

notebook

November 17, 2024

0.1 Libraries

```
[ ]: import os
import random
import matplotlib.pyplot as plt
from PIL import Image

import torch
import torch.nn as nn
from torchvision import datasets, transforms
import torchvision.transforms.functional as TF
from torchvision.models import alexnet, AlexNet_Weights, AlexNet

from default_config import default_config, default_net_config, default_train_config, data_dir, train_dir, \
    no_transform_config
from convolutionalNetwork import ConvolutionalNetwork
from predict import predict
from plot_scores import plot_scores
from plot_transformations import plot_transformations
from plot_individual_feature_maps import plot_individual_feature_maps
from denormalize_image import denormalize_image
from loaders import get_train_loader
from result_handler import result_handler
from train_model import train_model
```

0.2 Check device

```
[2]: device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
print(device)
torch.__version__  
  
cuda  
  
[2]: '2.5.1+cu124'
```

0.3 Seed

```
[3]: seed = 42

random.seed(seed)
torch.manual_seed(seed)
torch.cuda.manual_seed(seed)
```

0.4 Explorative Data Analysis

0.4.1 Dataset walking

```
[4]: for dirpath, dirnames, filenames in os.walk(data_dir):
    if len(dirnames) == 0: # only innermost directories
        print(f"'{dirpath}' directory contains {len(filenames)} images")

'data\test\cats' directory contains 200 images
'data\test\dogs' directory contains 200 images
'data\train\cats' directory contains 1000 images
'data\train\dogs' directory contains 1000 images
'data\validation\cats' directory contains 300 images
'data\validation\dogs' directory contains 300 images
```

0.4.2 Labels

```
[5]: print(datasets.ImageFolder(train_dir, transform=transforms.ToTensor()).class_to_idx)

{'cats': 0, 'dogs': 1}
```

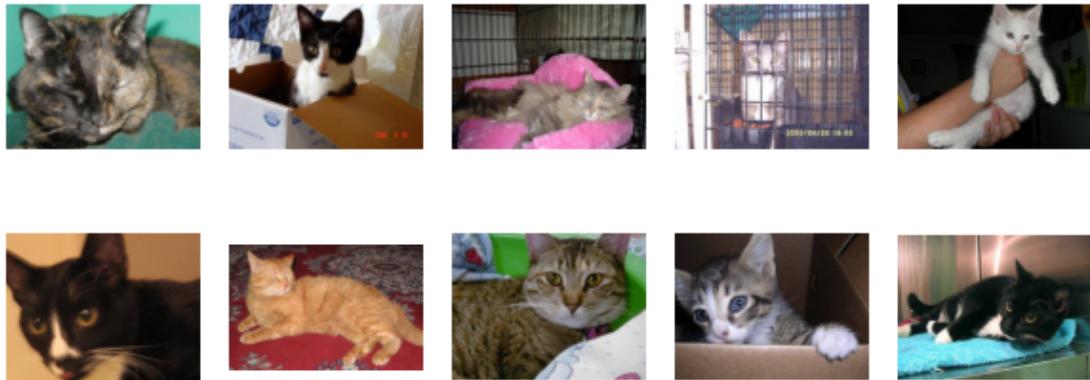
0.4.3 Plot 10 random images of both cats and dogs

```
[6]: train_cats_dir = f"{train_dir}/cats"
train_dogs_dir = f"{train_dir}/dogs"

cats_images = random.sample([f"{train_cats_dir}/{filename}" for filename in os.listdir(train_cats_dir)], 10)
dogs_images = random.sample([f"{train_dogs_dir}/{filename}" for filename in os.listdir(train_dogs_dir)], 10)

# Plot cat images
fig1, axes1 = plt.subplots(2, 5, figsize=(6, 3))
for i, img in enumerate(cats_images):
    axes1[i // 5, i % 5].imshow(plt.imread(img))
    axes1[i // 5, i % 5].axis("off")
plt.tight_layout()
plt.show()

# Plot dog images
fig2, axes2 = plt.subplots(2, 5, figsize=(6, 3))
for i, img in enumerate(dogs_images):
    axes2[i // 5, i % 5].imshow(plt.imread(img))
    axes2[i // 5, i % 5].axis("off")
plt.tight_layout()
plt.show()
```





0.5 Image Size

```
[7]: image = Image.open(cats_images[1])
print(f"Image size: {image.size}")

# Plot image_resized
plt.figure(figsize=(4, 4))
plt.imshow(image)
plt.title("Original Image")
plt.axis("off")
plt.show()
```

Image size: (500, 374)

Original Image



```
[8]: factors = [125, 150, 175, 200, 225, 250]
transformed_images = []
for factor in factors:
```

```

transformed_image = TF.resize(image, factor)
transformed_images.append(transformed_image)

plot_transformations(transformed_images, factors)

```



An image size of 225 seems good, however, for compatibility with pre-trained models we choose 224.

```
[9]: image_resized = TF.resize(image, 224)
```

0.6 Base Model

```

net_config0 = {**default_net_config,
    "cv_layers": [
        {"out_channels": 32, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": False},
        {"out_channels": 64, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": False},
        {"out_channels": 128, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": False},
        {"out_channels": 256, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": False},
    ],
    "fc_layers": [
        {"out_features": 256, "batch_norm": False, "dropout_rate": 0},
        {"out_features": 128, "batch_norm": False, "dropout_rate": 0},
    ]
}

config0 = [{**default_config, "label": "base_model", "n_epochs": 25, "net_config": net_config0, "transform_config": no_transform_config}]
results = result_handler(config0, device)
plot_scores(results)

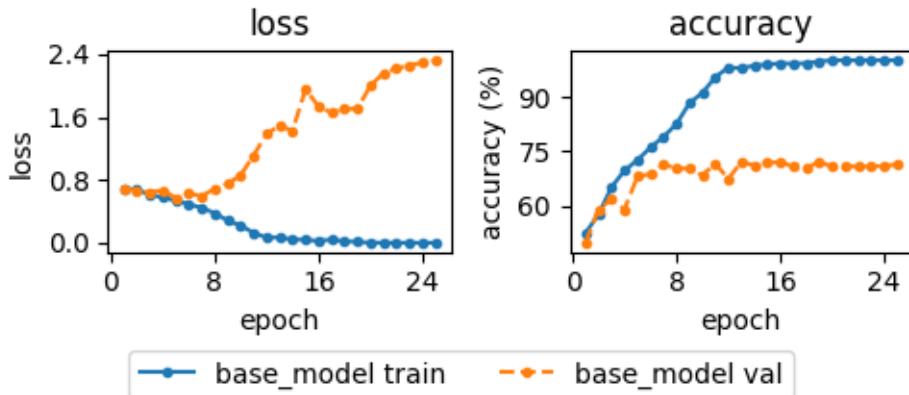
```

Experiment: base_model
Epoch 1/25 | Train Loss: 0.6952 (acc. 52.65%) | Val Loss: 0.6951 (acc. 50.00%) |
Time: 35s

```

Epoch 2/25 | Train Loss: 0.6737 (acc. 57.75%) | Val Loss: 0.6627 (acc. 59.17%) |
Time: 35s
Epoch 3/25 | Train Loss: 0.6153 (acc. 65.20%) | Val Loss: 0.6417 (acc. 61.83%) |
Time: 34s
Epoch 4/25 | Train Loss: 0.5763 (acc. 69.80%) | Val Loss: 0.6698 (acc. 59.17%) |
Time: 34s
Epoch 5/25 | Train Loss: 0.5369 (acc. 72.65%) | Val Loss: 0.5722 (acc. 68.17%) |
Time: 33s
Epoch 6/25 | Train Loss: 0.4914 (acc. 76.10%) | Val Loss: 0.6250 (acc. 68.83%) |
Time: 34s
Epoch 7/25 | Train Loss: 0.4459 (acc. 79.00%) | Val Loss: 0.5959 (acc. 71.50%) |
Time: 34s
Epoch 8/25 | Train Loss: 0.3771 (acc. 82.50%) | Val Loss: 0.6838 (acc. 70.33%) |
Time: 34s
Epoch 9/25 | Train Loss: 0.2845 (acc. 88.25%) | Val Loss: 0.7522 (acc. 70.33%) |
Time: 34s
Epoch 10/25 | Train Loss: 0.2194 (acc. 91.05%) | Val Loss: 0.8570 (acc. 68.50%) |
Time: 33s
Epoch 11/25 | Train Loss: 0.1277 (acc. 95.40%) | Val Loss: 1.1103 (acc. 71.67%) |
Time: 34s
Epoch 12/25 | Train Loss: 0.0657 (acc. 98.00%) | Val Loss: 1.3821 (acc. 67.50%) |
Time: 33s
Epoch 13/25 | Train Loss: 0.0685 (acc. 97.80%) | Val Loss: 1.4903 (acc. 72.17%) |
Time: 33s
Epoch 14/25 | Train Loss: 0.0439 (acc. 98.55%) | Val Loss: 1.4245 (acc. 71.17%) |
Time: 33s
Epoch 15/25 | Train Loss: 0.0373 (acc. 98.80%) | Val Loss: 1.9494 (acc. 71.83%) |
Time: 34s
Epoch 16/25 | Train Loss: 0.0244 (acc. 99.20%) | Val Loss: 1.7371 (acc. 72.17%) |
Time: 34s
Epoch 17/25 | Train Loss: 0.0406 (acc. 99.05%) | Val Loss: 1.6526 (acc. 70.83%) |
Time: 33s
Epoch 18/25 | Train Loss: 0.0201 (acc. 99.20%) | Val Loss: 1.7009 (acc. 70.50%) |
Time: 33s
Epoch 19/25 | Train Loss: 0.0110 (acc. 99.65%) | Val Loss: 1.7072 (acc. 72.17%) |
Time: 33s
Epoch 20/25 | Train Loss: 0.0020 (acc. 100.00%) | Val Loss: 1.9952 (acc. 70.83%) |
Time: 34s
Epoch 21/25 | Train Loss: 0.0004 (acc. 100.00%) | Val Loss: 2.1588 (acc. 71.00%) |
Time: 33s
Epoch 22/25 | Train Loss: 0.0002 (acc. 100.00%) | Val Loss: 2.2134 (acc. 70.83%) |
Time: 33s
Epoch 23/25 | Train Loss: 0.0001 (acc. 100.00%) | Val Loss: 2.2571 (acc. 71.00%) |
Time: 34s
Epoch 24/25 | Train Loss: 0.0001 (acc. 100.00%) | Val Loss: 2.2897 (acc. 71.00%) |
Time: 33s
Epoch 25/25 | Train Loss: 0.0001 (acc. 100.00%) | Val Loss: 2.3216 (acc. 71.50%) |
Time: 33s
Training Time: 840s

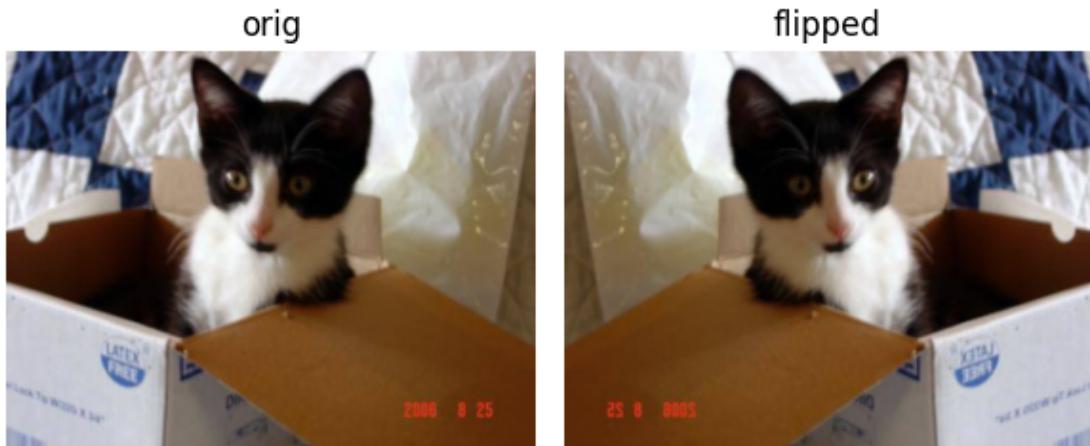
```



0.7 Data Augmentation

0.7.1 Flip

```
[11]: transformed_images = []
transformed_images.append(image_resized)
transformed_images.append(TF.hflip(image_resized))
plot_transformations(transformed_images, ["orig", "flipped"])
```



```
[12]: transformed_images = []
transformed_images.append(image_resized)
transformed_images.append(TF.vflip(image_resized))
plot_transformations(transformed_images, ["orig", "flipped"])
```



Choose to only horizontal flip.

0.7.2 Image color

Brightness

```
[13]: factors = [0.6, 0.8, 1.0, 1.2, 1.4]
```

```
transformed_images = []
for factor in factors:
    transformed_image = TF.adjust_brightness(image_resized, factor)
    transformed_images.append(transformed_image)

plot_transformations(transformed_images, factors)
```



Contrast

```
[14]: factors = [0.4, 0.6, 0.8, 1.0, 1.2, 1.4]

transformed_images = []
for factor in factors:
    transformed_image = TF.adjust_contrast(image_resized, factor)
    transformed_images.append(transformed_image)

plot_transformations(transformed_images, factors)
```



Saturation

```
[15]: factors = [0.2, 0.8, 1.0, 1.2, 1.6, 2.0]

transformed_images = []
for factor in factors:
    transformed_image = TF.adjust_saturation(image_resized, factor)
    transformed_images.append(transformed_image)

plot_transformations(transformed_images, factors)
```



```
Hue  
[16]: factors = [0.2, 0.1, 0, -0.1, -0.2]
```

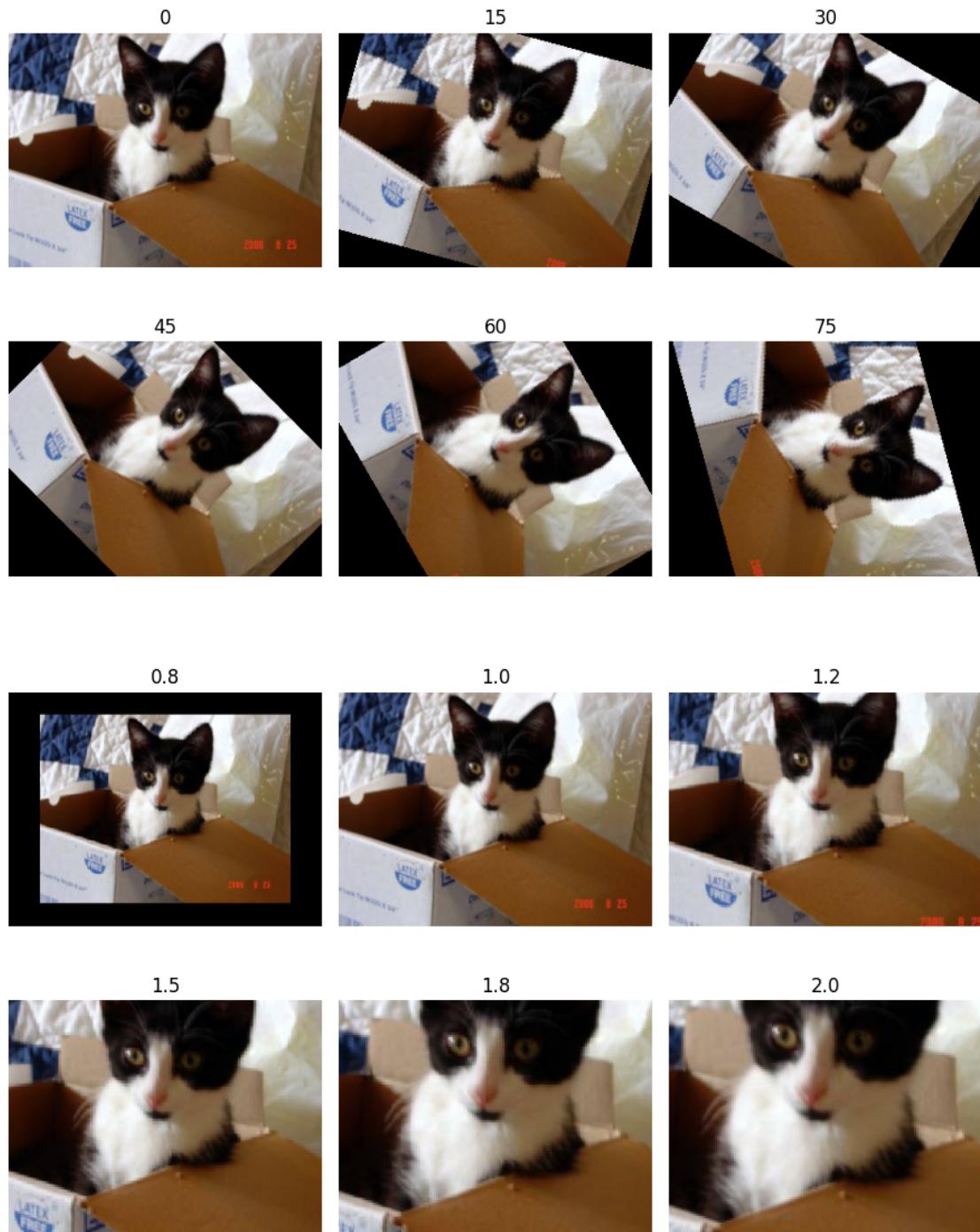
```
transformed_images = []  
for factor in factors:  
    transformed_image = TF.adjust_hue(image_resized, factor)  
    transformed_images.append(transformed_image)  
  
plot_transformations(transformed_images, factors)
```



0.7.3 Affine (rotation, scaling, translation, shearing)

```
[17]: def apply_affine(image, angle, translate=(0, 0), scale=1.0, shear=0):  
    return TF.affine(image, angle=angle, translate=translate, scale=scale, shear=shear)  
  
    # Rotation  
    angles = [0, 15, 30, 45, 60, 75]  
    transformed_images = [apply_affine(image_resized, angle=angle) for angle in angles]  
    plot_transformations(transformed_images, angles)  
  
    # Scales  
    scales = [0.8, 1.0, 1.2, 1.5, 1.8, 2.0]  
    transformed_images = [apply_affine(image_resized, angle=0, scale=scale) for scale in scales]  
    plot_transformations(transformed_images, scales)  
  
    # Translations  
    translations = [(-10, 0), (10, 0), (20, 0), (30, 0), (40, 0), (50, 0)]  
    transformed_images = [apply_affine(image_resized, angle=0, translate=translate) for translate in  
    ↪translations]  
    plot_transformations(transformed_images, [t[0] for t in translations])  
  
    # Shear  
    shears = [0, 10, 20, 30, 40, 50]
```

```
transformed_images = [apply_affine(image_resized, angle=0, shear=shear) for shear in shears]
plot_transformations(transformed_images, shears)
```





0.7.4 Final loader

With normalization

```
[18]: train_loader = get_train_loader()
images, _ = next(iter(train_loader))
fig, axes = plt.subplots(2, 5, figsize=(10, 5))
for i in range(10):
    img = images[i].permute(1, 2, 0).cpu().numpy() # convert to (H, W, C)
```

```

img = img.clip(0, 1) # clip values to [0, 1]
axes[i // 5, i % 5].imshow(img)
axes[i // 5, i % 5].axis("off")
plt.tight_layout()
plt.show()

```

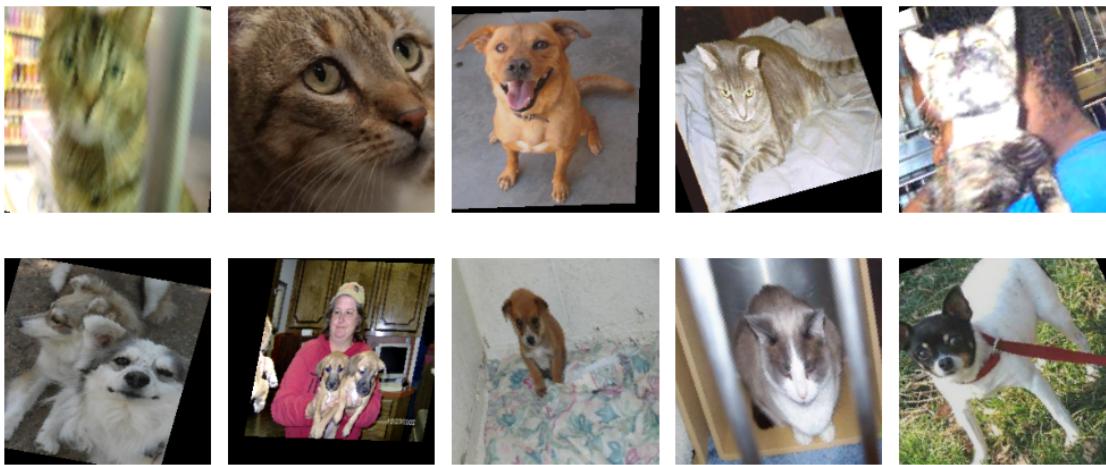


Without normalization

```

[19]: train_loader = get_train_loader()
images, _ = next(iter(train_loader))
fig, axes = plt.subplots(2, 5, figsize=(10, 5))
for i in range(10):
    axes[i // 5, i % 5].imshow(denormalize_image(images[i]).permute(1, 2, 0)) # denormalize and convert to
    ↪ (H, W, C)
    axes[i // 5, i % 5].axis("off")
plt.tight_layout()
plt.show()

```



0.8 With Data Augmentation

```
[20]: config0 = [**default_config, "label": "w_augmentation", "net_config": net_config0}]
results = result_handler(config0, device)
plot_scores(results)
```

```
Experiment: w_augmentation
Epoch 1/120 | Train Loss: 0.6994 (acc. 51.70%) | Val Loss: 0.6878 (acc. 60.17%)
| Time: 34s
Epoch 2/120 | Train Loss: 0.6895 (acc. 53.75%) | Val Loss: 0.6895 (acc. 50.33%)
| Time: 34s
Epoch 3/120 | Train Loss: 0.6801 (acc. 54.30%) | Val Loss: 0.6847 (acc. 55.33%)
| Time: 34s
Epoch 4/120 | Train Loss: 0.6598 (acc. 59.65%) | Val Loss: 0.6549 (acc. 60.83%)
| Time: 33s
Epoch 5/120 | Train Loss: 0.6371 (acc. 64.40%) | Val Loss: 0.6706 (acc. 61.67%)
| Time: 34s
Epoch 6/120 | Train Loss: 0.6208 (acc. 65.10%) | Val Loss: 0.6582 (acc. 62.33%)
| Time: 34s
Epoch 7/120 | Train Loss: 0.6096 (acc. 66.50%) | Val Loss: 0.6502 (acc. 65.00%)
| Time: 34s
Epoch 8/120 | Train Loss: 0.5936 (acc. 67.80%) | Val Loss: 0.6547 (acc. 66.00%)
| Time: 34s
Epoch 9/120 | Train Loss: 0.5776 (acc. 69.35%) | Val Loss: 0.5995 (acc. 68.83%)
| Time: 33s
Epoch 10/120 | Train Loss: 0.5514 (acc. 70.85%) | Val Loss: 0.6134 (acc. 68.83%)
| Time: 34s
Epoch 11/120 | Train Loss: 0.5418 (acc. 71.05%) | Val Loss: 0.5918 (acc. 71.00%)
| Time: 34s
Epoch 12/120 | Train Loss: 0.5302 (acc. 72.05%) | Val Loss: 0.5703 (acc. 71.17%)
| Time: 34s
Epoch 13/120 | Train Loss: 0.5586 (acc. 70.55%) | Val Loss: 0.5582 (acc. 71.33%)
| Time: 34s
Epoch 14/120 | Train Loss: 0.5514 (acc. 71.90%) | Val Loss: 0.5450 (acc. 73.17%)
| Time: 34s
Epoch 15/120 | Train Loss: 0.5221 (acc. 73.55%) | Val Loss: 0.5334 (acc. 72.33%)
| Time: 34s
Epoch 16/120 | Train Loss: 0.4971 (acc. 76.05%) | Val Loss: 0.5384 (acc. 75.00%)
| Time: 34s
Epoch 17/120 | Train Loss: 0.5000 (acc. 76.45%) | Val Loss: 0.5475 (acc. 72.83%)
| Time: 34s
Epoch 18/120 | Train Loss: 0.4822 (acc. 77.20%) | Val Loss: 0.5633 (acc. 72.33%)
| Time: 34s
Epoch 19/120 | Train Loss: 0.4796 (acc. 77.05%) | Val Loss: 0.5226 (acc. 77.83%)
| Time: 34s
Epoch 20/120 | Train Loss: 0.4964 (acc. 76.40%) | Val Loss: 0.5302 (acc. 74.00%)
| Time: 34s
Epoch 21/120 | Train Loss: 0.4484 (acc. 78.90%) | Val Loss: 0.6042 (acc. 74.00%)
| Time: 34s
Epoch 22/120 | Train Loss: 0.4650 (acc. 79.00%) | Val Loss: 0.5727 (acc. 70.17%)
| Time: 34s
Epoch 23/120 | Train Loss: 0.4698 (acc. 77.70%) | Val Loss: 0.5292 (acc. 75.83%)
| Time: 33s
Epoch 24/120 | Train Loss: 0.4604 (acc. 78.50%) | Val Loss: 0.4854 (acc. 77.67%)
| Time: 34s
Epoch 25/120 | Train Loss: 0.4516 (acc. 78.15%) | Val Loss: 0.5270 (acc. 76.00%)
| Time: 34s
Epoch 26/120 | Train Loss: 0.4324 (acc. 79.65%) | Val Loss: 0.4821 (acc. 77.17%)
| Time: 34s
Epoch 27/120 | Train Loss: 0.4048 (acc. 80.90%) | Val Loss: 0.4799 (acc. 79.83%)
| Time: 34s
Epoch 28/120 | Train Loss: 0.4169 (acc. 80.40%) | Val Loss: 0.5001 (acc. 80.50%)
| Time: 34s
Epoch 29/120 | Train Loss: 0.4174 (acc. 79.10%) | Val Loss: 0.4819 (acc. 80.00%)
| Time: 34s
Epoch 30/120 | Train Loss: 0.3744 (acc. 83.40%) | Val Loss: 0.5007 (acc. 80.67%)
| Time: 34s
```

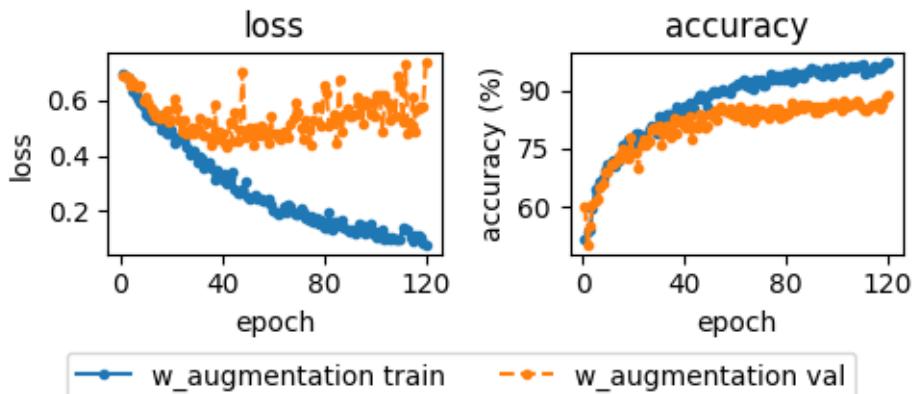
Epoch 31/120 | Train Loss: 0.3946 (acc. 82.45%) | Val Loss: 0.5338 (acc. 75.83%)
| Time: 34s
Epoch 32/120 | Train Loss: 0.3896 (acc. 82.05%) | Val Loss: 0.4811 (acc. 79.00%)
| Time: 34s
Epoch 33/120 | Train Loss: 0.3570 (acc. 83.80%) | Val Loss: 0.4761 (acc. 80.67%)
| Time: 34s
Epoch 34/120 | Train Loss: 0.3720 (acc. 83.80%) | Val Loss: 0.5233 (acc. 81.00%)
| Time: 34s
Epoch 35/120 | Train Loss: 0.3777 (acc. 83.05%) | Val Loss: 0.4648 (acc. 78.00%)
| Time: 34s
Epoch 36/120 | Train Loss: 0.3590 (acc. 84.55%) | Val Loss: 0.4369 (acc. 82.83%)
| Time: 34s
Epoch 37/120 | Train Loss: 0.3132 (acc. 85.80%) | Val Loss: 0.5858 (acc. 78.67%)
| Time: 34s
Epoch 38/120 | Train Loss: 0.3517 (acc. 83.70%) | Val Loss: 0.4601 (acc. 81.67%)
| Time: 34s
Epoch 39/120 | Train Loss: 0.3332 (acc. 84.80%) | Val Loss: 0.4874 (acc. 82.33%)
| Time: 34s
Epoch 40/120 | Train Loss: 0.3167 (acc. 85.80%) | Val Loss: 0.4798 (acc. 80.83%)
| Time: 33s
Epoch 41/120 | Train Loss: 0.3366 (acc. 84.85%) | Val Loss: 0.4495 (acc. 80.50%)
| Time: 34s
Epoch 42/120 | Train Loss: 0.3023 (acc. 86.95%) | Val Loss: 0.4302 (acc. 83.50%)
| Time: 34s
Epoch 43/120 | Train Loss: 0.3226 (acc. 86.00%) | Val Loss: 0.5216 (acc. 77.67%)
| Time: 34s
Epoch 44/120 | Train Loss: 0.3410 (acc. 85.15%) | Val Loss: 0.4522 (acc. 81.00%)
| Time: 34s
Epoch 45/120 | Train Loss: 0.2803 (acc. 87.95%) | Val Loss: 0.5553 (acc. 80.50%)
| Time: 34s
Epoch 46/120 | Train Loss: 0.2632 (acc. 88.60%) | Val Loss: 0.4526 (acc. 83.83%)
| Time: 34s
Epoch 47/120 | Train Loss: 0.2690 (acc. 88.90%) | Val Loss: 0.4936 (acc. 83.00%)
| Time: 34s
Epoch 48/120 | Train Loss: 0.2800 (acc. 87.25%) | Val Loss: 0.7044 (acc. 80.50%)
| Time: 34s
Epoch 49/120 | Train Loss: 0.3054 (acc. 85.70%) | Val Loss: 0.4693 (acc. 80.83%)
| Time: 34s
Epoch 50/120 | Train Loss: 0.2540 (acc. 88.55%) | Val Loss: 0.4721 (acc. 83.67%)
| Time: 34s
Epoch 51/120 | Train Loss: 0.2448 (acc. 89.65%) | Val Loss: 0.5040 (acc. 83.17%)
| Time: 34s
Epoch 52/120 | Train Loss: 0.2511 (acc. 89.60%) | Val Loss: 0.4375 (acc. 84.83%)
| Time: 34s
Epoch 53/120 | Train Loss: 0.2566 (acc. 89.35%) | Val Loss: 0.5014 (acc. 82.17%)
| Time: 33s
Epoch 54/120 | Train Loss: 0.2481 (acc. 89.65%) | Val Loss: 0.4713 (acc. 85.67%)
| Time: 34s
Epoch 55/120 | Train Loss: 0.2428 (acc. 90.40%) | Val Loss: 0.5083 (acc. 84.83%)
| Time: 34s
Epoch 56/120 | Train Loss: 0.2408 (acc. 89.80%) | Val Loss: 0.4770 (acc. 84.83%)
| Time: 34s
Epoch 57/120 | Train Loss: 0.2381 (acc. 89.55%) | Val Loss: 0.4902 (acc. 84.33%)
| Time: 34s
Epoch 58/120 | Train Loss: 0.2443 (acc. 89.10%) | Val Loss: 0.4495 (acc. 85.17%)
| Time: 34s
Epoch 59/120 | Train Loss: 0.2241 (acc. 90.75%) | Val Loss: 0.5438 (acc. 83.83%)
| Time: 34s
Epoch 60/120 | Train Loss: 0.2040 (acc. 91.30%) | Val Loss: 0.4785 (acc. 83.17%)
| Time: 34s
Epoch 61/120 | Train Loss: 0.1963 (acc. 91.95%) | Val Loss: 0.4777 (acc. 84.67%)
| Time: 34s
Epoch 62/120 | Train Loss: 0.1884 (acc. 91.75%) | Val Loss: 0.4696 (acc. 85.67%)
| Time: 33s
Epoch 63/120 | Train Loss: 0.1929 (acc. 92.90%) | Val Loss: 0.4613 (acc. 82.33%)
| Time: 34s
Epoch 64/120 | Train Loss: 0.2146 (acc. 91.05%) | Val Loss: 0.4857 (acc. 83.50%)
| Time: 33s

```
Epoch 65/120 | Train Loss: 0.1977 (acc. 92.10%) | Val Loss: 0.4766 (acc. 84.67%)
| Time: 34s
Epoch 66/120 | Train Loss: 0.2258 (acc. 90.85%) | Val Loss: 0.4648 (acc. 82.67%)
| Time: 34s
Epoch 67/120 | Train Loss: 0.2171 (acc. 90.50%) | Val Loss: 0.5159 (acc. 82.00%)
| Time: 33s
Epoch 68/120 | Train Loss: 0.1954 (acc. 92.65%) | Val Loss: 0.5347 (acc. 85.33%)
| Time: 34s
Epoch 69/120 | Train Loss: 0.1857 (acc. 92.35%) | Val Loss: 0.5925 (acc. 83.33%)
| Time: 34s
Epoch 70/120 | Train Loss: 0.1920 (acc. 92.65%) | Val Loss: 0.5608 (acc. 85.00%)
| Time: 34s
Epoch 71/120 | Train Loss: 0.2130 (acc. 91.45%) | Val Loss: 0.5002 (acc. 84.33%)
| Time: 34s
Epoch 72/120 | Train Loss: 0.1979 (acc. 91.45%) | Val Loss: 0.4596 (acc. 84.00%)
| Time: 34s
Epoch 73/120 | Train Loss: 0.1767 (acc. 92.95%) | Val Loss: 0.5268 (acc. 83.00%)
| Time: 34s
Epoch 74/120 | Train Loss: 0.1656 (acc. 94.20%) | Val Loss: 0.4926 (acc. 84.83%)
| Time: 34s
Epoch 75/120 | Train Loss: 0.1819 (acc. 92.65%) | Val Loss: 0.4421 (acc. 85.17%)
| Time: 34s
Epoch 76/120 | Train Loss: 0.1640 (acc. 93.85%) | Val Loss: 0.5294 (acc. 83.67%)
| Time: 34s
Epoch 77/120 | Train Loss: 0.1723 (acc. 92.85%) | Val Loss: 0.5780 (acc. 85.17%)
| Time: 34s
Epoch 78/120 | Train Loss: 0.1559 (acc. 93.60%) | Val Loss: 0.5791 (acc. 82.83%)
| Time: 34s
Epoch 79/120 | Train Loss: 0.1657 (acc. 92.95%) | Val Loss: 0.5074 (acc. 83.50%)
| Time: 34s
Epoch 80/120 | Train Loss: 0.1373 (acc. 94.05%) | Val Loss: 0.6580 (acc. 84.17%)
| Time: 34s
Epoch 81/120 | Train Loss: 0.1428 (acc. 94.15%) | Val Loss: 0.6294 (acc. 83.67%)
| Time: 34s
Epoch 82/120 | Train Loss: 0.1931 (acc. 92.45%) | Val Loss: 0.5093 (acc. 86.67%)
| Time: 34s
Epoch 83/120 | Train Loss: 0.1341 (acc. 94.80%) | Val Loss: 0.5239 (acc. 85.33%)
| Time: 33s
Epoch 84/120 | Train Loss: 0.1632 (acc. 93.45%) | Val Loss: 0.5531 (acc. 85.00%)
| Time: 34s
Epoch 85/120 | Train Loss: 0.1598 (acc. 93.85%) | Val Loss: 0.4482 (acc. 85.67%)
| Time: 34s
Epoch 86/120 | Train Loss: 0.1448 (acc. 94.25%) | Val Loss: 0.6787 (acc. 86.33%)
| Time: 34s
Epoch 87/120 | Train Loss: 0.1676 (acc. 93.40%) | Val Loss: 0.4874 (acc. 85.17%)
| Time: 34s
Epoch 88/120 | Train Loss: 0.1412 (acc. 94.55%) | Val Loss: 0.5527 (acc. 86.17%)
| Time: 34s
Epoch 89/120 | Train Loss: 0.1353 (acc. 94.55%) | Val Loss: 0.5746 (acc. 85.67%)
| Time: 34s
Epoch 90/120 | Train Loss: 0.1245 (acc. 95.55%) | Val Loss: 0.5443 (acc. 85.67%)
| Time: 34s
Epoch 91/120 | Train Loss: 0.1351 (acc. 95.00%) | Val Loss: 0.5426 (acc. 84.17%)
| Time: 35s
Epoch 92/120 | Train Loss: 0.1204 (acc. 95.25%) | Val Loss: 0.5516 (acc. 86.00%)
| Time: 34s
Epoch 93/120 | Train Loss: 0.1281 (acc. 94.30%) | Val Loss: 0.6152 (acc. 84.17%)
| Time: 34s
Epoch 94/120 | Train Loss: 0.1511 (acc. 93.95%) | Val Loss: 0.5863 (acc. 86.00%)
| Time: 34s
Epoch 95/120 | Train Loss: 0.1466 (acc. 94.25%) | Val Loss: 0.5165 (acc. 85.17%)
| Time: 34s
Epoch 96/120 | Train Loss: 0.1164 (acc. 95.45%) | Val Loss: 0.5992 (acc. 86.00%)
| Time: 33s
Epoch 97/120 | Train Loss: 0.1358 (acc. 94.60%) | Val Loss: 0.5839 (acc. 85.67%)
| Time: 34s
Epoch 98/120 | Train Loss: 0.1526 (acc. 93.85%) | Val Loss: 0.5531 (acc. 86.67%)
| Time: 34s
```

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Epoch 99/120 | Train Loss: 0.1201 (acc. 95.60%) | Val Loss: 0.5915 (acc. 86.67%)
| Time: 34s
Epoch 100/120 | Train Loss: 0.1278 (acc. 94.75%) | Val Loss: 0.5410 (acc.
86.50%) | Time: 34s
Epoch 101/120 | Train Loss: 0.1037 (acc. 95.50%) | Val Loss: 0.6229 (acc.
85.83%) | Time: 34s
Epoch 102/120 | Train Loss: 0.1052 (acc. 96.05%) | Val Loss: 0.6190 (acc.
84.67%) | Time: 34s
Epoch 103/120 | Train Loss: 0.1343 (acc. 94.55%) | Val Loss: 0.4870 (acc.
87.17%) | Time: 34s
Epoch 104/120 | Train Loss: 0.1016 (acc. 95.80%) | Val Loss: 0.6222 (acc.
85.67%) | Time: 34s
Epoch 105/120 | Train Loss: 0.1025 (acc. 95.90%) | Val Loss: 0.5933 (acc.
86.33%) | Time: 34s
Epoch 106/120 | Train Loss: 0.1005 (acc. 96.00%) | Val Loss: 0.5320 (acc.
86.50%) | Time: 34s
Epoch 107/120 | Train Loss: 0.1053 (acc. 95.80%) | Val Loss: 0.5832 (acc.
86.67%) | Time: 34s
Epoch 108/120 | Train Loss: 0.0956 (acc. 96.05%) | Val Loss: 0.5449 (acc.
87.33%) | Time: 34s
Epoch 109/120 | Train Loss: 0.0990 (acc. 96.30%) | Val Loss: 0.6869 (acc.
86.33%) | Time: 34s
Epoch 110/120 | Train Loss: 0.1009 (acc. 96.60%) | Val Loss: 0.6611 (acc.
85.50%) | Time: 34s
Epoch 111/120 | Train Loss: 0.1411 (acc. 94.25%) | Val Loss: 0.5240 (acc.
85.00%) | Time: 34s
Epoch 112/120 | Train Loss: 0.1319 (acc. 94.55%) | Val Loss: 0.7344 (acc.
84.67%) | Time: 34s
Epoch 113/120 | Train Loss: 0.1309 (acc. 94.85%) | Val Loss: 0.4805 (acc.
86.00%) | Time: 34s
Epoch 114/120 | Train Loss: 0.1069 (acc. 95.80%) | Val Loss: 0.5167 (acc.
86.50%) | Time: 34s
Epoch 115/120 | Train Loss: 0.0910 (acc. 96.20%) | Val Loss: 0.6112 (acc.
86.17%) | Time: 34s
Epoch 116/120 | Train Loss: 0.1115 (acc. 95.60%) | Val Loss: 0.4870 (acc.
87.00%) | Time: 34s
Epoch 117/120 | Train Loss: 0.1119 (acc. 95.45%) | Val Loss: 0.5688 (acc.
85.17%) | Time: 34s
Epoch 118/120 | Train Loss: 0.1028 (acc. 96.25%) | Val Loss: 0.5792 (acc.
86.50%) | Time: 34s
Epoch 119/120 | Train Loss: 0.0835 (acc. 96.95%) | Val Loss: 0.5764 (acc.
88.50%) | Time: 34s
Epoch 120/120 | Train Loss: 0.0785 (acc. 97.15%) | Val Loss: 0.7381 (acc.
88.83%) | Time: 34s
Training Time: 4035s

```



0.9 Regularization

```
[21]: net_config1 = {**default_net_config,
    "cv_layers": [
        {"out_channels": 32, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
        {"out_channels": 64, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
        {"out_channels": 128, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
        {"out_channels": 256, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
    ],
    "fc_layers": [
        {"out_features": 256, "batch_norm": True, "dropout_rate": 0.4},
        {"out_features": 128, "batch_norm": True, "dropout_rate": 0.2},
    ]
}

train_config1 = {**default_train_config, "step_size": 25, "gamma": 0.5, "weight_decay": 1e-4}

configs1 = [
    {**default_config, "label": "reg_1", "net_config": net_config1},
    {**default_config, "label": "reg_2", "net_config": net_config1, "train_config": train_config1},
]

results = result_handler(configs1, device)
plot_scores(results)
```

Experiment: reg_1
Epoch 1/120 | Train Loss: 0.6962 (acc. 56.95%) | Val Loss: 0.8926 (acc. 54.83%)
| Time: 34s
Epoch 2/120 | Train Loss: 0.6597 (acc. 58.95%) | Val Loss: 0.6464 (acc. 63.17%)
| Time: 34s
Epoch 3/120 | Train Loss: 0.6288 (acc. 64.65%) | Val Loss: 0.6925 (acc. 56.33%)
| Time: 34s
Epoch 4/120 | Train Loss: 0.5979 (acc. 67.80%) | Val Loss: 0.6143 (acc. 61.50%)
| Time: 34s
Epoch 5/120 | Train Loss: 0.5828 (acc. 68.55%) | Val Loss: 0.6010 (acc. 70.17%)
| Time: 34s
Epoch 6/120 | Train Loss: 0.5800 (acc. 68.15%) | Val Loss: 0.6204 (acc. 69.33%)
| Time: 34s
Epoch 7/120 | Train Loss: 0.5622 (acc. 70.75%) | Val Loss: 0.6065 (acc. 68.17%)
| Time: 34s
Epoch 8/120 | Train Loss: 0.5561 (acc. 72.35%) | Val Loss: 0.5784 (acc. 71.33%)
| Time: 34s
Epoch 9/120 | Train Loss: 0.5447 (acc. 72.15%) | Val Loss: 0.5474 (acc. 71.67%)
| Time: 34s
Epoch 10/120 | Train Loss: 0.5238 (acc. 73.80%) | Val Loss: 0.6497 (acc. 66.00%)
| Time: 34s
Epoch 11/120 | Train Loss: 0.5209 (acc. 74.15%) | Val Loss: 0.5724 (acc. 71.17%)
| Time: 34s
Epoch 12/120 | Train Loss: 0.5160 (acc. 73.65%) | Val Loss: 0.6286 (acc. 67.50%)
| Time: 34s
Epoch 13/120 | Train Loss: 0.5104 (acc. 74.75%) | Val Loss: 0.6504 (acc. 68.50%)
| Time: 34s
Epoch 14/120 | Train Loss: 0.4879 (acc. 75.85%) | Val Loss: 0.5559 (acc. 73.50%)
| Time: 34s
Epoch 15/120 | Train Loss: 0.4844 (acc. 76.60%) | Val Loss: 0.5910 (acc. 72.17%)
| Time: 34s
Epoch 16/120 | Train Loss: 0.4893 (acc. 76.20%) | Val Loss: 0.6220 (acc. 70.50%)
| Time: 34s
Epoch 17/120 | Train Loss: 0.4809 (acc. 77.30%) | Val Loss: 0.5460 (acc. 71.00%)
| Time: 34s
Epoch 18/120 | Train Loss: 0.4896 (acc. 76.25%) | Val Loss: 0.5584 (acc. 71.00%)
| Time: 34s
Epoch 19/120 | Train Loss: 0.4742 (acc. 77.50%) | Val Loss: 0.5032 (acc. 75.67%)

```
| Time: 34s
Epoch 20/120 | Train Loss: 0.4576 (acc. 78.55%) | Val Loss: 0.4965 (acc. 75.83%)
| Time: 34s
Epoch 21/120 | Train Loss: 0.4478 (acc. 78.45%) | Val Loss: 0.5090 (acc. 75.33%)
| Time: 34s
Epoch 22/120 | Train Loss: 0.4220 (acc. 81.10%) | Val Loss: 0.5131 (acc. 77.83%)
| Time: 34s
Epoch 23/120 | Train Loss: 0.4385 (acc. 79.40%) | Val Loss: 0.5742 (acc. 71.17%)
| Time: 34s
Epoch 24/120 | Train Loss: 0.4452 (acc. 78.00%) | Val Loss: 0.5460 (acc. 72.67%)
| Time: 34s
Epoch 25/120 | Train Loss: 0.4184 (acc. 81.15%) | Val Loss: 0.4871 (acc. 77.00%)
| Time: 34s
Epoch 26/120 | Train Loss: 0.4355 (acc. 80.25%) | Val Loss: 0.4897 (acc. 77.67%)
| Time: 34s
Epoch 27/120 | Train Loss: 0.4517 (acc. 79.40%) | Val Loss: 0.4839 (acc. 75.33%)
| Time: 34s
Epoch 28/120 | Train Loss: 0.4137 (acc. 82.15%) | Val Loss: 0.4873 (acc. 76.67%)
| Time: 34s
Epoch 29/120 | Train Loss: 0.4234 (acc. 80.20%) | Val Loss: 0.6243 (acc. 69.50%)
| Time: 34s
Epoch 30/120 | Train Loss: 0.4175 (acc. 81.00%) | Val Loss: 0.4784 (acc. 78.00%)
| Time: 34s
Epoch 31/120 | Train Loss: 0.3980 (acc. 81.00%) | Val Loss: 0.4372 (acc. 80.67%)
| Time: 34s
Epoch 32/120 | Train Loss: 0.3954 (acc. 81.20%) | Val Loss: 0.5249 (acc. 76.83%)
| Time: 34s
Epoch 33/120 | Train Loss: 0.3764 (acc. 82.85%) | Val Loss: 0.4968 (acc. 76.67%)
| Time: 34s
Epoch 34/120 | Train Loss: 0.3727 (acc. 84.40%) | Val Loss: 0.4571 (acc. 80.17%)
| Time: 34s
Epoch 35/120 | Train Loss: 0.3894 (acc. 82.70%) | Val Loss: 0.4526 (acc. 79.33%)
| Time: 34s
Epoch 36/120 | Train Loss: 0.3736 (acc. 82.20%) | Val Loss: 0.4761 (acc. 78.33%)
| Time: 34s
Epoch 37/120 | Train Loss: 0.3521 (acc. 84.20%) | Val Loss: 0.4387 (acc. 81.00%)
| Time: 34s
Epoch 38/120 | Train Loss: 0.3841 (acc. 82.60%) | Val Loss: 0.4475 (acc. 80.83%)
| Time: 34s
Epoch 39/120 | Train Loss: 0.3636 (acc. 84.70%) | Val Loss: 0.4355 (acc. 80.50%)
| Time: 34s
Epoch 40/120 | Train Loss: 0.3646 (acc. 84.25%) | Val Loss: 0.4286 (acc. 80.67%)
| Time: 34s
Epoch 41/120 | Train Loss: 0.3341 (acc. 85.10%) | Val Loss: 0.4978 (acc. 79.33%)
| Time: 34s
Epoch 42/120 | Train Loss: 0.3456 (acc. 85.15%) | Val Loss: 0.4592 (acc. 81.50%)
| Time: 34s
Epoch 43/120 | Train Loss: 0.3361 (acc. 86.00%) | Val Loss: 0.6471 (acc. 70.50%)
| Time: 34s
Epoch 44/120 | Train Loss: 0.3250 (acc. 85.95%) | Val Loss: 0.4087 (acc. 81.50%)
| Time: 34s
Epoch 45/120 | Train Loss: 0.3379 (acc. 85.60%) | Val Loss: 0.4383 (acc. 79.83%)
| Time: 34s
Epoch 46/120 | Train Loss: 0.3135 (acc. 86.95%) | Val Loss: 0.4213 (acc. 82.33%)
| Time: 34s
Epoch 47/120 | Train Loss: 0.3069 (acc. 86.90%) | Val Loss: 0.4665 (acc. 80.67%)
| Time: 34s
Epoch 48/120 | Train Loss: 0.3151 (acc. 86.00%) | Val Loss: 0.4264 (acc. 80.67%)
| Time: 34s
Epoch 49/120 | Train Loss: 0.3276 (acc. 86.00%) | Val Loss: 0.3953 (acc. 83.17%)
| Time: 34s
Epoch 50/120 | Train Loss: 0.3132 (acc. 86.35%) | Val Loss: 0.4257 (acc. 82.50%)
| Time: 34s
Epoch 51/120 | Train Loss: 0.3066 (acc. 87.05%) | Val Loss: 0.5127 (acc. 78.83%)
| Time: 34s
Epoch 52/120 | Train Loss: 0.3112 (acc. 86.45%) | Val Loss: 0.5312 (acc. 78.50%)
| Time: 34s
Epoch 53/120 | Train Loss: 0.3156 (acc. 86.65%) | Val Loss: 0.3942 (acc. 83.50%)
```

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| Time: 34s
Epoch 54/120 | Train Loss: 0.3116 (acc. 86.35%) | Val Loss: 0.4176 (acc. 81.83%)
| Time: 34s
Epoch 55/120 | Train Loss: 0.2975 (acc. 87.35%) | Val Loss: 0.4386 (acc. 83.50%)
| Time: 34s
Epoch 56/120 | Train Loss: 0.3050 (acc. 86.00%) | Val Loss: 0.7170 (acc. 74.00%)
| Time: 34s
Epoch 57/120 | Train Loss: 0.3050 (acc. 87.30%) | Val Loss: 0.4180 (acc. 80.67%)
| Time: 34s
Epoch 58/120 | Train Loss: 0.3050 (acc. 87.45%) | Val Loss: 0.4370 (acc. 83.00%)
| Time: 34s
Epoch 59/120 | Train Loss: 0.3016 (acc. 87.30%) | Val Loss: 0.3755 (acc. 83.50%)
| Time: 34s
Epoch 60/120 | Train Loss: 0.2823 (acc. 87.10%) | Val Loss: 0.4339 (acc. 82.50%)
| Time: 34s
Epoch 61/120 | Train Loss: 0.2761 (acc. 88.35%) | Val Loss: 0.4827 (acc. 80.83%)
| Time: 34s
Epoch 62/120 | Train Loss: 0.2846 (acc. 87.85%) | Val Loss: 0.4043 (acc. 84.00%)
| Time: 34s
Epoch 63/120 | Train Loss: 0.3026 (acc. 86.60%) | Val Loss: 0.4255 (acc. 81.83%)
| Time: 34s
Epoch 64/120 | Train Loss: 0.2699 (acc. 88.85%) | Val Loss: 0.5582 (acc. 81.83%)
| Time: 34s
Epoch 65/120 | Train Loss: 0.2812 (acc. 87.60%) | Val Loss: 0.4267 (acc. 84.67%)
| Time: 34s
Epoch 66/120 | Train Loss: 0.2652 (acc. 89.10%) | Val Loss: 0.4230 (acc. 83.00%)
| Time: 34s
Epoch 67/120 | Train Loss: 0.2534 (acc. 89.50%) | Val Loss: 0.4107 (acc. 84.50%)
| Time: 34s
Epoch 68/120 | Train Loss: 0.2712 (acc. 88.05%) | Val Loss: 0.3898 (acc. 83.83%)
| Time: 34s
Epoch 69/120 | Train Loss: 0.2681 (acc. 88.85%) | Val Loss: 0.4008 (acc. 83.00%)
| Time: 34s
Epoch 70/120 | Train Loss: 0.2444 (acc. 89.45%) | Val Loss: 0.3871 (acc. 85.33%)
| Time: 34s
Epoch 71/120 | Train Loss: 0.2469 (acc. 89.15%) | Val Loss: 0.4005 (acc. 83.00%)
| Time: 34s
Epoch 72/120 | Train Loss: 0.2669 (acc. 89.15%) | Val Loss: 0.3852 (acc. 82.83%)
| Time: 34s
Epoch 73/120 | Train Loss: 0.2582 (acc. 88.95%) | Val Loss: 0.3484 (acc. 87.33%)
| Time: 34s
Epoch 74/120 | Train Loss: 0.2702 (acc. 89.15%) | Val Loss: 0.3432 (acc. 86.67%)
| Time: 34s
Epoch 75/120 | Train Loss: 0.2332 (acc. 90.90%) | Val Loss: 0.4229 (acc. 84.33%)
| Time: 34s
Epoch 76/120 | Train Loss: 0.2543 (acc. 89.50%) | Val Loss: 0.4300 (acc. 84.33%)
| Time: 34s
Epoch 77/120 | Train Loss: 0.2333 (acc. 90.00%) | Val Loss: 0.4691 (acc. 83.50%)
| Time: 34s
Epoch 78/120 | Train Loss: 0.2250 (acc. 90.50%) | Val Loss: 0.4165 (acc. 84.67%)
| Time: 34s
Epoch 79/120 | Train Loss: 0.2584 (acc. 87.75%) | Val Loss: 0.4136 (acc. 84.50%)
| Time: 34s
Epoch 80/120 | Train Loss: 0.2141 (acc. 90.85%) | Val Loss: 0.4059 (acc. 86.00%)
| Time: 34s
Epoch 81/120 | Train Loss: 0.2380 (acc. 89.85%) | Val Loss: 0.3663 (acc. 85.33%)
| Time: 34s
Epoch 82/120 | Train Loss: 0.2045 (acc. 91.65%) | Val Loss: 0.3784 (acc. 86.50%)
| Time: 34s
Epoch 83/120 | Train Loss: 0.2251 (acc. 90.80%) | Val Loss: 0.4138 (acc. 85.33%)
| Time: 34s
Epoch 84/120 | Train Loss: 0.2103 (acc. 91.55%) | Val Loss: 0.4051 (acc. 85.67%)
| Time: 34s
Epoch 85/120 | Train Loss: 0.2098 (acc. 90.80%) | Val Loss: 0.4096 (acc. 86.00%)
| Time: 34s
Epoch 86/120 | Train Loss: 0.2307 (acc. 90.75%) | Val Loss: 0.5740 (acc. 78.33%)
| Time: 34s
Epoch 87/120 | Train Loss: 0.2109 (acc. 91.40%) | Val Loss: 0.4140 (acc. 86.00%)
```

```
| Time: 34s
Epoch 88/120 | Train Loss: 0.2360 (acc. 90.40%) | Val Loss: 0.6556 (acc. 79.67%)
| Time: 34s
Epoch 89/120 | Train Loss: 0.2013 (acc. 91.50%) | Val Loss: 0.3833 (acc. 87.17%)
| Time: 34s
Epoch 90/120 | Train Loss: 0.1938 (acc. 92.55%) | Val Loss: 0.3877 (acc. 85.00%)
| Time: 34s
Epoch 91/120 | Train Loss: 0.1927 (acc. 92.95%) | Val Loss: 0.4278 (acc. 85.17%)
| Time: 34s
Epoch 92/120 | Train Loss: 0.2265 (acc. 91.05%) | Val Loss: 0.4150 (acc. 84.83%)
| Time: 34s
Epoch 93/120 | Train Loss: 0.2065 (acc. 91.95%) | Val Loss: 0.3894 (acc. 85.17%)
| Time: 34s
Epoch 94/120 | Train Loss: 0.1946 (acc. 91.65%) | Val Loss: 0.3629 (acc. 86.83%)
| Time: 34s
Epoch 95/120 | Train Loss: 0.1932 (acc. 92.35%) | Val Loss: 0.8695 (acc. 73.67%)
| Time: 34s
Epoch 96/120 | Train Loss: 0.2053 (acc. 92.25%) | Val Loss: 0.4317 (acc. 85.50%)
| Time: 34s
Epoch 97/120 | Train Loss: 0.1840 (acc. 93.00%) | Val Loss: 0.4594 (acc. 85.00%)
| Time: 34s
Epoch 98/120 | Train Loss: 0.2060 (acc. 91.90%) | Val Loss: 0.4642 (acc. 82.50%)
| Time: 34s
Epoch 99/120 | Train Loss: 0.1801 (acc. 92.45%) | Val Loss: 0.3906 (acc. 85.50%)
| Time: 34s
Epoch 100/120 | Train Loss: 0.1802 (acc. 93.25%) | Val Loss: 0.4055 (acc.
86.67%) | Time: 34s
Epoch 101/120 | Train Loss: 0.1609 (acc. 93.85%) | Val Loss: 0.4797 (acc.
84.50%) | Time: 34s
Epoch 102/120 | Train Loss: 0.1848 (acc. 93.05%) | Val Loss: 0.5259 (acc.
83.67%) | Time: 34s
Epoch 103/120 | Train Loss: 0.1772 (acc. 92.55%) | Val Loss: 0.6819 (acc.
79.17%) | Time: 34s
Epoch 104/120 | Train Loss: 0.1614 (acc. 93.15%) | Val Loss: 0.3821 (acc.
86.83%) | Time: 34s
Epoch 105/120 | Train Loss: 0.1660 (acc. 93.20%) | Val Loss: 0.4707 (acc.
85.33%) | Time: 34s
Epoch 106/120 | Train Loss: 0.1755 (acc. 93.05%) | Val Loss: 0.4738 (acc.
86.00%) | Time: 34s
Epoch 107/120 | Train Loss: 0.1603 (acc. 93.75%) | Val Loss: 0.4198 (acc.
86.17%) | Time: 34s
Epoch 108/120 | Train Loss: 0.1622 (acc. 93.65%) | Val Loss: 0.4181 (acc.
85.83%) | Time: 34s
Epoch 109/120 | Train Loss: 0.1887 (acc. 91.50%) | Val Loss: 0.7485 (acc.
81.00%) | Time: 34s
Epoch 110/120 | Train Loss: 0.1603 (acc. 94.00%) | Val Loss: 0.4439 (acc.
85.50%) | Time: 34s
Epoch 111/120 | Train Loss: 0.1324 (acc. 94.55%) | Val Loss: 0.3805 (acc.
87.83%) | Time: 34s
Epoch 112/120 | Train Loss: 0.1569 (acc. 93.70%) | Val Loss: 0.4204 (acc.
87.00%) | Time: 34s
Epoch 113/120 | Train Loss: 0.1614 (acc. 92.95%) | Val Loss: 0.4518 (acc.
85.67%) | Time: 34s
Epoch 114/120 | Train Loss: 0.1423 (acc. 94.70%) | Val Loss: 0.5452 (acc.
84.83%) | Time: 34s
Epoch 115/120 | Train Loss: 0.1704 (acc. 93.15%) | Val Loss: 0.4222 (acc.
86.17%) | Time: 34s
Epoch 116/120 | Train Loss: 0.1626 (acc. 92.75%) | Val Loss: 0.3715 (acc.
87.50%) | Time: 34s
Epoch 117/120 | Train Loss: 0.1605 (acc. 93.40%) | Val Loss: 0.4975 (acc.
85.00%) | Time: 34s
Epoch 118/120 | Train Loss: 0.1431 (acc. 93.75%) | Val Loss: 0.7164 (acc.
81.00%) | Time: 34s
Epoch 119/120 | Train Loss: 0.1447 (acc. 93.85%) | Val Loss: 0.4568 (acc.
86.17%) | Time: 34s
Epoch 120/120 | Train Loss: 0.1490 (acc. 94.25%) | Val Loss: 0.3999 (acc.
87.67%) | Time: 34s
Training Time: 4112s
```

Experiment: reg_2

Epoch 1/120 | Train Loss: 0.6836 (acc. 59.30%) | Val Loss: 0.6645 (acc. 60.33%)
| Time: 34s

Epoch 2/120 | Train Loss: 0.6343 (acc. 63.45%) | Val Loss: 0.7115 (acc. 60.00%)
| Time: 34s

Epoch 3/120 | Train Loss: 0.6051 (acc. 65.35%) | Val Loss: 0.6021 (acc. 67.83%)
| Time: 34s

Epoch 4/120 | Train Loss: 0.5782 (acc. 69.55%) | Val Loss: 0.6000 (acc. 68.50%)
| Time: 34s

Epoch 5/120 | Train Loss: 0.5681 (acc. 70.35%) | Val Loss: 0.6545 (acc. 61.83%)
| Time: 34s

Epoch 6/120 | Train Loss: 0.5626 (acc. 70.25%) | Val Loss: 0.6416 (acc. 65.83%)
| Time: 34s

Epoch 7/120 | Train Loss: 0.5540 (acc. 70.65%) | Val Loss: 0.5522 (acc. 71.83%)
| Time: 34s

Epoch 8/120 | Train Loss: 0.5263 (acc. 72.70%) | Val Loss: 0.5408 (acc. 73.67%)
| Time: 34s

Epoch 9/120 | Train Loss: 0.5294 (acc. 74.80%) | Val Loss: 0.5783 (acc. 66.67%)
| Time: 34s

Epoch 10/120 | Train Loss: 0.5449 (acc. 73.15%) | Val Loss: 0.5389 (acc. 72.67%)
| Time: 34s

Epoch 11/120 | Train Loss: 0.5085 (acc. 73.80%) | Val Loss: 0.5492 (acc. 72.50%)
| Time: 34s

Epoch 12/120 | Train Loss: 0.5174 (acc. 75.65%) | Val Loss: 0.5291 (acc. 74.17%)
| Time: 34s

Epoch 13/120 | Train Loss: 0.5021 (acc. 75.25%) | Val Loss: 0.5505 (acc. 72.83%)
| Time: 34s

Epoch 14/120 | Train Loss: 0.4755 (acc. 77.80%) | Val Loss: 0.5586 (acc. 73.17%)
| Time: 34s

Epoch 15/120 | Train Loss: 0.5140 (acc. 75.05%) | Val Loss: 0.5026 (acc. 75.67%)
| Time: 34s

Epoch 16/120 | Train Loss: 0.4761 (acc. 77.00%) | Val Loss: 0.5039 (acc. 75.33%)
| Time: 34s

Epoch 17/120 | Train Loss: 0.4528 (acc. 79.15%) | Val Loss: 0.5285 (acc. 75.00%)
| Time: 34s

Epoch 18/120 | Train Loss: 0.4641 (acc. 78.05%) | Val Loss: 0.4713 (acc. 77.33%)
| Time: 34s

Epoch 19/120 | Train Loss: 0.4549 (acc. 78.20%) | Val Loss: 0.6147 (acc. 72.17%)
| Time: 34s

Epoch 20/120 | Train Loss: 0.4364 (acc. 79.45%) | Val Loss: 0.5405 (acc. 77.00%)
| Time: 34s

Epoch 21/120 | Train Loss: 0.4396 (acc. 80.25%) | Val Loss: 0.5171 (acc. 76.33%)
| Time: 34s

Epoch 22/120 | Train Loss: 0.4259 (acc. 81.00%) | Val Loss: 0.4854 (acc. 76.17%)
| Time: 34s

Epoch 23/120 | Train Loss: 0.4458 (acc. 80.75%) | Val Loss: 0.4847 (acc. 75.67%)
| Time: 34s

Epoch 24/120 | Train Loss: 0.4250 (acc. 80.05%) | Val Loss: 0.4432 (acc. 79.17%)
| Time: 34s

Epoch 25/120 | Train Loss: 0.4174 (acc. 80.80%) | Val Loss: 0.5482 (acc. 72.50%)
| Time: 34s

Epoch 26/120 | Train Loss: 0.3966 (acc. 83.20%) | Val Loss: 0.4327 (acc. 79.83%)
| Time: 34s

Epoch 27/120 | Train Loss: 0.3544 (acc. 84.80%) | Val Loss: 0.4410 (acc. 79.50%)
| Time: 34s

Epoch 28/120 | Train Loss: 0.3779 (acc. 83.60%) | Val Loss: 0.5682 (acc. 78.00%)
| Time: 34s

Epoch 29/120 | Train Loss: 0.3680 (acc. 83.10%) | Val Loss: 0.4246 (acc. 80.00%)
| Time: 34s

Epoch 30/120 | Train Loss: 0.3695 (acc. 83.45%) | Val Loss: 0.4102 (acc. 81.83%)
| Time: 34s

Epoch 31/120 | Train Loss: 0.3606 (acc. 83.85%) | Val Loss: 0.4239 (acc. 79.50%)
| Time: 34s

Epoch 32/120 | Train Loss: 0.3457 (acc. 85.00%) | Val Loss: 0.4096 (acc. 81.83%)
| Time: 34s

Epoch 33/120 | Train Loss: 0.3729 (acc. 83.15%) | Val Loss: 0.4049 (acc. 81.67%)
| Time: 34s

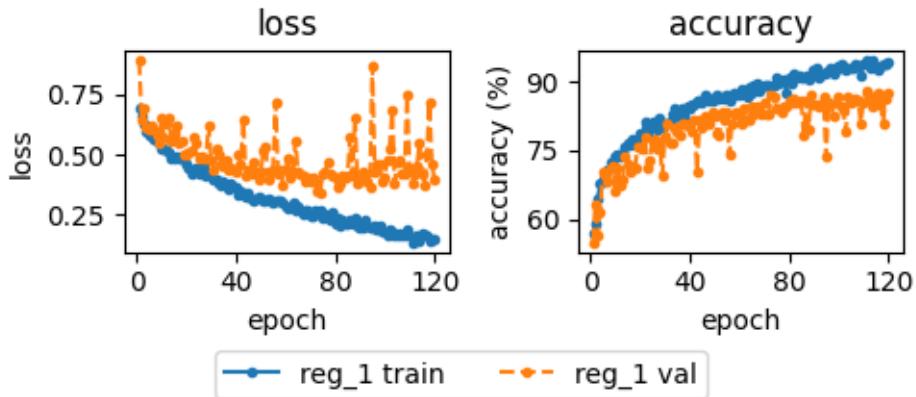
Epoch 34/120 | Train Loss: 0.3425 (acc. 85.30%) | Val Loss: 0.4355 (acc. 78.67%)
| Time: 34s
Epoch 35/120 | Train Loss: 0.3354 (acc. 85.30%) | Val Loss: 0.4183 (acc. 79.17%)
| Time: 34s
Epoch 36/120 | Train Loss: 0.3577 (acc. 85.05%) | Val Loss: 0.4828 (acc. 80.33%)
| Time: 34s
Epoch 37/120 | Train Loss: 0.3456 (acc. 84.60%) | Val Loss: 0.3931 (acc. 82.50%)
| Time: 34s
Epoch 38/120 | Train Loss: 0.3322 (acc. 85.55%) | Val Loss: 0.3965 (acc. 83.17%)
| Time: 34s
Epoch 39/120 | Train Loss: 0.3058 (acc. 86.40%) | Val Loss: 0.4111 (acc. 82.83%)
| Time: 35s
Epoch 40/120 | Train Loss: 0.3404 (acc. 85.35%) | Val Loss: 0.4212 (acc. 79.83%)
| Time: 34s
Epoch 41/120 | Train Loss: 0.3401 (acc. 85.35%) | Val Loss: 0.4509 (acc. 80.83%)
| Time: 34s
Epoch 42/120 | Train Loss: 0.2948 (acc. 87.25%) | Val Loss: 0.3992 (acc. 82.67%)
| Time: 34s
Epoch 43/120 | Train Loss: 0.3022 (acc. 86.25%) | Val Loss: 0.3992 (acc. 83.00%)
| Time: 34s
Epoch 44/120 | Train Loss: 0.3162 (acc. 86.10%) | Val Loss: 0.4753 (acc. 81.50%)
| Time: 34s
Epoch 45/120 | Train Loss: 0.3307 (acc. 85.55%) | Val Loss: 0.4022 (acc. 82.17%)
| Time: 34s
Epoch 46/120 | Train Loss: 0.3134 (acc. 86.85%) | Val Loss: 0.3986 (acc. 83.33%)
| Time: 34s
Epoch 47/120 | Train Loss: 0.3016 (acc. 86.40%) | Val Loss: 0.5512 (acc. 76.83%)
| Time: 34s
Epoch 48/120 | Train Loss: 0.3121 (acc. 86.80%) | Val Loss: 0.4064 (acc. 82.17%)
| Time: 34s
Epoch 49/120 | Train Loss: 0.3283 (acc. 86.20%) | Val Loss: 0.4151 (acc. 81.83%)
| Time: 34s
Epoch 50/120 | Train Loss: 0.2865 (acc. 87.75%) | Val Loss: 0.4047 (acc. 80.00%)
| Time: 34s
Epoch 51/120 | Train Loss: 0.2695 (acc. 89.45%) | Val Loss: 0.5261 (acc. 78.67%)
| Time: 34s
Epoch 52/120 | Train Loss: 0.2730 (acc. 88.40%) | Val Loss: 0.3803 (acc. 83.00%)
| Time: 34s
Epoch 53/120 | Train Loss: 0.2533 (acc. 89.05%) | Val Loss: 0.3699 (acc. 83.00%)
| Time: 34s
Epoch 54/120 | Train Loss: 0.2447 (acc. 90.15%) | Val Loss: 0.3862 (acc. 82.50%)
| Time: 34s
Epoch 55/120 | Train Loss: 0.2711 (acc. 88.95%) | Val Loss: 0.4081 (acc. 82.17%)
| Time: 34s
Epoch 56/120 | Train Loss: 0.2641 (acc. 88.65%) | Val Loss: 0.3790 (acc. 83.67%)
| Time: 34s
Epoch 57/120 | Train Loss: 0.2395 (acc. 90.30%) | Val Loss: 0.3818 (acc. 84.17%)
| Time: 34s
Epoch 58/120 | Train Loss: 0.2488 (acc. 89.30%) | Val Loss: 0.4039 (acc. 83.33%)
| Time: 34s
Epoch 59/120 | Train Loss: 0.2345 (acc. 89.45%) | Val Loss: 0.4069 (acc. 83.33%)
| Time: 34s
Epoch 60/120 | Train Loss: 0.2545 (acc. 89.45%) | Val Loss: 0.3925 (acc. 81.67%)
| Time: 34s
Epoch 61/120 | Train Loss: 0.2547 (acc. 89.15%) | Val Loss: 0.3998 (acc. 82.00%)
| Time: 34s
Epoch 62/120 | Train Loss: 0.2528 (acc. 89.35%) | Val Loss: 0.3963 (acc. 83.33%)
| Time: 34s
Epoch 63/120 | Train Loss: 0.2303 (acc. 90.40%) | Val Loss: 0.3564 (acc. 84.17%)
| Time: 34s
Epoch 64/120 | Train Loss: 0.2378 (acc. 89.85%) | Val Loss: 0.3902 (acc. 83.17%)
| Time: 34s
Epoch 65/120 | Train Loss: 0.2459 (acc. 90.00%) | Val Loss: 0.4037 (acc. 83.33%)
| Time: 34s
Epoch 66/120 | Train Loss: 0.2132 (acc. 91.40%) | Val Loss: 0.4060 (acc. 82.50%)
| Time: 34s
Epoch 67/120 | Train Loss: 0.2265 (acc. 90.70%) | Val Loss: 0.4332 (acc. 82.83%)
| Time: 34s

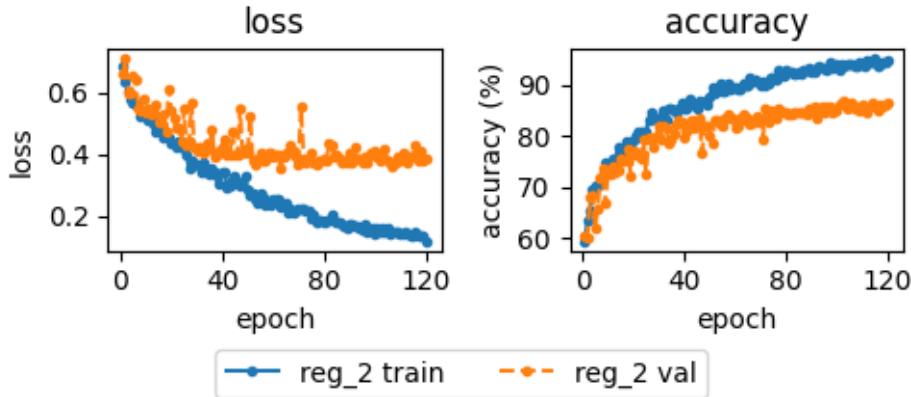
```
Epoch 68/120 | Train Loss: 0.2146 (acc. 91.25%) | Val Loss: 0.4085 (acc. 82.83%)
| Time: 34s
Epoch 69/120 | Train Loss: 0.2202 (acc. 90.65%) | Val Loss: 0.3930 (acc. 83.83%)
| Time: 34s
Epoch 70/120 | Train Loss: 0.2231 (acc. 90.00%) | Val Loss: 0.3705 (acc. 82.83%)
| Time: 34s
Epoch 71/120 | Train Loss: 0.2257 (acc. 90.90%) | Val Loss: 0.5548 (acc. 79.50%)
| Time: 34s
Epoch 72/120 | Train Loss: 0.2224 (acc. 90.10%) | Val Loss: 0.3889 (acc. 85.33%)
| Time: 34s
Epoch 73/120 | Train Loss: 0.2189 (acc. 90.40%) | Val Loss: 0.3737 (acc. 82.83%)
| Time: 34s
Epoch 74/120 | Train Loss: 0.2150 (acc. 91.35%) | Val Loss: 0.3786 (acc. 85.00%)
| Time: 34s
Epoch 75/120 | Train Loss: 0.1934 (acc. 91.40%) | Val Loss: 0.4055 (acc. 84.50%)
| Time: 34s
Epoch 76/120 | Train Loss: 0.2077 (acc. 91.25%) | Val Loss: 0.3716 (acc. 83.33%)
| Time: 34s
Epoch 77/120 | Train Loss: 0.1775 (acc. 92.90%) | Val Loss: 0.3672 (acc. 85.33%)
| Time: 34s
Epoch 78/120 | Train Loss: 0.1895 (acc. 91.70%) | Val Loss: 0.3786 (acc. 85.17%)
| Time: 34s
Epoch 79/120 | Train Loss: 0.1848 (acc. 92.00%) | Val Loss: 0.3830 (acc. 84.50%)
| Time: 34s
Epoch 80/120 | Train Loss: 0.1781 (acc. 92.90%) | Val Loss: 0.3858 (acc. 84.50%)
| Time: 34s
Epoch 81/120 | Train Loss: 0.1880 (acc. 92.50%) | Val Loss: 0.3819 (acc. 84.33%)
| Time: 34s
Epoch 82/120 | Train Loss: 0.1884 (acc. 92.70%) | Val Loss: 0.4351 (acc. 84.17%)
| Time: 34s
Epoch 83/120 | Train Loss: 0.2066 (acc. 92.20%) | Val Loss: 0.4312 (acc. 84.50%)
| Time: 34s
Epoch 84/120 | Train Loss: 0.1839 (acc. 92.30%) | Val Loss: 0.3898 (acc. 84.67%)
| Time: 34s
Epoch 85/120 | Train Loss: 0.1813 (acc. 92.65%) | Val Loss: 0.4003 (acc. 84.67%)
| Time: 34s
Epoch 86/120 | Train Loss: 0.1831 (acc. 92.30%) | Val Loss: 0.3869 (acc. 84.67%)
| Time: 34s
Epoch 87/120 | Train Loss: 0.1765 (acc. 93.15%) | Val Loss: 0.3765 (acc. 84.50%)
| Time: 34s
Epoch 88/120 | Train Loss: 0.1671 (acc. 93.00%) | Val Loss: 0.3776 (acc. 84.17%)
| Time: 34s
Epoch 89/120 | Train Loss: 0.1641 (acc. 93.55%) | Val Loss: 0.3761 (acc. 85.50%)
| Time: 34s
Epoch 90/120 | Train Loss: 0.1715 (acc. 92.65%) | Val Loss: 0.4062 (acc. 84.83%)
| Time: 34s
Epoch 91/120 | Train Loss: 0.1762 (acc. 92.65%) | Val Loss: 0.3752 (acc. 85.67%)
| Time: 34s
Epoch 92/120 | Train Loss: 0.1673 (acc. 93.35%) | Val Loss: 0.4252 (acc. 83.67%)
| Time: 34s
Epoch 93/120 | Train Loss: 0.1655 (acc. 93.70%) | Val Loss: 0.3844 (acc. 85.33%)
| Time: 34s
Epoch 94/120 | Train Loss: 0.1607 (acc. 93.30%) | Val Loss: 0.3873 (acc. 85.83%)
| Time: 34s
Epoch 95/120 | Train Loss: 0.1577 (acc. 93.45%) | Val Loss: 0.3750 (acc. 84.67%)
| Time: 34s
Epoch 96/120 | Train Loss: 0.1712 (acc. 93.15%) | Val Loss: 0.3911 (acc. 85.67%)
| Time: 34s
Epoch 97/120 | Train Loss: 0.1462 (acc. 94.35%) | Val Loss: 0.3730 (acc. 85.67%)
| Time: 34s
Epoch 98/120 | Train Loss: 0.1576 (acc. 93.35%) | Val Loss: 0.4075 (acc. 84.67%)
| Time: 34s
Epoch 99/120 | Train Loss: 0.1636 (acc. 93.60%) | Val Loss: 0.3994 (acc. 85.17%)
| Time: 34s
Epoch 100/120 | Train Loss: 0.1412 (acc. 94.25%) | Val Loss: 0.4108 (acc.
85.17%) | Time: 34s
Epoch 101/120 | Train Loss: 0.1632 (acc. 93.05%) | Val Loss: 0.3921 (acc.
86.17%) | Time: 34s
```

```

Epoch 102/120 | Train Loss: 0.1473 (acc. 94.10%) | Val Loss: 0.3816 (acc.
86.50%) | Time: 34s
Epoch 103/120 | Train Loss: 0.1616 (acc. 93.85%) | Val Loss: 0.3904 (acc.
86.83%) | Time: 34s
Epoch 104/120 | Train Loss: 0.1503 (acc. 94.05%) | Val Loss: 0.4195 (acc.
85.33%) | Time: 34s
Epoch 105/120 | Train Loss: 0.1607 (acc. 93.95%) | Val Loss: 0.3830 (acc.
86.17%) | Time: 34s
Epoch 106/120 | Train Loss: 0.1445 (acc. 94.15%) | Val Loss: 0.3717 (acc.
86.67%) | Time: 34s
Epoch 107/120 | Train Loss: 0.1506 (acc. 93.90%) | Val Loss: 0.3647 (acc.
85.50%) | Time: 34s
Epoch 108/120 | Train Loss: 0.1465 (acc. 93.80%) | Val Loss: 0.3742 (acc.
85.67%) | Time: 34s
Epoch 109/120 | Train Loss: 0.1480 (acc. 94.65%) | Val Loss: 0.3903 (acc.
85.17%) | Time: 34s
Epoch 110/120 | Train Loss: 0.1402 (acc. 93.95%) | Val Loss: 0.3808 (acc.
86.33%) | Time: 34s
Epoch 111/120 | Train Loss: 0.1420 (acc. 93.65%) | Val Loss: 0.4025 (acc.
85.33%) | Time: 34s
Epoch 112/120 | Train Loss: 0.1481 (acc. 94.80%) | Val Loss: 0.4009 (acc.
84.50%) | Time: 34s
Epoch 113/120 | Train Loss: 0.1451 (acc. 94.60%) | Val Loss: 0.3759 (acc.
85.83%) | Time: 34s
Epoch 114/120 | Train Loss: 0.1347 (acc. 94.50%) | Val Loss: 0.3902 (acc.
86.50%) | Time: 34s
Epoch 115/120 | Train Loss: 0.1350 (acc. 95.25%) | Val Loss: 0.3958 (acc.
85.83%) | Time: 34s
Epoch 116/120 | Train Loss: 0.1492 (acc. 93.60%) | Val Loss: 0.4291 (acc.
85.17%) | Time: 34s
Epoch 117/120 | Train Loss: 0.1390 (acc. 94.25%) | Val Loss: 0.3823 (acc.
86.33%) | Time: 35s
Epoch 118/120 | Train Loss: 0.1388 (acc. 94.50%) | Val Loss: 0.4105 (acc.
85.83%) | Time: 34s
Epoch 119/120 | Train Loss: 0.1387 (acc. 94.65%) | Val Loss: 0.3825 (acc.
86.17%) | Time: 34s
Epoch 120/120 | Train Loss: 0.1183 (acc. 94.95%) | Val Loss: 0.3888 (acc.
86.50%) | Time: 34s
Training Time: 4112s

```





0.9.1 Adding one more convolutional layer

```
[22]: net_config2 = {**default_net_config,
    "cv_layers": [
        {"out_channels": 64, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
        {"out_channels": 128, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
        {"out_channels": 256, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
        {"out_channels": 512, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
        {"out_channels": 512, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
    ],
    "fc_layers": [
        {"out_features": 512, "batch_norm": True, "dropout_rate": 0.4},
        {"out_features": 256, "batch_norm": True, "dropout_rate": 0.2},
    ],
}
configs2 = [
    {**default_config, "label": "reg_3", "net_config": net_config2},
    {**default_config, "label": "reg_4", "net_config": net_config2, "train_config": train_config1}
]
results = result_handler(configs2, device)
plot_scores(results)
```

```
Experiment: reg_3
Epoch 1/120 | Train Loss: 0.7206 (acc. 55.15%) | Val Loss: 0.7543 (acc. 56.83%)
| Time: 67s
Epoch 2/120 | Train Loss: 0.6802 (acc. 57.90%) | Val Loss: 0.7889 (acc. 58.50%)
| Time: 67s
Epoch 3/120 | Train Loss: 0.6636 (acc. 60.65%) | Val Loss: 0.6234 (acc. 63.00%)
| Time: 67s
Epoch 4/120 | Train Loss: 0.6367 (acc. 63.45%) | Val Loss: 0.5956 (acc. 68.83%)
| Time: 67s
Epoch 5/120 | Train Loss: 0.6149 (acc. 66.10%) | Val Loss: 0.6728 (acc. 61.50%)
| Time: 67s
Epoch 6/120 | Train Loss: 0.6022 (acc. 66.60%) | Val Loss: 0.6197 (acc. 65.00%)
| Time: 67s
Epoch 7/120 | Train Loss: 0.5728 (acc. 70.70%) | Val Loss: 0.5960 (acc. 68.67%)
| Time: 67s
Epoch 8/120 | Train Loss: 0.5657 (acc. 71.15%) | Val Loss: 0.7474 (acc. 61.00%)
| Time: 67s
```

```
Epoch 9/120 | Train Loss: 0.5561 (acc. 71.15%) | Val Loss: 0.5889 (acc. 70.33%)
| Time: 67s
Epoch 10/120 | Train Loss: 0.5503 (acc. 72.65%) | Val Loss: 0.5609 (acc. 71.17%)
| Time: 67s
Epoch 11/120 | Train Loss: 0.5269 (acc. 72.90%) | Val Loss: 0.5995 (acc. 64.33%)
| Time: 67s
Epoch 12/120 | Train Loss: 0.5106 (acc. 74.65%) | Val Loss: 0.5758 (acc. 72.50%)
| Time: 67s
Epoch 13/120 | Train Loss: 0.5094 (acc. 75.35%) | Val Loss: 0.5395 (acc. 74.83%)
| Time: 67s
Epoch 14/120 | Train Loss: 0.4990 (acc. 75.45%) | Val Loss: 0.5470 (acc. 74.00%)
| Time: 67s
Epoch 15/120 | Train Loss: 0.4923 (acc. 76.70%) | Val Loss: 0.6012 (acc. 68.67%)
| Time: 67s
Epoch 16/120 | Train Loss: 0.4936 (acc. 76.90%) | Val Loss: 0.4990 (acc. 74.83%)
| Time: 67s
Epoch 17/120 | Train Loss: 0.4631 (acc. 79.30%) | Val Loss: 0.5559 (acc. 72.17%)
| Time: 67s
Epoch 18/120 | Train Loss: 0.4567 (acc. 78.95%) | Val Loss: 0.5044 (acc. 73.50%)
| Time: 67s
Epoch 19/120 | Train Loss: 0.4417 (acc. 78.95%) | Val Loss: 0.5147 (acc. 75.83%)
| Time: 67s
Epoch 20/120 | Train Loss: 0.4621 (acc. 78.85%) | Val Loss: 0.4939 (acc. 78.17%)
| Time: 67s
Epoch 21/120 | Train Loss: 0.4443 (acc. 79.30%) | Val Loss: 0.5131 (acc. 75.17%)
| Time: 67s
Epoch 22/120 | Train Loss: 0.4118 (acc. 80.95%) | Val Loss: 0.6186 (acc. 73.50%)
| Time: 67s
Epoch 23/120 | Train Loss: 0.4778 (acc. 76.40%) | Val Loss: 0.4806 (acc. 78.00%)
| Time: 67s
Epoch 24/120 | Train Loss: 0.4142 (acc. 80.80%) | Val Loss: 0.4869 (acc. 77.17%)
| Time: 67s
Epoch 25/120 | Train Loss: 0.4148 (acc. 80.40%) | Val Loss: 0.4357 (acc. 78.00%)
| Time: 67s
Epoch 26/120 | Train Loss: 0.4125 (acc. 81.50%) | Val Loss: 0.4279 (acc. 81.17%)
| Time: 67s
Epoch 27/120 | Train Loss: 0.3962 (acc. 81.20%) | Val Loss: 0.4663 (acc. 79.33%)
| Time: 67s
Epoch 28/120 | Train Loss: 0.3772 (acc. 84.10%) | Val Loss: 0.4881 (acc. 78.50%)
| Time: 67s
Epoch 29/120 | Train Loss: 0.3432 (acc. 84.60%) | Val Loss: 0.4451 (acc. 81.00%)
| Time: 67s
Epoch 30/120 | Train Loss: 0.3646 (acc. 83.65%) | Val Loss: 0.4301 (acc. 81.17%)
| Time: 67s
Epoch 31/120 | Train Loss: 0.3487 (acc. 84.25%) | Val Loss: 0.5731 (acc. 76.00%)
| Time: 67s
Epoch 32/120 | Train Loss: 0.3363 (acc. 84.75%) | Val Loss: 0.5071 (acc. 76.17%)
| Time: 67s
Epoch 33/120 | Train Loss: 0.3626 (acc. 83.65%) | Val Loss: 0.3897 (acc. 82.50%)
| Time: 67s
Epoch 34/120 | Train Loss: 0.3289 (acc. 85.75%) | Val Loss: 0.3771 (acc. 86.00%)
| Time: 67s
Epoch 35/120 | Train Loss: 0.3029 (acc. 87.25%) | Val Loss: 0.4087 (acc. 84.00%)
| Time: 67s
Epoch 36/120 | Train Loss: 0.3089 (acc. 86.50%) | Val Loss: 0.3707 (acc. 84.00%)
| Time: 67s
Epoch 37/120 | Train Loss: 0.3221 (acc. 86.55%) | Val Loss: 0.4977 (acc. 80.00%)
| Time: 67s
Epoch 38/120 | Train Loss: 0.2892 (acc. 87.15%) | Val Loss: 0.3727 (acc. 85.17%)
| Time: 67s
Epoch 39/120 | Train Loss: 0.2993 (acc. 87.10%) | Val Loss: 0.4675 (acc. 81.17%)
| Time: 67s
Epoch 40/120 | Train Loss: 0.3062 (acc. 86.55%) | Val Loss: 0.3523 (acc. 84.83%)
| Time: 67s
Epoch 41/120 | Train Loss: 0.2927 (acc. 87.40%) | Val Loss: 0.3551 (acc. 83.83%)
| Time: 67s
Epoch 42/120 | Train Loss: 0.2845 (acc. 87.90%) | Val Loss: 0.3976 (acc. 83.50%)
| Time: 67s
```

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Epoch 43/120 | Train Loss: 0.2866 (acc. 88.35%) | Val Loss: 0.6133 (acc. 78.50%)
| Time: 67s
Epoch 44/120 | Train Loss: 0.2843 (acc. 88.35%) | Val Loss: 0.3339 (acc. 85.50%)
| Time: 67s
Epoch 45/120 | Train Loss: 0.2659 (acc. 89.25%) | Val Loss: 0.3488 (acc. 84.67%)
| Time: 67s
Epoch 46/120 | Train Loss: 0.2761 (acc. 88.70%) | Val Loss: 0.3933 (acc. 86.33%)
| Time: 67s
Epoch 47/120 | Train Loss: 0.2852 (acc. 87.85%) | Val Loss: 0.3365 (acc. 84.83%)
| Time: 67s
Epoch 48/120 | Train Loss: 0.2639 (acc. 88.00%) | Val Loss: 0.3755 (acc. 84.00%)
| Time: 67s
Epoch 49/120 | Train Loss: 0.2497 (acc. 89.95%) | Val Loss: 0.7493 (acc. 73.17%)
| Time: 67s
Epoch 50/120 | Train Loss: 0.2600 (acc. 89.60%) | Val Loss: 0.2911 (acc. 88.33%)
| Time: 67s
Epoch 51/120 | Train Loss: 0.2528 (acc. 89.40%) | Val Loss: 0.3326 (acc. 86.00%)
| Time: 67s
Epoch 52/120 | Train Loss: 0.2187 (acc. 90.60%) | Val Loss: 0.4604 (acc. 82.83%)
| Time: 67s
Epoch 53/120 | Train Loss: 0.2296 (acc. 90.75%) | Val Loss: 0.3377 (acc. 86.00%)
| Time: 67s
Epoch 54/120 | Train Loss: 0.2347 (acc. 90.05%) | Val Loss: 0.4674 (acc. 82.50%)
| Time: 67s
Epoch 55/120 | Train Loss: 0.2162 (acc. 90.70%) | Val Loss: 0.3766 (acc. 85.00%)
| Time: 67s
Epoch 56/120 | Train Loss: 0.1940 (acc. 92.00%) | Val Loss: 0.3656 (acc. 86.33%)
| Time: 67s
Epoch 57/120 | Train Loss: 0.1849 (acc. 92.70%) | Val Loss: 0.3781 (acc. 85.67%)
| Time: 67s
Epoch 58/120 | Train Loss: 0.2236 (acc. 90.80%) | Val Loss: 0.7648 (acc. 75.83%)
| Time: 67s
Epoch 59/120 | Train Loss: 0.1955 (acc. 91.55%) | Val Loss: 0.4405 (acc. 84.00%)
| Time: 67s
Epoch 60/120 | Train Loss: 0.2079 (acc. 91.60%) | Val Loss: 0.3520 (acc. 87.00%)
| Time: 67s
Epoch 61/120 | Train Loss: 0.2027 (acc. 91.70%) | Val Loss: 0.3833 (acc. 86.17%)
| Time: 67s
Epoch 62/120 | Train Loss: 0.2129 (acc. 90.40%) | Val Loss: 0.3591 (acc. 86.00%)
| Time: 67s
Epoch 63/120 | Train Loss: 0.1757 (acc. 92.80%) | Val Loss: 0.3098 (acc. 88.33%)
| Time: 67s
Epoch 64/120 | Train Loss: 0.1723 (acc. 92.95%) | Val Loss: 0.3120 (acc. 87.50%)
| Time: 67s
Epoch 65/120 | Train Loss: 0.1906 (acc. 92.45%) | Val Loss: 0.3507 (acc. 86.83%)
| Time: 67s
Epoch 66/120 | Train Loss: 0.1713 (acc. 92.95%) | Val Loss: 0.3310 (acc. 87.17%)
| Time: 67s
Epoch 67/120 | Train Loss: 0.1631 (acc. 93.30%) | Val Loss: 0.2971 (acc. 89.00%)
| Time: 67s
Epoch 68/120 | Train Loss: 0.1673 (acc. 93.75%) | Val Loss: 0.3352 (acc. 88.67%)
| Time: 67s
Epoch 69/120 | Train Loss: 0.1557 (acc. 93.70%) | Val Loss: 0.4033 (acc. 87.17%)
| Time: 67s
Epoch 70/120 | Train Loss: 0.1711 (acc. 93.10%) | Val Loss: 0.3080 (acc. 89.67%)
| Time: 67s
Epoch 71/120 | Train Loss: 0.1537 (acc. 93.90%) | Val Loss: 0.3449 (acc. 86.83%)
| Time: 67s
Epoch 72/120 | Train Loss: 0.1642 (acc. 93.20%) | Val Loss: 0.3177 (acc. 88.00%)
| Time: 67s
Epoch 73/120 | Train Loss: 0.1374 (acc. 94.15%) | Val Loss: 0.2684 (acc. 88.83%)
| Time: 67s
Epoch 74/120 | Train Loss: 0.1266 (acc. 95.05%) | Val Loss: 0.2855 (acc. 88.83%)
| Time: 67s
Epoch 75/120 | Train Loss: 0.1609 (acc. 93.70%) | Val Loss: 0.3289 (acc. 89.33%)
| Time: 67s
Epoch 76/120 | Train Loss: 0.1678 (acc. 92.65%) | Val Loss: 0.2932 (acc. 88.17%)
| Time: 67s
```

```
Epoch 77/120 | Train Loss: 0.1437 (acc. 94.80%) | Val Loss: 0.4449 (acc. 85.17%)
| Time: 67s
Epoch 78/120 | Train Loss: 0.1824 (acc. 92.70%) | Val Loss: 0.3284 (acc. 87.00%)
| Time: 67s
Epoch 79/120 | Train Loss: 0.1366 (acc. 94.65%) | Val Loss: 0.3170 (acc. 87.33%)
| Time: 67s
Epoch 80/120 | Train Loss: 0.1377 (acc. 94.35%) | Val Loss: 0.3692 (acc. 87.50%)
| Time: 67s
Epoch 81/120 | Train Loss: 0.1326 (acc. 95.30%) | Val Loss: 0.2757 (acc. 87.67%)
| Time: 67s
Epoch 82/120 | Train Loss: 0.1139 (acc. 95.55%) | Val Loss: 0.3848 (acc. 87.17%)
| Time: 68s
Epoch 83/120 | Train Loss: 0.1520 (acc. 93.85%) | Val Loss: 0.3718 (acc. 86.00%)
| Time: 67s
Epoch 84/120 | Train Loss: 0.1272 (acc. 95.35%) | Val Loss: 0.3369 (acc. 87.00%)
| Time: 67s
Epoch 85/120 | Train Loss: 0.1166 (acc. 95.50%) | Val Loss: 0.2958 (acc. 89.67%)
| Time: 67s
Epoch 86/120 | Train Loss: 0.1233 (acc. 95.45%) | Val Loss: 0.3126 (acc. 88.50%)
| Time: 67s
Epoch 87/120 | Train Loss: 0.1655 (acc. 94.05%) | Val Loss: 0.3738 (acc. 87.67%)
| Time: 67s
Epoch 88/120 | Train Loss: 0.1296 (acc. 94.65%) | Val Loss: 0.2697 (acc. 90.00%)
| Time: 67s
Epoch 89/120 | Train Loss: 0.1159 (acc. 95.75%) | Val Loss: 0.5481 (acc. 85.00%)
| Time: 67s
Epoch 90/120 | Train Loss: 0.1388 (acc. 94.20%) | Val Loss: 0.4467 (acc. 87.17%)
| Time: 67s
Epoch 91/120 | Train Loss: 0.1342 (acc. 94.90%) | Val Loss: 0.2801 (acc. 90.83%)
| Time: 67s
Epoch 92/120 | Train Loss: 0.1434 (acc. 94.15%) | Val Loss: 0.3517 (acc. 88.50%)
| Time: 67s
Epoch 93/120 | Train Loss: 0.1240 (acc. 95.05%) | Val Loss: 0.2855 (acc. 89.83%)
| Time: 67s
Epoch 94/120 | Train Loss: 0.0916 (acc. 96.35%) | Val Loss: 0.3218 (acc. 90.33%)
| Time: 67s
Epoch 95/120 | Train Loss: 0.0975 (acc. 96.00%) | Val Loss: 0.5325 (acc. 85.17%)
| Time: 67s
Epoch 96/120 | Train Loss: 0.1017 (acc. 96.30%) | Val Loss: 0.3723 (acc. 88.00%)
| Time: 67s
Epoch 97/120 | Train Loss: 0.1237 (acc. 94.30%) | Val Loss: 0.2634 (acc. 91.00%)
| Time: 67s
Epoch 98/120 | Train Loss: 0.1012 (acc. 95.90%) | Val Loss: 0.3041 (acc. 90.33%)
| Time: 67s
Epoch 99/120 | Train Loss: 0.1016 (acc. 96.25%) | Val Loss: 0.3535 (acc. 88.33%)
| Time: 67s
Epoch 100/120 | Train Loss: 0.0990 (acc. 95.95%) | Val Loss: 0.2743 (acc.
91.17%) | Time: 67s
Epoch 101/120 | Train Loss: 0.1105 (acc. 95.70%) | Val Loss: 0.2681 (acc.
90.33%) | Time: 67s
Epoch 102/120 | Train Loss: 0.1064 (acc. 96.00%) | Val Loss: 0.4660 (acc.
88.00%) | Time: 67s
Epoch 103/120 | Train Loss: 0.1173 (acc. 95.05%) | Val Loss: 0.2934 (acc.
89.83%) | Time: 67s
Epoch 104/120 | Train Loss: 0.1039 (acc. 95.80%) | Val Loss: 0.2386 (acc.
91.50%) | Time: 67s
Epoch 105/120 | Train Loss: 0.1126 (acc. 96.50%) | Val Loss: 0.3063 (acc.
90.83%) | Time: 67s
Epoch 106/120 | Train Loss: 0.1080 (acc. 96.30%) | Val Loss: 0.3350 (acc.
89.67%) | Time: 67s
Epoch 107/120 | Train Loss: 0.0932 (acc. 96.20%) | Val Loss: 0.2827 (acc.
90.33%) | Time: 67s
Epoch 108/120 | Train Loss: 0.0998 (acc. 96.50%) | Val Loss: 0.3170 (acc.
89.67%) | Time: 67s
Epoch 109/120 | Train Loss: 0.1282 (acc. 95.30%) | Val Loss: 0.3020 (acc.
89.50%) | Time: 67s
Epoch 110/120 | Train Loss: 0.0889 (acc. 96.60%) | Val Loss: 0.4448 (acc.
85.83%) | Time: 67s
```

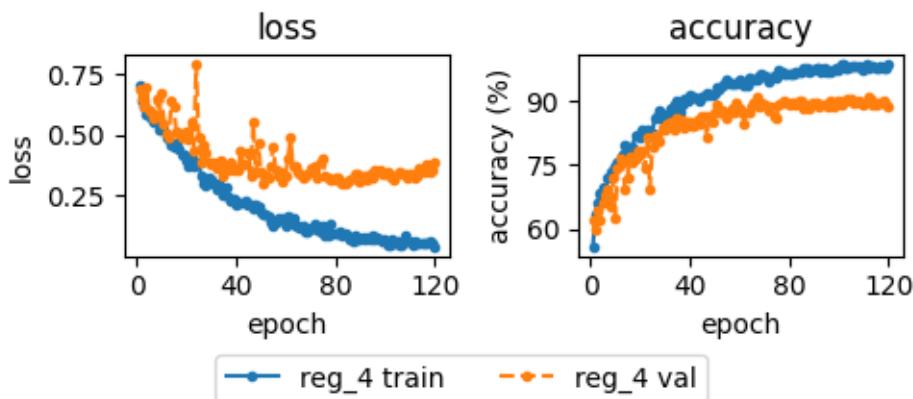
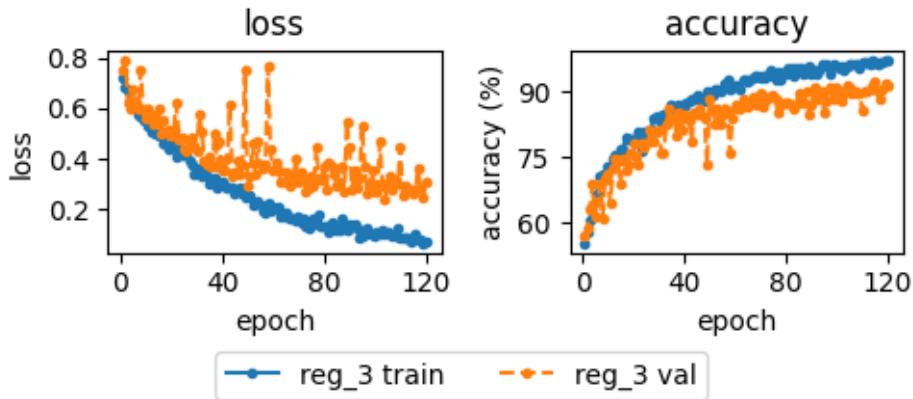
```
Epoch 111/120 | Train Loss: 0.0856 (acc. 96.65%) | Val Loss: 0.2558 (acc. 90.00%) | Time: 67s
Epoch 112/120 | Train Loss: 0.0883 (acc. 96.85%) | Val Loss: 0.2908 (acc. 90.17%) | Time: 67s
Epoch 113/120 | Train Loss: 0.0900 (acc. 96.55%) | Val Loss: 0.2865 (acc. 90.67%) | Time: 67s
Epoch 114/120 | Train Loss: 0.0760 (acc. 97.10%) | Val Loss: 0.2750 (acc. 91.33%) | Time: 67s
Epoch 115/120 | Train Loss: 0.0827 (acc. 96.75%) | Val Loss: 0.2618 (acc. 92.17%) | Time: 67s
Epoch 116/120 | Train Loss: 0.1015 (acc. 96.25%) | Val Loss: 0.2775 (acc. 90.33%) | Time: 67s
Epoch 117/120 | Train Loss: 0.0798 (acc. 96.95%) | Val Loss: 0.3634 (acc. 88.17%) | Time: 67s
Epoch 118/120 | Train Loss: 0.0842 (acc. 96.95%) | Val Loss: 0.2854 (acc. 90.67%) | Time: 67s
Epoch 119/120 | Train Loss: 0.0669 (acc. 97.25%) | Val Loss: 0.2490 (acc. 91.83%) | Time: 67s
Epoch 120/120 | Train Loss: 0.0740 (acc. 97.15%) | Val Loss: 0.3117 (acc. 91.67%) | Time: 67s
Training Time: 8018s
```

```
Experiment: reg_4
Epoch 1/120 | Train Loss: 0.7047 (acc. 55.85%) | Val Loss: 0.6922 (acc. 62.00%) | Time: 67s
Epoch 2/120 | Train Loss: 0.6393 (acc. 63.35%) | Val Loss: 0.6482 (acc. 59.83%) | Time: 67s
Epoch 3/120 | Train Loss: 0.6206 (acc. 66.35%) | Val Loss: 0.6200 (acc. 64.17%) | Time: 67s
Epoch 4/120 | Train Loss: 0.5876 (acc. 68.50%) | Val Loss: 0.6980 (acc. 62.17%) | Time: 67s
Epoch 5/120 | Train Loss: 0.5801 (acc. 69.85%) | Val Loss: 0.6019 (acc. 66.17%) | Time: 67s
Epoch 6/120 | Train Loss: 0.5693 (acc. 68.80%) | Val Loss: 0.5931 (acc. 68.17%) | Time: 67s
Epoch 7/120 | Train Loss: 0.5562 (acc. 72.05%) | Val Loss: 0.5676 (acc. 69.17%) | Time: 67s
Epoch 8/120 | Train Loss: 0.5508 (acc. 73.50%) | Val Loss: 0.6502 (acc. 65.50%) | Time: 67s
Epoch 9/120 | Train Loss: 0.5197 (acc. 73.90%) | Val Loss: 0.5756 (acc. 72.00%) | Time: 67s
Epoch 10/120 | Train Loss: 0.5229 (acc. 74.70%) | Val Loss: 0.6711 (acc. 62.50%) | Time: 67s
Epoch 11/120 | Train Loss: 0.5215 (acc. 75.45%) | Val Loss: 0.5439 (acc. 74.50%) | Time: 67s
Epoch 12/120 | Train Loss: 0.4906 (acc. 76.55%) | Val Loss: 0.5044 (acc. 76.67%) | Time: 67s
Epoch 13/120 | Train Loss: 0.4835 (acc. 77.25%) | Val Loss: 0.4873 (acc. 75.83%) | Time: 67s
Epoch 14/120 | Train Loss: 0.4614 (acc. 79.60%) | Val Loss: 0.6430 (acc. 69.33%) | Time: 67s
Epoch 15/120 | Train Loss: 0.4500 (acc. 79.40%) | Val Loss: 0.6143 (acc. 72.00%) | Time: 67s
Epoch 16/120 | Train Loss: 0.4687 (acc. 78.00%) | Val Loss: 0.5107 (acc. 77.00%) | Time: 67s
Epoch 17/120 | Train Loss: 0.4408 (acc. 79.45%) | Val Loss: 0.5049 (acc. 75.50%) | Time: 67s
Epoch 18/120 | Train Loss: 0.4183 (acc. 81.80%) | Val Loss: 0.4865 (acc. 76.50%) | Time: 67s
Epoch 19/120 | Train Loss: 0.4158 (acc. 81.90%) | Val Loss: 0.4882 (acc. 78.50%) | Time: 67s
Epoch 20/120 | Train Loss: 0.3973 (acc. 81.45%) | Val Loss: 0.5123 (acc. 77.67%) | Time: 67s
Epoch 21/120 | Train Loss: 0.3712 (acc. 83.45%) | Val Loss: 0.4798 (acc. 78.33%) | Time: 67s
Epoch 22/120 | Train Loss: 0.4021 (acc. 83.05%) | Val Loss: 0.5558 (acc. 74.17%) | Time: 67s
Epoch 23/120 | Train Loss: 0.3716 (acc. 83.20%) | Val Loss: 0.4363 (acc. 81.33%)
```

```
| Time: 67s
Epoch 24/120 | Train Loss: 0.3868 (acc. 81.95%) | Val Loss: 0.7918 (acc. 69.50%)
| Time: 67s
Epoch 25/120 | Train Loss: 0.3843 (acc. 82.60%) | Val Loss: 0.4914 (acc. 79.17%)
| Time: 67s
Epoch 26/120 | Train Loss: 0.3303 (acc. 86.25%) | Val Loss: 0.3908 (acc. 81.83%)
| Time: 67s
Epoch 27/120 | Train Loss: 0.3031 (acc. 86.35%) | Val Loss: 0.4620 (acc. 81.67%)
| Time: 67s
Epoch 28/120 | Train Loss: 0.2944 (acc. 87.65%) | Val Loss: 0.4229 (acc. 80.83%)
| Time: 67s
Epoch 29/120 | Train Loss: 0.3225 (acc. 85.80%) | Val Loss: 0.3870 (acc. 83.83%)
| Time: 67s
Epoch 30/120 | Train Loss: 0.3118 (acc. 87.05%) | Val Loss: 0.3783 (acc. 83.17%)
| Time: 67s
Epoch 31/120 | Train Loss: 0.2989 (acc. 86.45%) | Val Loss: 0.3883 (acc. 84.67%)
| Time: 67s
Epoch 32/120 | Train Loss: 0.2765 (acc. 88.50%) | Val Loss: 0.3599 (acc. 85.33%)
| Time: 67s
Epoch 33/120 | Train Loss: 0.2972 (acc. 87.10%) | Val Loss: 0.3706 (acc. 84.83%)
| Time: 67s
Epoch 34/120 | Train Loss: 0.2757 (acc. 89.10%) | Val Loss: 0.3927 (acc. 83.50%)
| Time: 68s
Epoch 35/120 | Train Loss: 0.2514 (acc. 90.20%) | Val Loss: 0.3298 (acc. 86.00%)
| Time: 68s
Epoch 36/120 | Train Loss: 0.2860 (acc. 87.55%) | Val Loss: 0.3622 (acc. 85.00%)
| Time: 67s
Epoch 37/120 | Train Loss: 0.2438 (acc. 89.35%) | Val Loss: 0.3580 (acc. 85.50%)
| Time: 67s
Epoch 38/120 | Train Loss: 0.2286 (acc. 90.60%) | Val Loss: 0.3856 (acc. 84.00%)
| Time: 67s
Epoch 39/120 | Train Loss: 0.2383 (acc. 90.10%) | Val Loss: 0.3534 (acc. 85.33%)
| Time: 67s
Epoch 40/120 | Train Loss: 0.2089 (acc. 91.50%) | Val Loss: 0.3663 (acc. 85.00%)
| Time: 68s
Epoch 41/120 | Train Loss: 0.2168 (acc. 91.05%) | Val Loss: 0.3586 (acc. 84.17%)
| Time: 67s
Epoch 42/120 | Train Loss: 0.2216 (acc. 90.95%) | Val Loss: 0.4370 (acc. 84.33%)
| Time: 70s
Epoch 43/120 | Train Loss: 0.2208 (acc. 90.60%) | Val Loss: 0.3776 (acc. 85.50%)
| Time: 67s
Epoch 44/120 | Train Loss: 0.2285 (acc. 90.15%) | Val Loss: 0.3789 (acc. 84.67%)
| Time: 67s
Epoch 45/120 | Train Loss: 0.2159 (acc. 90.85%) | Val Loss: 0.4297 (acc. 86.50%)
| Time: 67s
Epoch 46/120 | Train Loss: 0.2089 (acc. 91.30%) | Val Loss: 0.3336 (acc. 86.67%)
| Time: 67s
Epoch 47/120 | Train Loss: 0.1955 (acc. 92.10%) | Val Loss: 0.5513 (acc. 81.50%)
| Time: 67s
Epoch 48/120 | Train Loss: 0.2087 (acc. 91.45%) | Val Loss: 0.3444 (acc. 86.33%)
| Time: 67s
Epoch 49/120 | Train Loss: 0.2035 (acc. 91.45%) | Val Loss: 0.4692 (acc. 85.33%)
| Time: 67s
Epoch 50/120 | Train Loss: 0.1823 (acc. 91.95%) | Val Loss: 0.3462 (acc. 87.33%)
| Time: 67s
Epoch 51/120 | Train Loss: 0.1732 (acc. 93.45%) | Val Loss: 0.3008 (acc. 89.00%)
| Time: 67s
Epoch 52/120 | Train Loss: 0.1742 (acc. 92.75%) | Val Loss: 0.3278 (acc. 87.33%)
| Time: 67s
Epoch 53/120 | Train Loss: 0.1615 (acc. 93.55%) | Val Loss: 0.3221 (acc. 88.00%)
| Time: 67s
Epoch 54/120 | Train Loss: 0.1429 (acc. 94.00%) | Val Loss: 0.3693 (acc. 87.00%)
| Time: 67s
Epoch 55/120 | Train Loss: 0.1290 (acc. 94.85%) | Val Loss: 0.4544 (acc. 86.17%)
| Time: 67s
Epoch 56/120 | Train Loss: 0.1425 (acc. 94.20%) | Val Loss: 0.3564 (acc. 87.17%)
| Time: 67s
Epoch 57/120 | Train Loss: 0.1544 (acc. 93.95%) | Val Loss: 0.3282 (acc. 88.33%)
```

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| Time: 67s
Epoch 58/120 | Train Loss: 0.1483 (acc. 94.25%) | Val Loss: 0.3485 (acc. 87.33%)
| Time: 67s
Epoch 59/120 | Train Loss: 0.1574 (acc. 93.95%) | Val Loss: 0.3070 (acc. 89.50%)
| Time: 67s
Epoch 60/120 | Train Loss: 0.1253 (acc. 95.10%) | Val Loss: 0.3293 (acc. 88.17%)
| Time: 67s
Epoch 61/120 | Train Loss: 0.1670 (acc. 94.75%) | Val Loss: 0.4046 (acc. 87.50%)
| Time: 67s
Epoch 62/120 | Train Loss: 0.1581 (acc. 93.65%) | Val Loss: 0.4881 (acc. 84.83%)
| Time: 67s
Epoch 63/120 | Train Loss: 0.1563 (acc. 93.85%) | Val Loss: 0.3700 (acc. 87.50%)
| Time: 67s
Epoch 64/120 | Train Loss: 0.1228 (acc. 95.65%) | Val Loss: 0.3689 (acc. 87.33%)
| Time: 67s
Epoch 65/120 | Train Loss: 0.1254 (acc. 95.05%) | Val Loss: 0.3460 (acc. 88.83%)
| Time: 67s
Epoch 66/120 | Train Loss: 0.1189 (acc. 95.20%) | Val Loss: 0.3387 (acc. 89.50%)
| Time: 67s
Epoch 67/120 | Train Loss: 0.1289 (acc. 95.00%) | Val Loss: 0.3249 (acc. 91.00%)
| Time: 67s
Epoch 68/120 | Train Loss: 0.1008 (acc. 96.10%) | Val Loss: 0.3334 (acc. 88.83%)
| Time: 67s
Epoch 69/120 | Train Loss: 0.0984 (acc. 96.20%) | Val Loss: 0.3412 (acc. 89.50%)
| Time: 67s
Epoch 70/120 | Train Loss: 0.1160 (acc. 95.95%) | Val Loss: 0.3617 (acc. 89.17%)
| Time: 67s
Epoch 71/120 | Train Loss: 0.1178 (acc. 95.65%) | Val Loss: 0.3561 (acc. 88.67%)
| Time: 67s
Epoch 72/120 | Train Loss: 0.1307 (acc. 94.50%) | Val Loss: 0.3677 (acc. 87.83%)
| Time: 67s
Epoch 73/120 | Train Loss: 0.1076 (acc. 95.65%) | Val Loss: 0.3262 (acc. 88.83%)
| Time: 67s
Epoch 74/120 | Train Loss: 0.1048 (acc. 96.10%) | Val Loss: 0.3870 (acc. 86.33%)
| Time: 67s
Epoch 75/120 | Train Loss: 0.1219 (acc. 95.70%) | Val Loss: 0.4031 (acc. 86.17%)
| Time: 67s
Epoch 76/120 | Train Loss: 0.0832 (acc. 97.15%) | Val Loss: 0.3331 (acc. 89.33%)
| Time: 67s
Epoch 77/120 | Train Loss: 0.0879 (acc. 96.85%) | Val Loss: 0.3198 (acc. 89.50%)
| Time: 67s
Epoch 78/120 | Train Loss: 0.1347 (acc. 96.40%) | Val Loss: 0.3182 (acc. 90.00%)
| Time: 67s
Epoch 79/120 | Train Loss: 0.0964 (acc. 96.50%) | Val Loss: 0.3149 (acc. 89.50%)
| Time: 67s
Epoch 80/120 | Train Loss: 0.0950 (acc. 96.25%) | Val Loss: 0.3244 (acc. 89.33%)
| Time: 67s
Epoch 81/120 | Train Loss: 0.0960 (acc. 96.45%) | Val Loss: 0.3273 (acc. 89.67%)
| Time: 67s
Epoch 82/120 | Train Loss: 0.0992 (acc. 96.45%) | Val Loss: 0.3052 (acc. 89.50%)
| Time: 67s
Epoch 83/120 | Train Loss: 0.0868 (acc. 97.05%) | Val Loss: 0.3015 (acc. 89.00%)
| Time: 67s
Epoch 84/120 | Train Loss: 0.0902 (acc. 96.65%) | Val Loss: 0.2983 (acc. 90.00%)
| Time: 67s
Epoch 85/120 | Train Loss: 0.0824 (acc. 96.75%) | Val Loss: 0.3060 (acc. 90.00%)
| Time: 67s
Epoch 86/120 | Train Loss: 0.0683 (acc. 97.70%) | Val Loss: 0.3179 (acc. 88.17%)
| Time: 67s
Epoch 87/120 | Train Loss: 0.0651 (acc. 97.65%) | Val Loss: 0.3229 (acc. 89.17%)
| Time: 67s
Epoch 88/120 | Train Loss: 0.0832 (acc. 96.70%) | Val Loss: 0.3387 (acc. 88.33%)
| Time: 67s
Epoch 89/120 | Train Loss: 0.0677 (acc. 97.15%) | Val Loss: 0.3406 (acc. 89.17%)
| Time: 67s
Epoch 90/120 | Train Loss: 0.0668 (acc. 97.25%) | Val Loss: 0.3052 (acc. 89.67%)
| Time: 67s
Epoch 91/120 | Train Loss: 0.0771 (acc. 97.55%) | Val Loss: 0.3154 (acc. 89.83%)
```

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| Time: 67s
Epoch 92/120 | Train Loss: 0.0714 (acc. 97.60%) | Val Loss: 0.3325 (acc. 88.83%)
| Time: 67s
Epoch 93/120 | Train Loss: 0.0774 (acc. 97.05%) | Val Loss: 0.3195 (acc. 89.17%)
| Time: 67s
Epoch 94/120 | Train Loss: 0.0665 (acc. 97.60%) | Val Loss: 0.3369 (acc. 89.33%)
| Time: 67s
Epoch 95/120 | Train Loss: 0.0829 (acc. 96.95%) | Val Loss: 0.3272 (acc. 89.33%)
| Time: 67s
Epoch 96/120 | Train Loss: 0.0704 (acc. 97.35%) | Val Loss: 0.3520 (acc. 88.83%)
| Time: 67s
Epoch 97/120 | Train Loss: 0.0814 (acc. 96.75%) | Val Loss: 0.3474 (acc. 90.00%)
| Time: 67s
Epoch 98/120 | Train Loss: 0.0725 (acc. 97.10%) | Val Loss: 0.3524 (acc. 88.67%)
| Time: 67s
Epoch 99/120 | Train Loss: 0.0598 (acc. 97.70%) | Val Loss: 0.3396 (acc. 89.50%)
| Time: 67s
Epoch 100/120 | Train Loss: 0.0665 (acc. 97.20%) | Val Loss: 0.3376 (acc.
90.17%) | Time: 67s
Epoch 101/120 | Train Loss: 0.0456 (acc. 98.50%) | Val Loss: 0.3500 (acc.
89.00%) | Time: 67s
Epoch 102/120 | Train Loss: 0.0472 (acc. 98.50%) | Val Loss: 0.3313 (acc.
90.17%) | Time: 67s
Epoch 103/120 | Train Loss: 0.0674 (acc. 97.70%) | Val Loss: 0.3263 (acc.
90.17%) | Time: 67s
Epoch 104/120 | Train Loss: 0.0554 (acc. 97.95%) | Val Loss: 0.3132 (acc.
90.67%) | Time: 67s
Epoch 105/120 | Train Loss: 0.0589 (acc. 98.00%) | Val Loss: 0.3411 (acc.
90.67%) | Time: 67s
Epoch 106/120 | Train Loss: 0.0456 (acc. 98.05%) | Val Loss: 0.3470 (acc.
89.83%) | Time: 67s
Epoch 107/120 | Train Loss: 0.0433 (acc. 98.30%) | Val Loss: 0.3356 (acc.
89.67%) | Time: 67s
Epoch 108/120 | Train Loss: 0.0856 (acc. 98.25%) | Val Loss: 0.3408 (acc.
90.00%) | Time: 67s
Epoch 109/120 | Train Loss: 0.0578 (acc. 97.95%) | Val Loss: 0.3249 (acc.
89.50%) | Time: 68s
Epoch 110/120 | Train Loss: 0.0625 (acc. 97.45%) | Val Loss: 0.3357 (acc.
89.33%) | Time: 68s
Epoch 111/120 | Train Loss: 0.0448 (acc. 98.60%) | Val Loss: 0.3400 (acc.
89.50%) | Time: 68s
Epoch 112/120 | Train Loss: 0.0578 (acc. 97.95%) | Val Loss: 0.3215 (acc.
90.83%) | Time: 67s
Epoch 113/120 | Train Loss: 0.0525 (acc. 98.15%) | Val Loss: 0.3348 (acc.
90.50%) | Time: 68s
Epoch 114/120 | Train Loss: 0.0510 (acc. 98.00%) | Val Loss: 0.3671 (acc.
89.17%) | Time: 67s
Epoch 115/120 | Train Loss: 0.0532 (acc. 97.95%) | Val Loss: 0.3569 (acc.
89.33%) | Time: 68s
Epoch 116/120 | Train Loss: 0.0564 (acc. 97.85%) | Val Loss: 0.3501 (acc.
89.50%) | Time: 68s
Epoch 117/120 | Train Loss: 0.0544 (acc. 98.00%) | Val Loss: 0.3818 (acc.
89.67%) | Time: 67s
Epoch 118/120 | Train Loss: 0.0606 (acc. 97.85%) | Val Loss: 0.3494 (acc.
90.17%) | Time: 67s
Epoch 119/120 | Train Loss: 0.0563 (acc. 97.65%) | Val Loss: 0.3548 (acc.
89.33%) | Time: 68s
Epoch 120/120 | Train Loss: 0.0384 (acc. 98.65%) | Val Loss: 0.3839 (acc.
88.67%) | Time: 67s
Training Time: 8039s
```



0.10 Predict

```
[27]: test_image = "data/test/cats/cat.1306.jpg"
net_config2 = {**default_net_config,
    "cv_layers": [
        {"out_channels": 64, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
        {"out_channels": 128, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
        {"out_channels": 256, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
        {"out_channels": 512, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
        {"out_channels": 512, "kernel_size": 3, "stride": 1, "padding": 1, "max_pool": 2, "max_pool_stride": 2, "batch_norm": True},
    ],
    "fc_layers": [
        {"out_features": 512, "batch_norm": True, "dropout_rate": 0.4},
        {"out_features": 256, "batch_norm": True, "dropout_rate": 0.2},
    ],
}
model = ConvolutionalNetwork(net_config2)
predict(model, device, "models/reg_4.pth", "results/reg_4.csv")
plot_individual_feature_maps(model, device, test_image, "results/feature_maps_reg_4.png")
```

Total Correctly Classified: 366 | Total Misclassified: 34 | Accuracy: 91.5%
 Class-wise Correctly Classified Counts:

- Class cat: 175
- Class dog: 191

Class-wise Misclassified Counts:

- Class cat: 25
- Class dog: 9

Cat Accuracy: 87.5% | Dog Accuracy: 95.5%

Correctly Classified



Misclassified

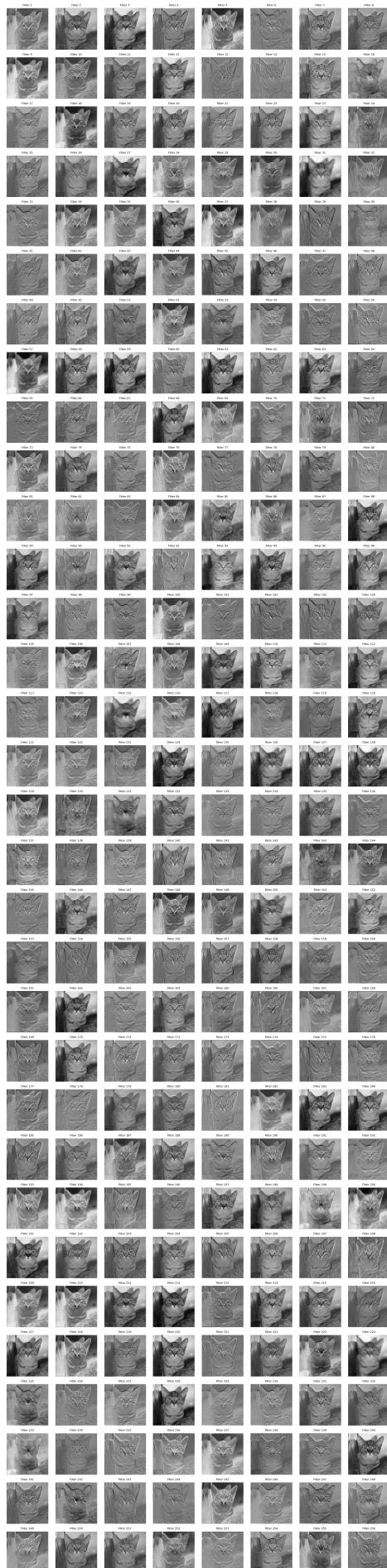


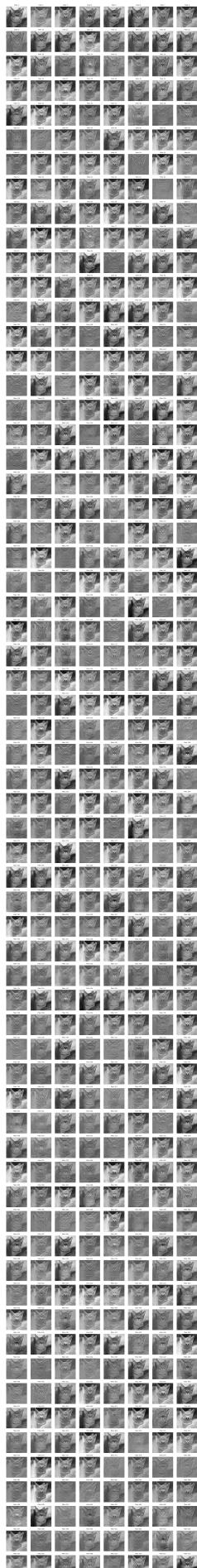
Original Image













0.11 Transfer Learning

```
[28]: num_classes = default_config["net_config"]["num_classes"]

model_alexnet = alexnet(weights=AlexNet_Weights.DEFAULT)

# Freeze all parameters/layers except last one
for name, param in model_alexnet.named_parameters():
    if("bn" not in name):
        param.requires_grad = False

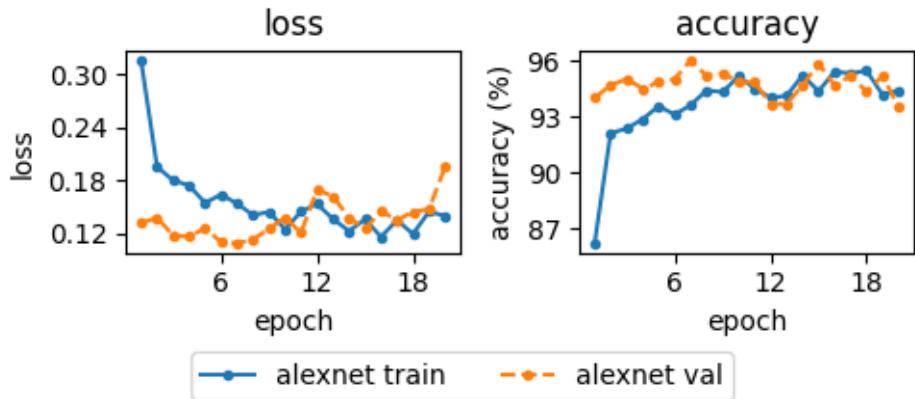
# Change last layer to output 2 classes
model_alexnet.classifier[6] = nn.Linear(4096, num_classes)

config_alexnet = {**default_config, "label": "alexnet", "n_epochs": 20}

results = {}
results["alexnet"] = train_model(model_alexnet, device, config_alexnet)
plot_scores(results)
```

Experiment: alexnet

```
Epoch 1/20 | Train Loss: 0.3162 (acc. 86.20%) | Val Loss: 0.1319 (acc. 94.00%) |
Time: 43s
Epoch 2/20 | Train Loss: 0.1956 (acc. 92.10%) | Val Loss: 0.1380 (acc. 94.67%) |
Time: 38s
Epoch 3/20 | Train Loss: 0.1803 (acc. 92.35%) | Val Loss: 0.1180 (acc. 95.00%) |
Time: 37s
Epoch 4/20 | Train Loss: 0.1746 (acc. 92.85%) | Val Loss: 0.1164 (acc. 94.50%) |
Time: 38s
Epoch 5/20 | Train Loss: 0.1548 (acc. 93.55%) | Val Loss: 0.1260 (acc. 94.83%) |
Time: 37s
Epoch 6/20 | Train Loss: 0.1642 (acc. 93.10%) | Val Loss: 0.1105 (acc. 95.00%) |
Time: 36s
Epoch 7/20 | Train Loss: 0.1540 (acc. 93.60%) | Val Loss: 0.1089 (acc. 96.00%) |
Time: 36s
Epoch 8/20 | Train Loss: 0.1409 (acc. 94.40%) | Val Loss: 0.1133 (acc. 95.17%) |
Time: 35s
Epoch 9/20 | Train Loss: 0.1446 (acc. 94.30%) | Val Loss: 0.1256 (acc. 95.33%) |
Time: 36s
Epoch 10/20 | Train Loss: 0.1248 (acc. 95.15%) | Val Loss: 0.1380 (acc. 94.83%) |
Time: 35s
Epoch 11/20 | Train Loss: 0.1448 (acc. 94.50%) | Val Loss: 0.1210 (acc. 94.83%) |
Time: 36s
Epoch 12/20 | Train Loss: 0.1536 (acc. 94.00%) | Val Loss: 0.1698 (acc. 93.67%) |
Time: 35s
Epoch 13/20 | Train Loss: 0.1365 (acc. 94.10%) | Val Loss: 0.1622 (acc. 93.67%) |
Time: 35s
Epoch 14/20 | Train Loss: 0.1229 (acc. 95.20%) | Val Loss: 0.1379 (acc. 94.67%) |
Time: 35s
Epoch 15/20 | Train Loss: 0.1361 (acc. 94.35%) | Val Loss: 0.1254 (acc. 95.83%) |
Time: 36s
Epoch 16/20 | Train Loss: 0.1163 (acc. 95.40%) | Val Loss: 0.1454 (acc. 94.67%) |
Time: 36s
Epoch 17/20 | Train Loss: 0.1351 (acc. 95.30%) | Val Loss: 0.1353 (acc. 95.17%) |
Time: 40s
Epoch 18/20 | Train Loss: 0.1196 (acc. 95.45%) | Val Loss: 0.1446 (acc. 94.33%) |
Time: 35s
Epoch 19/20 | Train Loss: 0.1448 (acc. 94.15%) | Val Loss: 0.1477 (acc. 95.17%) |
Time: 33s
Epoch 20/20 | Train Loss: 0.1400 (acc. 94.40%) | Val Loss: 0.1953 (acc. 93.50%) |
Time: 33s
Training Time: 724s
```



```
[26]: model = AlexNet(num_classes=num_classes)
predict(model, device, "models/alexnet.pth", "results/alexnet.csv")
plot_individual_feature_maps(model, device, test_image, "results/feature_maps_alexnet.png")
```

Total Correctly Classified: 374 | Total Misclassified: 26 | Accuracy: 93.5%

Class-wise Correctly Classified Counts:

- Class cat: 191
- Class dog: 183

Class-wise Misclassified Counts:

- Class cat: 9
- Class dog: 17

Cat Accuracy: 95.5% | Dog Accuracy: 91.5%



Original Image



