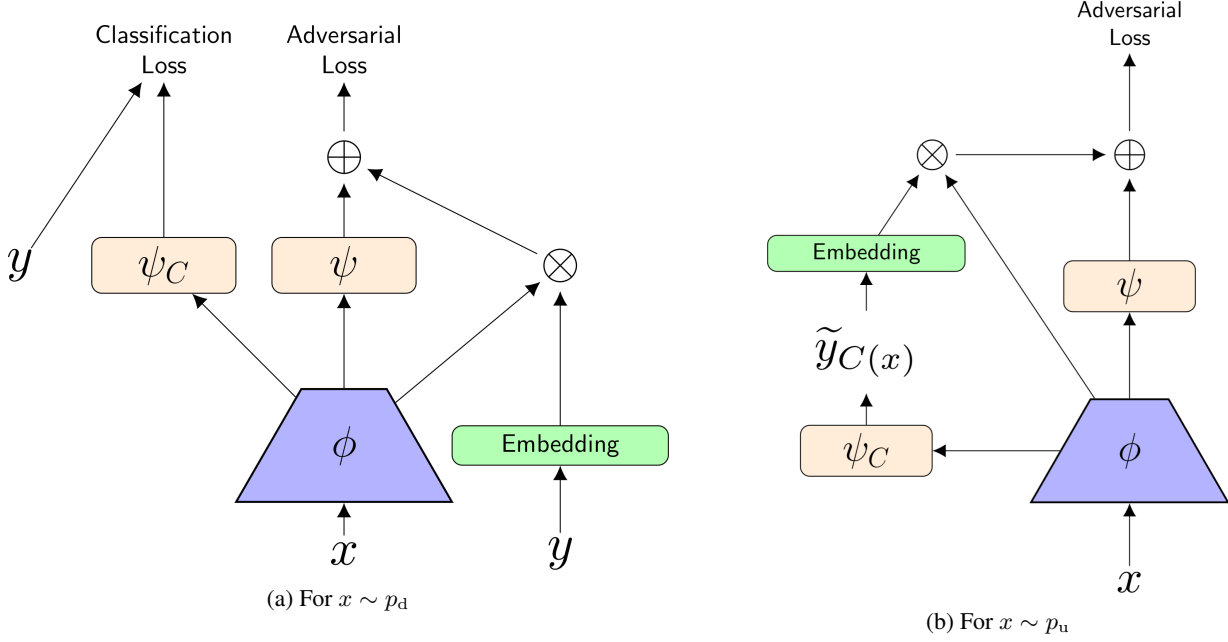


Figure 1: The architectures of the semi supervised GANs that we train. **1a** shows the auxiliary classifier architecture [3] of our SAGAN, the same as used for fully supervised experiments. When  $x \sim p_d$  the discriminator treats the example as shown in **1a**. In the diagram the green "Embedding" block is the projection discriminator embedding for a class,  $\phi$  is the discriminator up to the penultimate feature layer,  $\psi$  is a linear layer with scalar output,  $\psi_C$  is a linear layer with output size  $n$  classes. When  $x \sim p_u$  and the label is not available, it is treated as shown in **1b**. This is similar to  $S^2$ GAN [2]. Both ACGAN-SLL and MHGAN-SLL use these architectures, the only difference between the two is the form of the classification Loss for labelled examples.

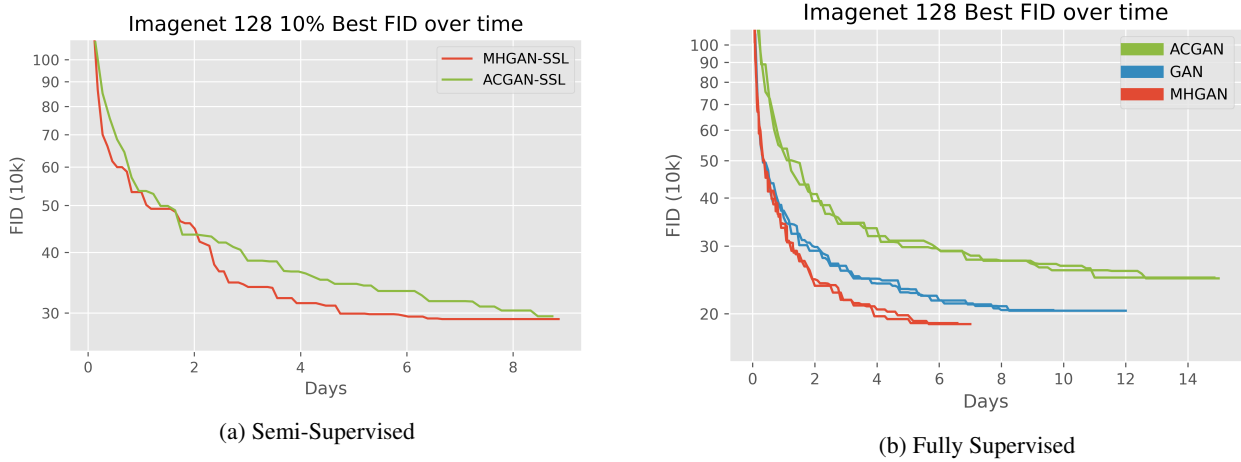


Figure 2: The best FID of our models plotted by duration of training. The multi-hinge loss accelerates training over SAGAN and ACGAN baselines in both fully supervised and semi-supervised settings.

### 3.1. MHShared GAN finetuning for Imagenet $64 \times 64$

We also performed the MHShared GAN finetuning on the SAGAN in **Table 1** (trained for 1M steps) and after 15k steps the IS went to 30.47 and the FID went to 10.03 (and the validation classification accuracy went to 23.60% while the generator classification self accuracy went to 62.66%, both started at  $1/n$  class). Again the diversity of the generator visibly declined;

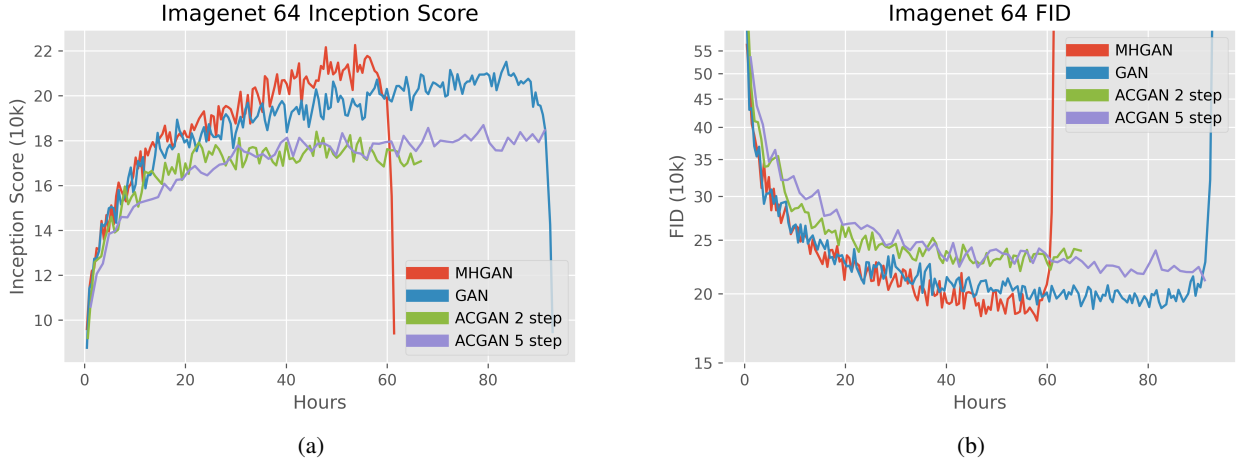


Figure 3: Inception Scores and FIDs (10k) for supervised image generation on Imagenet  $64 \times 64$ . 1 Million D-steps for SAGAN and MHGAN can be completed in about 48 hours.

some examples of this are in [Figure 4](#).

#### 4. Imagenet $128 \times 128$ MHGAN samples

We include 8 random samples from each of the classes in Imagenet  $128 \times 128$  sampled from our MHGAN, starting from the class "tench" (which we incorrectly referred to as "trout" in the main text of the paper), in [Figures 5 to 29](#). Each group of 10 classes was compressed with JPEG quality 30 out of filesize considerations.



Figure 4: Before/After performing the MHSharedGAN finetuning to lower the diversity, but raise the quality (according to IS and FID metrics) of samples on Imagenet  $64 \times 64$ . The top row of images is sampled from SAGAN trained for 1M steps. And the bottom row is that same model after 15k steps using the MHSharedGAN strategy, where the projection discriminator weights are shared between a itself and a classifier optimized with multi-hinge loss.

## References

- [1] tensorflow/gan, June 2020. original-date: 2019-04-29T16:24:10Z.
- [2] Mario Lucic, Michael Tschannen, Marvin Ritter, Xiaohua Zhai, Olivier Bachem, and Sylvain Gelly. High-fidelity image generation with fewer labels. *arXiv preprint arXiv:1903.02271*, 2019.
- [3] Takeru Miyato and Masanori Koyama. cGANs with projection discriminator. In *International Conference on Learning Representations*, 2018.
- [4] Han Zhang, Ian Goodfellow, Dimitris Metaxas, and Augustus Odena. Self-attention generative adversarial networks. In Kamalika Chaudhuri and Ruslan Salakhutdinov, editors, *Proceedings of the 36th International Conference on Machine Learning*, volume 97 of *Proceedings of Machine Learning Research*, pages 7354–7363, Long Beach, California, USA, 09–15 Jun 2019. PMLR.





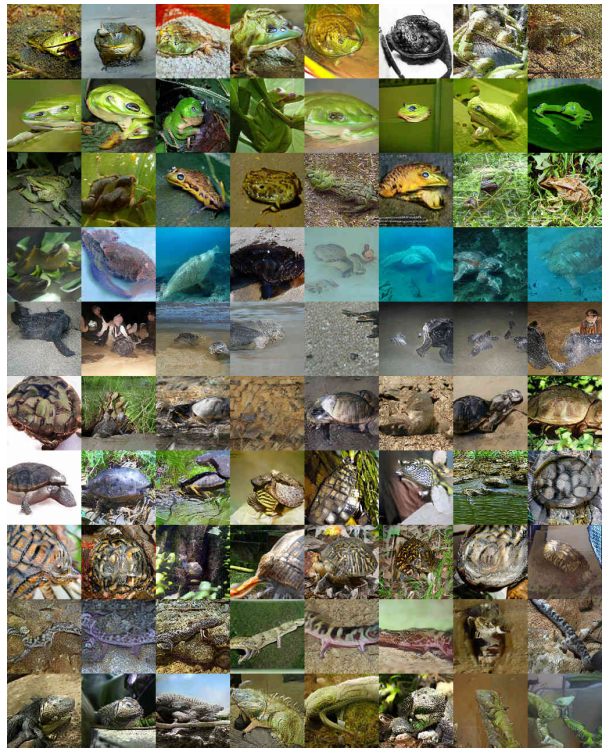
(a) Classes 0 to 9 sampled from MHGAN: tench, goldfish, great white shark, tiger shark, hammerhead, electric ray, stingray, cock, hen, ostrich



(b) Classes 10 to 19 sampled from MHGAN: brambling, goldfinch, house finch, junco, indigo bunting, robin, bulbul, jay, magpie, chickadee



(c) Classes 20 to 29 sampled from MHGAN: water ouzel, kite, bald eagle, vulture, great grey owl, European fire salamander, common newt, eft, spotted salamander, axolotl



(d) Classes 30 to 39 sampled from MHGAN: bullfrog, tree frog, tailed frog, loggerhead, leatherback turtle, mud turtle, terrapin, box turtle, banded gecko, common iguana

Figure 5: Classes 0 to 39 sampled from MHGAN

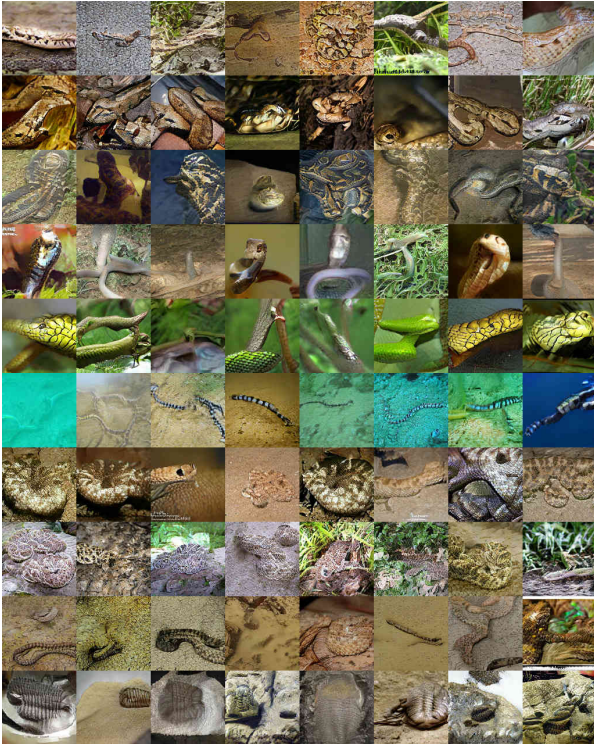




(a) Classes 40 to 49 sampled from MHGAN: American chameleon. whiptail. agama. frilled lizard. alligator lizard. Gila monster. green lizard. African chameleon. Komodo dragon. African crocodile



(b) Classes 50 to 59 sampled from MHGAN: American alligator. triceratops. thunder snake. ringneck snake. hognose snake. green snake. king snake. garter snake. water snake. vine snake



(c) Classes 60 to 69 sampled from MHGAN: night snake. boa constrictor. rock python. Indian cobra. green mamba. sea snake. horned viper. diamondback. sidewinder. trilobite



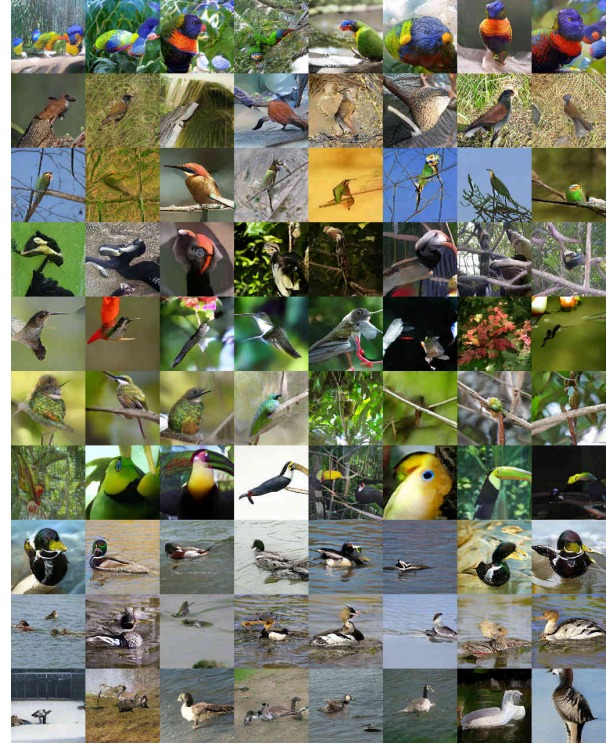
(d) Classes 70 to 79 sampled from MHGAN: harvestman. scorpion. black and gold garden spider. barn spider. garden spider. black widow. tarantula. wolf spider. tick. centipede

Figure 6: Classes 40 to 79 sampled from MHGAN





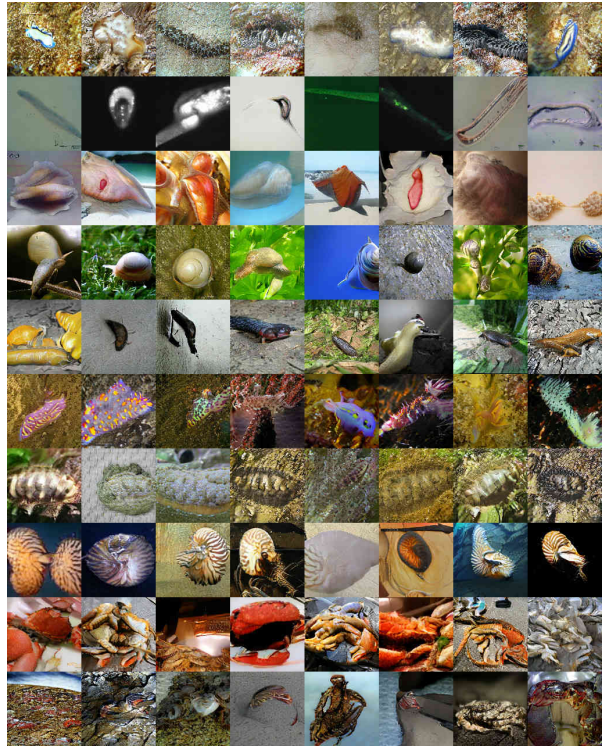
(a) Classes 80 to 89 sampled from MHGAN: black grouse. ptarmigan. ruffed grouse. prairie chicken. peacock. quail. partridge. African grey. macaw. sulphur-crested cockatoo



(b) Classes 90 to 99 sampled from MHGAN: lorikeet. coucal. bee eater. hornbill. hummingbird. jacamar. toucan. drake. red-breasted merganser. goose



(c) Classes 100 to 109 sampled from MHGAN: black swan. tusker. echidna. platypus. wallaby. koala. wombat. jellyfish. sea anemone. brain coral



(d) Classes 110 to 119 sampled from MHGAN: flatworm. nematode. conch. snail. slug. sea slug. chiton. chambered nautilus. Dungeness crab. rock crab

Figure 7: Classes 80 to 119 sampled from MHGAN





(a) Classes 120 to 129 sampled from MHGAN: fiddler crab, king crab, American lobster, spiny lobster, crayfish, hermit crab, isopod, white stork, black stork, spoonbill



(c) Classes 140 to 149 sampled from MHGAN: red-backed sandpiper, redshank, dowitcher, oystercatcher, pelican, king penguin, albatross, grey whale, killer whale, dugong



(b) Classes 130 to 139 sampled from MHGAN: flamingo, little blue heron, American egret, bittern, crane, limpkin, European gallinule, American coot, bustard, ruddy turnstone



(d) Classes 150 to 159 sampled from MHGAN: sea lion, Chihuahua, Japanese spaniel, Maltese dog, Pekinese, Shih-Tzu, Blenheim spaniel, papillon, toy terrier, Rhodesian ridgeback

Figure 8: Classes 120 to 159 sampled from MHGAN





(a) Classes 160 to 169 sampled from MHGAN: Afghan hound, basset, beagle, bloodhound, bluetick, black-and-tan coonhound, Walker hound, English foxhound, redbone, borzoi



(b) Classes 170 to 179 sampled from MHGAN: Irish wolfhound, Italian greyhound, whippet, Ibizan hound, Norwegian elkhound, otterhound, Saluki, Scottish deerhound, Weimaraner, Staffordshire bullterrier



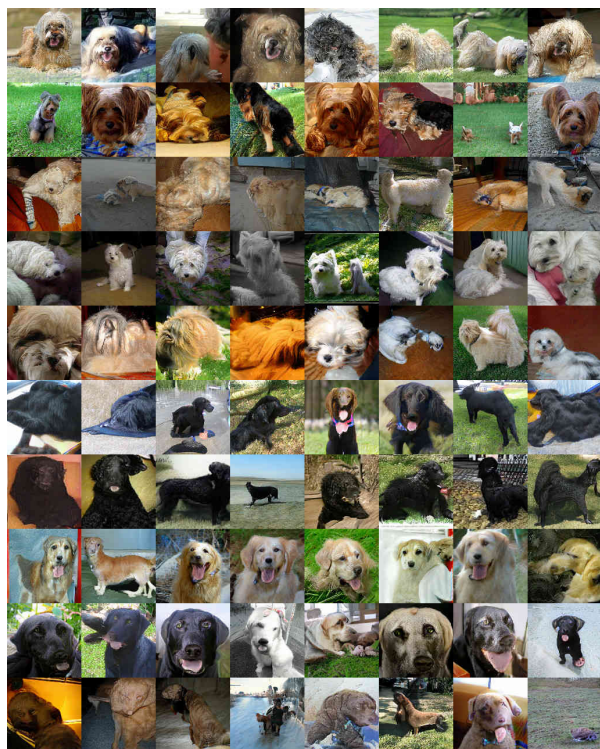
(c) Classes 180 to 189 sampled from MHGAN: American Staffordshire terrier, Bedlington terrier, Border terrier, Kerry blue terrier, Irish terrier, Norfolk terrier, Norwich terrier, Yorkshire terrier, wire-haired fox terrier, Lakeland terrier



(d) Classes 190 to 199 sampled from MHGAN: Sealyham terrier, Airedale, cairn, Australian terrier, Dandie Dinmont, Boston bull, miniature schnauzer, giant schnauzer, standard schnauzer, Scotch terrier

Figure 9: Classes 160 to 199 sampled from MHGAN

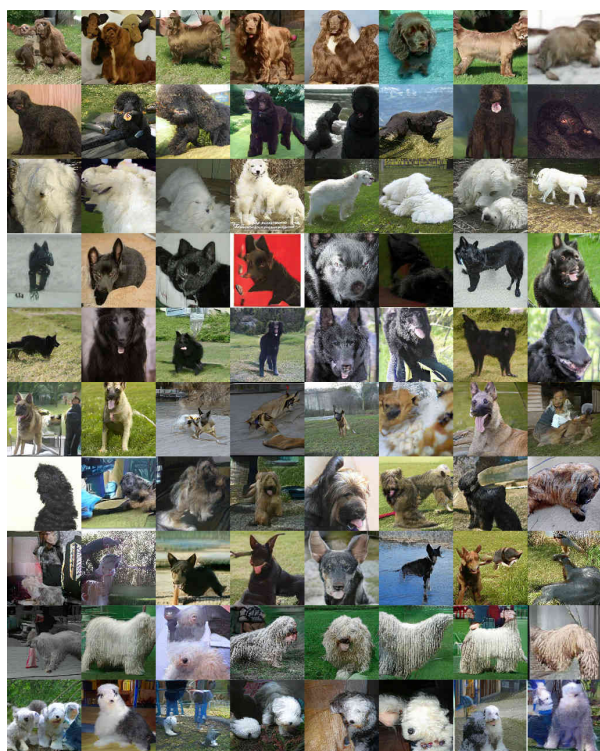




(a) Classes 200 to 209 sampled from MHGAN: Tibetan terrier. silky terrier. soft-coated wheaten terrier. West Highland white terrier. Lhasa. flat-coated retriever. curly-coated retriever. golden retriever. Labrador retriever. Chesapeake Bay retriever



(b) Classes 210 to 219 sampled from MHGAN: German short-haired pointer. vizsla. English setter. Irish setter. Gordon setter. Brittany spaniel. clumber. English springer. Welsh springer spaniel. cocker spaniel



(c) Classes 220 to 229 sampled from MHGAN: Sussex spaniel. Irish water spaniel. kuvasz. schipperke. groenendael. malinois. briard. kelpie. komondor. Old English sheepdog



(d) Classes 230 to 239 sampled from MHGAN: Shetland sheepdog. collie. Border collie. Bouvier des Flandres. Rottweiler. German shepherd. Doberman. miniature pinscher. Greater Swiss Mountain dog. Bernese mountain dog

Figure 10: Classes 200 to 239 sampled from MHGAN





(a) Classes 240 to 249 sampled from MHGAN: Appenzeller, EntleBucher, boxer, bull mastiff, Tibetan mastiff, French bulldog, Great Dane, Saint Bernard, Eskimo dog, malamute



(b) Classes 250 to 259 sampled from MHGAN: Siberian husky, dalmatian, affenpinscher, basenji, pug, Leonberg, Newfoundland, Great Pyrenees, Samoyed, Pomeranian



(c) Classes 260 to 269 sampled from MHGAN: chow, keeshond, Brabancon griffon, Pembroke, Cardigan, toy poodle, miniature poodle, standard poodle, Mexican hairless, timber wolf



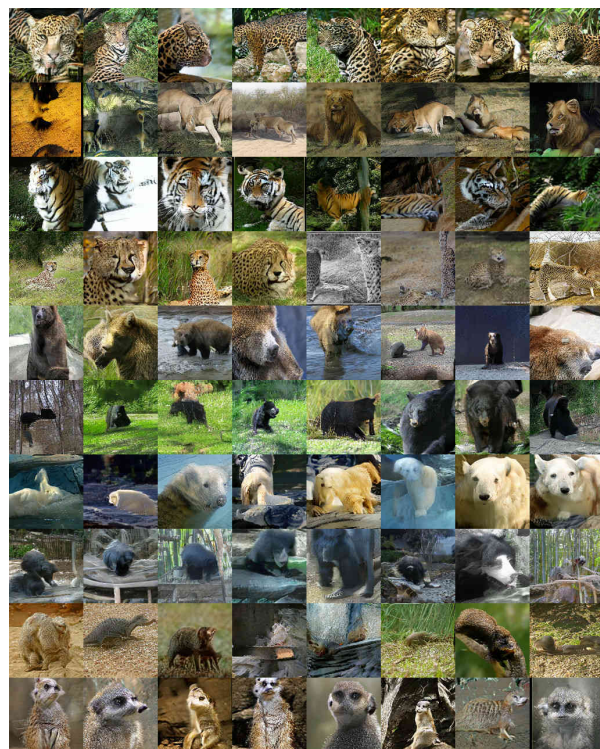
(d) Classes 270 to 279 sampled from MHGAN: white wolf, red wolf, coyote, dingo, dhole, African hunting dog, hyena, red fox, kit fox, Arctic fox

Figure 11: Classes 240 to 279 sampled from MHGAN





(a) Classes 280 to 289 sampled from MHGAN: grey fox. tabby. tiger cat. Persian cat. Siamese cat. Egyptian cat. cougar. lynx. leopard. snow leopard



(b) Classes 290 to 299 sampled from MHGAN: jaguar. lion. tiger. cheetah. brown bear. American black bear. ice bear. sloth bear. mongoose. meerkat



(c) Classes 300 to 309 sampled from MHGAN: tiger beetle. ladybug. ground beetle. long-horned beetle. leaf beetle. dung beetle. rhinoceros beetle. weevil. fly. bee



(d) Classes 310 to 319 sampled from MHGAN: ant. grasshopper. cricket. walking stick. cockroach. mantis. cicada. leafhopper. lacewing. dragonfly

Figure 12: Classes 280 to 319 sampled from MHGAN





(a) Classes 320 to 329 sampled from MHGAN: damselfly, admiral, ringlet, monarch, cabbage butterfly, sulphur butterfly, lycaenid, starfish, sea urchin, sea cucumber



(c) Classes 340 to 349 sampled from MHGAN: zebra, hog, wild boar, warthog, hippopotamus, ox, water buffalo, bison, ram, bighorn



(b) Classes 330 to 339 sampled from MHGAN: wood rabbit, hare, Angora, hamster, porcupine, fox squirrel, marmot, beaver, guinea pig, sorrel



(d) Classes 350 to 359 sampled from MHGAN: ibex, hartebeest, impala, gazelle, Arabian camel, llama, weasel, mink, polecat, black-footed ferret

Figure 13: Classes 320 to 359 sampled from MHGAN





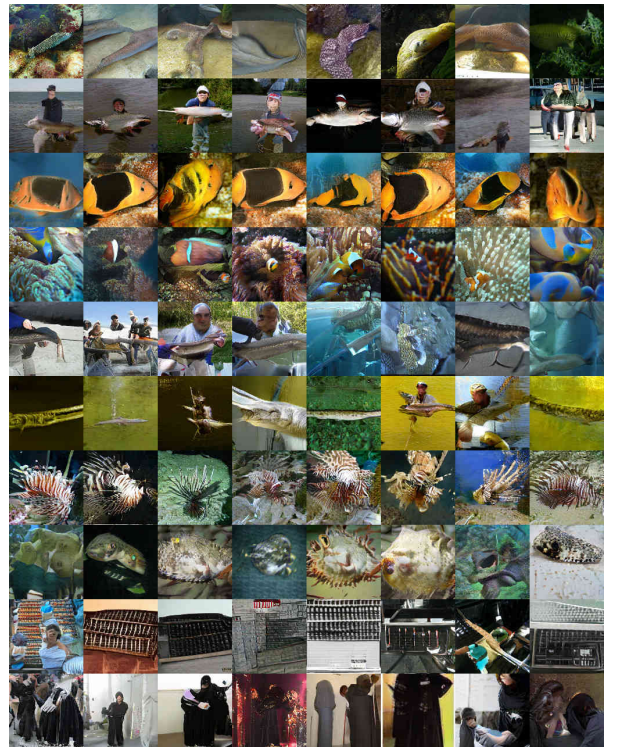
(a) Classes 360 to 369 sampled from MHGAN: otter, skunk, badger, armadillo, three-toed sloth, orangutan, gorilla, chimpanzee, gibbon, siamang



(b) Classes 370 to 379 sampled from MHGAN: guenon, patas, baboon, macaque, langur, colobus, proboscis monkey, marmoset, capuchin, howler monkey



(c) Classes 380 to 389 sampled from MHGAN: titi, spider monkey, squirrel monkey, Madagascar cat, indri, Indian elephant, African elephant, lesser panda, giant panda, barracouta



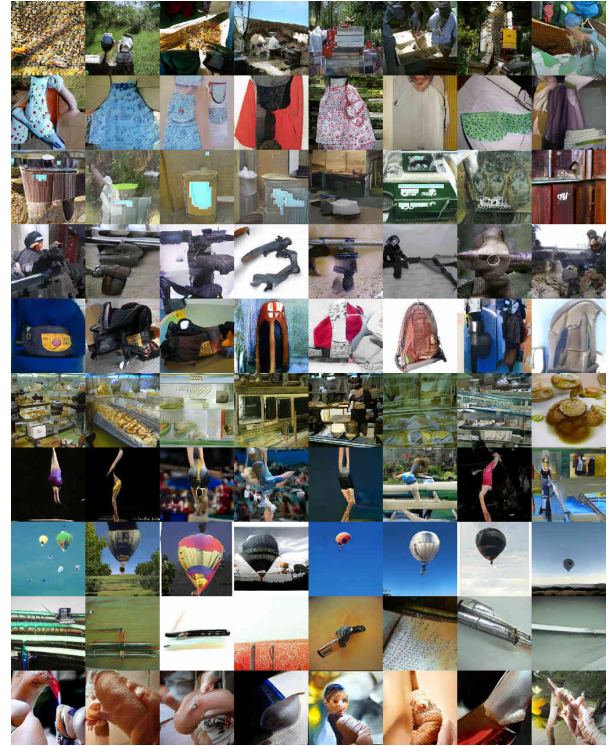
(d) Classes 390 to 399 sampled from MHGAN: eel, coho, rock beauty, anemone fish, sturgeon, gar, lionfish, puffer, abacus, abaya

Figure 14: Classes 360 to 399 sampled from MHGAN





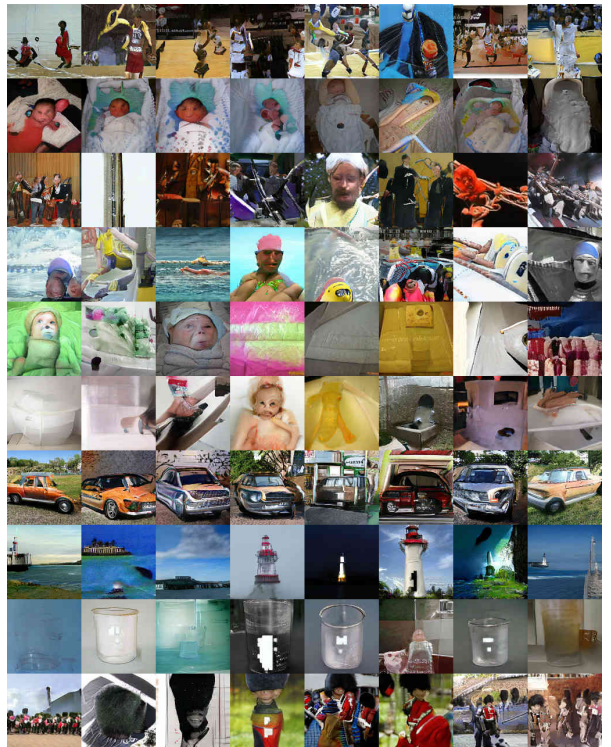
(a) Classes 400 to 409 sampled from MHGAN: academic gown, accordion, acoustic guitar, aircraft carrier, airliner, airship, altar, ambulance, amphibian, analog clock



(b) Classes 410 to 419 sampled from MHGAN: apiary, apron, ashcan, assault rifle, backpack, bakery, balance beam, balloon, ballpoint, Band Aid



(c) Classes 420 to 429 sampled from MHGAN: banjo, bannister, barbell, barber chair, barbershop, barn, barometer, barrel, barrow, baseball



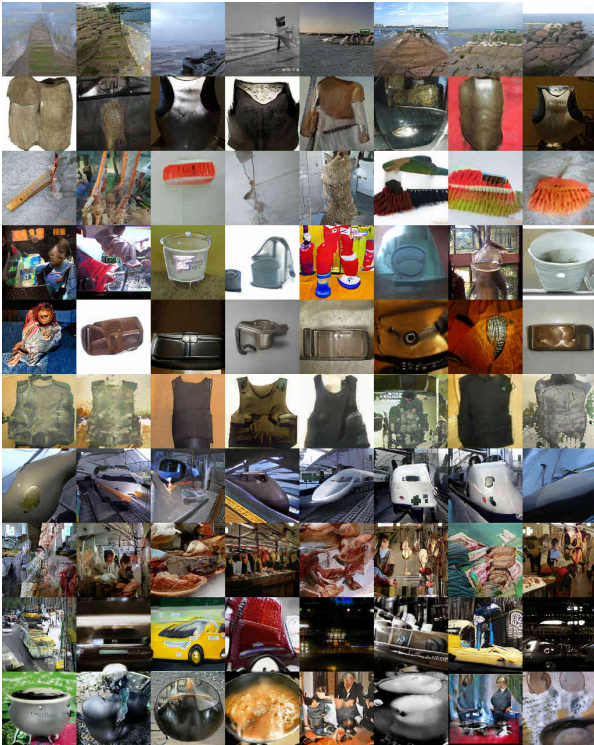
(d) Classes 430 to 439 sampled from MHGAN: basketball, bassinet, bassoon, bathing cap, bath towel, bathtub, beach wagon, beacon, beaker, bearskin

Figure 15: Classes 400 to 439 sampled from MHGAN

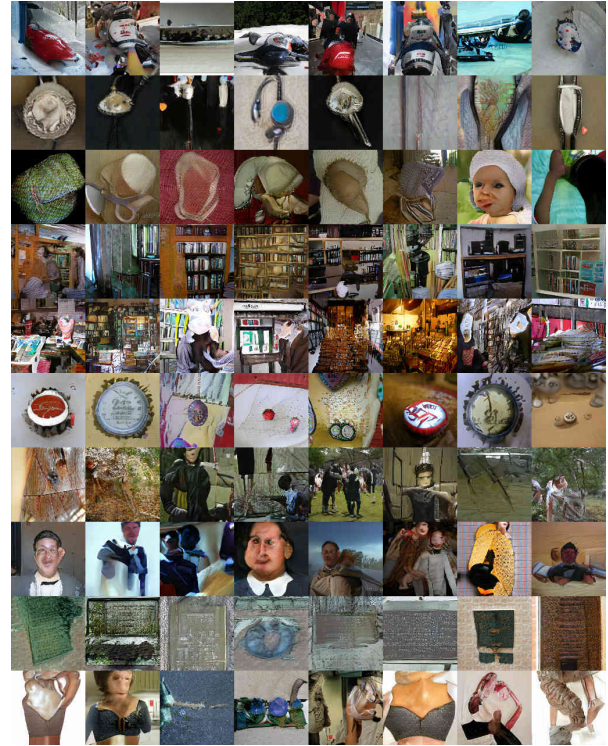




(a) Classes 440 to 449 sampled from MHGAN: beer bottle. beer glass. bell cote. bib. bicycle-built-for-two. bikini. binder. binoculars. birdhouse. boathouse



(c) Classes 460 to 469 sampled from MHGAN: breakwater. breastplate. broom. bucket. buckle. bulletproof vest. bullet train. butcher shop. cab. caldron



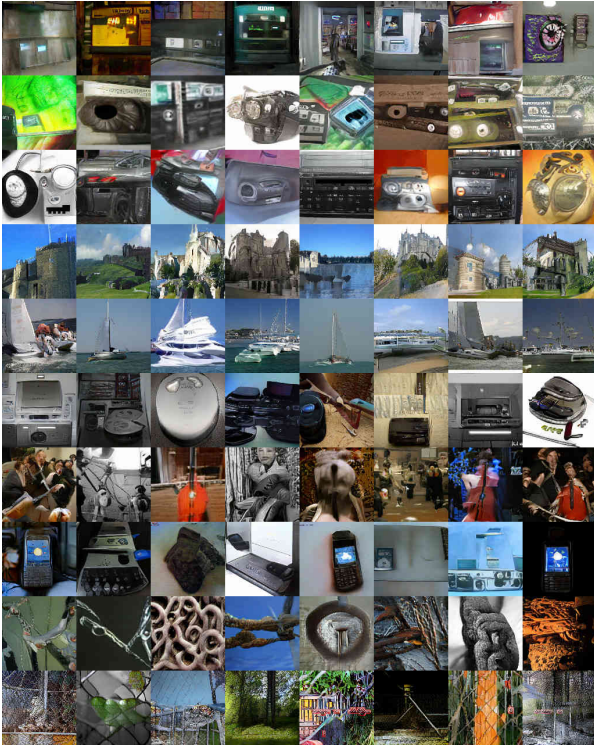
(b) Classes 450 to 459 sampled from MHGAN: bobsled. bolo tie. bonnet. bookcase. bookshop. bottlecap. bow. bow tie. brass. brassiere



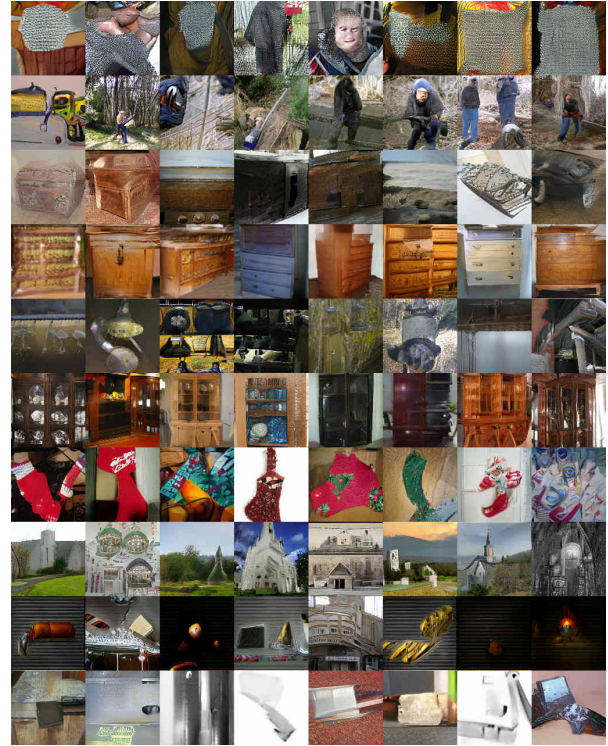
(d) Classes 470 to 479 sampled from MHGAN: candle. cannon. canoe. can opener. cardigan. car mirror. carousel. carpenter's kit. carton. car wheel

Figure 16: Classes 440 to 479 sampled from MHGAN

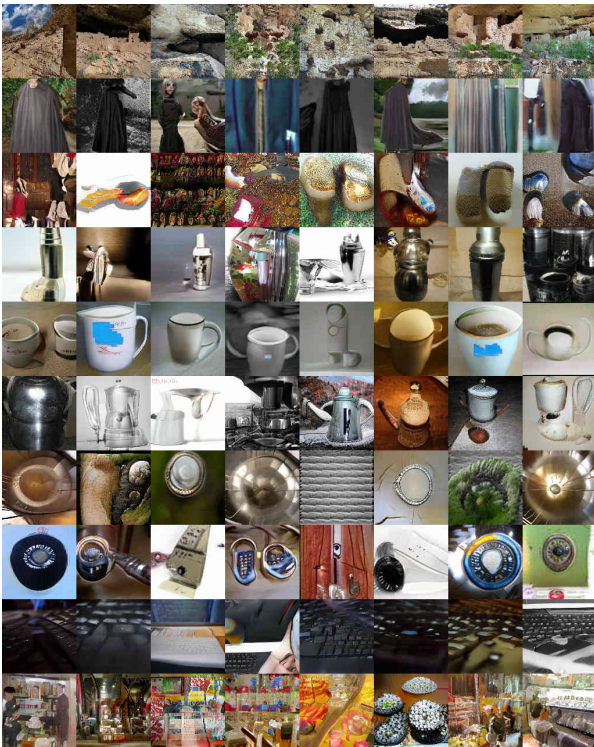




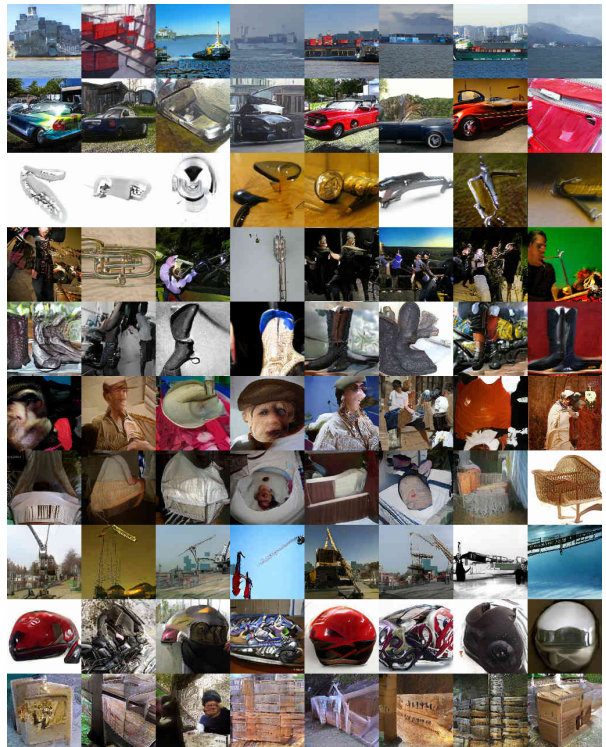
(a) Classes 480 to 489 sampled from MHGAN: cash machine. cassette. cassette player. castle. catamaran. CD player. cello. cellular telephone. chain. chainlink fence



(b) Classes 490 to 499 sampled from MHGAN: chain mail. chain saw. chest. chiffonier. chime. china cabinet. Christmas stocking. church. cinema. cleaver



(c) Classes 500 to 509 sampled from MHGAN: cliff dwelling. cloak. clog. cocktail shaker. coffee mug. coffeepot. coil. combination lock. computer keyboard. confectionery



(d) Classes 510 to 519 sampled from MHGAN: container ship. convertible. corkscrew. cornet. cowboy boot. cowboy hat. cradle. crane. crash helmet. crate

Figure 17: Classes 480 to 519 sampled from MHGAN





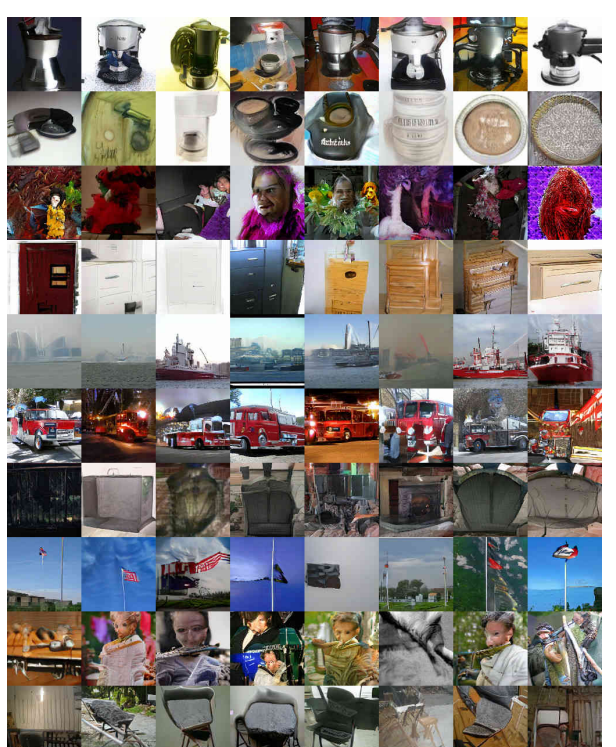
(a) Classes 520 to 529 sampled from MHGAN: crib, Crock Pot, croquet ball, crutch, cuirass, dam, desk, desktop computer, dial telephone, diaper



(b) Classes 530 to 539 sampled from MHGAN: digital clock, digital watch, dining table, dishrag, dishwasher, disk brake, dock, dogsled, dome, doormat



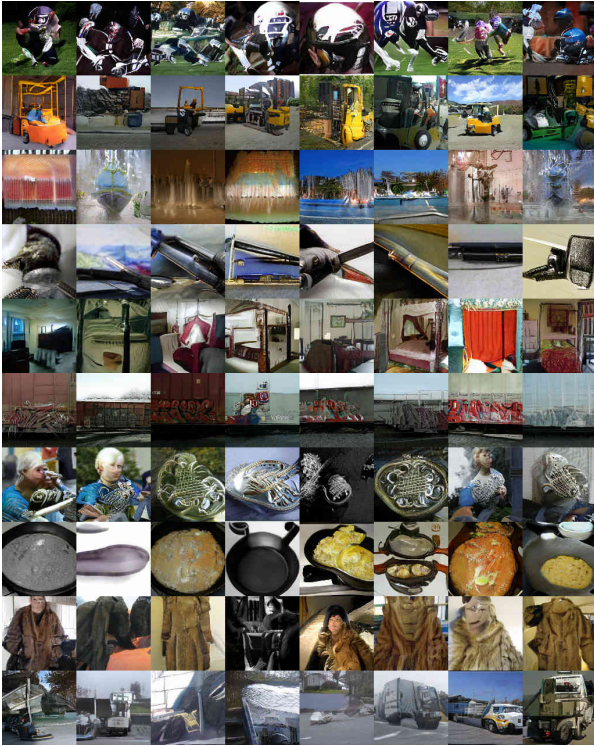
(c) Classes 540 to 549 sampled from MHGAN: drilling platform, drum, drumstick, dumbbell, Dutch oven, electric fan, electric guitar, electric locomotive, entertainment center, envelope



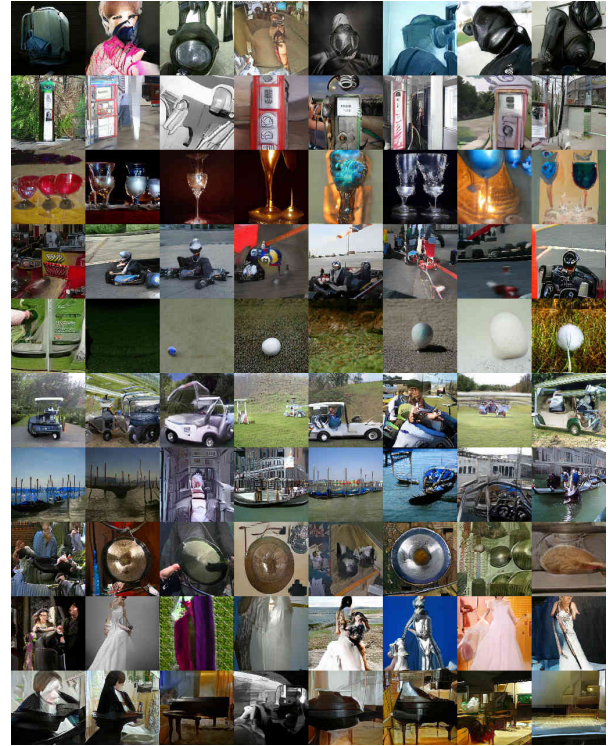
(d) Classes 550 to 559 sampled from MHGAN: espresso maker, face powder, feather boa, file, fireboat, fire engine, fire screen, flagpole, flute, folding chair

Figure 18: Classes 520 to 559 sampled from MHGAN

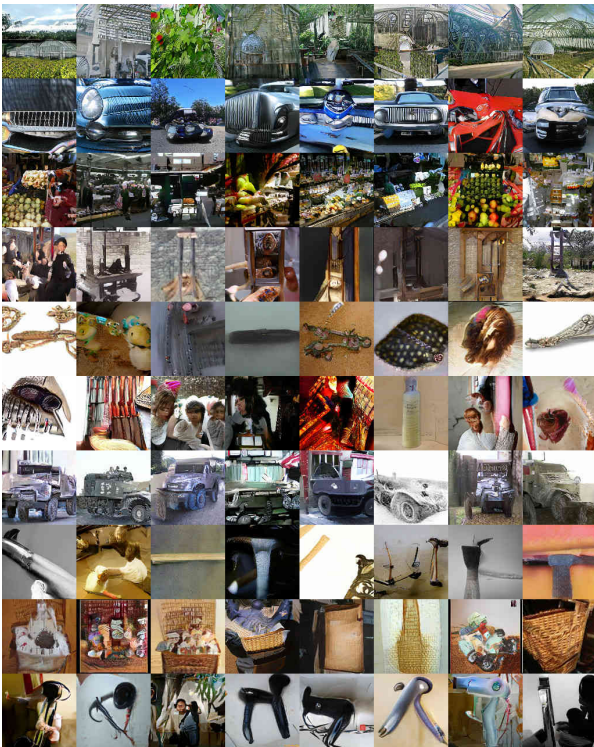




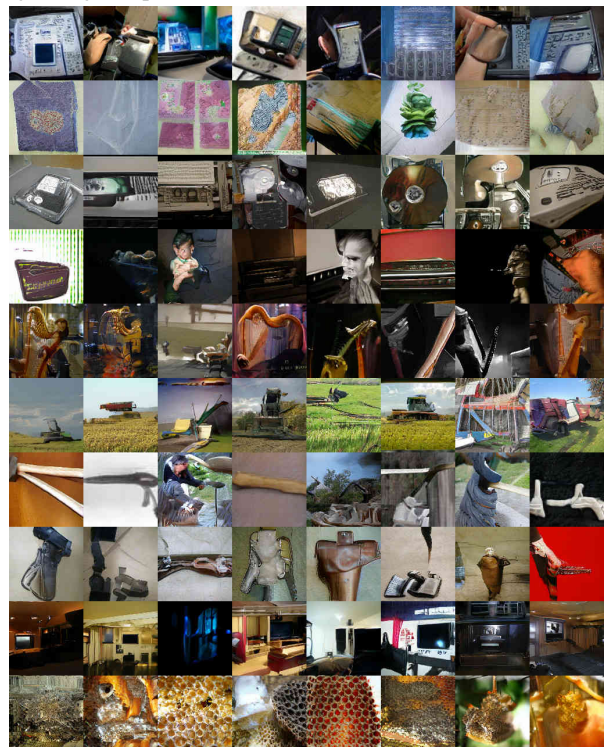
(a) Classes 560 to 569 sampled from MHGAN: football helmet, forklift, fountain, fountain pen, four-poster, freight car, French horn, frying pan, fur coat, garbage truck



(b) Classes 570 to 579 sampled from MHGAN: gasmask, gas pump, goblet, go-kart, golf ball, golfcart, gondola, gong, gown, grand piano



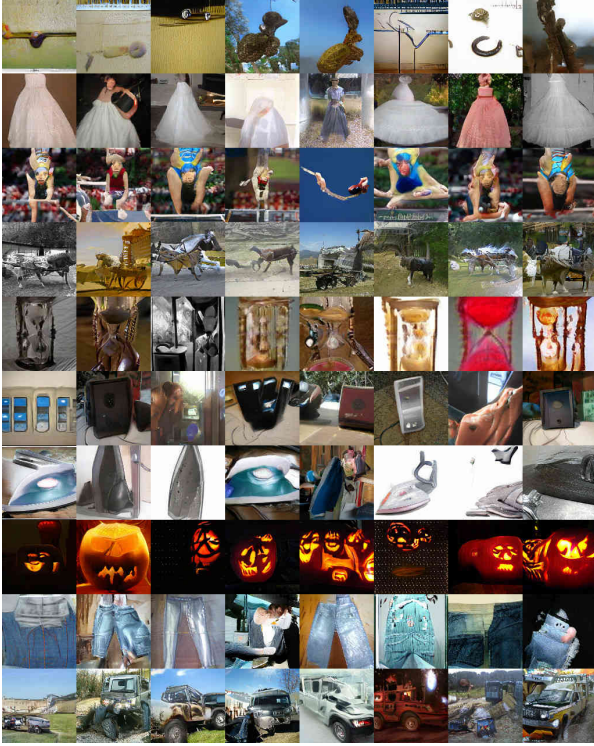
(c) Classes 580 to 589 sampled from MHGAN: greenhouse, grille, grocery store, guillotine, hair slide, hair spray, half track, hammer, hamper, hand blower



(d) Classes 590 to 599 sampled from MHGAN: hand-held computer, handkerchief, hard disc, harmonica, harp, harvester, hatchet, holster, home theater, honeycomb

Figure 19: Classes 560 to 599 sampled from MHGAN

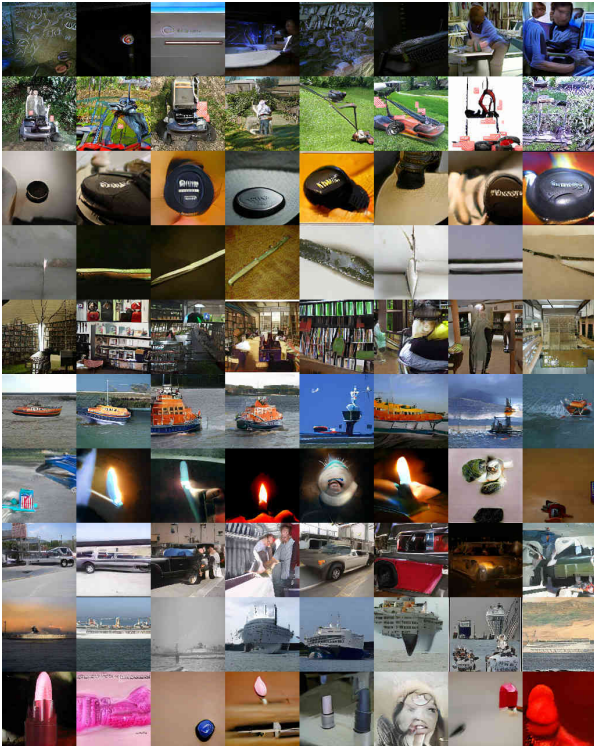




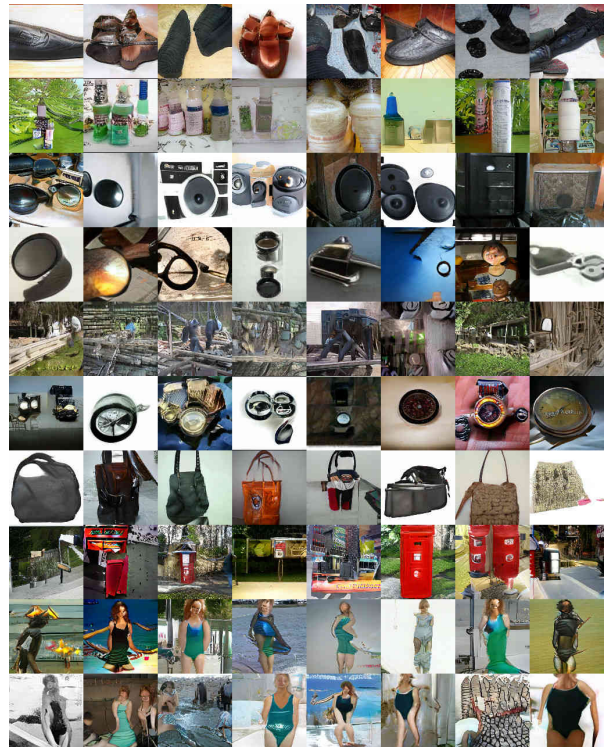
(a) Classes 600 to 609 sampled from MHGAN: hook. hoopskirt. horizontal bar. horse cart. hourglass. iPod. iron. jack-o'-lantern. jean. jeep



(b) Classes 610 to 619 sampled from MHGAN: jersey. jigsaw puzzle. jinrikisha. joystick. kimono. knee pad. knot. lab coat. ladle. lampshade



(c) Classes 620 to 629 sampled from MHGAN: laptop. lawn mower. lens cap. letter opener. library. lifeboat. lighter. limousine. liner. lipstick



(d) Classes 630 to 639 sampled from MHGAN: Loafer. lotion. loudspeaker. loupe. lumbermill. magnetic compass. mailbag. mailbox. maillot. maillot

Figure 20: Classes 600 to 639 sampled from MHGAN

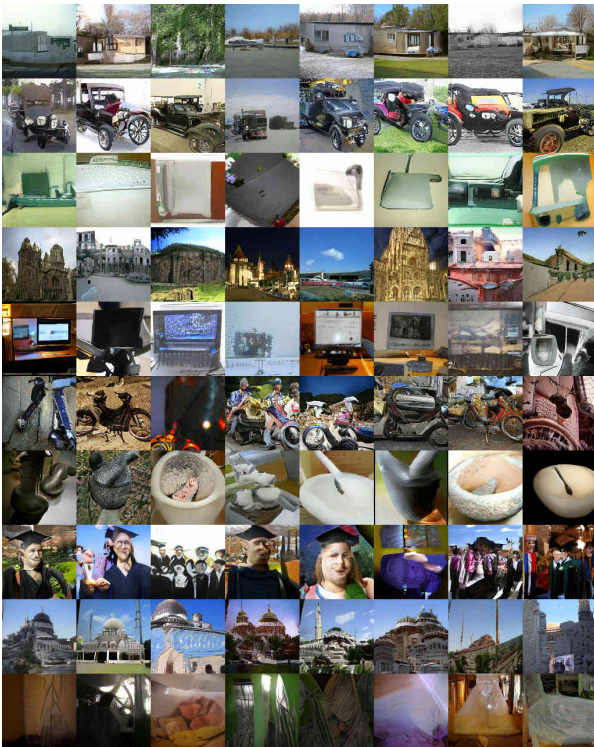




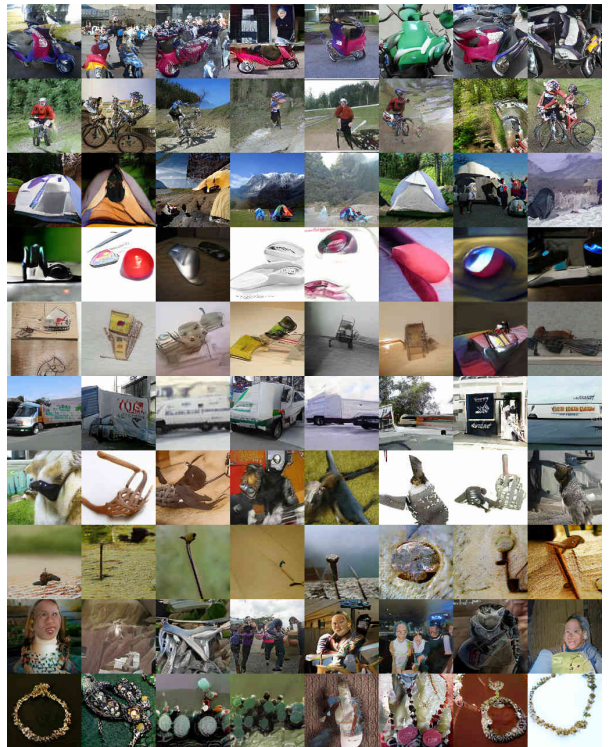
(a) Classes 640 to 649 sampled from MHGAN: manhole cover, maraca, marimba, mask, matchstick, maypole, maze, measuring cup, medicine chest, megalith



(b) Classes 650 to 659 sampled from MHGAN: microphone, microwave, military uniform, milk can, minibus, miniskirt, minivan, missile, mitten, mixing bowl



(c) Classes 660 to 669 sampled from MHGAN: mobile home, Model T, modem, monastery, monitor, moped, mortar, mortarboard, mosque, mosquito net



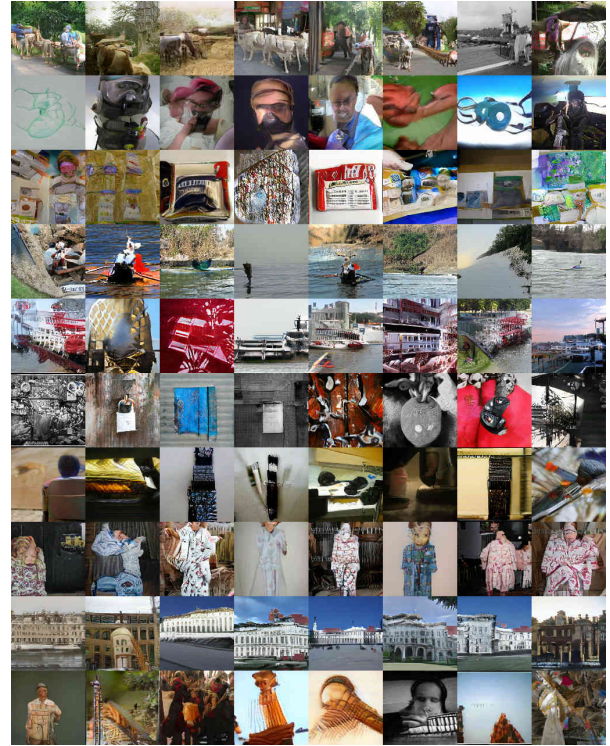
(d) Classes 670 to 679 sampled from MHGAN: motor scooter, mountain bike, mountain tent, mouse, mousetrap, moving van, muzzle, nail, neck brace, necklace

Figure 21: Classes 640 to 679 sampled from MHGAN

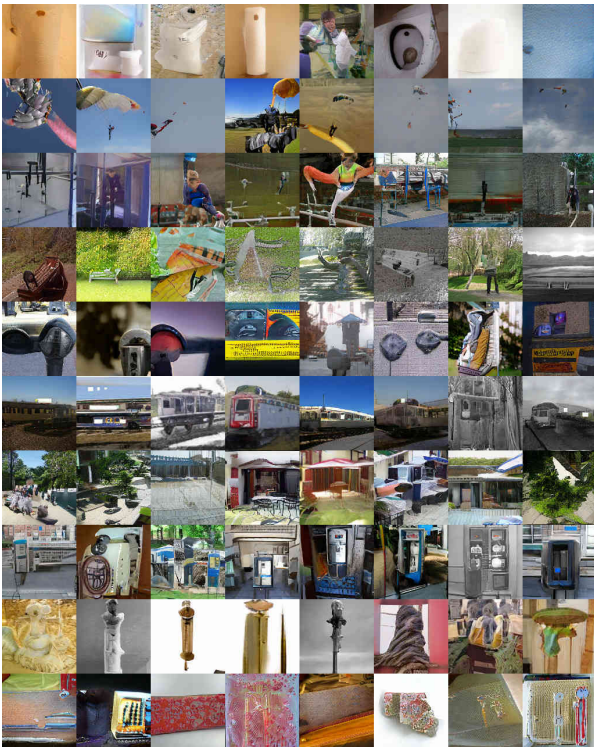




(a) Classes 680 to 689 sampled from MHGAN: nipple. notebook. obelisk. oboe. ocarina. odometer. oil filter. organ. oscilloscope. overskirt



(b) Classes 690 to 699 sampled from MHGAN: oxcart. oxygen mask. packet. paddle. paddlewheel. padlock. paintbrush. pajama. palace. panpipe



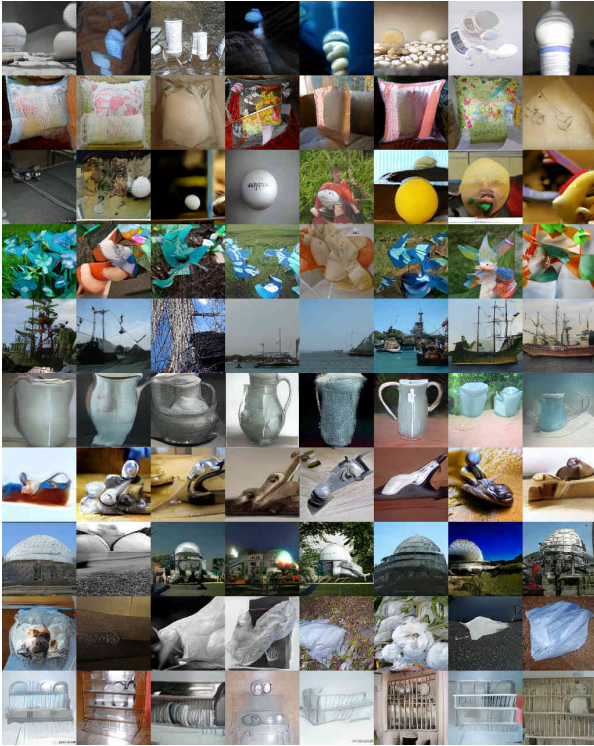
(c) Classes 700 to 709 sampled from MHGAN: paper towel. parachute. parallel bars. park bench. parking meter. passenger car. patio. pay-phone. pedestal. pencil box



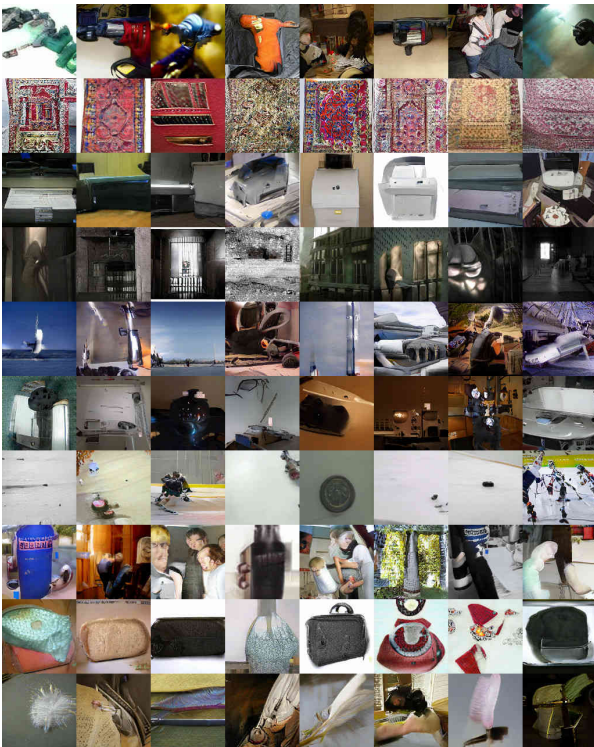
(d) Classes 710 to 719 sampled from MHGAN: pencil sharpener. perfume. Petri dish. photocopier. pick. pickelhaube. picket fence. pickup. pier. piggy bank

Figure 22: Classes 680 to 719 sampled from MHGAN





(a) Classes 720 to 729 sampled from MHGAN: pill bottle. pillow. ping-pong ball. pinwheel. pirate. pitcher. plane. planetarium. plastic bag. plate rack



(c) Classes 740 to 749 sampled from MHGAN: power drill. prayer rug. printer. prison. projectile. projector. puck. punching bag. purse. quill



(b) Classes 730 to 739 sampled from MHGAN: plow. plunger. Polaroid camera. pole. police van. poncho. pool table. pop bottle. pot. potter's wheel



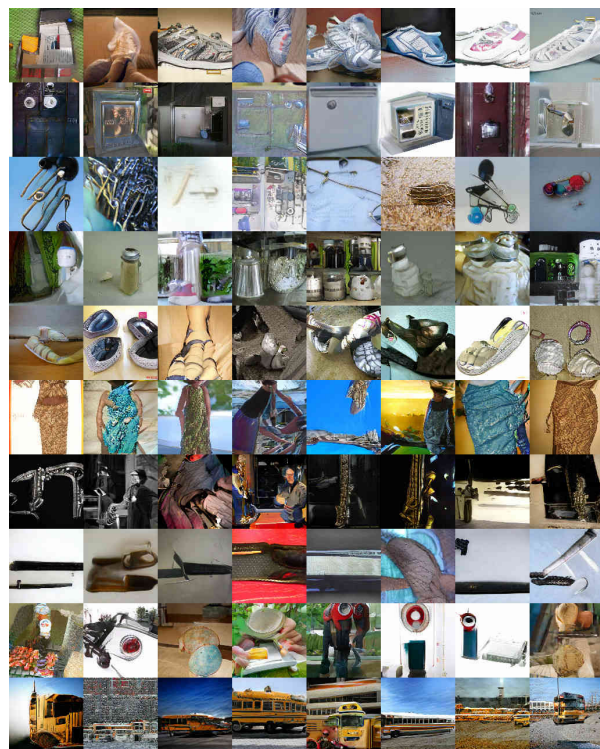
(d) Classes 750 to 759 sampled from MHGAN: quilt. racer. racket. radiator. radio. radio telescope. rain barrel. recreational vehicle. reel. reflex camera

Figure 23: Classes 720 to 759 sampled from MHGAN





(a) Classes 760 to 769 sampled from MHGAN: refrigerator, remote control, restaurant, revolver, rifle, rocking chair, rotisserie, rubber eraser, rugby ball, rule



(b) Classes 770 to 779 sampled from MHGAN: running shoe, safe, safety pin, saltshaker, sandal, sarong, sax, scabbard, scale, school bus



(c) Classes 780 to 789 sampled from MHGAN: schooner, scoreboard, screen, screw, screwdriver, seat belt, sewing machine, shield, shoe shop, shoji



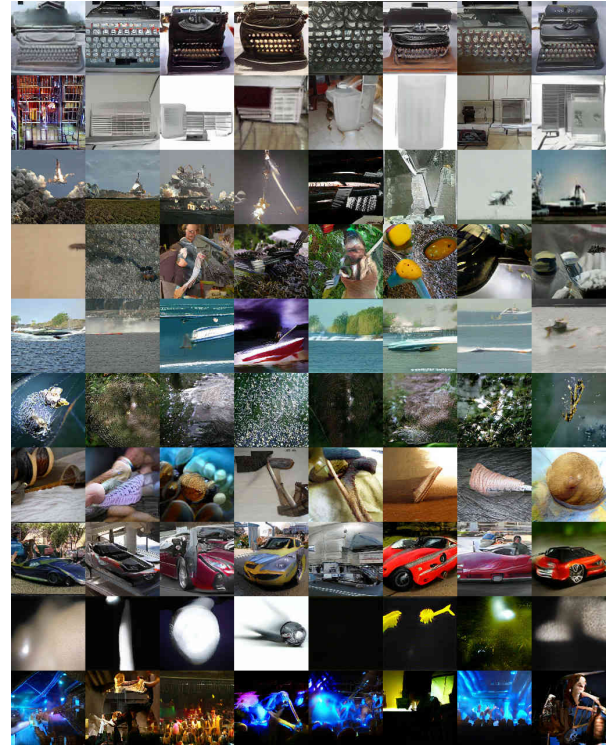
(d) Classes 790 to 799 sampled from MHGAN: shopping basket, shopping cart, shovel, shower cap, shower curtain, ski, ski mask, sleeping bag, slide rule, sliding door

Figure 24: Classes 760 to 799 sampled from MHGAN





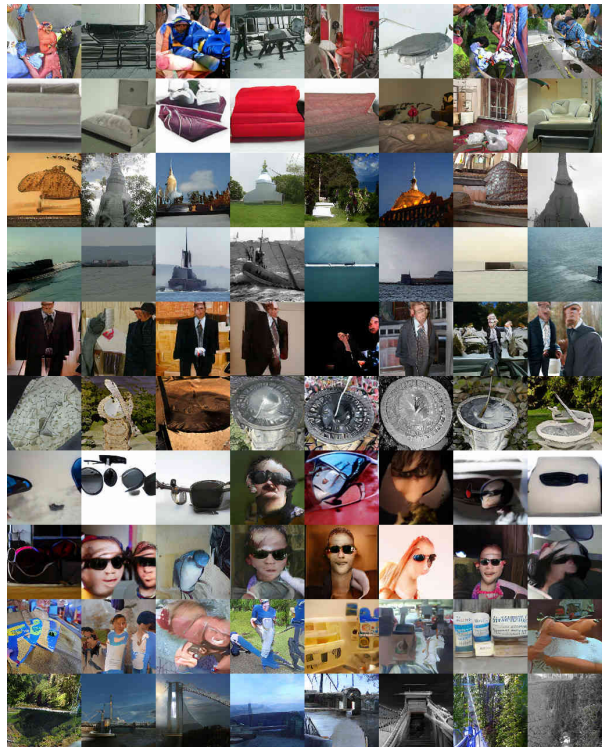
(a) Classes 800 to 809 sampled from MHGAN: slot. snorkel. snowmobile. snowplow. soap dispenser. soccer ball. sock. solar dish. sombrero. soup bowl



(b) Classes 810 to 819 sampled from MHGAN: space bar. space heater. space shuttle. spatula. speedboat. spider web. spindle. sports car. spotlight. stage



(c) Classes 820 to 829 sampled from MHGAN: steam locomotive. steel arch bridge. steel drum. stethoscope. stole. stone wall. stopwatch. stove. strainer. streetcar



(d) Classes 830 to 839 sampled from MHGAN: stretcher. studio couch. stupa. submarine. suit. sundial. sunglass. sunglasses. sunscreen. suspension bridge

Figure 25: Classes 800 to 839 sampled from MHGAN





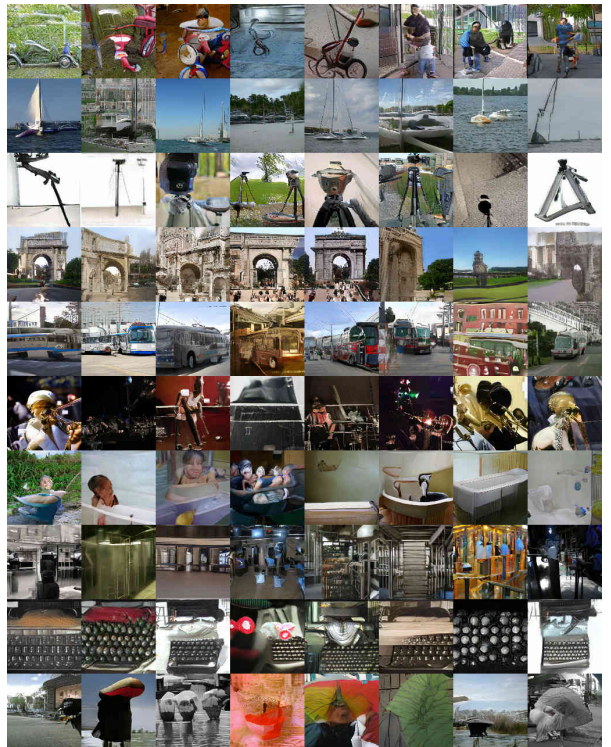
(a) Classes 840 to 849 sampled from MHGAN: swab, sweat-shirt, swimming trunks, swing, switch, syringe, table lamp, tank, tape player, teapot



(b) Classes 850 to 859 sampled from MHGAN: teddy, television, tennis ball, thatch, theater curtain, thimble, thresher, throne, tile roof, toaster



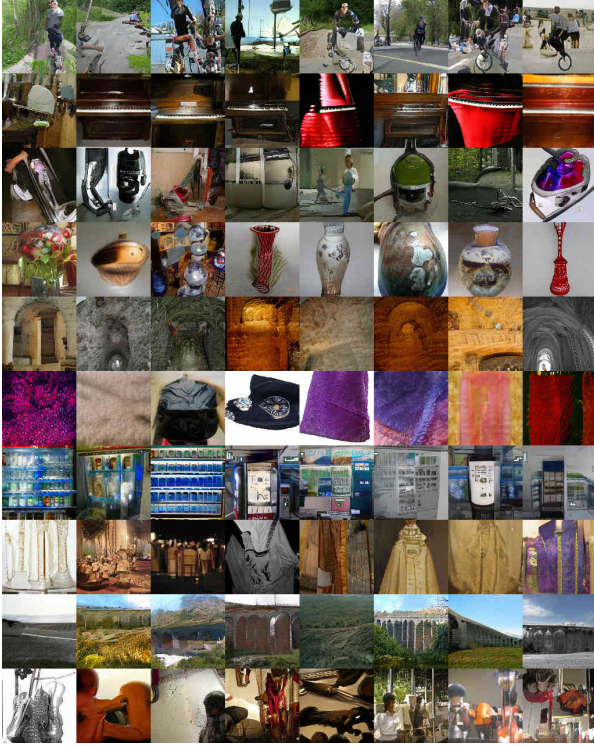
(c) Classes 860 to 869 sampled from MHGAN: tobacco shop, toilet seat, torch, totem pole, tow truck, toyshop, tractor, trailer truck, tray, trench coat



(d) Classes 870 to 879 sampled from MHGAN: tricycle, trimaran, tripod, triumphal arch, trolleybus, trombone, tub, turnstile, typewriter keyboard, umbrella

Figure 26: Classes 840 to 879 sampled from MHGAN

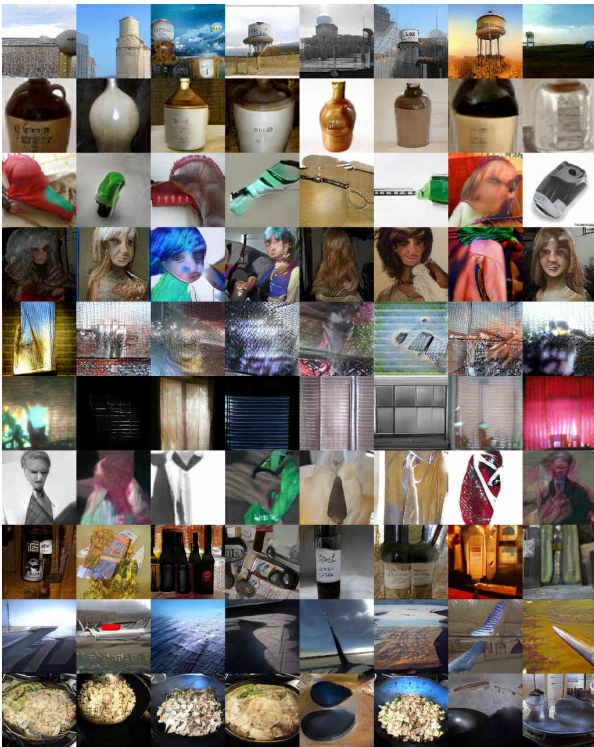




(a) Classes 880 to 889 sampled from MHGAN: unicycle. upright. vacuum. vase. vault. velvet. vending machine. vestment. viaduct. violin



(b) Classes 890 to 899 sampled from MHGAN: volleyball. waffle iron. wall clock. wallet. wardrobe. warplane. washbasin. washer. water bottle. water jug



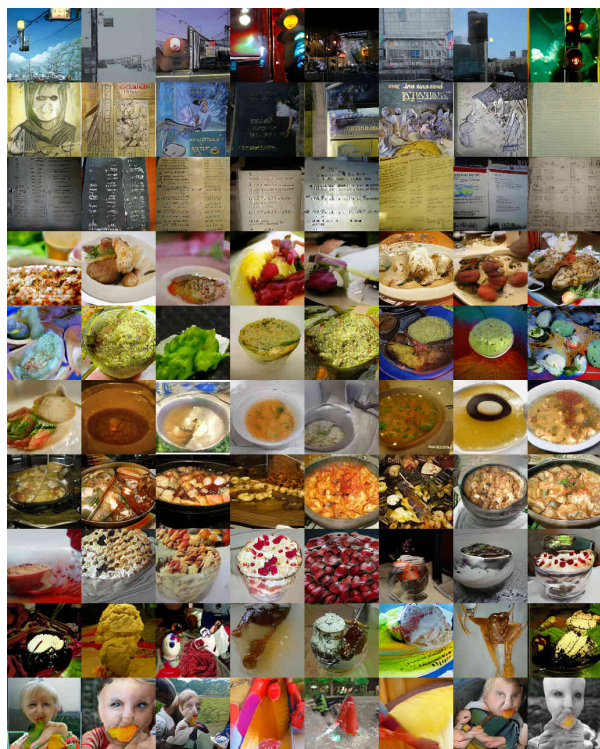
(c) Classes 900 to 909 sampled from MHGAN: water tower. whiskey jug. whistle. wig. window screen. window shade. Windsor tie. wine bottle. wing. wok



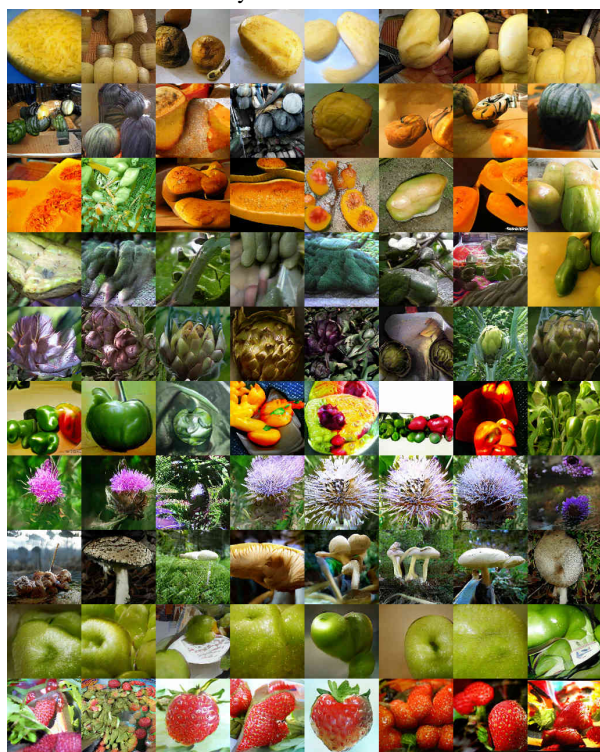
(d) Classes 910 to 919 sampled from MHGAN: wooden spoon. wool. worm fence. wreck. yawl. yurt. web site. comic book. crossword puzzle. street sign

Figure 27: Classes 880 to 919 sampled from MHGAN





(a) Classes 920 to 929 sampled from MHGAN: traffic light. book jacket. menu. plate. guacamole. consomme. hot pot. trifle. ice cream. ice lolly



(c) Classes 940 to 949 sampled from MHGAN: spaghetti squash. acorn squash. butternut squash. cucumber. artichoke. bell pepper. cardoon. mushroom. Granny Smith. strawberry



(b) Classes 930 to 939 sampled from MHGAN: French loaf. bagel. pretzel. cheeseburger. hotdog. mashed potato. head cabbage. broccoli. cauliflower. zucchini



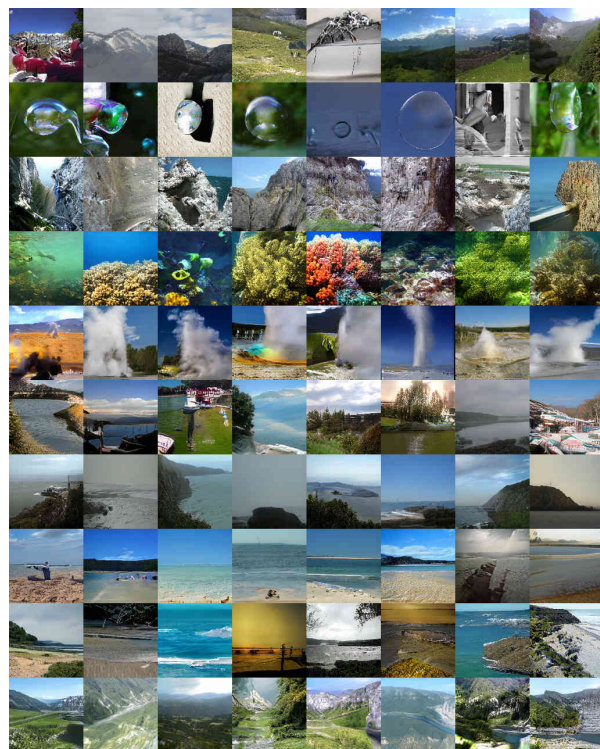
(d) Classes 950 to 959 sampled from MHGAN: orange. lemon. fig. pineapple. banana. jackfruit. custard apple. pomegranate. hay. carbonara

Figure 28: Classes 920 to 959 sampled from MHGAN





(a) Classes 960 to 969 sampled from MHGAN: chocolate sauce, dough, meat loaf, pizza, potpie, burrito, red wine, espresso, cup, eggnog



(b) Classes 970 to 979 sampled from MHGAN: alp, bubble, cliff, coral reef, geyser, lakeside, promontory, sandbar, seashore, valley



(c) Classes 980 to 989 sampled from MHGAN: volcano, ballplayer, groom, scuba diver, rapeseed, daisy, yellow lady's slipper, corn, acorn, hip



(d) Classes 990 to 999 sampled from MHGAN: buckeye, coral fungus, agaric, gyromitra, stinkhorn, earthstar, hen-of-the-woods, bolete, ear, toilet tissue

Figure 29: Classes 960 to 999 sampled from MHGAN