VGG Neural Network

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VGG

- Developed by Oxford's *Visual Geometry Group* (Simonyan & Zisserman, 2014) as "Very Deep Convolutional Networks for Large-Scale Image Recognition".
- Broke ImageNet records by proving depth + small filters outperform earlier wide, shallow CNNs.
- Core idea: stack many 3 × 3 conv layers instead of a few large ones—simple, uniform, easy to reproduce
- Two canonical variants: VGG-16 (16 weight layers) and VGG-19 (19 weight layers)

Architecture

- Input: fixed 224 × 224 RGB image.
- Convolution blocks
  - Repeated 3 × 3, stride 1 filters with ReLU after each.
  - Two to four conv layers per block, then 2 × 2 max-pool (stride 2) halves width & height.
- After 5 pooling blocks → flatten → three fully connected layers (4096-4096-1000) + soft-max.
- Parameter cost: ≈138 M (VGG-16) — memory-hungry but highly transferable

VGG-16 vs VGG-19 & Practical Considerations

Features	VGG16	VGG19
Convolution Layer	13	16
Fully Connected Layer	3	3
Trainable parameter	138,357,500	143,667,240 (Estimate)
Model size (MB)	527.79	548.1 (Estimate)

Impact, Applications & Limitations

- Backbone for transfer learning in:
  - Medical imaging (tumor detection, radiology)
  - Object & face recognition, biometric security
  - Satellite / environmental monitoring
  - Neural style transfer & Fast-RCNN object detection baseline.
- Strengths
  - Straightforward architecture = easy fine-tuning
  - Consistent 3×3 kernels generalize well across domains.
- Limitations
  - Huge parameter count ➔ high VRAM & inference latency.
  - Largely outperformed by newer, lighter models in accuracy : compute trade-off

HW3: Various CNN Model test Presentation

Results Case1: using “real” folder name

Input Images


bike


bird


butterfly


cat


chicken


dog


flower


horse


sheep


woman

ResNet50	VGGNet16	InceptionV3	ConvNeXt	EfficientNet	ResNet50 _prob	VGGNet16 _prob	InceptionV3 _prob	ConvNeXt _prob	EfficientNet _prob	label
moped	moped	stopwatch	moped	moped	0.80533	0.42419	1	0.82751	0.65037	bike
bee_eater	house_finch	web_site	bee_eater	bee_eater	0.52949	0.96203	1	0.92659	0.73385	bird
cabbage_butterfly	cabbage_butterfly	web_site	ringlet	ringlet	0.60616	0.77259	1	0.92665	0.75696	butterfly
tabby	tabby	web_site	Egyptian_cat	Egyptian_cat	0.65129	0.48065	0.99981	0.77957	0.45926	cat
hen	hen	pencil_sharper	hen	hen	0.99086	0.96126	0.85818	0.88911	0.69796	chicken
wire-haired_fox_terrier	German_shepherd	web_site	toy_terrier	kelpie	0.16791	0.14802	0.99998	0.47487	0.30531	dog
tray	pitcher	clog	hair_slide	lampshade	0.41643	0.14068	0.86002	0.29183	0.49116	flower
hartebeest	hartebeest	vase	sorrel	hartebeest	0.49483	0.87577	0.47337	0.2562	0.62734	horse
ram	ram	web_site	hog	ram	0.75918	0.72313	0.85689	0.76543	0.41133	sheep
sombrero	ice_lolly	saltshaker	tennis_ball	sombrero	0.64053	0.06982	0.99947	0.32151	0.14389	woman
Accuracy	Accuracy	Accuracy	Accuracy	Accuracy						
5.3	5	0	6	4.5						

Accuracy Score
1
0.8
0.5

Table 1: Model comparative result table for case1

Input Images


bike


bird


butterfly


cat


chicken


dog


flower


horse


sheep


woman

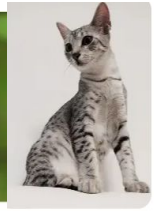
Predicted Label Images


Bee-eater | bird | Britannica.com


House Finch - eBird


Cabbage butterfly – Mort Bay


Ringlet | The Wildlife Trusts


Egyptian Cat


Egyptian Cats - Dagmara Mach


Tabby Free Stock Photo - Public


Wire Fox Terrier - Pictures, Information,


German Shepherd | Breed, Size, Coat &


Toy Fox Terrier - Pictures, Information


Wild Australian Kelpie


Sorrel Horse: Telling Sorrels Apart From Red

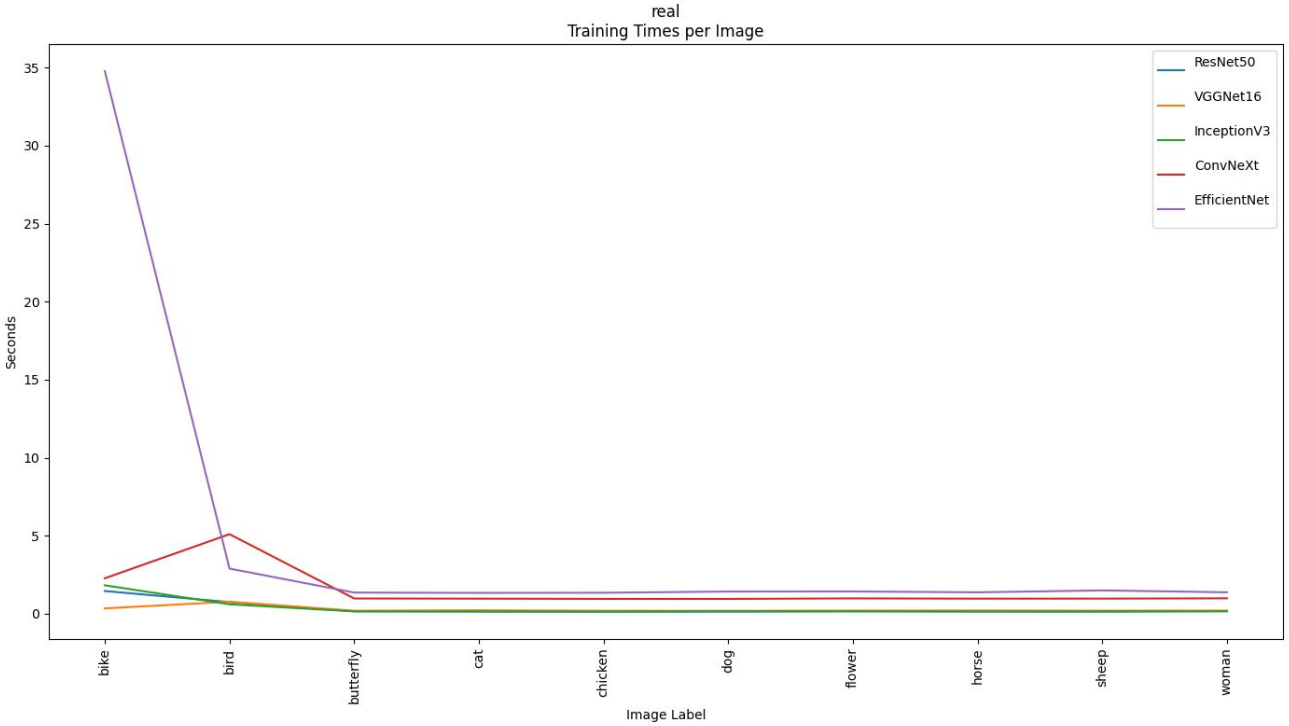

Hartebeest | Creatures of the


Feral Hog Management Program to


Sombrero Unisex Explorer


How to Start a Moped: Everything You Need to Know

Results Case1: using “real” folder name



Lowest inference time

- ResNet50
- InceptionV3
- VGGNet16

Results Case2: using “synthetic” folder name

Input Images


bicycle


bird


butterfly


cat


chicken


dog


horse


rose

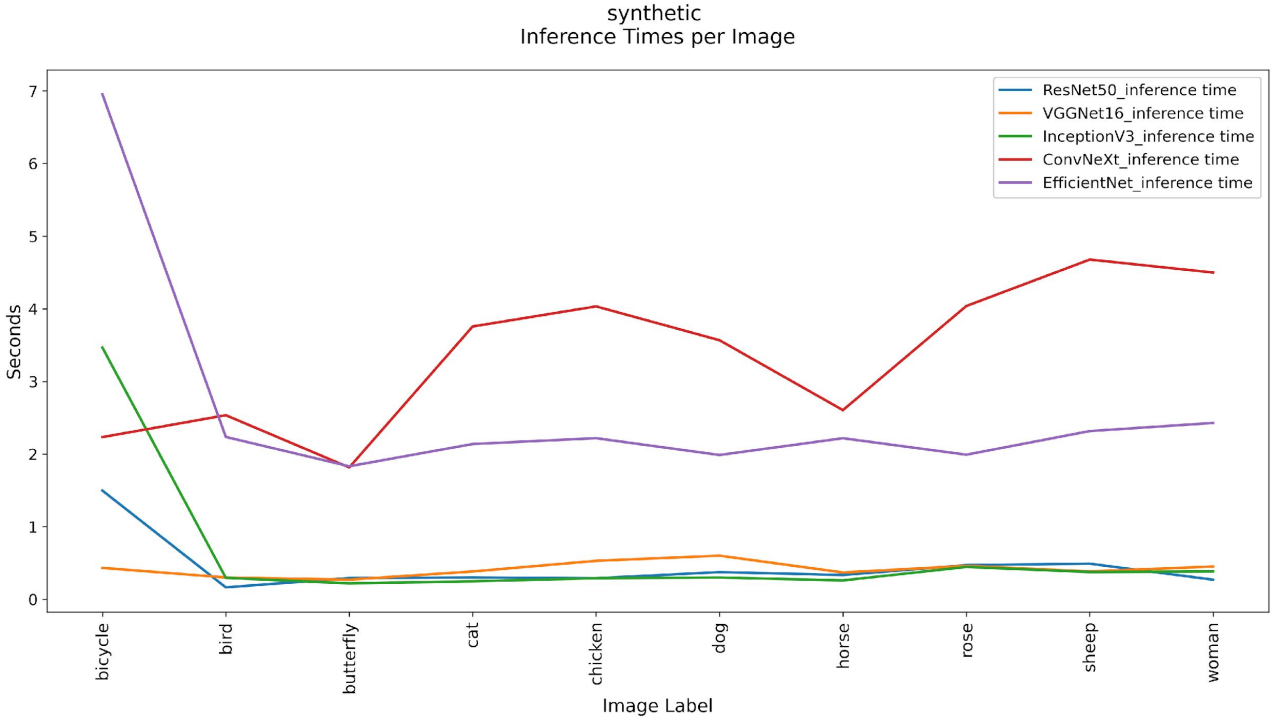

sheep


woman

ResNet50	VGGNet16	InceptionV3	ConvNeXt	EfficientNet	ResNet50_prob	VGGNet16_prob	InceptionV3_prob	ConvNeXt_prob	EfficientNet_prob	label
tricycle	tricycle	clog	bicycle-built-for-two	tricycle	0.84685	0.19208	0.59291	0.25444	0.81799	bicycle
pinwheel	jellyfish	flatworm	sulphur-crested_cockatoo	bee_eater	0.69915	0.17417	1	0.56962	0.35358	bird
pinwheel	bubble	flatworm	bubble	lacewing	0.49099	0.22225	0.89689	0.59244	0.64869	butterfly
laptop	tabby	web_site	tabby	Persian_cat	0.39527	0.2078	1	0.28785	0.49993	cat
hen	cock	stopwatch	hen	hen	0.50245	0.67628	0.58571	0.7616	0.6226	chicken
tennis_ball	golden_retriever	flatworm	tennis_ball	golden_retriever	0.91886	0.57009	0.92717	0.27182	0.60391	dog
alp	sorrel	flatworm	carousel	alp	0.37877	0.2142	0.98597	0.59683	0.38357	horse
vase	pot	web_site	necklace	coil	0.16037	0.3725	0.79715	0.24576	0.14973	rose
balloon	Arctic_fox	clog	Arctic_fox	Arctic_fox	0.09864	0.15921	0.99436	0.28605	0.14845	sheep
picket_fence	balloon	flatworm	picket_fence	picket_fence	0.99313	0.29855	0.99996	0.92295	0.77555	woman
Accuracy	Accuracy	Accuracy	Accuracy	Accuracy						
1.5	3.8	0	4.4	4						

Accuracy Score
1
0.8
0.5

Results Case2: using “synthetic” folder name



Lowest inference time

- ResNet50
- InceptionV3
- VGGNet16

Results Case3: using “test1” folder name

Input Images


bed


bird house


car


dog


eagle


female


horse


house


pigeon

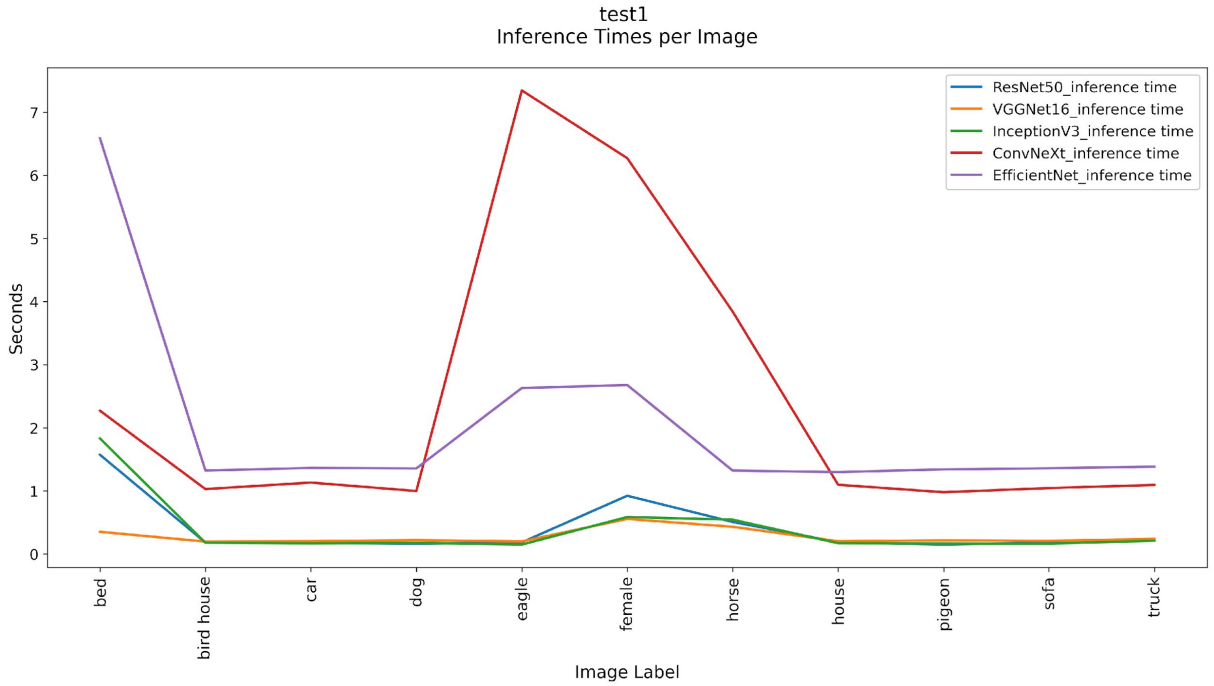

sofa


truck

ResNet50	VGGNet16	InceptionV3	ConvNeXt	EfficientNet	ResNet50_prob	VGGNet16_prob	InceptionV3_prob	ConvNeXt_prob	EfficientNet_prob	label
home_theater	studio_couch	web_site	studio_couch	studio_couch	0.34067	0.26746	0.99992	0.25554	0.64738	bed
birdhouse	birdhouse	tennis_ball	birdhouse	birdhouse	0.99989	0.99863	0.99632	0.92486	0.81878	bird house
minivan	minivan	bow	beach_wagon	minivan	0.30592	0.16888	0.97962	0.81965	0.35422	car
whippet	Ibizan_hound	web_site	dingo	American_Staffordshire_terrier	0.55377	0.26041	1	0.3576	0.51846	dog
hornbill	bald_eagle	web_site	kite	macaw	0.30271	0.46598	1	0.25597	0.51434	eagle
trench_coat	trench_coat	stole	wig	wig	0.8986	0.18629	0.99968	0.45983	0.60992	female
sorrel	sorrel	web_site	gazelle	sorrel	0.86249	0.86109	0.99999	0.64218	0.63947	horse
picket_fence	patio	stopwatch	patio	patio	0.3221	0.16284	1	0.17431	0.2332	house
partridge	partridge	web_site	partridge	partridge	0.30066	0.25714	0.95404	0.37752	0.40252	pigeon
home_theater	studio_couch	pitcher	studio_couch	pedestal	0.5361	0.99577	0.99989	0.79505	0.44423	sofa
trailer_truck	garbage_truck	clog	garbage_truck	garbage_truck	0.72648	0.88189	0.99388	0.77973	0.58087	truck
Accuracy	Accuracy	Accuracy	Accuracy	Accuracy						
5.5	7	0	4	5.5						

Accuracy Score
1
0.8
0.5

Results Case3: using “test1” folder name



Lowest inference time

- ResNet50
- InceptionV3
- VGGNet16

Results Case4: using “test2” folder name

Input Images


automobile


bed


bird house


dog


eagle


female


horse


house


pigeon

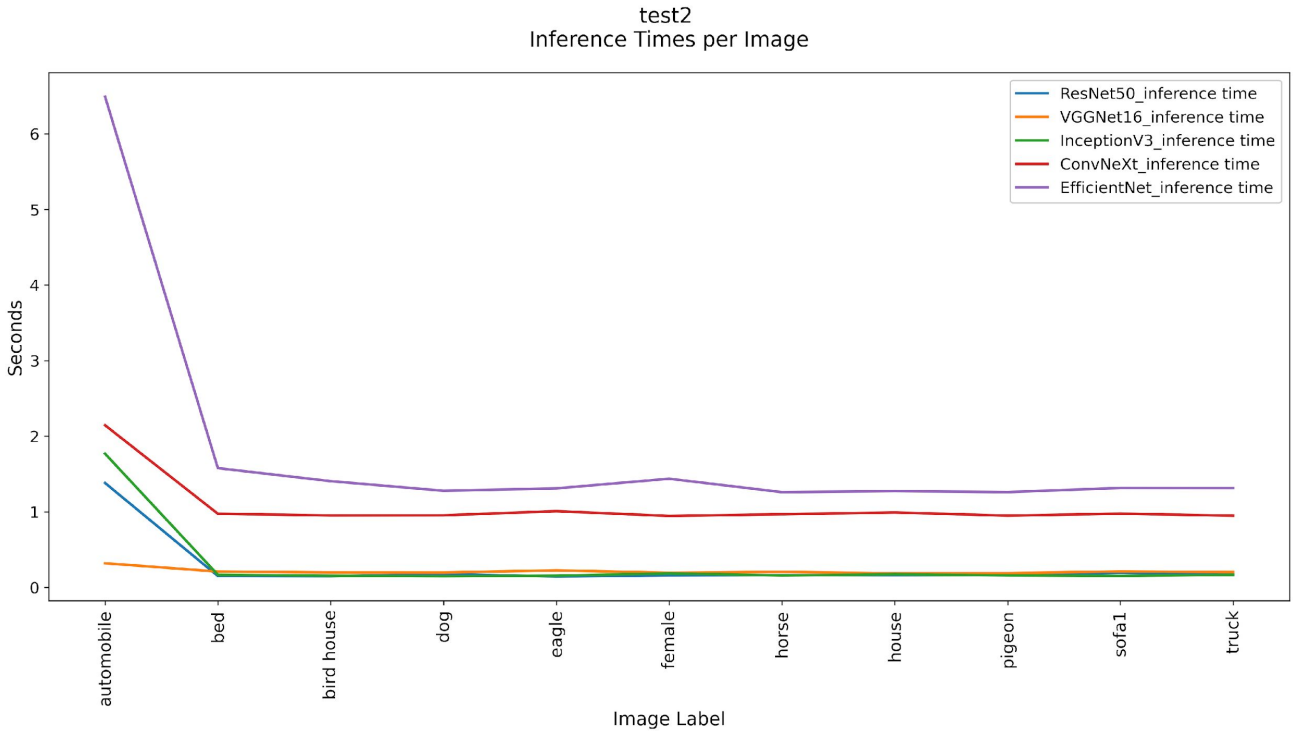

sofa1


truck

ResNet50	VGGNet16	InceptionV3	ConvNeXt	EfficientNet	ResNet50_prob	VGGNet16_prob	InceptionV3_prob	ConvNeXt_prob	EfficientNet_prob	label
balloon	cab	stopwatch	solar_dish	lakeside	0.26035	0.25555	0.94278	0.67278	0.16456	automobile
studio_couch	studio_couch	flatworm	quilt	quilt	0.51293	0.81496	1	0.81613	0.75614	bed
birdhouse	birdhouse	web_site	birdhouse	birdhouse	1	1	1	0.76124	0.83851	bird house
kuvasz	Labrador_retriever	web_site	kuvasz	kuvasz	0.43705	0.4033	0.99177	0.29176	0.58353	dog
bald_eagle	bald_eagle	web_site	bald_eagle	bald_eagle	1	0.99968	1	0.88781	0.82653	eagle
umbrella	dumbbell	English_foxhound	comic_book	mask	0.06532	0.15229	0.76666	0.22708	0.10937	female
sorrel	sorrel	web_site	sorrel	Saluki	0.91842	0.99405	1	0.50848	0.35146	horse
window_screen	picket_fence	leatherback_turtle	patio	window_screen	0.1748	0.18918	0.7165	0.44986	0.53039	house
whippet	goose	flatworm	hen	partridge	0.11009	0.21103	1	0.14806	0.70049	pigeon
studio_couch	studio_couch	stopwatch	studio_couch	studio_couch	0.98675	0.7529	0.99865	0.93918	0.77844	sofa1
crane	crane	flatworm	garbage_truck	garbage_truck	0.44036	0.62959	1	0.77316	0.74995	truck
Accuracy	Accuracy	Accuracy	Accuracy	Accuracy						
5	6	0	6	6						

Accuracy Score
1
0.8
0.5

Results Case4: using “test2” folder name

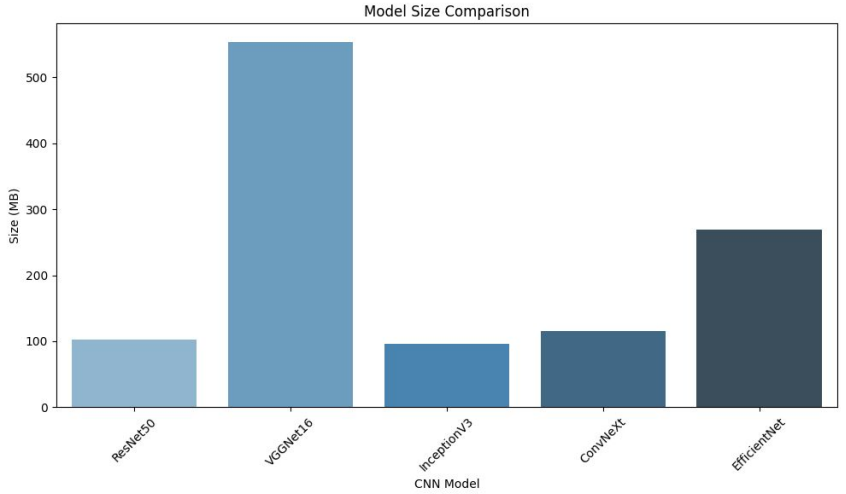


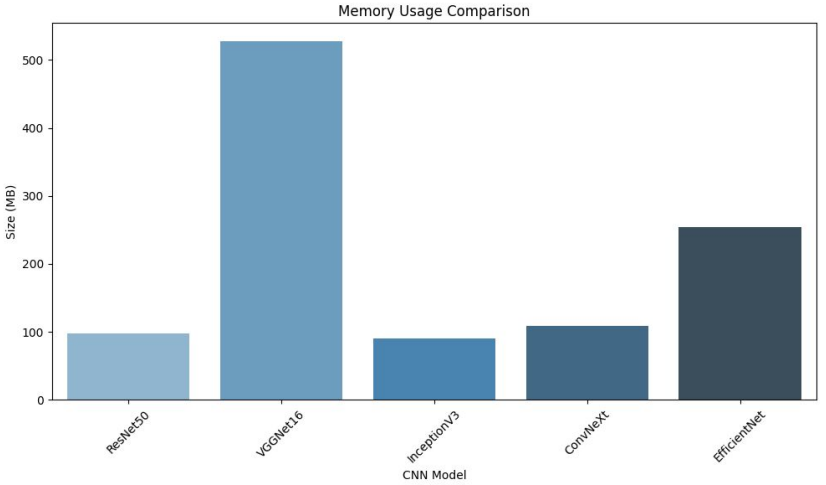
Lowest inference time

- ResNet50
- InceptionV3
- VGGNet16

Summary

Model	Accuracy (Out of 10) Real Folder Data	Accuracy (Out of 10) Synthetic Folder Data	Accuracy (Out of 10) Test1 Folder Data	Accuracy (Out of 10) Test2 Folder Data	Overall Average Accuracy Score (Out of 40)
ResNet50	5.3	1.5	5.5	5	17.3
VGGNet16	5	3.8	7	6	21.8
InceptionV3	0	0	0	0	0
ConvNeXt	6	4.4	4	6	20.4
EfficientNet	4.5	4	5.5	6	20





Summary

1. Top 3 Models by Prediction Accuracy

Rank	Model
1	VGGNet16
2	ConvNet
3	EfficientNet

These 3 models likely have more parameters or better architecture features that capture complex patterns.

2. Top 3 Models by Inference Speed

Rank	Model
1	ResNet50
2	InceptionV3
3	VGGNet16

Trade-off: While ResNet50 and InceptionV3 are faster, they sacrifice accuracy. VGGNet16 balances both speed and performance.

Summary

3. Key Metrics Comparison

Metric	Best Model	Worst Model
Accuracy	VGGNet16	InceptionV3
Speed	ResNet50	EfficientNet
Memory Usage and Model size	InceptionV3	VGGNet16

4. Observations

Prediction Quality: VGGNet16 consistently outperforms others, while inceptionV3 fails entirely (possibly due to trianing issues).

Speed Vs Accuracy: ResNet50 is fastest but moderately less accurate.

VGGNet16 offers the best model performance although it consumes large memory usage and model size.

Appendix: Each image top3 prediction for case 1

Image	Actual Label	Model	Top 1 Prediction	Top 1 Prob	Top 2 Prediction	Top 2 Prob	Top 3 Prediction	Top 3 Prob
Image 1	bike	ResNet50	moped	0.80533	mountain_bike	0.17422	motor_scooter	0.0076
Image 1	bike	VGGNet16	moped	0.42419	unicycle	0.26255	mountain_bike	0.18356
Image 1	bike	InceptionV3	stopwatch	1	corn	1.95E-08	binoculars	3.79E-09
Image 1	bike	ConvNeXt	moped	0.82751	motor_scooter	0.02408	disk_brake	0.01532
Image 1	bike	EfficientNet	moped	0.65037	motor_scooter	0.05748	mountain_bike	0.05247
Image 2	bird	ResNet50	bee_eater	0.52949	house_finch	0.26879	hummingbird	0.0707
Image 2	bird	VGGNet16	house_finch	0.96203	bee_eater	0.01625	robin	0.00518
Image 2	bird	InceptionV3	web_site	1	nematode	4.35E-07	stopwatch	3.86E-10
Image 2	bird	ConvNeXt	bee_eater	0.92659	bulbul	0.01431	house_finch	0.00222
Image 2	bird	EfficientNet	bee_eater	0.73385	macaw	0.07315	jacamar	0.02246
Image 3	butterfly	ResNet50	cabbage_butterfly	0.60616	ringlet	0.29663	lycaenid	0.06681
Image 3	butterfly	VGGNet16	cabbage_butterfly	0.77259	lycaenid	0.13074	ringlet	0.07076
Image 3	butterfly	InceptionV3	web_site	1	hare	3.53E-11	stopwatch	3.56E-15
Image 3	butterfly	ConvNeXt	ringlet	0.92665	cardoon	0.01275	cabbage_butterfly	0.00761
Image 3	butterfly	EfficientNet	ringlet	0.75696	cabbage_butterfly	0.04268	lycaenid	0.03297
Image 4	cat	ResNet50	tabby	0.65129	tiger_cat	0.18943	Egyptian_cat	0.14717
Image 4	cat	VGGNet16	tabby	0.48065	tiger_cat	0.34209	Egyptian_cat	0.1431
Image 4	cat	InceptionV3	web_site	0.99981	toaster	0.00016	stopwatch	3.04E-05
Image 4	cat	ConvNeXt	Egyptian_cat	0.77957	tabby	0.06826	plastic_bag	0.01985
Image 4	cat	EfficientNet	Egyptian_cat	0.45926	tiger_cat	0.20828	tabby	0.1322
Image 5	chicken	ResNet50	hen	0.99086	cock	0.0085	partridge	0.00054
Image 5	chicken	VGGNet16	hen	0.96126	cock	0.03779	partridge	0.0008
Image 5	chicken	InceptionV3	pencil_sharpener	0.85818	stopwatch	0.10615	bow	0.03335
Image 5	chicken	ConvNeXt	hen	0.88911	partridge	0.01179	cock	0.00943
Image 5	chicken	EfficientNet	hen	0.69796	partridge	0.01859	cock	0.01164

Appendix: Each image top3 prediction for case 1

Image 6	dog	ResNet50	wire-haired_fox_terri	0.16791	Scotch_terrier	0.09301	toy_terrier	0.07495
Image 6	dog	VGGNet16	German_shepherd	0.14802	Ibizan_hound	0.10533	malinois	0.06943
Image 6	dog	InceptionV3	web_site	0.99998	stopwatch	2.10E-05	nematode	9.74E-11
Image 6	dog	ConvNeXt	toy_terrier	0.47487	Chihuahua	0.09561	wire-haired_fox_terri	0.053
Image 6	dog	EfficientNet	kelpie	0.30531	Ibizan_hound	0.06024	wire-haired_fox_terri	0.03702
Image 7	flower	ResNet50	tray	0.41643	binder	0.27031	monitor	0.04371
Image 7	flower	VGGNet16	pitcher	0.14068	coffee_mug	0.09043	vase	0.08902
Image 7	flower	InceptionV3	clog	0.86002	web_site	0.09871	flatworm	0.01345
Image 7	flower	ConvNeXt	hair_slide	0.29183	vase	0.22663	packet	0.04265
Image 7	flower	EfficientNet	lampshade	0.49116	wallet	0.04644	shower_curtain	0.04133
Image 8	horse	ResNet50	hartebeest	0.49483	gazelle	0.11975	sorrel	0.08185
Image 8	horse	VGGNet16	hartebeest	0.87577	impala	0.03302	lion	0.0302
Image 8	horse	InceptionV3	vase	0.47337	stopwatch	0.36263	web_site	0.1163
Image 8	horse	ConvNeXt	sorrel	0.2562	hartebeest	0.21072	gazelle	0.10287
Image 8	horse	EfficientNet	hartebeest	0.62734	gazelle	0.11879	impala	0.04647
Image 9	sheep	ResNet50	ram	0.75918	hog	0.08375	warthog	0.06509
Image 9	sheep	VGGNet16	ram	0.72313	hog	0.14006	wild_boar	0.07433
Image 9	sheep	InceptionV3	web_site	0.85689	ladle	0.04924	spotlight	0.02239
Image 9	sheep	ConvNeXt	hog	0.76543	ram	0.0332	wild_boar	0.02816
Image 9	sheep	EfficientNet	ram	0.41133	hog	0.10044	kelpie	0.09153
Image 10	woman	ResNet50	sombrero	0.64053	cowboy_hat	0.04725	ice_lolly	0.04103
Image 10	woman	VGGNet16	ice_lolly	0.06982	wig	0.05678	sunscreen	0.05473
Image 10	woman	InceptionV3	saltshaker	0.99947	pitcher	0.00037	spotlight	0.00016
Image 10	woman	ConvNeXt	tennis_ball	0.32151	Granny_Smith	0.12221	jackfruit	0.03655
Image 10	woman	EfficientNet	sombrero	0.14389	cowboy_hat	0.04632	sunscreen	0.03594