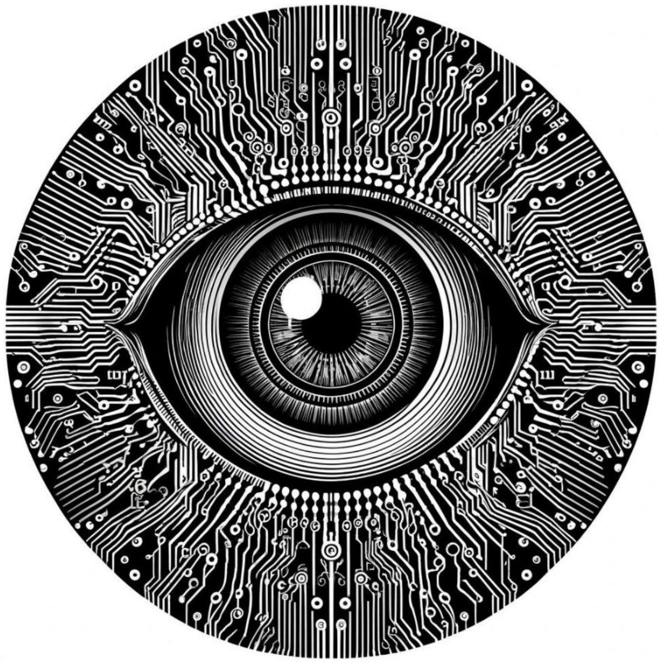
Image Data Augmentation



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Learning goals

- Use data augmentation to extend training datasets
- Gain familiarity with PyTorch’s transforms.v2: affine transformations, vertical and horizontal flipping, and random crops

Data augmentation

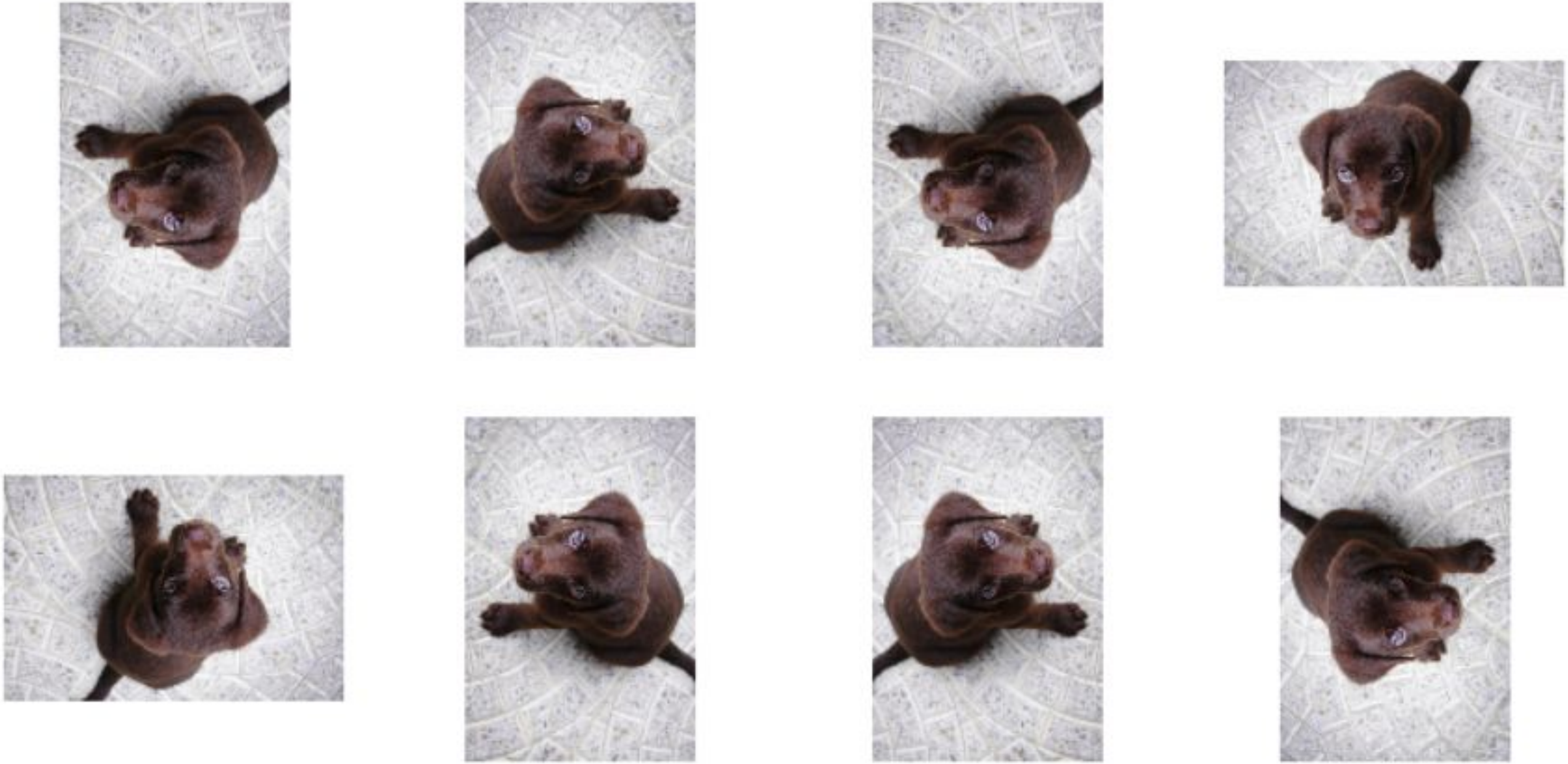
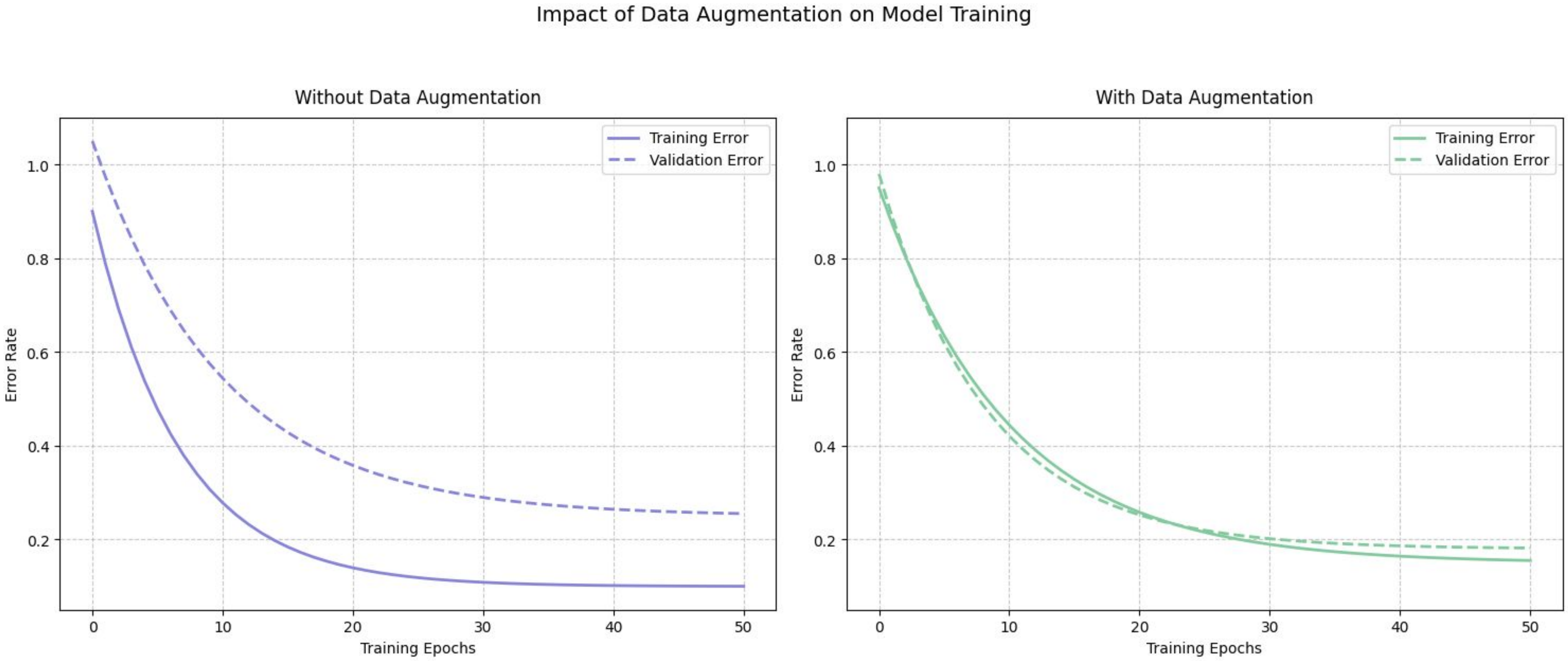


Image from https://docs.fast.ai/vision.augment

Data augmentation as regularization

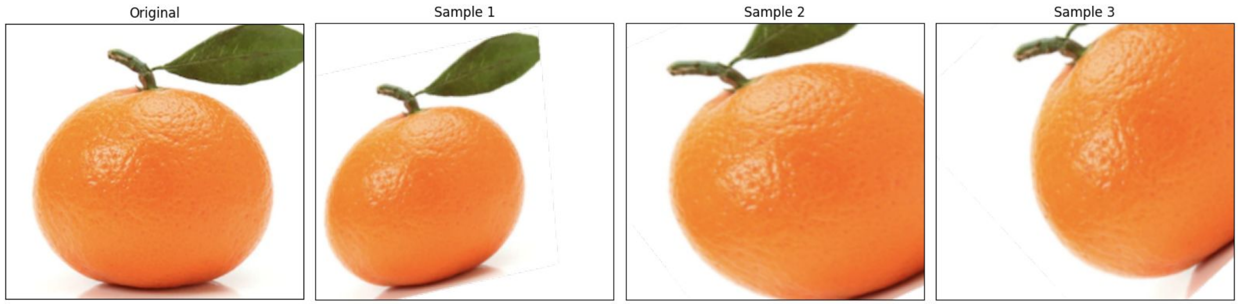


Affine transformations

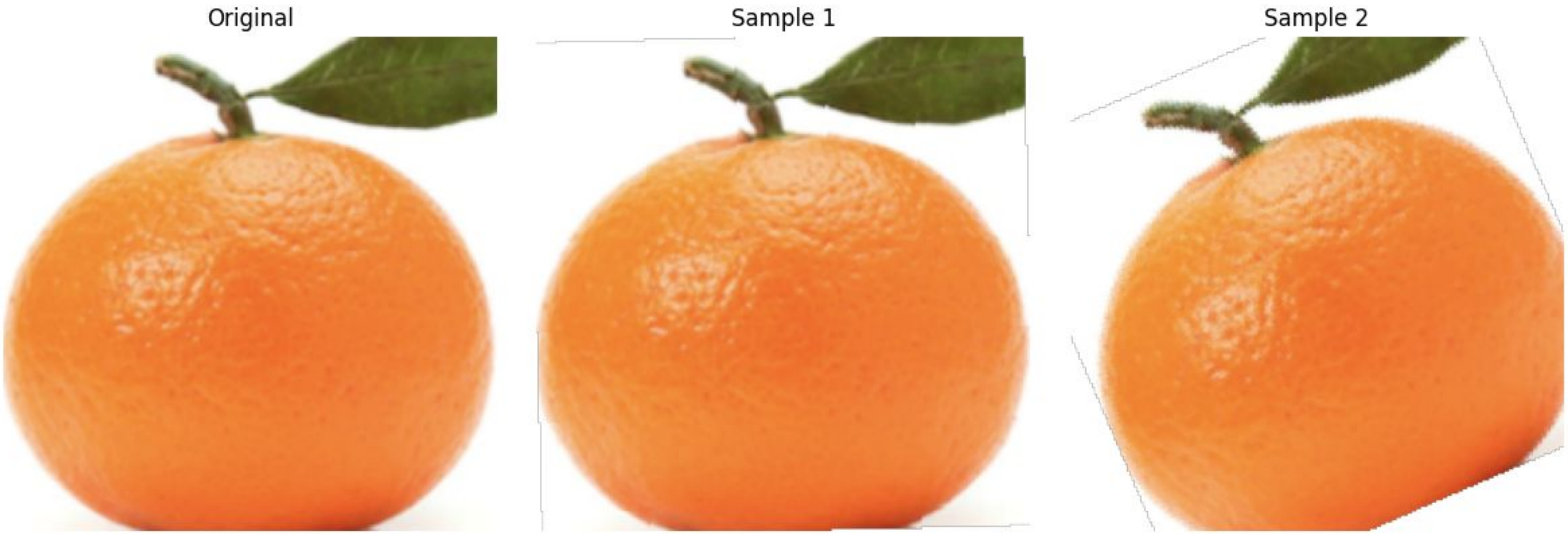
$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} \Delta_x \\ \Delta_y \end{pmatrix}$$

Linear transformation
(Rotation, scaling, shear)

Translation
(Moving along the axes)



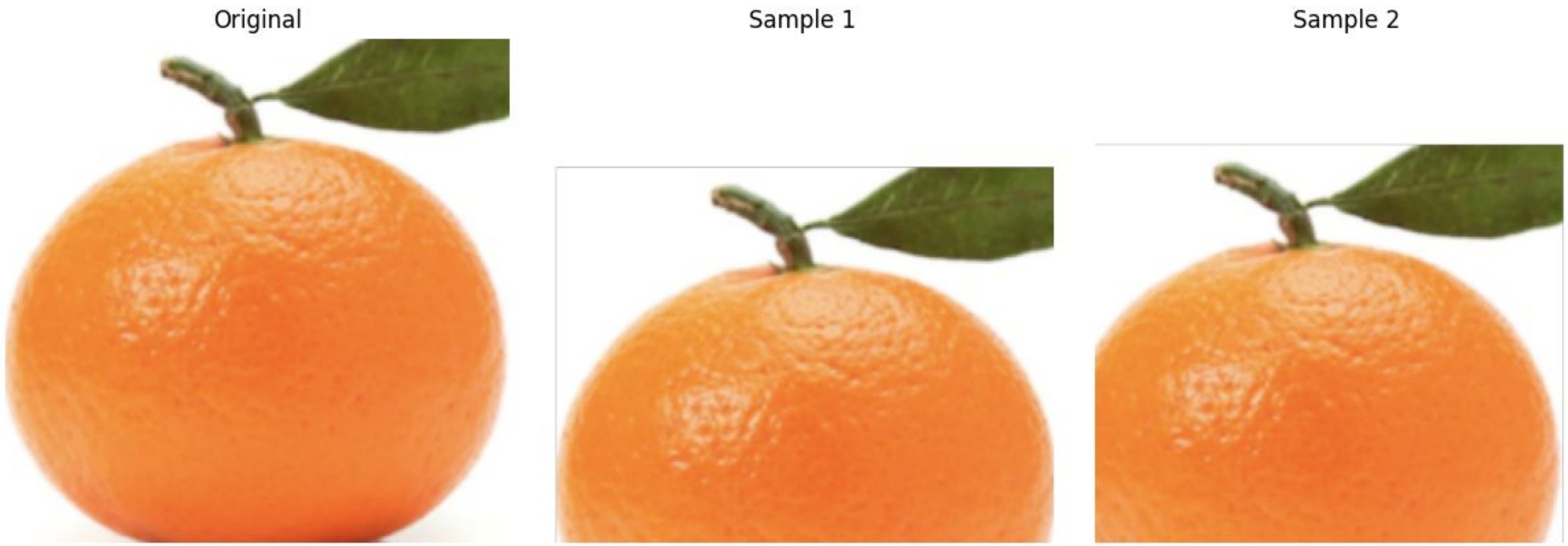
The RandomAffine transformation - rotation



$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

```
transforms.RandomAffine(degrees=45)
```

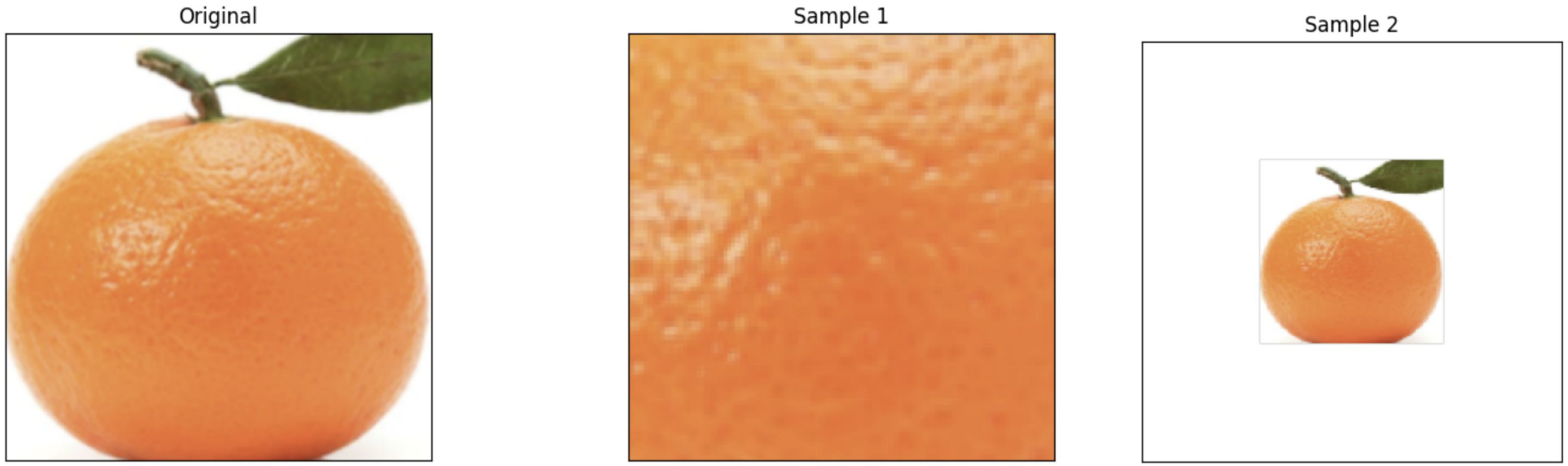
The RandomAffine transformation - translation



$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} t_x \\ t_y \end{pmatrix}$$

```
transforms.RandomAffine(degrees=0, translate=(0.4, 0.4))
```

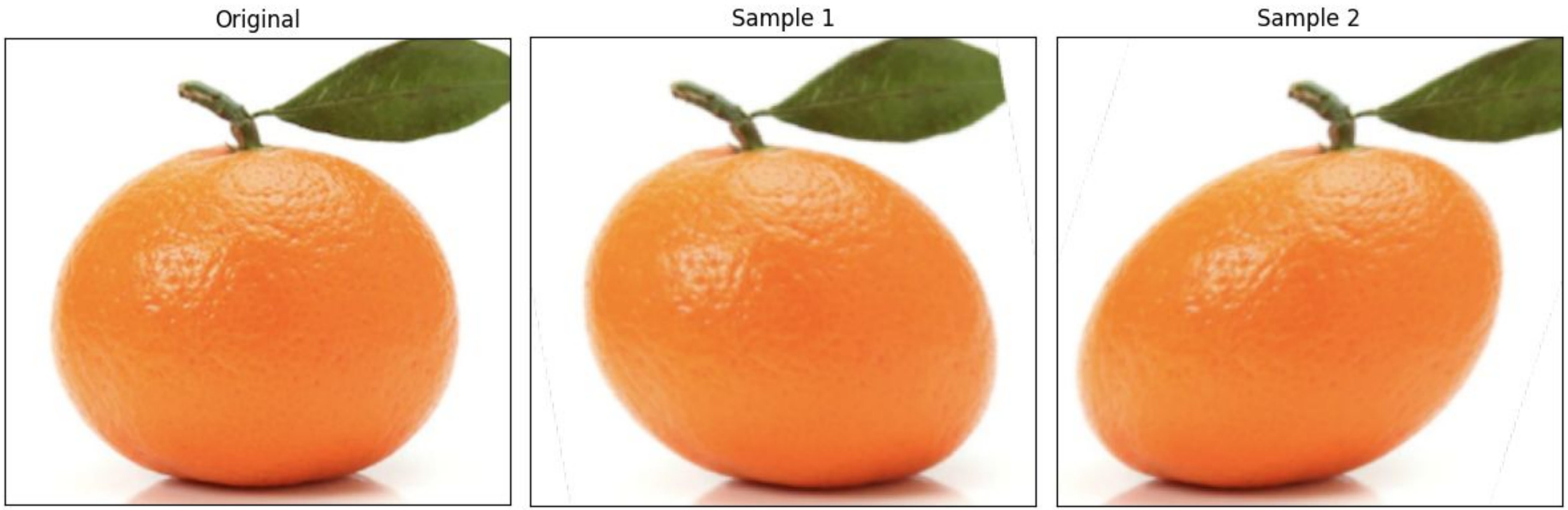
The RandomAffine transformation - scaling



$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} s_x & 0 \\ 0 & s_y \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

```
transforms.RandomAffine(degrees=0, scale=(0.25, 2.5))
```

The RandomAffine transformation - shear



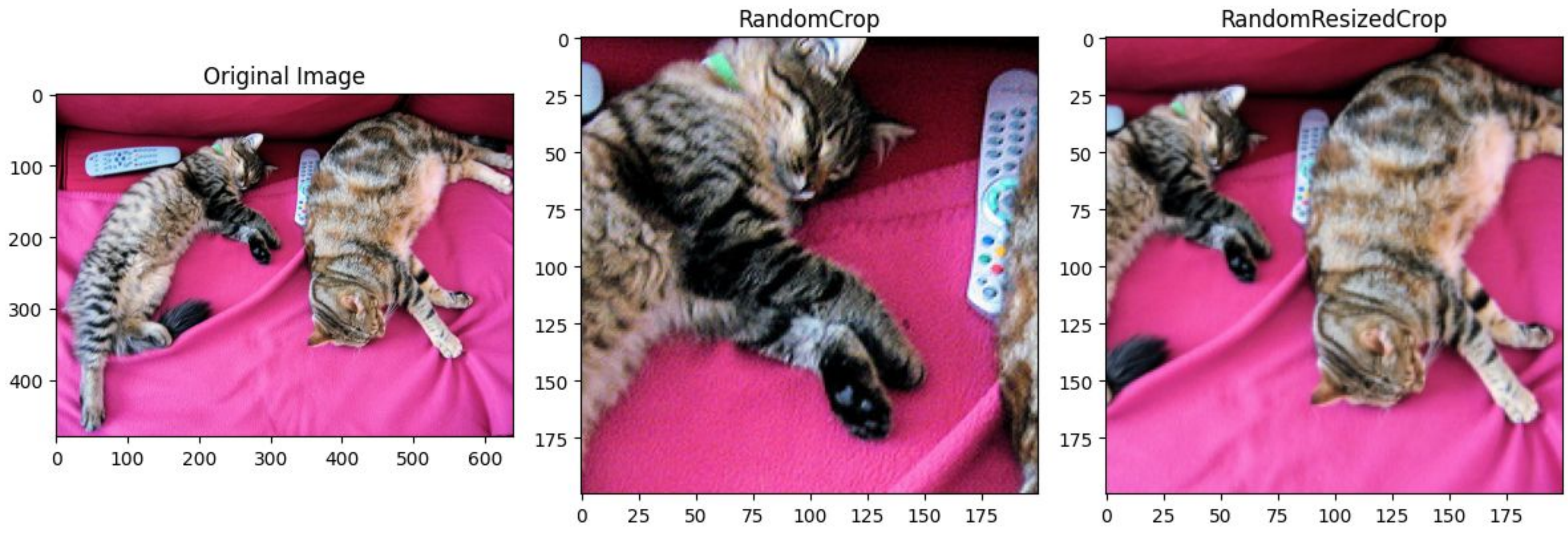
$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 1 & s_x \\ s_y & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

```
transforms.RandomAffine(degrees=0,shear=45)
```

Horizontal and vertical flipping


```
transforms.Compose([
        transforms.RandomHorizontalFlip(p=0.5),
        transforms.RandomVerticalFlip(p=0.5)
   ])
```

RandomCrop and RandomResizedCrop




```python
transforms.RandomCrop(size=224)
```

```python
transforms.RandomResizedCrop(
        size=224,
        scale=(0.08, 1.0),   # Range of size of crop
        ratio=(3/4, 4/3)     # Range of aspect ratio
    )
```

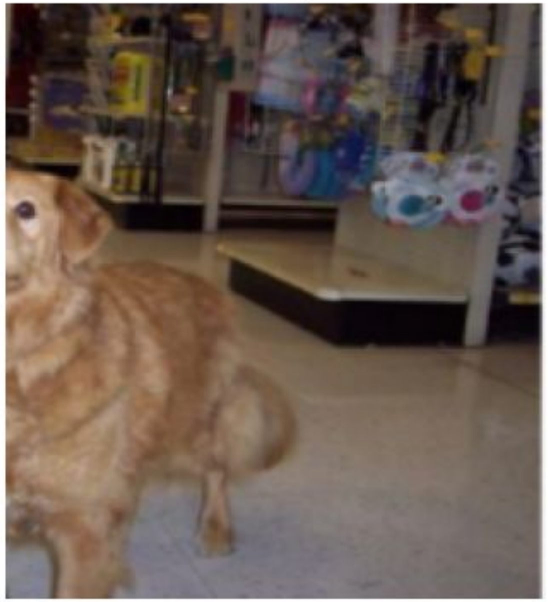
Blind data augmentation can damage your model

$\hat{y} =$ golden retriever (unit 207 on Imagenet)

Original

Sample 1

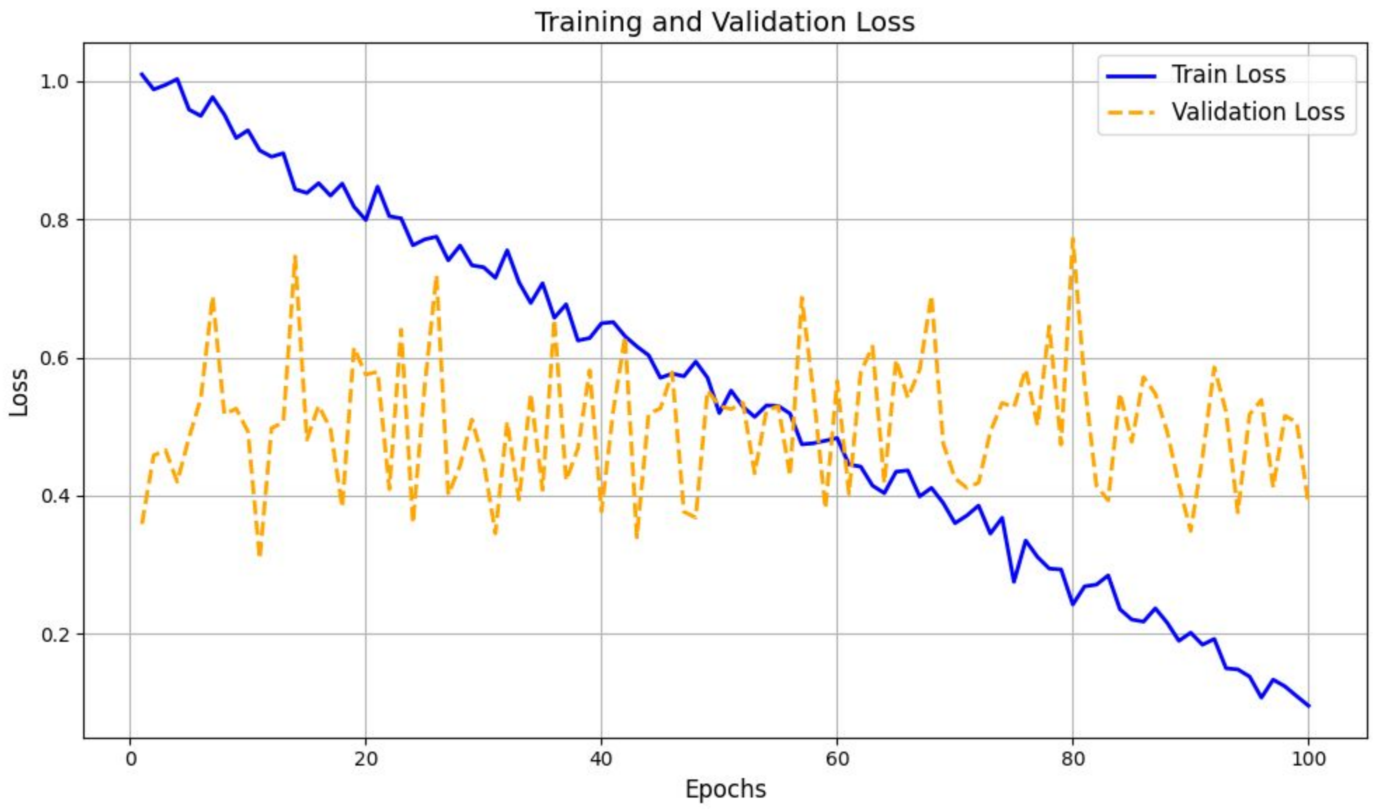
Sample 2



$$\text{Cross Entropy Loss} = -\log(0.003) = 5.809$$

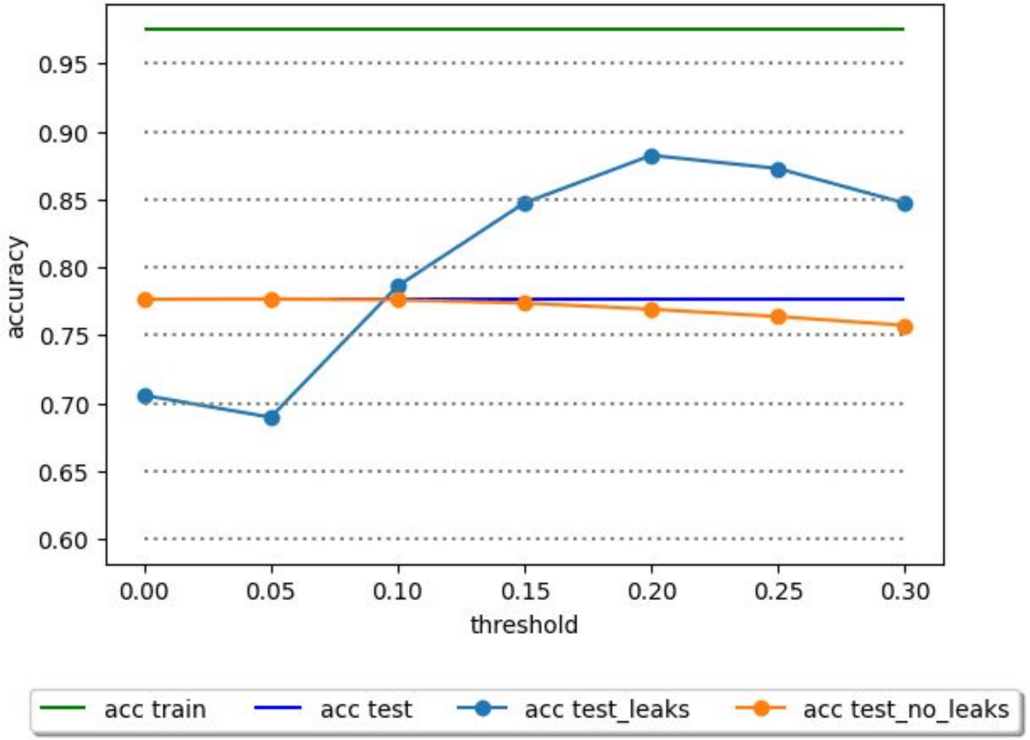
$$-\log(0.6) = 0.511$$

The validation set should not be augmented during training




```python
import torchvision.transforms.v2 as T

imagenet_mean = [0.485, 0.456, 0.406]
imagenet_std  = [0.229, 0.224, 0.225]

transform = T.Compose([

# Resize to 224x224
T.Resize((224, 224)),

# Convert to torch Image
T.ToImage(),

# Convert to scaled float tensor
T.ToDtype(torch.float32, scale=True),

# Apply ImageNet normalization
T.Normalize(mean=imagenet_mean,
            std=imagenet_std)
])
```

Augmentation should happen <u>after</u> train, validation, and test splitting



Images from "[On Leaky Datasets and a Clever Horse]"

Summary

Data augmentation creates synthetic input data

- Data augmentation can improve the robustness of a model and prevent overfitting

PyTorch transforms are powerful and composable

- `transforms.v2` provides rotation, scale, crop, and flip (+other) operations
- Each transform has specific parameters for fine control

Avoiding data leakage: best practices

- Apply augmentations after train, validation, and test split. Never augment validation data. Test augmentation effects through observation and loss values

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Further reading and references

Data augmentation is still data curation

- https://voxel51.com/blog/data-augmentation-is-still-data-curation/

Getting started with PyTorch's transforms v2

- https://pytorch.org/vision/main/auto_examples/transforms/plot_transforms_getting_started.html

Illustration of transforms

- https://pytorch.org/vision/main/auto_examples/transforms/plot_transforms_illustrations.html#sphx-glr-auto-examples-transforms-plot-transforms-illustrations-py

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