Artificial Neural Network

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Q: Compare performance of 10 CNNs pre-trained on ImageNet dataset using images of 20 classes of CIFAR-100 dataset.

Answer: Experiment Details: I took 10 models from keras. I have loaded them with Imagenet-1K weights without head. I have used these as a backbone and then added a 3 layer classification head (Figure 1).

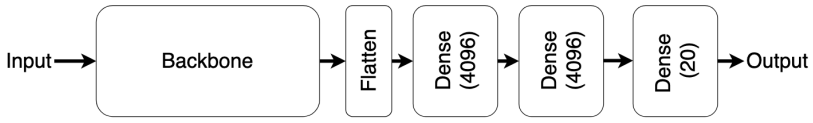

Figure 1: Model architecture of the evaluation system.

Then, 20 classes have selected been from CIFAR-100 dataset (see Table 1). I only filtered the dataset for required classes and use as it is (Train set and test set). Then I train all the heads for each backbone for 1 epoch. Then finally evaluate on the test set. The final results of all the models are in the Table 2.

Table 2: Performance of Pre-trained CNNs on 20 Classes of CIFAR-100

Model	Train	Test	Size (MB)	Train T (s)	Eval T (s)	Loss	Acc
Xception	10000	2000	431.9	3.19	0.30	1.076	0.692
VGG16	10000	2000	152.5	2.97	0.54	1.000	0.717
VGG19	10000	2000	172.7	3.70	0.67	0.877	0.751
ResNet50V2	10000	2000	442.2	3.06	0.22	1.068	0.701
ResNet101V2	10000	2000	515.0	4.12	0.46	1.111	0.677

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Table 2: Performance of Pre-trained CNNs on 20 Classes of CIFAR-100 (continued)

Model	Train	Test	Size (MB)	Train T (s)	Eval T (s)	Loss	Acc
InceptionV3	10000	2000	179.5	0.94	0.10	1.293	0.602
IncepResNetV2	10000	2000	295.6	1.76	0.18	1.008	0.684
MobileNet	10000	2000	140.7	0.83	0.06	0.945	0.717
MobileNetV2	10000	2000	253.0	1.57	0.08	1.061	0.691
DenseNet121	10000	2000	155.2	1.51	0.18	0.812	0.785

Performance Analysis of Pre-trained CNNs on CIFAR-100 (20 Classes)

1. Accuracy Comparison

- **Top Performer: DenseNet121** achieved the highest accuracy of **78.45%** with the lowest loss (0.812), indicating robust generalization to the selected subset of CIFAR-100.
- **High Accuracy Contenders: VGG19 (75.05%)**, **VGG16 and MobileNet (71.75%)**, and **Xception (69.15%)** also demonstrated strong accuracy. Notably, **MobileNet** achieved this with the smallest model size (140.7 MB), showcasing high efficiency.
- **Lower Accuracy Models: InceptionV3 (60.20%)** and **ResNet101V2 (67.70%)** performed relatively poorly, with InceptionV3 also having the highest evaluation loss (1.293), suggesting weaker feature extraction for this specific dataset subset.

2. Efficiency (Time vs Accuracy)

- **Fastest Models: MobileNet (0.83s training / 0.06s eval)** and **InceptionV3 (0.94s training / 0.10s eval)** showed very low compute times, making them ideal for fast and iterative training pipelines.
- **Trade-offs with Accuracy:** Although **InceptionV3** was fast, its performance was subpar in terms of accuracy. In contrast, **MobileNet** maintained a balanced trade-off between speed and precision.
- **Moderately Efficient and Accurate:** Models like **Xception**, **VGG16**, **VGG19**, and **ResNet variants** exhibited training times between 3–4 seconds and evaluation times close to 1 second, representing a reasonable compromise for practical use.

Table 1: Selected 20 Target Classes from CIFAR-100 Dataset

Class Index	Class Name	Class Index	Class Name
11	bicycle	26	leopard
12	bottle	27	lion
13	bowl	28	lizard
14	boy	29	lobster
15	bridge	30	man
16	bus	51	television
17	butterfly	52	tiger
18	camel	53	tractor
19	can	54	train
20	castle	55	trout

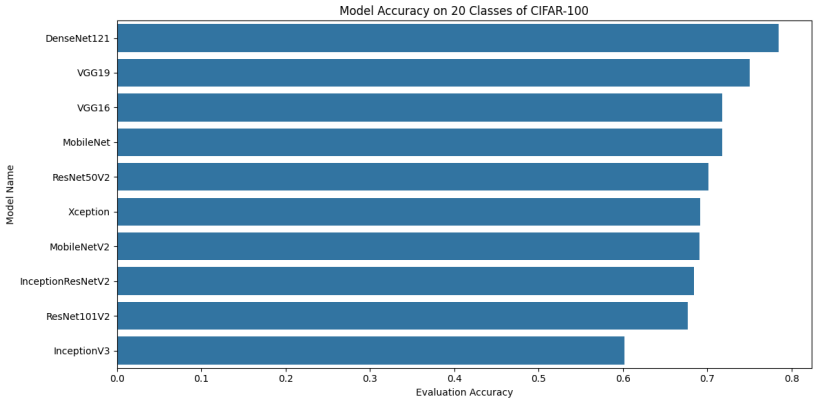

Figure 2: Evaluation accuracy of pre-trained CNNs on 20 classes of CIFAR-100.

3. Model Size vs Performance

- **Compact Yet Powerful:** Models such as **MobileNet** and **DenseNet121** delivered excellent accuracy with smaller model sizes (approximately 140–155 MB), making them suitable for deployment in resource-constrained environments.
- **Heavyweight Models with Moderate Returns: ResNet101V2 (515 MB)** and **ResNet50V2 (442 MB)** were the largest in terms of size, yet their accuracies (67.7% and 70.1%, respectively) were modest compared to lighter models such as **VGG16/VGG19**.

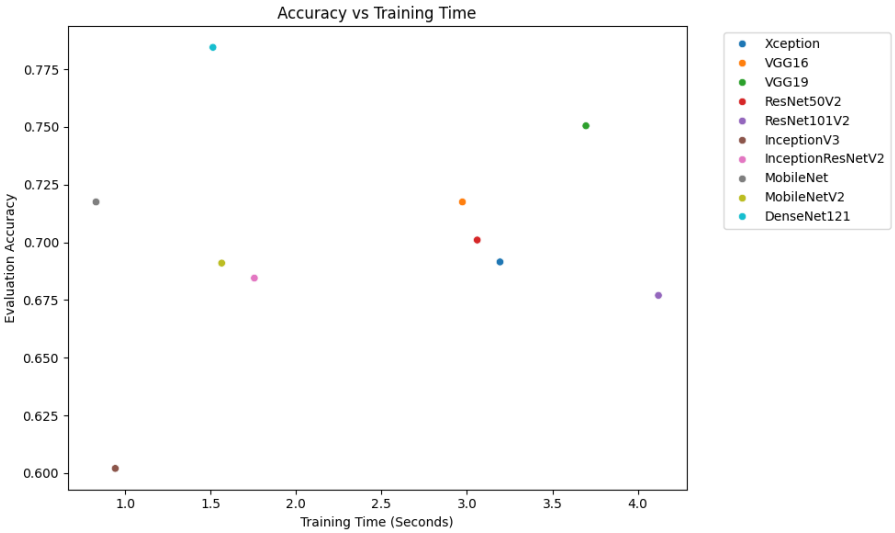

Figure 3: Comperison between the evaluation accuracy of pre-trained CNNs and training time.

4. Optimal Choices

- **Best Overall: DenseNet121** demonstrated the best overall performance considering accuracy, model size, and evaluation time.
- **Best for Efficiency: MobileNet** provides competitive accuracy with minimal computational cost and a small memory footprint.
- **Best Classic Architecture: VGG19** remains a solid baseline choice for its robust performance and interpretability.

Code Url: https://pastecode.dev/s/alv1a127

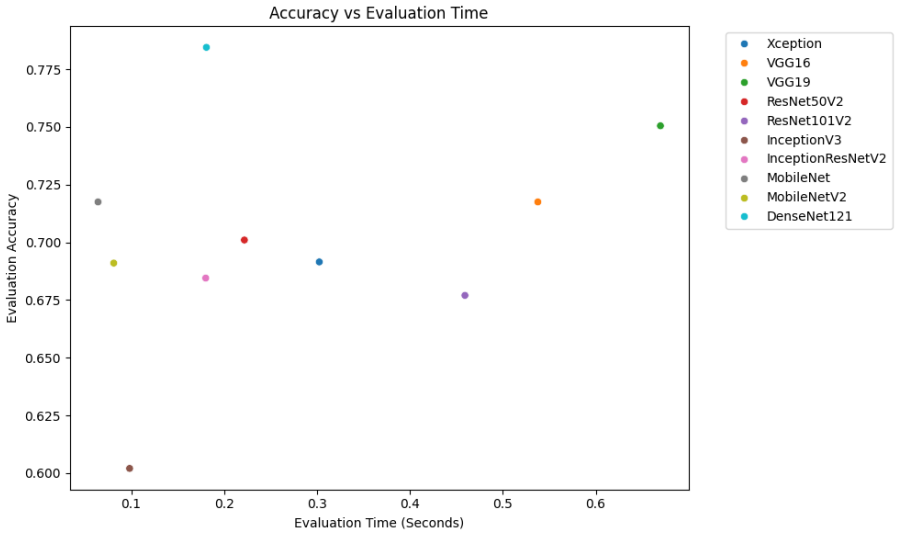

Figure 4: Comperison between the evaluation accuracy of pre-trained CNNs and evaluation time.

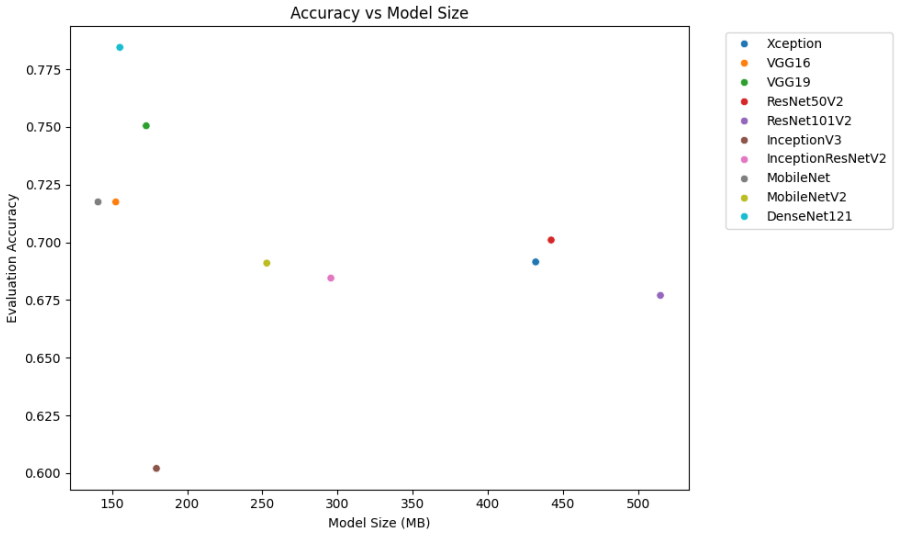

Figure 5: Comperison between the evaluation accuracy of pre-trained CNNs and model size.