Deep Learning Toolkit *(Einops)*

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Outline

Environment, Code Editor

Python

Tensor libraries – numpy, einsum, **einops**

PyTorch, Timm

Huggingface (HF), Gradio

HF Accelerator, GitHub

Pytorch Lightning

Einstein Operations: Einops

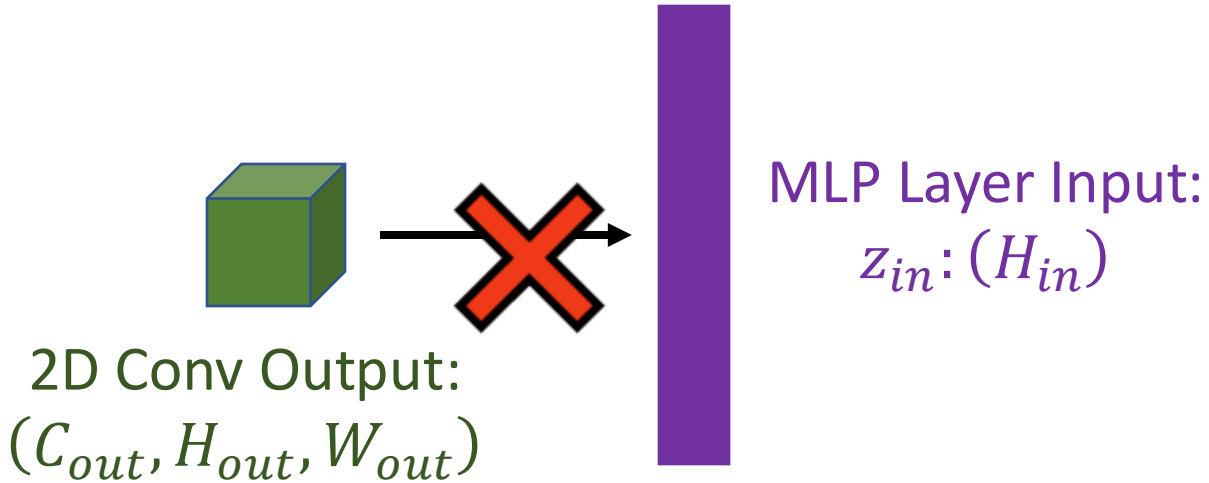
Rogozhnikov, Alex. "Einops: Clear and Reliable Tensor Manipulations with Einstein-like Notation." *International Conference on Learning Representations*. 2022.

https://github.com/arogozhnikov/einops

Motivation: Tensor shape and size between layers IO must match

Input/Output shape of 2D convolution: z_{in}: (C_{in}, H_{in}, W_{in}) and z_{out}: $(C_{out}, H_{out}, W_{out})$ where C: channel, H: height and W: width

Input/Output shape of an MLP layer: : z_{in}: (H_{in}) and z_{out}: (H_{out}) where H: height

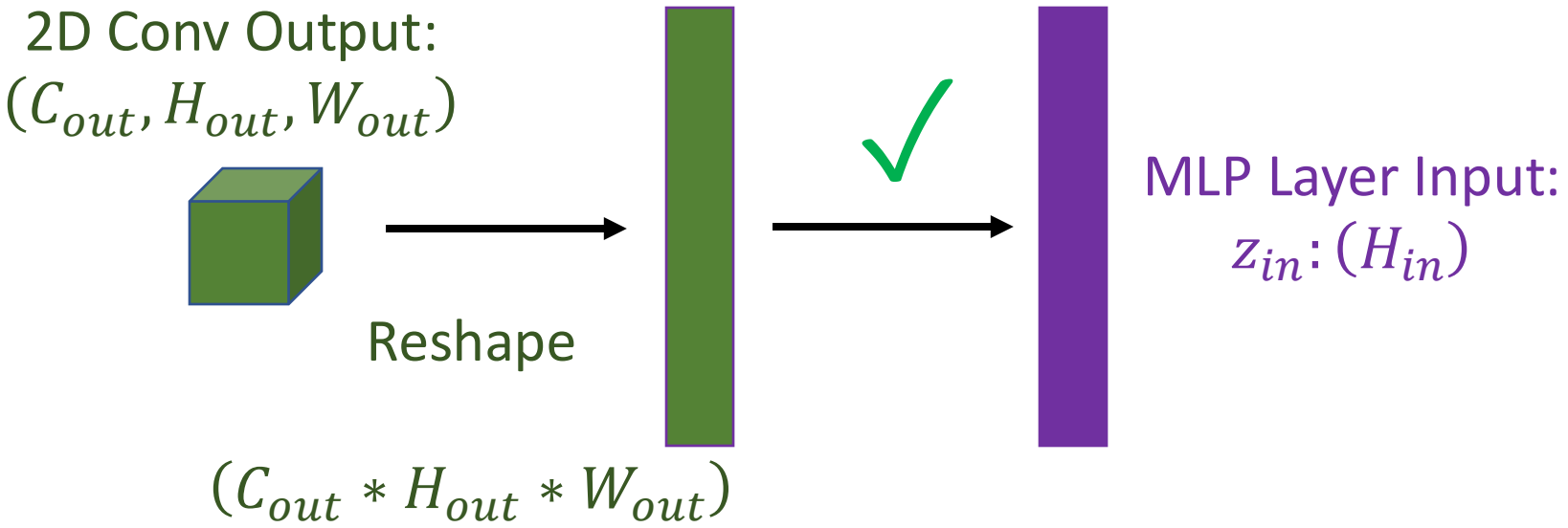


Solution: Reshape the 2D convolution output to match the input requirement of MLP

$$z_{out}: (C_{out}, H_{out}, W_{out}) \rightarrow (C_{out} * H_{out} * W_{out})$$

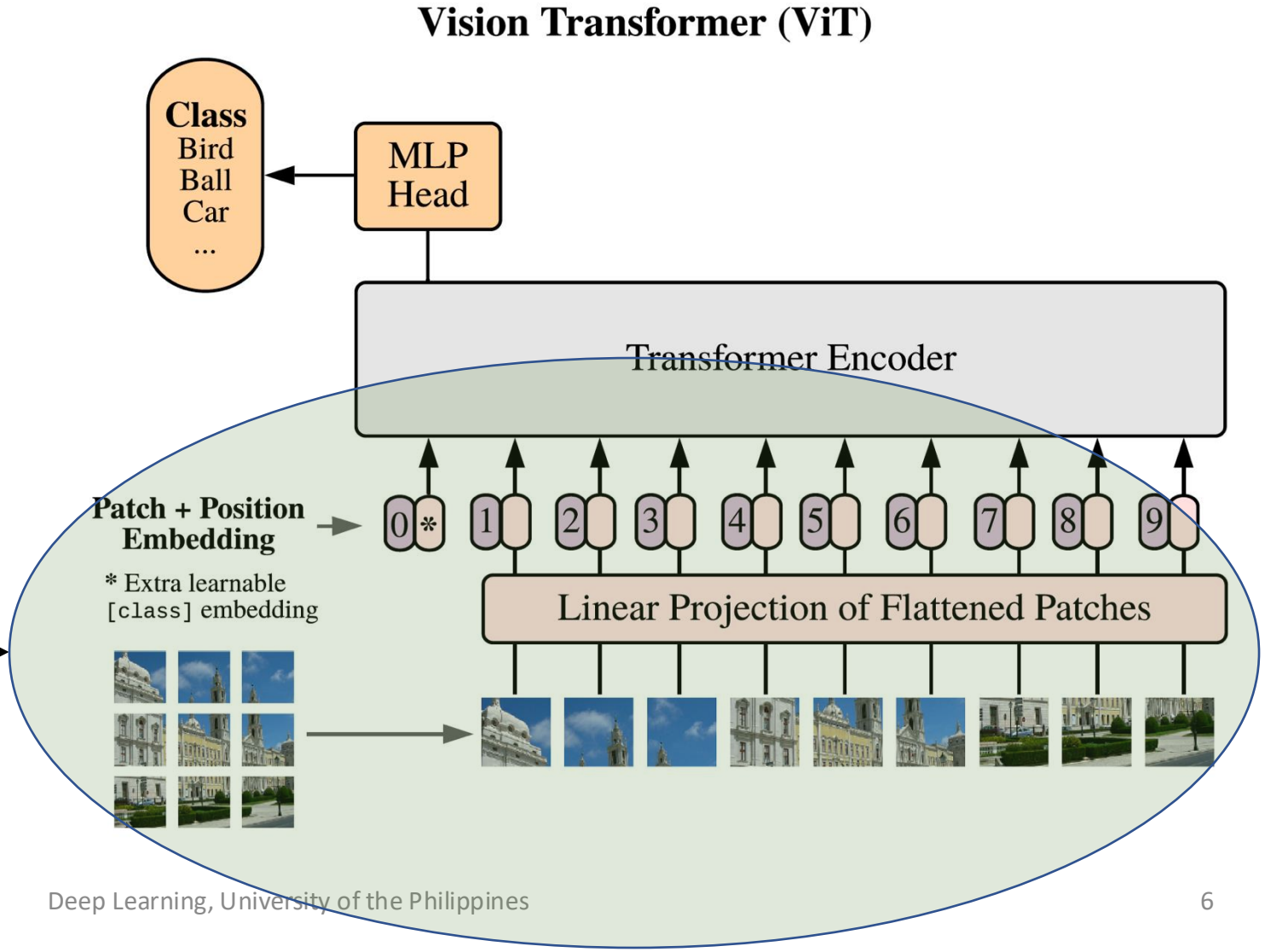
$$z_{in}: (H_{in})$$

$$\therefore H_{in} = C_{out} * H_{out} * W_{out}$$



Motivation: Upsize, Downsize, Stack, Split, View, Permute, etc

In Vision Transformer (ViT), we split an input image into patches.



Numpy/PyTorch vs Einops APIs

Operation	Numpy/PyTorch	Einops
Transpose	`transpose`	`rearrange`
Reshape	`reshape/view`	`rearrange`
Upsize	`repeat/upsample`	`repeat`
Downsize	`interpolate`	`reduce`
Split	`split`	`rearrange`
Permute	`permute`	`rearrange`

Install and Import

Install

```
pip install einops
```

Import

```
from einops import rearrange, repeat, reduce
```

Flatten

```
img = image.imread("aki_dog.jpg")
img = rearrange(img, "h w c -> (h w c)")
```

(224, 224, 3)

(150528,)

Syntax

Output shape:
Fuse height, width,
channel by multiplying
them together

Input tensor

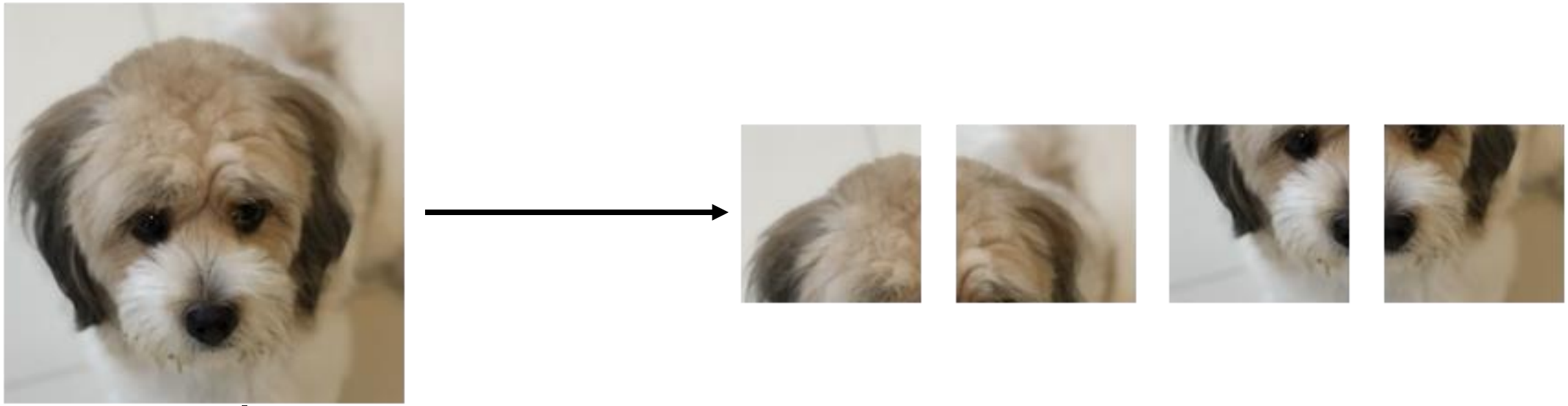
```
rearrange(img, "h w c -> (h w c)")
```

Input shape:
height, width, channel

Flatten in numpy

```
img = np.reshape(img, (-1,))
```

Image to Patches



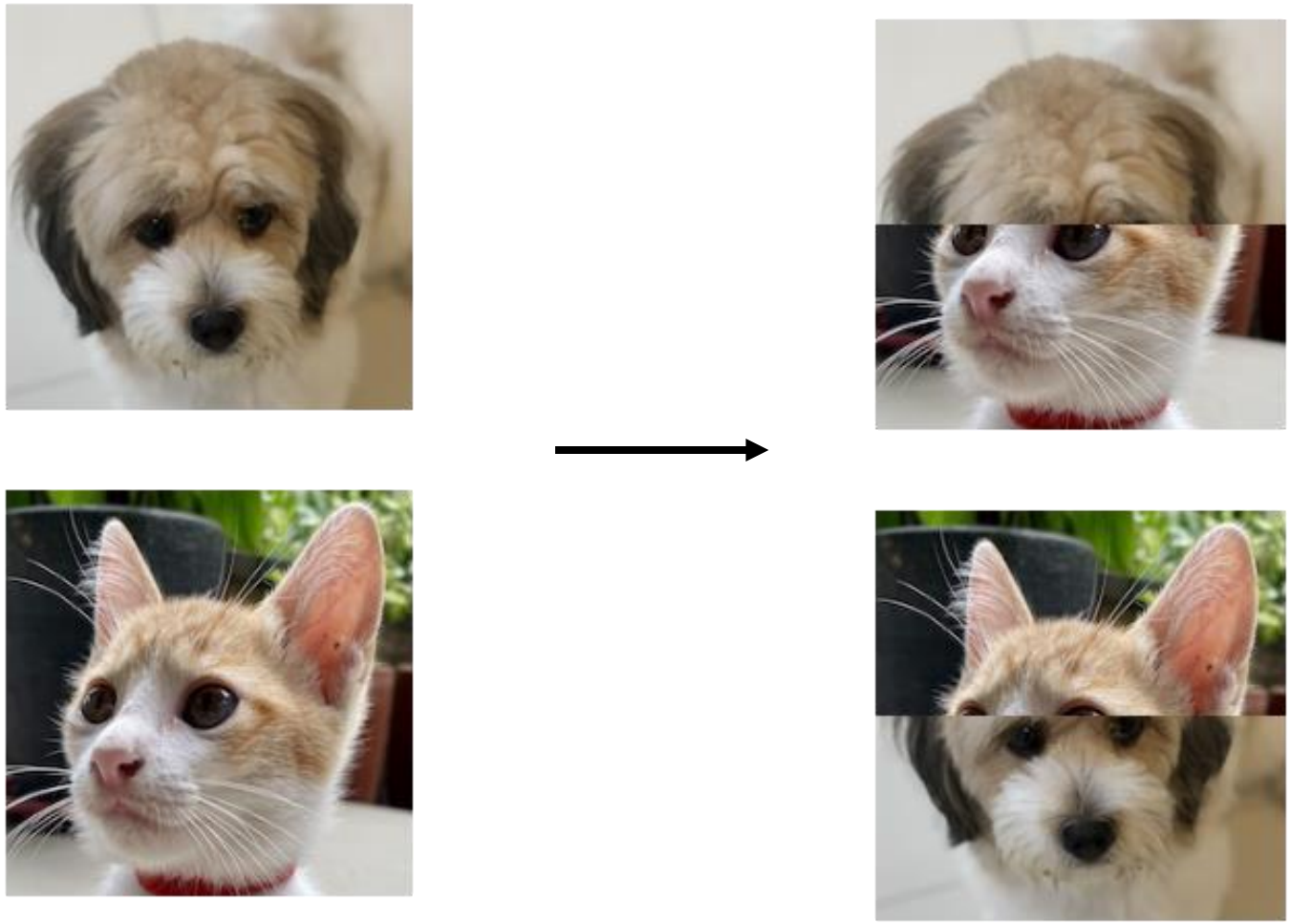
```
rearrange(img, "(p1 h) (p2 w) c -> (p1 p2) h w c", p1=2, p2=2)
```

Split the height into 2

Split the width into 2

An array of 4 image patches

Mixing 2 images



Load and store

```
img1 = image.imread("aki_dog.jpg")
img2 = image.imread("wonder_cat.jpg")
imgs = np.array([img1, img2])
```

Shape is now `(b h w c)` where batch size

`b=2`

Create a 2D array of images

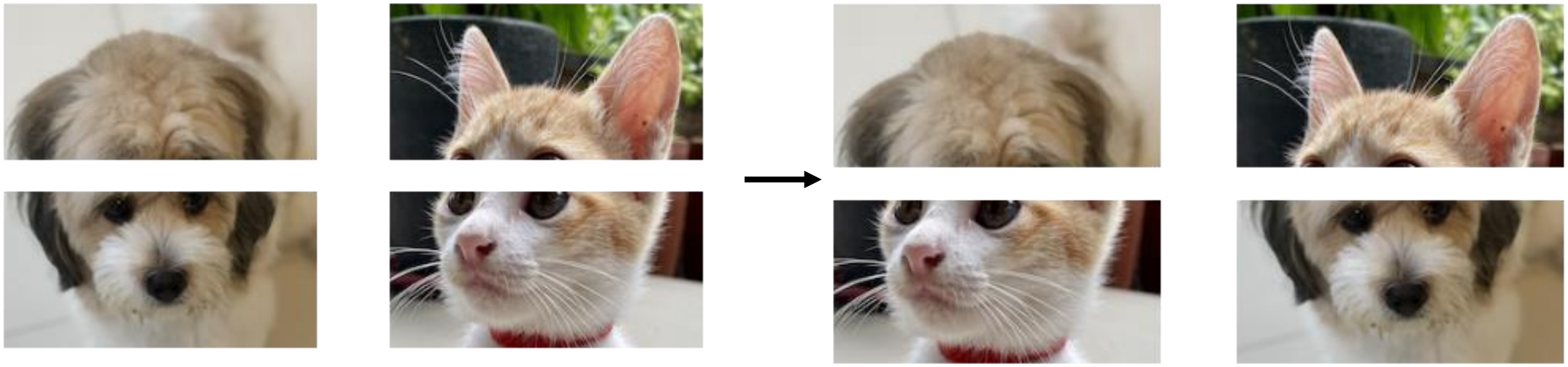
```
imgs = rearrange(imgs, "b (k h) w c -> k b h w c", k =2)
```

Reverse the order of the lower halves

```
imgs = np.concatenate([imgs[::2], imgs[1::,::-1]], axis=0)
```

Upper half array

Lower half array



Lastly, we fuse the 2D array into 1D array of images

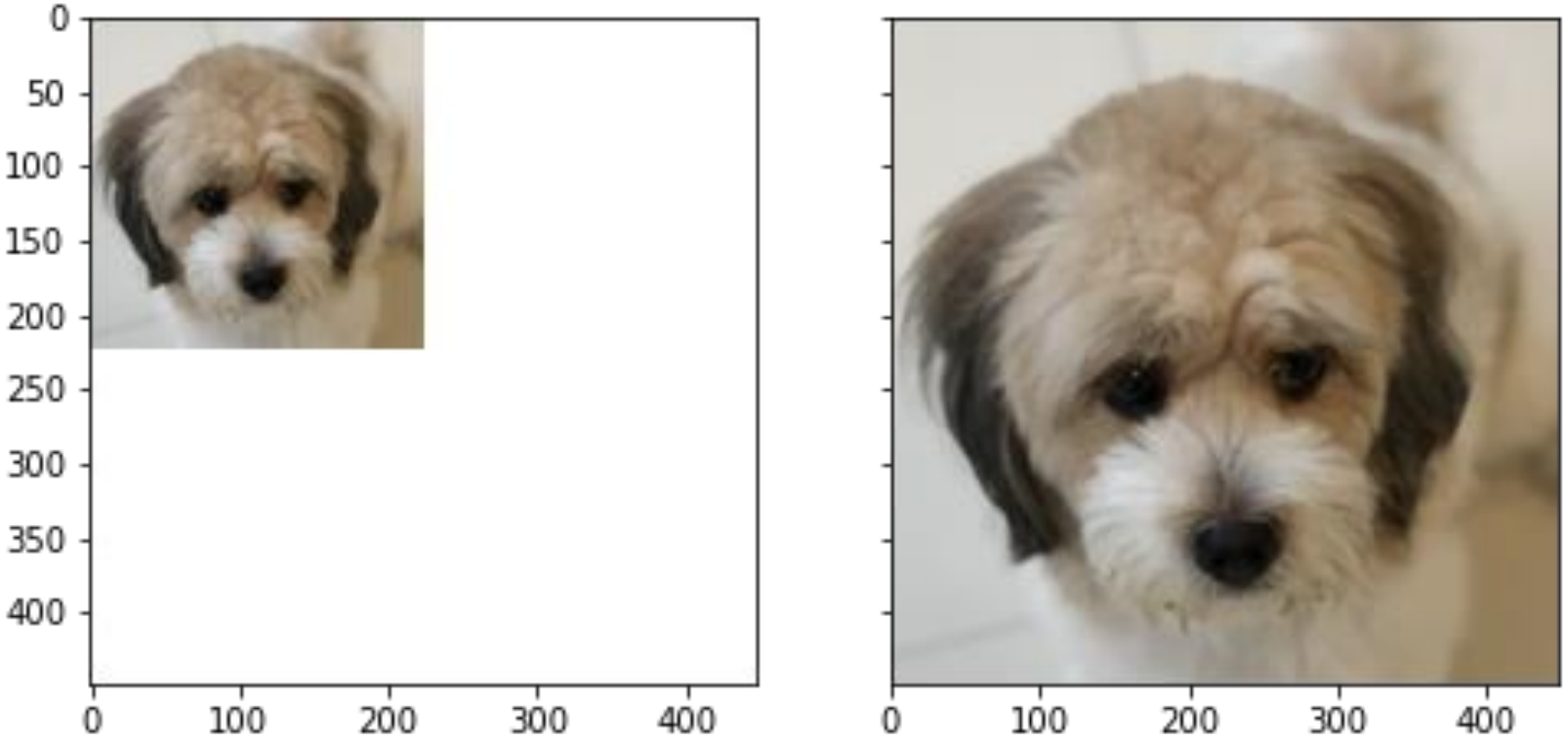
```
imgs = rearrange(imgs, ”k b h w c -> b (k h) w c")
```

RGB to Grayscale

```
img = reduce(img, "h w c -> h w", 'mean')
```

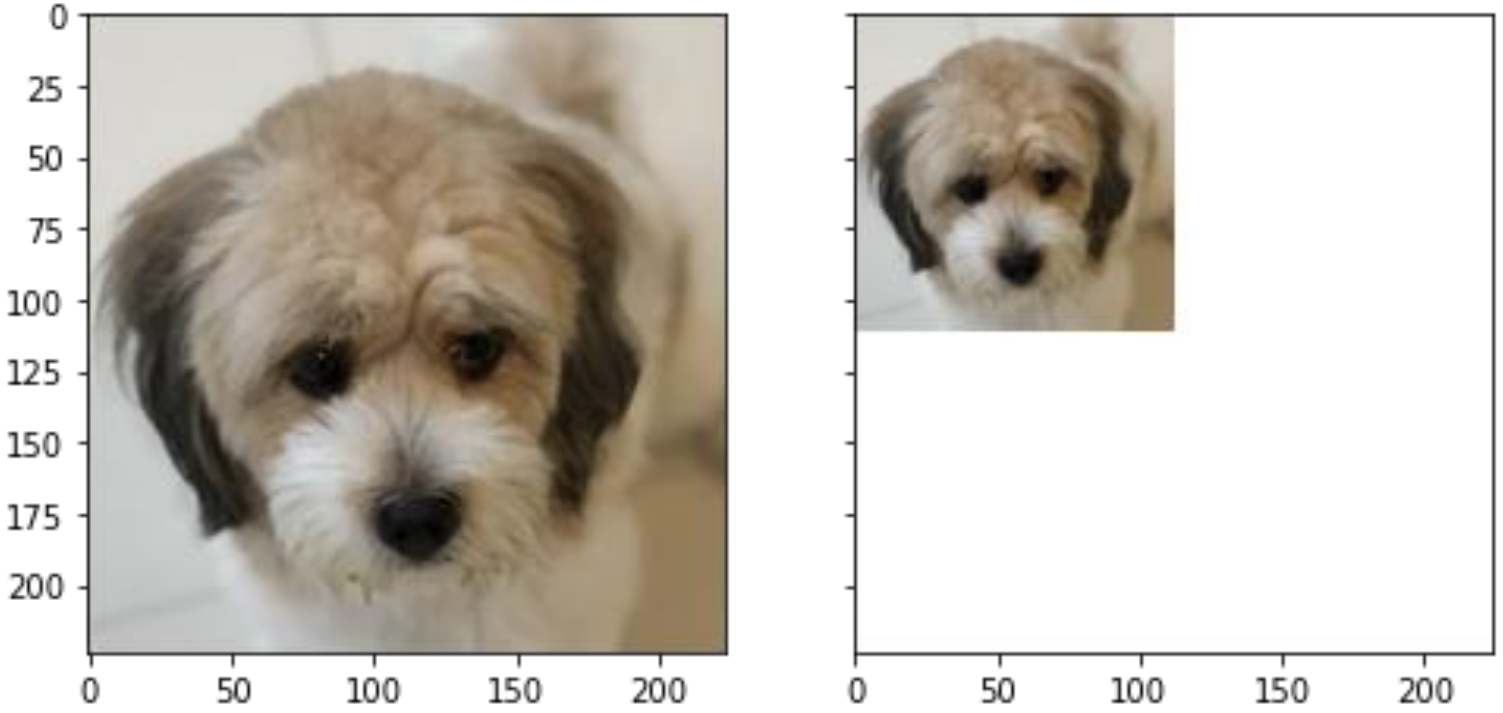
Upsize

```
repeat(img, "h w c -> (h 2) (w 2) c")
```



Downsize

```
reduce(img, "(h 2) (w 2) c -> h w c", 'mean')
```



End

https://github.com/roatienza/Deep-Learning-Experiments/blob/master/versions/2022/tools/python/einops_demo.ipynb