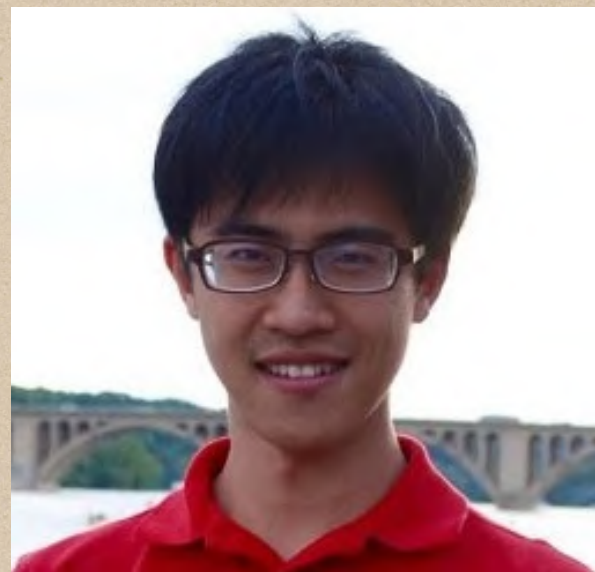# Positional Normalization (PONO)
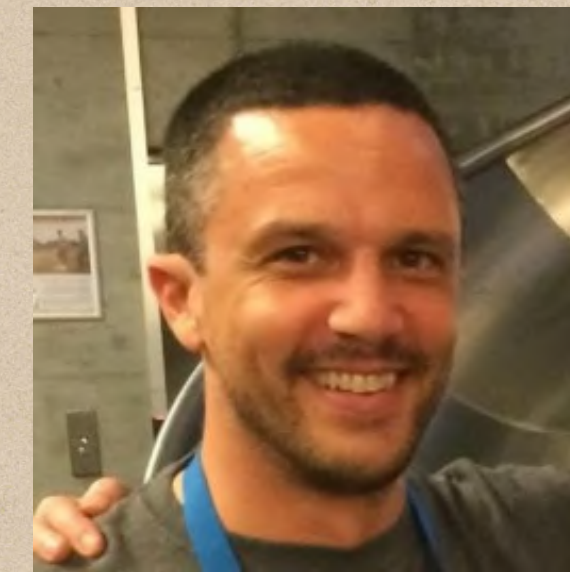
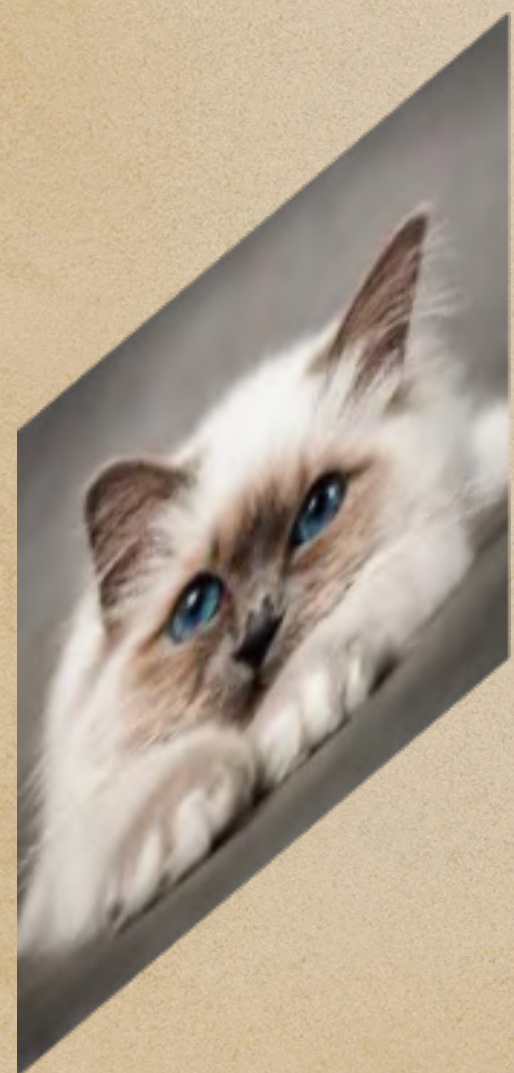Boyi Li*,   Felix Wu*,   Kilian Q. Weinberger,   Serge Belongie

Cornell University, Cornell Tech

Deep Features (in a given layer)

Conv

•••••▶

Deep Features (in a given layer)
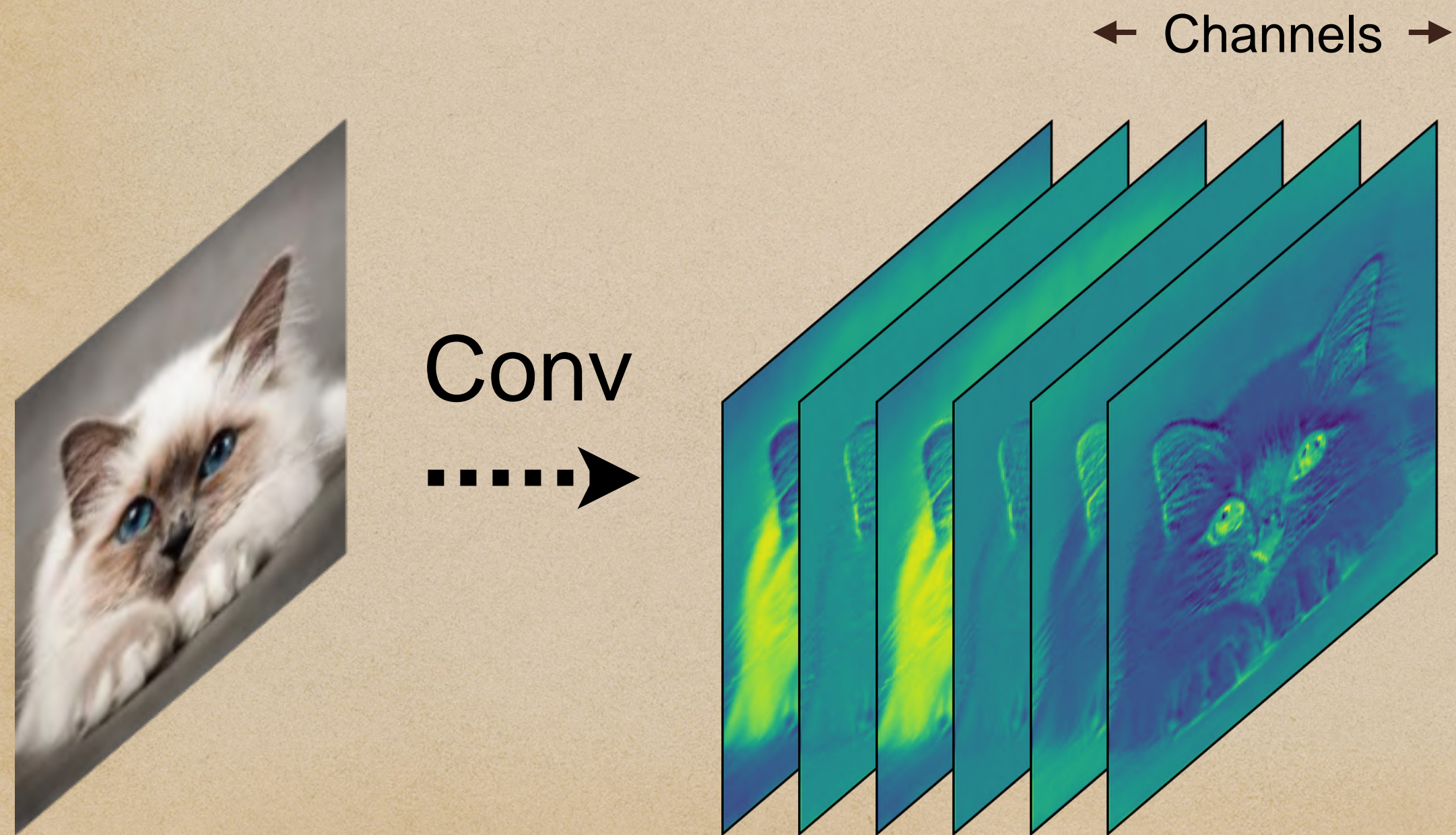
Channels
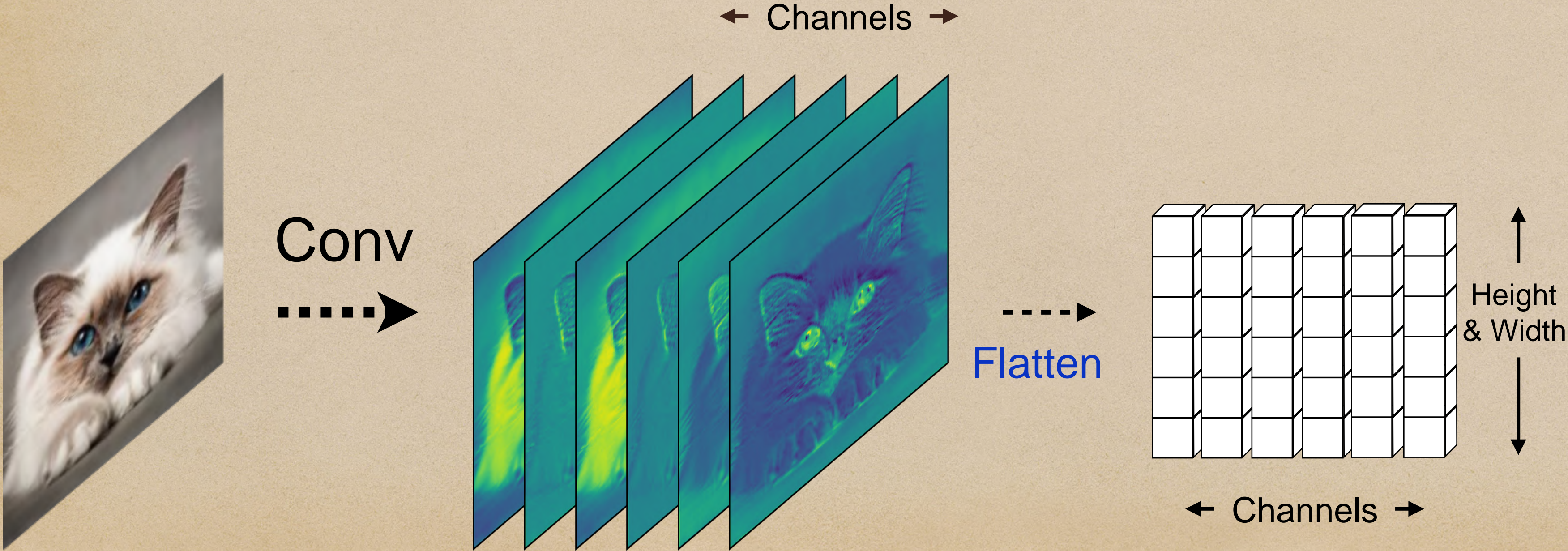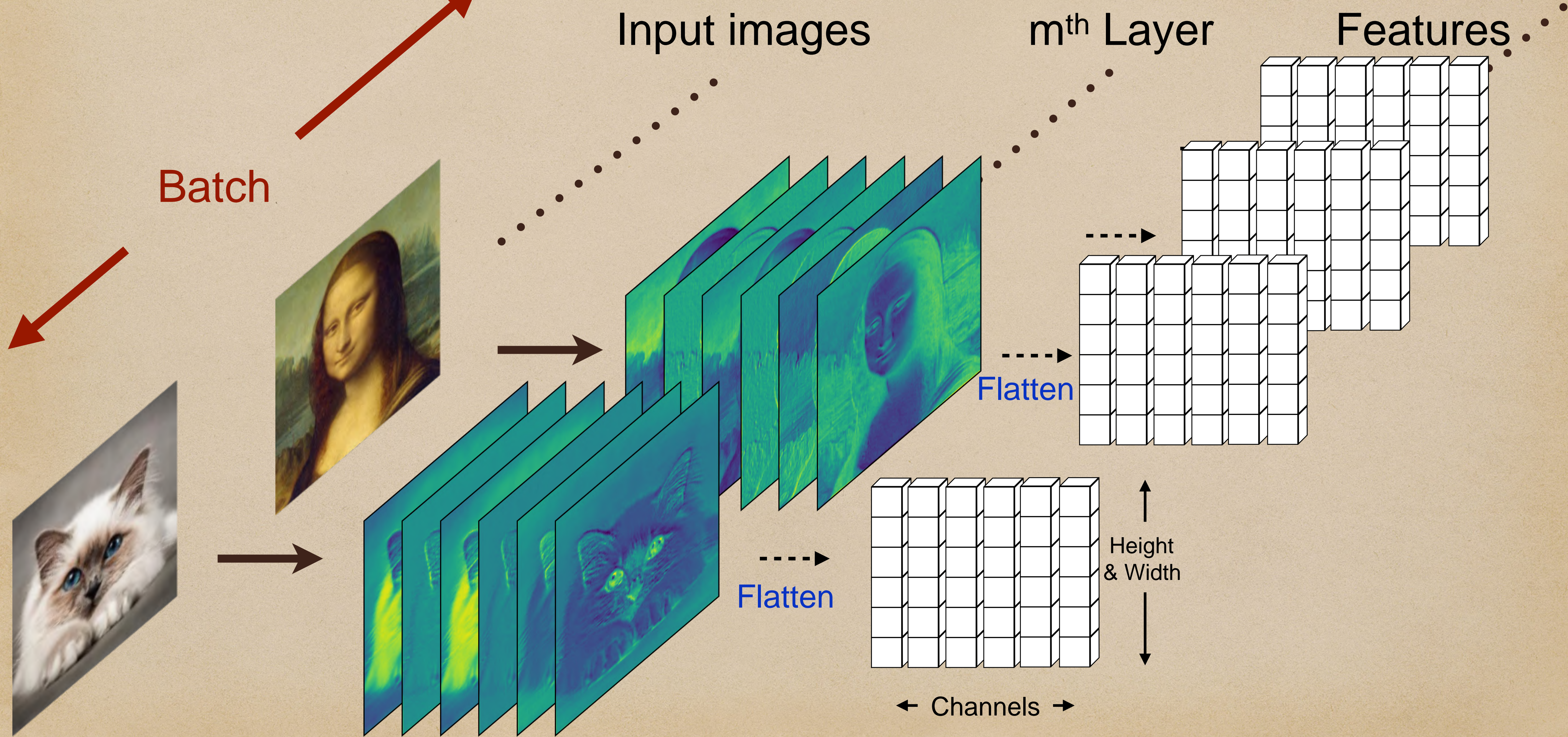
Conv

Deep Features (in a given layer)

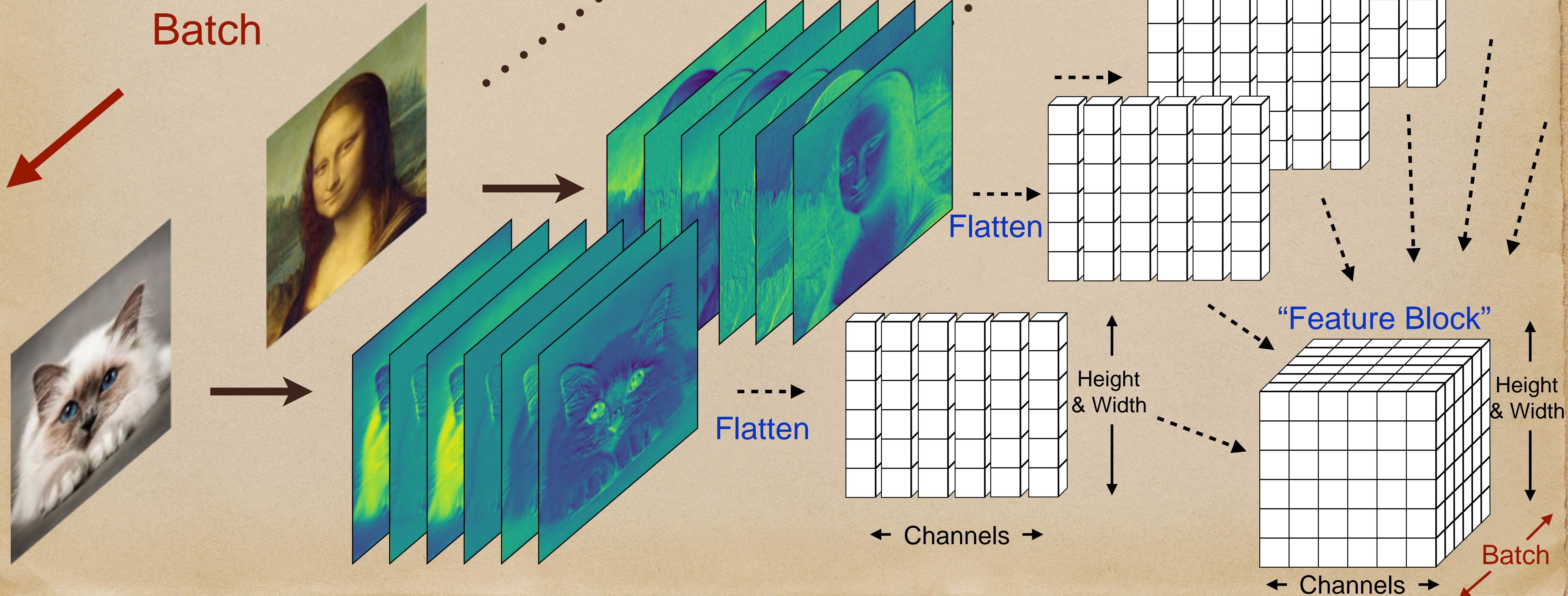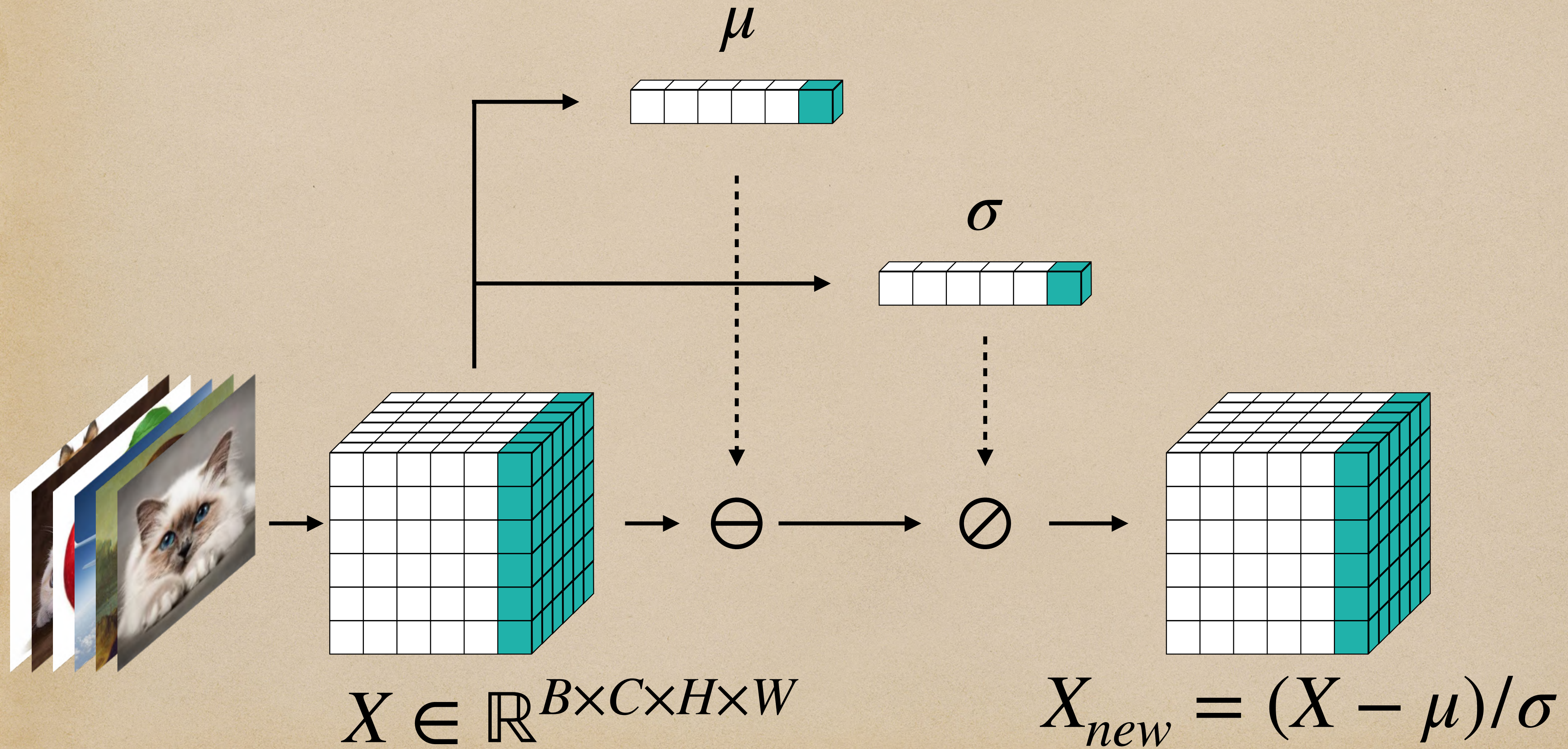Deep Features (in a given layer)

Deep Features (in a given layer)
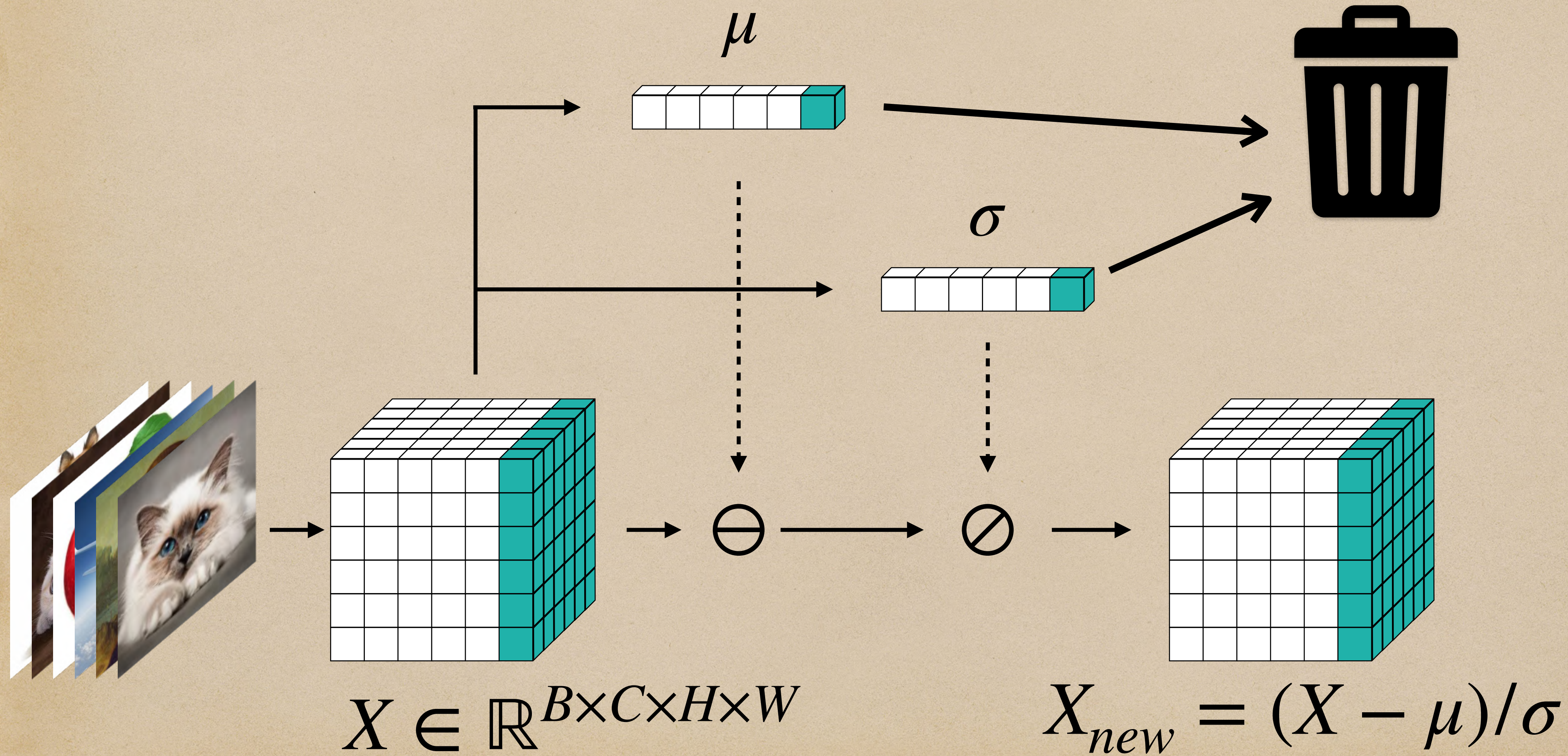
Batch

Input images

mth Layer

Features

Flatten

Flatten

Height & Width

Channels

"Feature Block"

Height & Width

Batch

Channels

Normalization

$$\mu$$

$$\sigma$$

$$X \in \mathbb{R}^{B \times C \times H \times W}$$

$$X_{new} = (X - \mu)/\sigma$$

Normalization

$$X \in \mathbb{R}^{B \times C \times H \times W}$$

$$X_{new} = (X - \mu)/\sigma$$

Normalization Variants

Batch Norm

(Ioffe & Szegedy, ICML 2015)

H:Height
W:Width

← C: Channel →
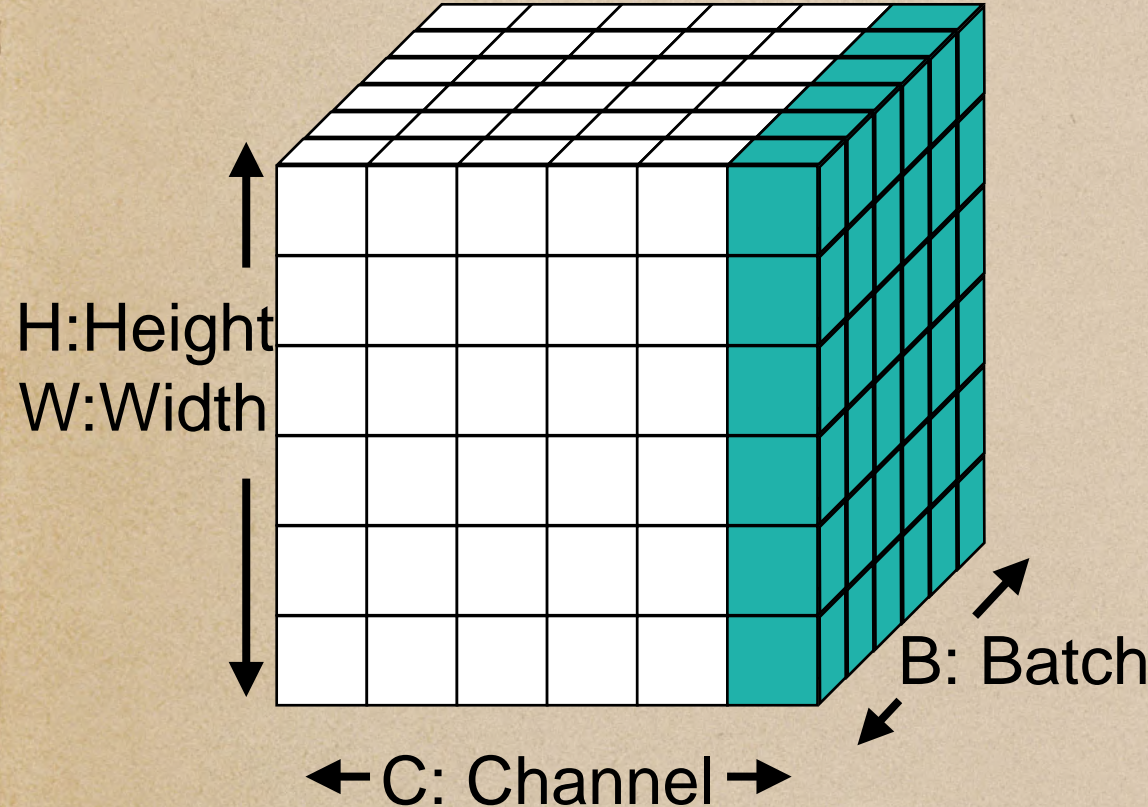
B: Batch

Mean / Std:

Subtracting the mean and dividing by the standard deviation (std)
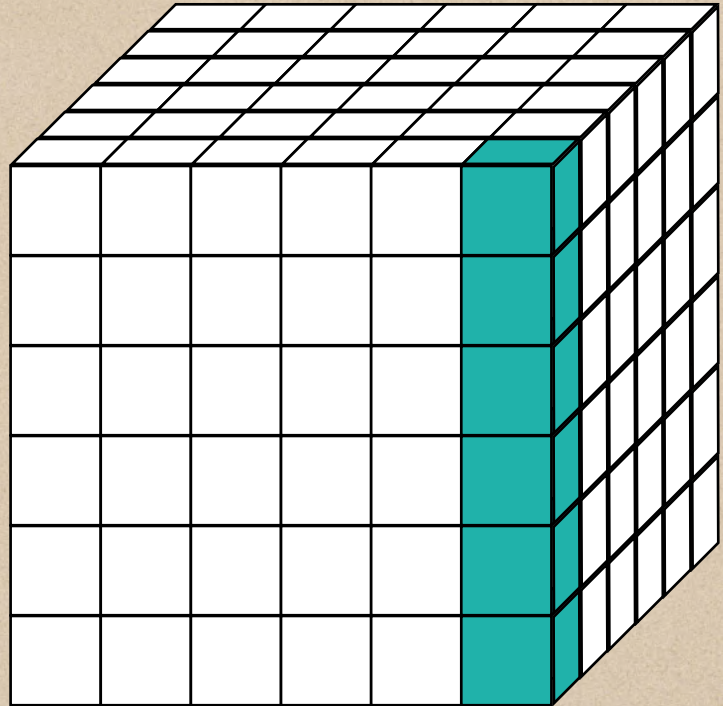
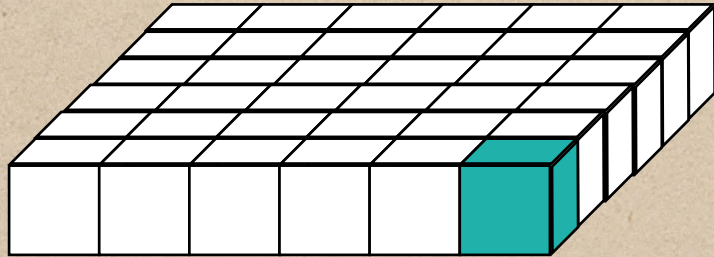# Normalization Variants

Batch Norm

(Ioffe & Szegedy, ICML 2015)

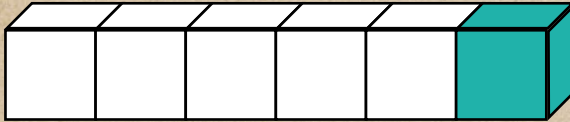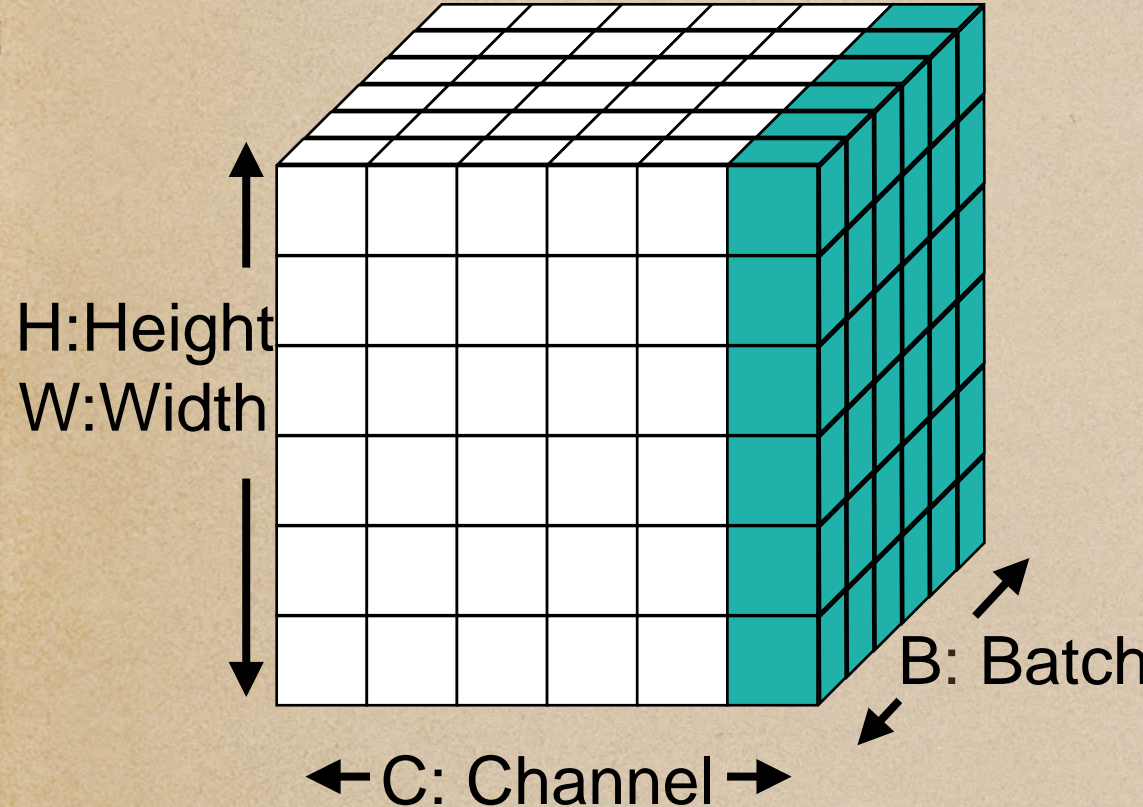**Instance Norm**

(Ulyanov et al., arXiv 2016)

H:Height
W:Width

B: Batch

← C: Channel →

Mean / Std:

Subtracting the mean and dividing by the standard deviation (std)
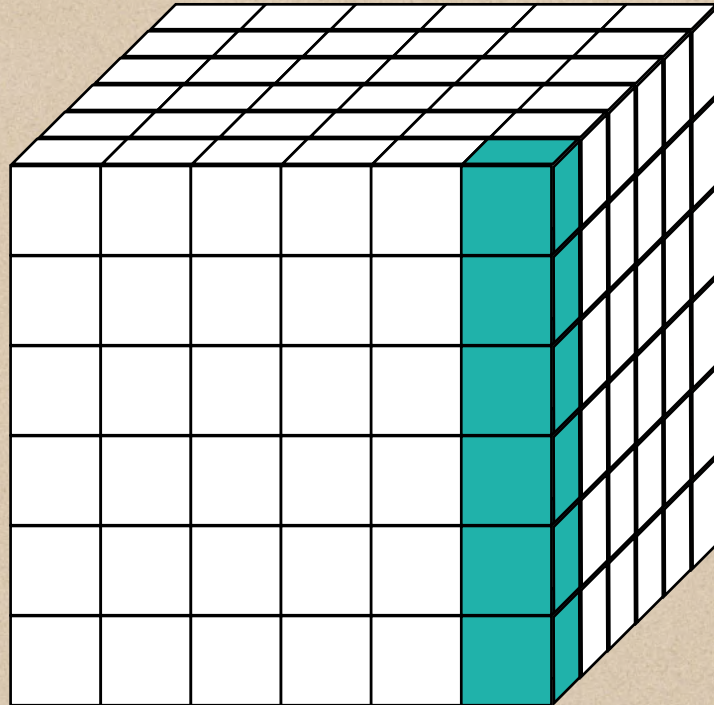
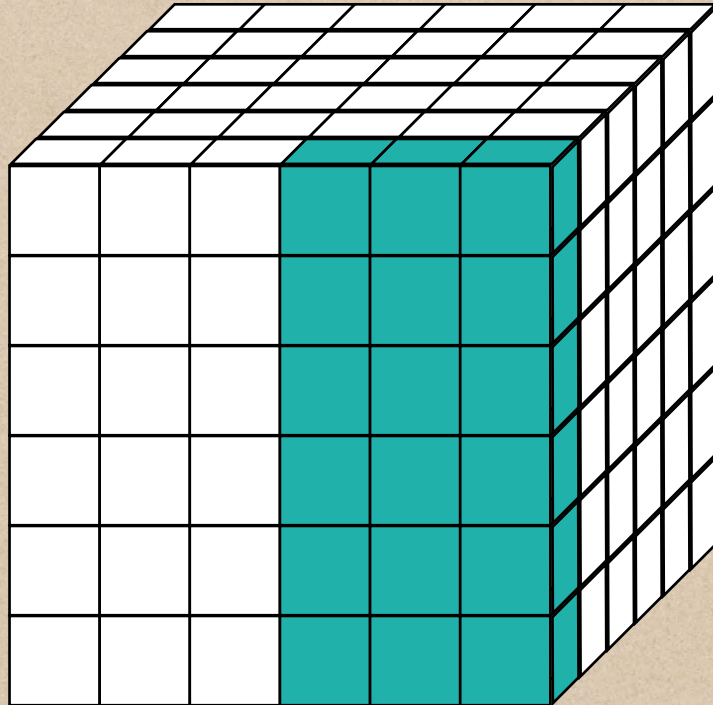# Normalization Variants

Batch Norm
(Ioffe & Szegedy, ICML 2015)
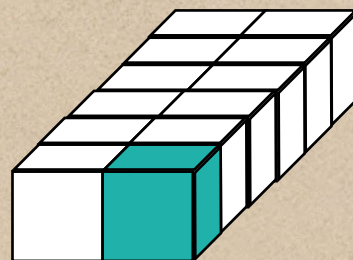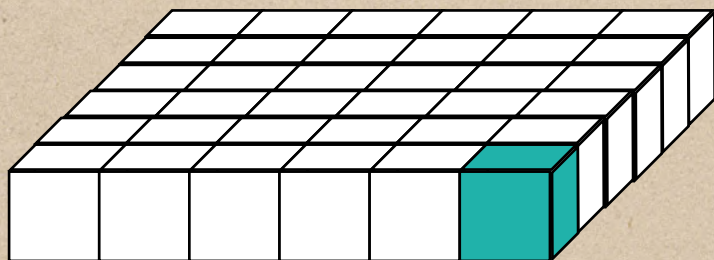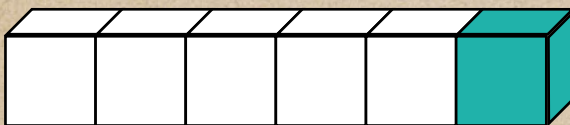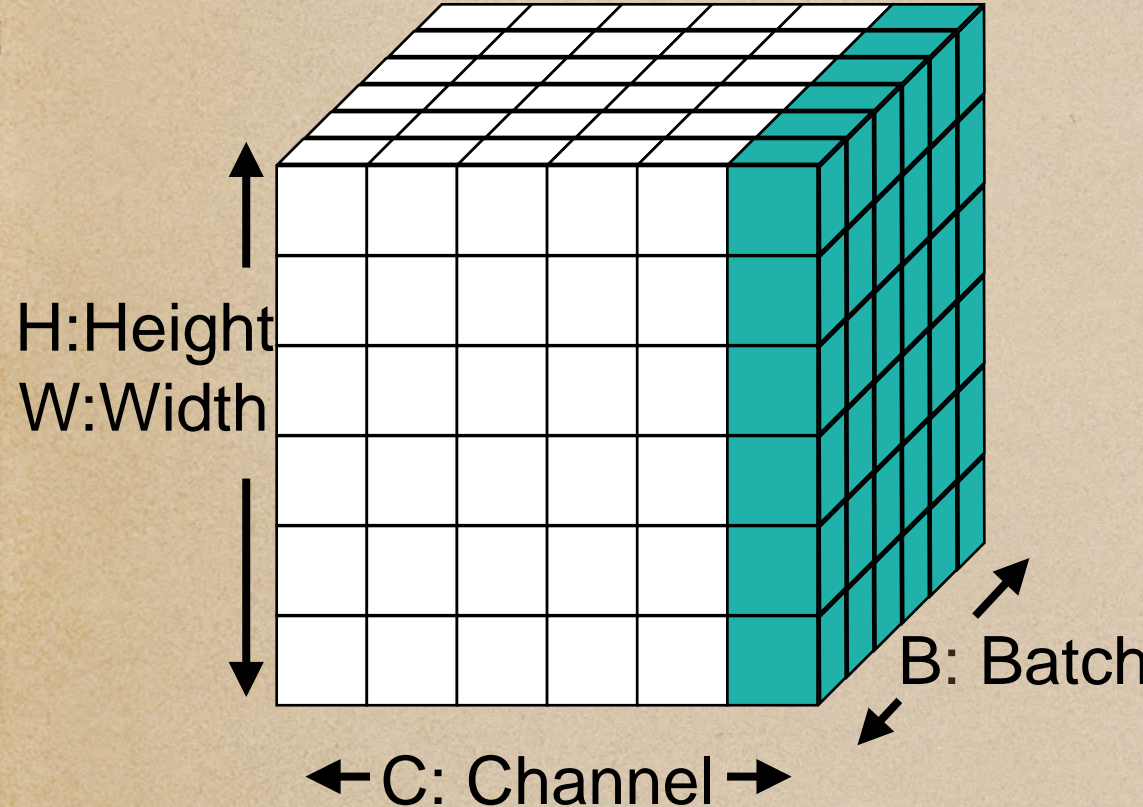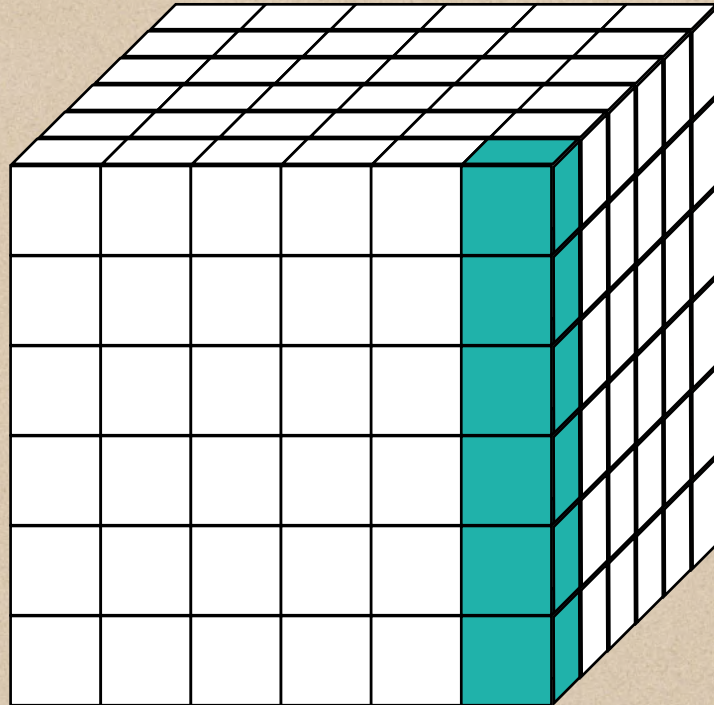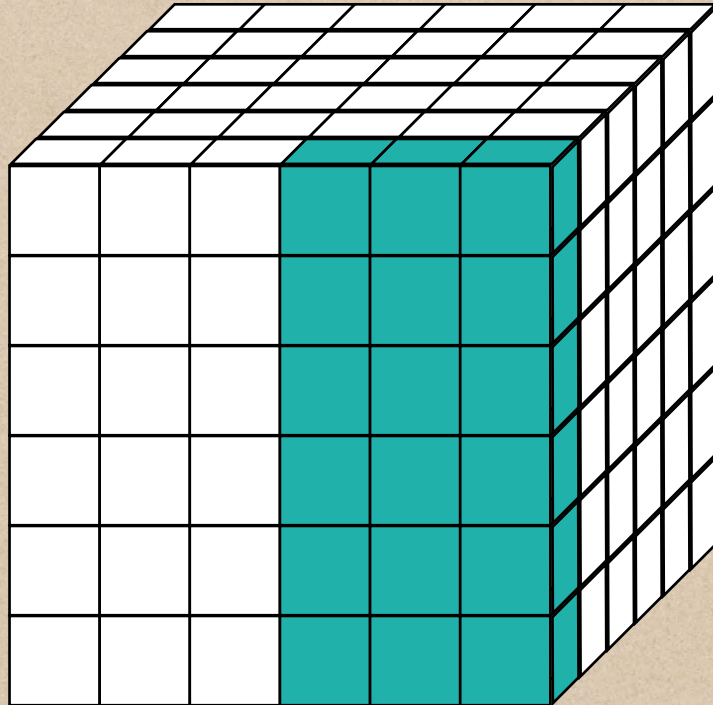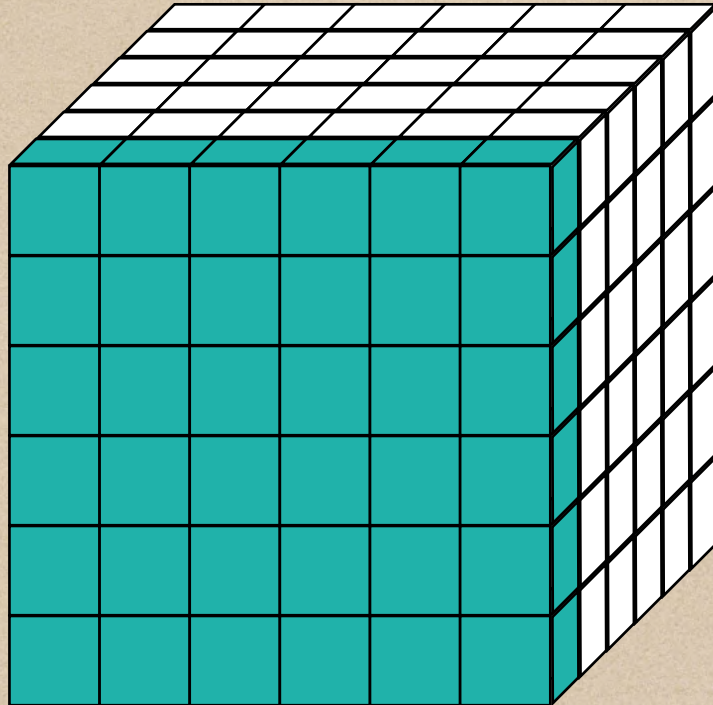
Instance Norm
(Ulyanov et al., arXiv 2016)

Group Norm
(Wu & He, ECCV 2018)

H:Height
W:Width

B: Batch
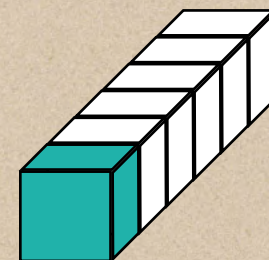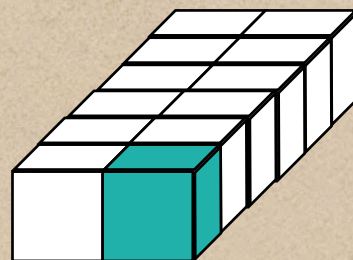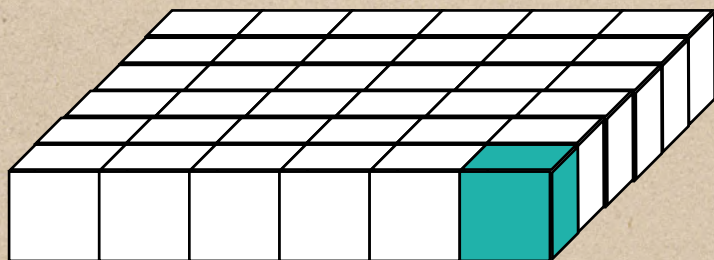
C: Channel
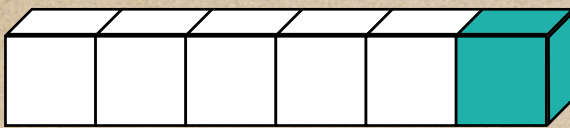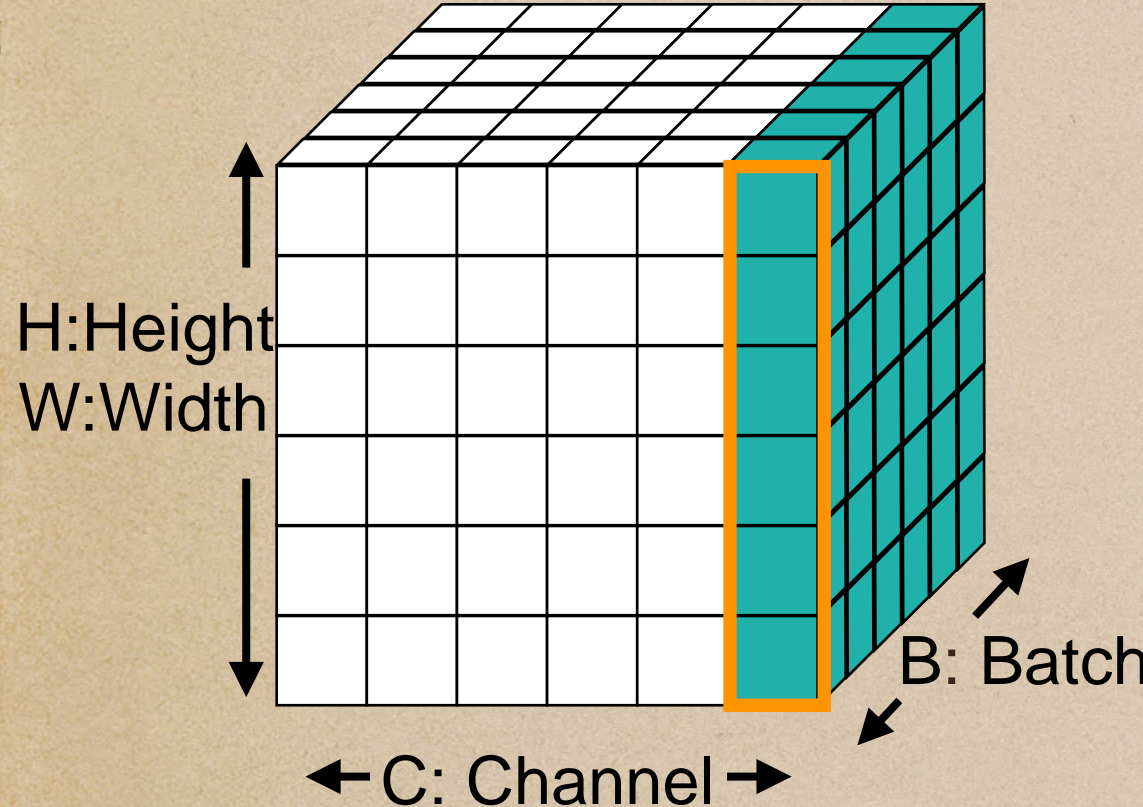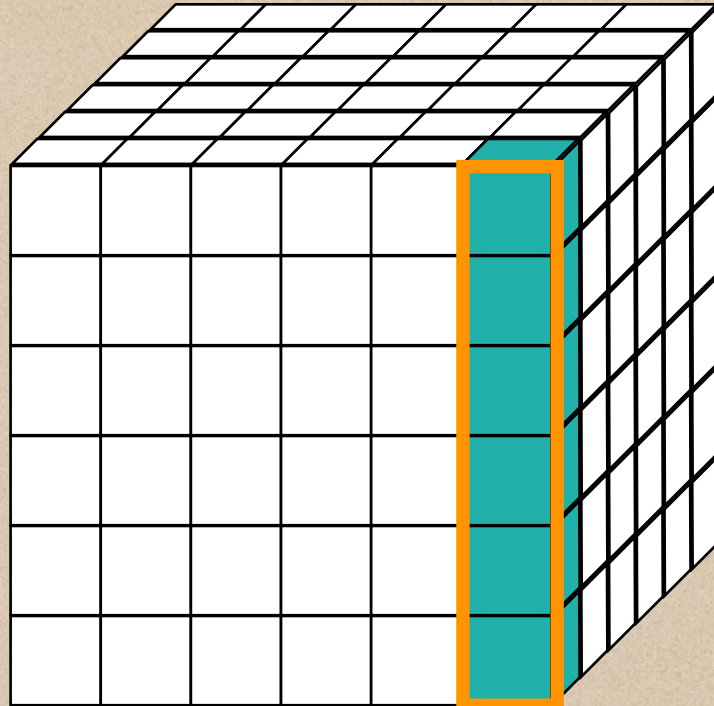
Mean / Std:

Subtracting the mean and dividing by the standard deviation (std)

Normalization Variants

Batch Norm	Instance Norm	Group Norm	Layer Norm
(Ioffe & Szegedy, ICML 2015)	(Ulyanov et al., arXiv 2016)	(Wu & He, ECCV 2018)	(Ba et al., NeurIPS 2016)

H:Height
W:Width

B: Batch

C: Channel

Mean / Std:

Subtracting the mean and dividing by the standard deviation (std)

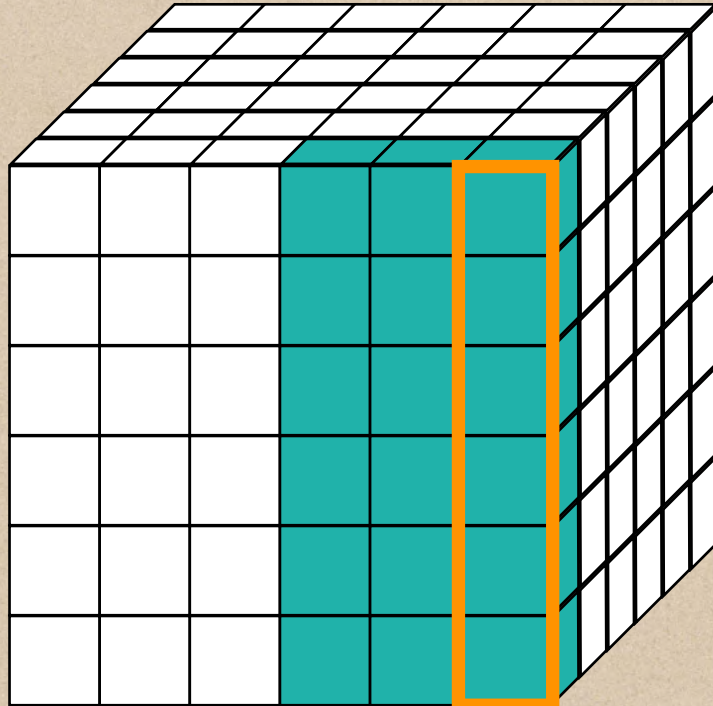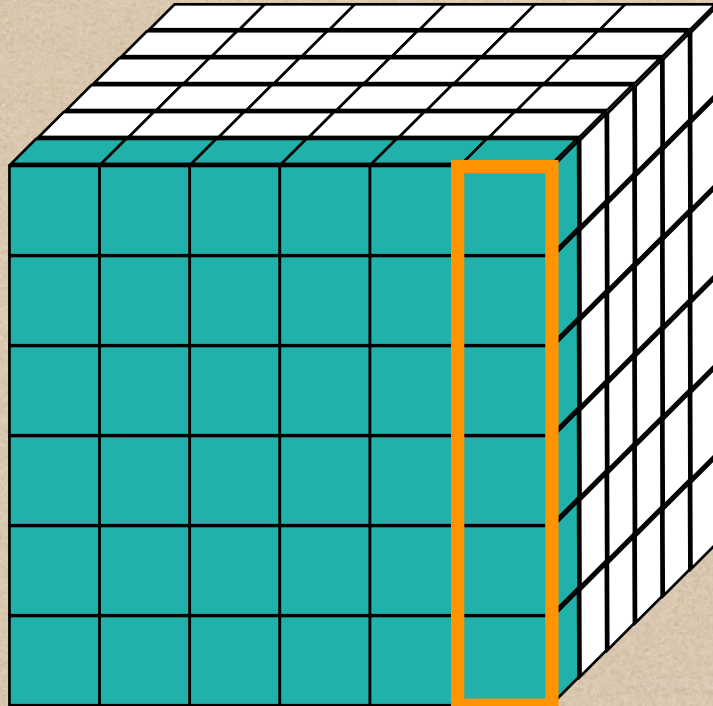# Normalization Variants

Batch Norm
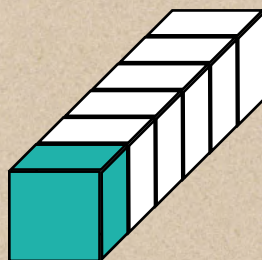(Ioffe & Szegedy, ICML 2015)

Instance Norm
(Ulyanov et al., arXiv 2016)

Group Norm
(Wu & He, ECCV 2018)

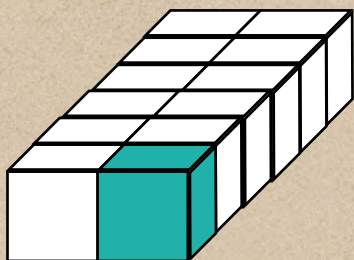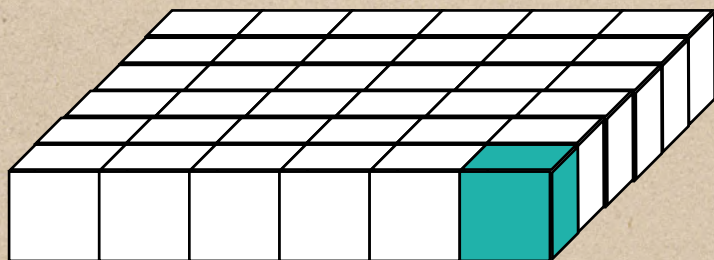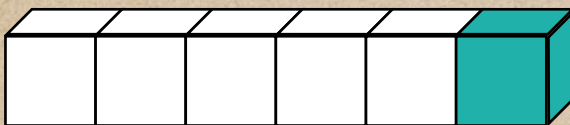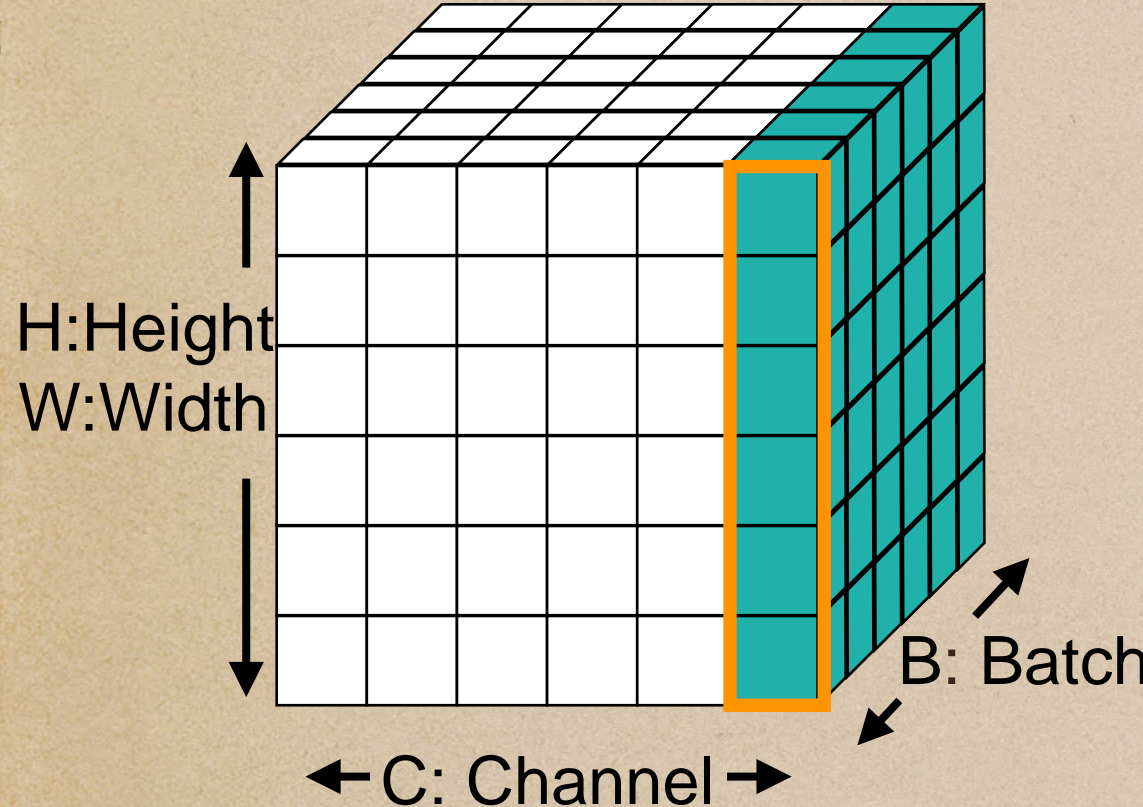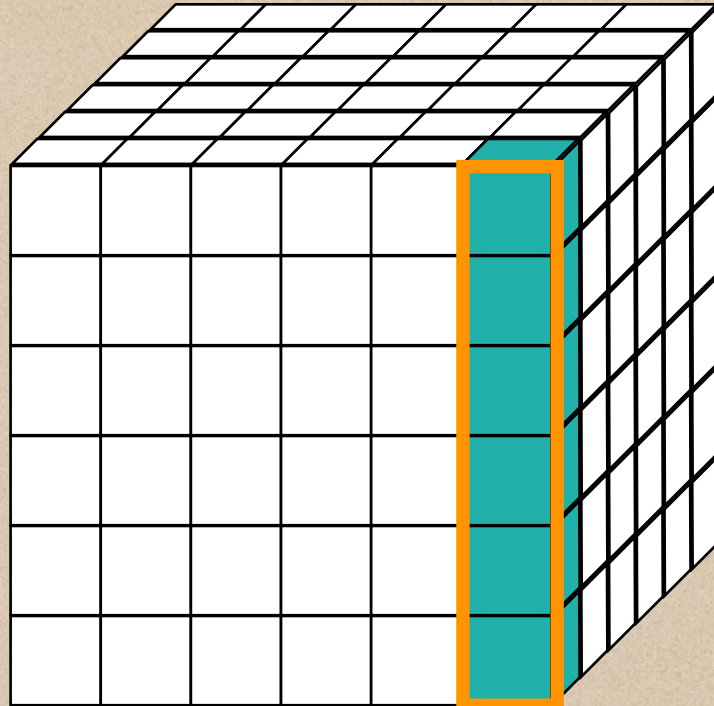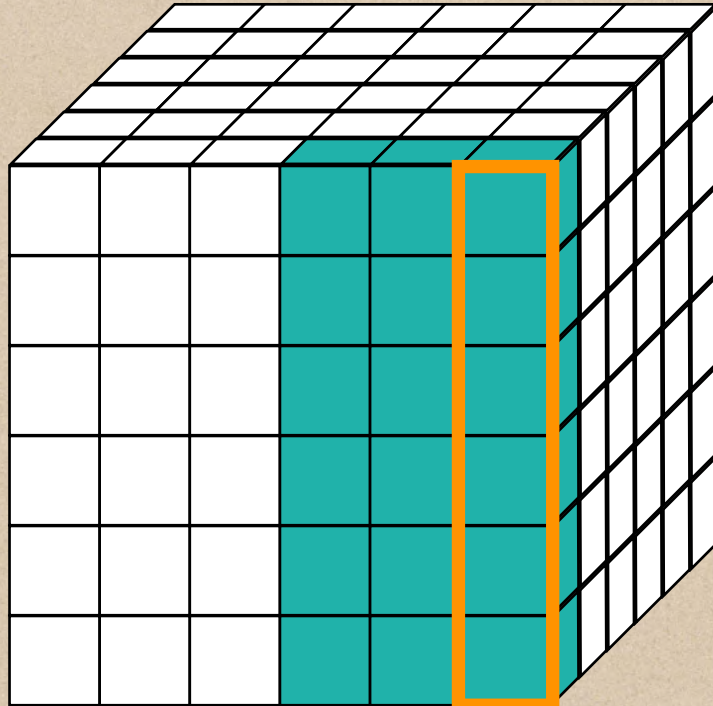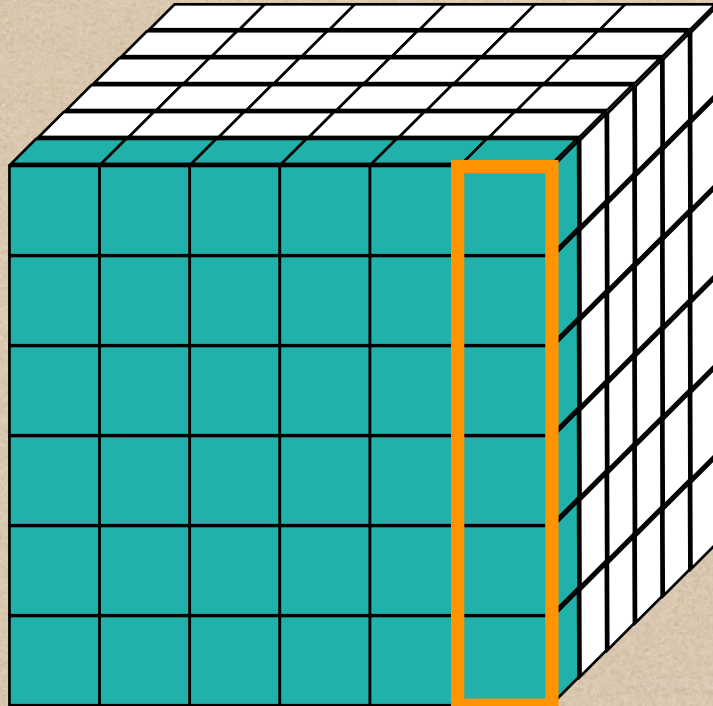Layer Norm
(Ba et al., NeurIPS 2016)
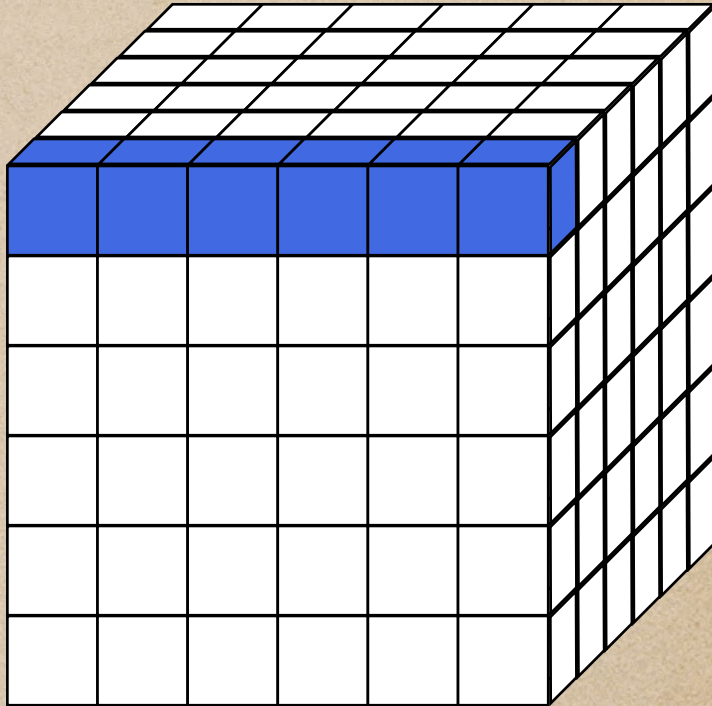
H:Height
W:Width

B: Batch
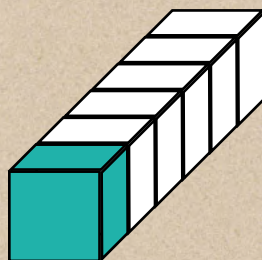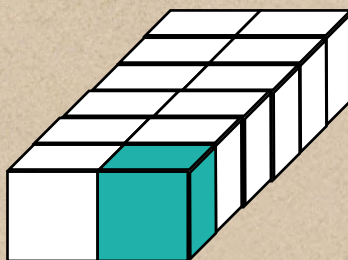
C: Channel

Mean / Std:

Subtracting the mean and dividing by the standard deviation (std)

Normalization Variants

Batch Norm
(Ioffe & Szegedy, ICML 2015)

Instance Norm
(Ulyanov et al., arXiv 2016)

Group Norm
(Wu & He, ECCV 2018)

Layer Norm
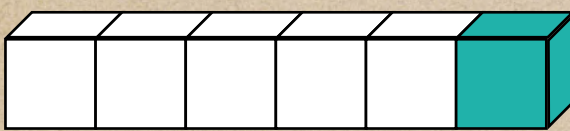(Ba et al., NeurIPS 2016)

Positional Norm

H:Height
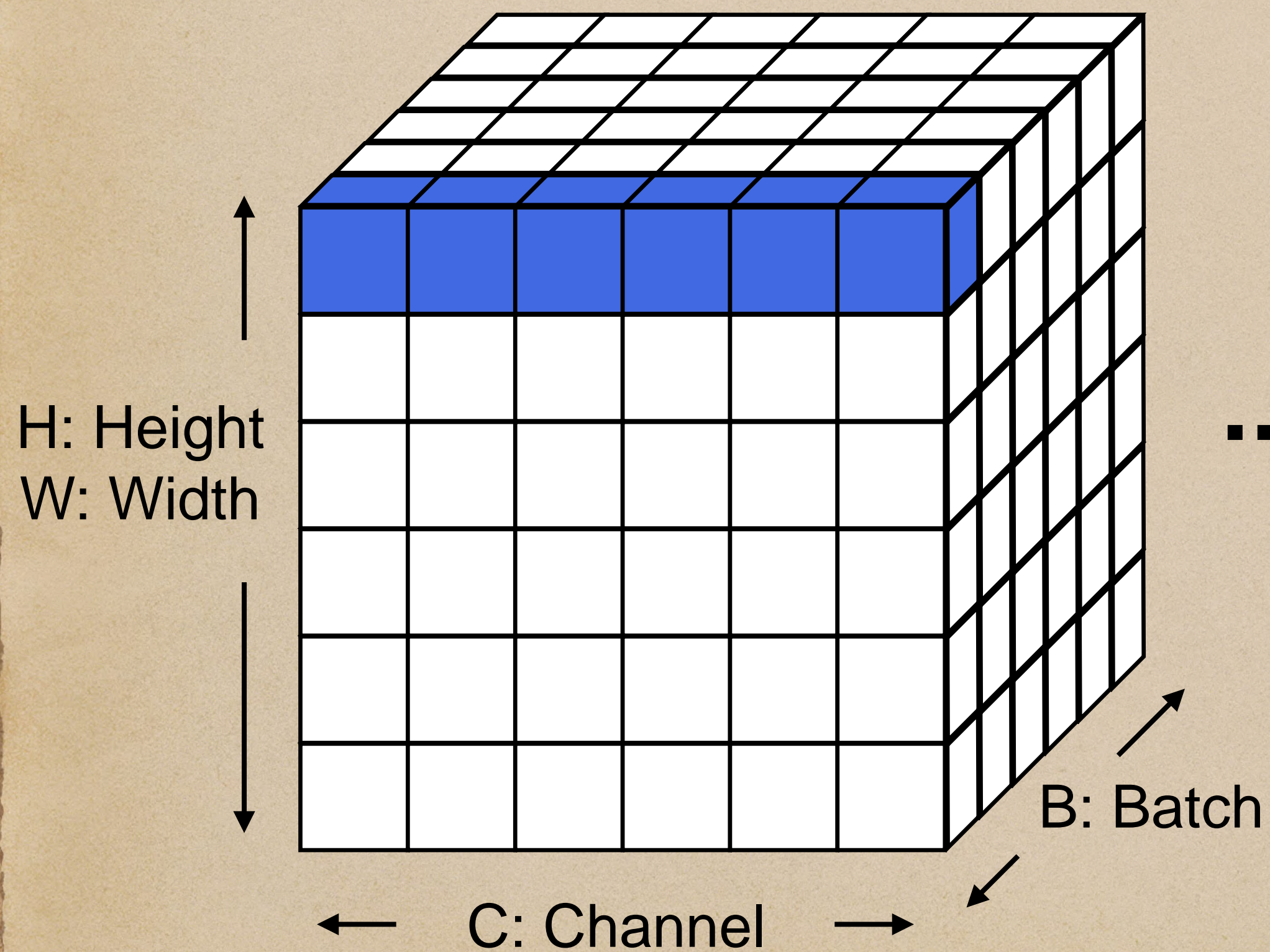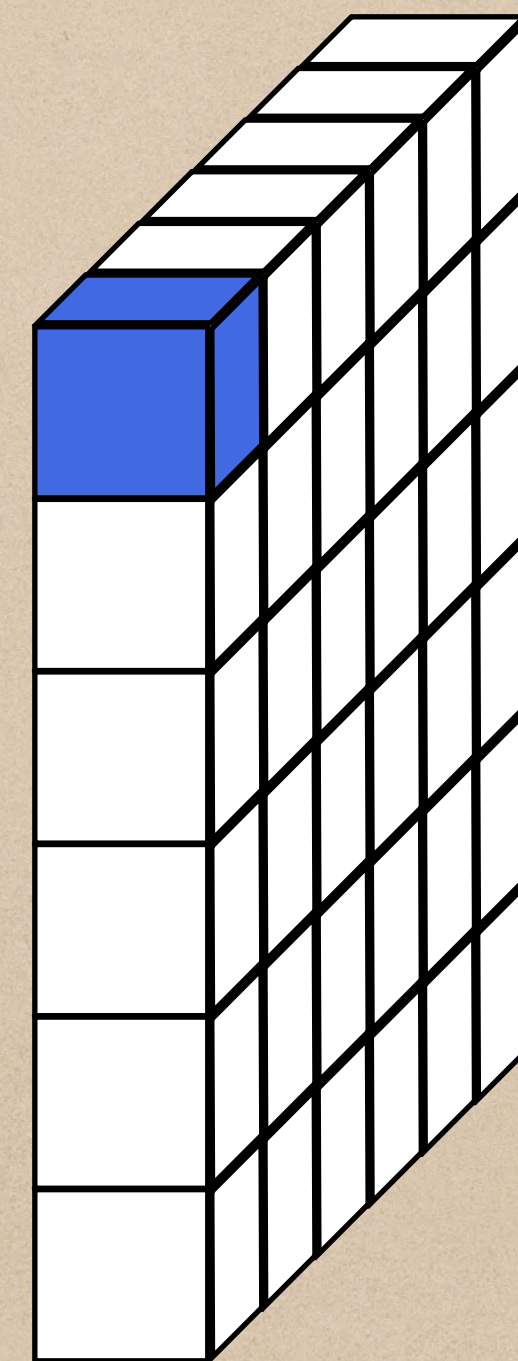W:Width

B: Batch

← C: Channel →

Mean / Std:
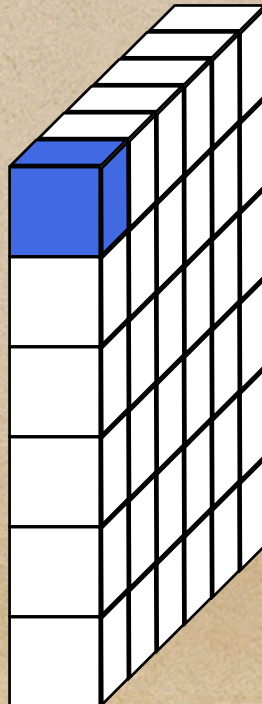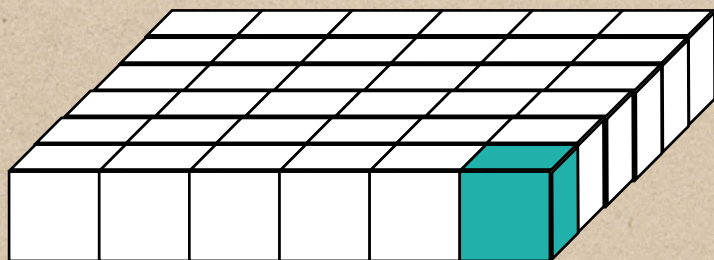
Subtracting the mean and dividing by the standard deviation (std)

Positional Normalization (PONO)

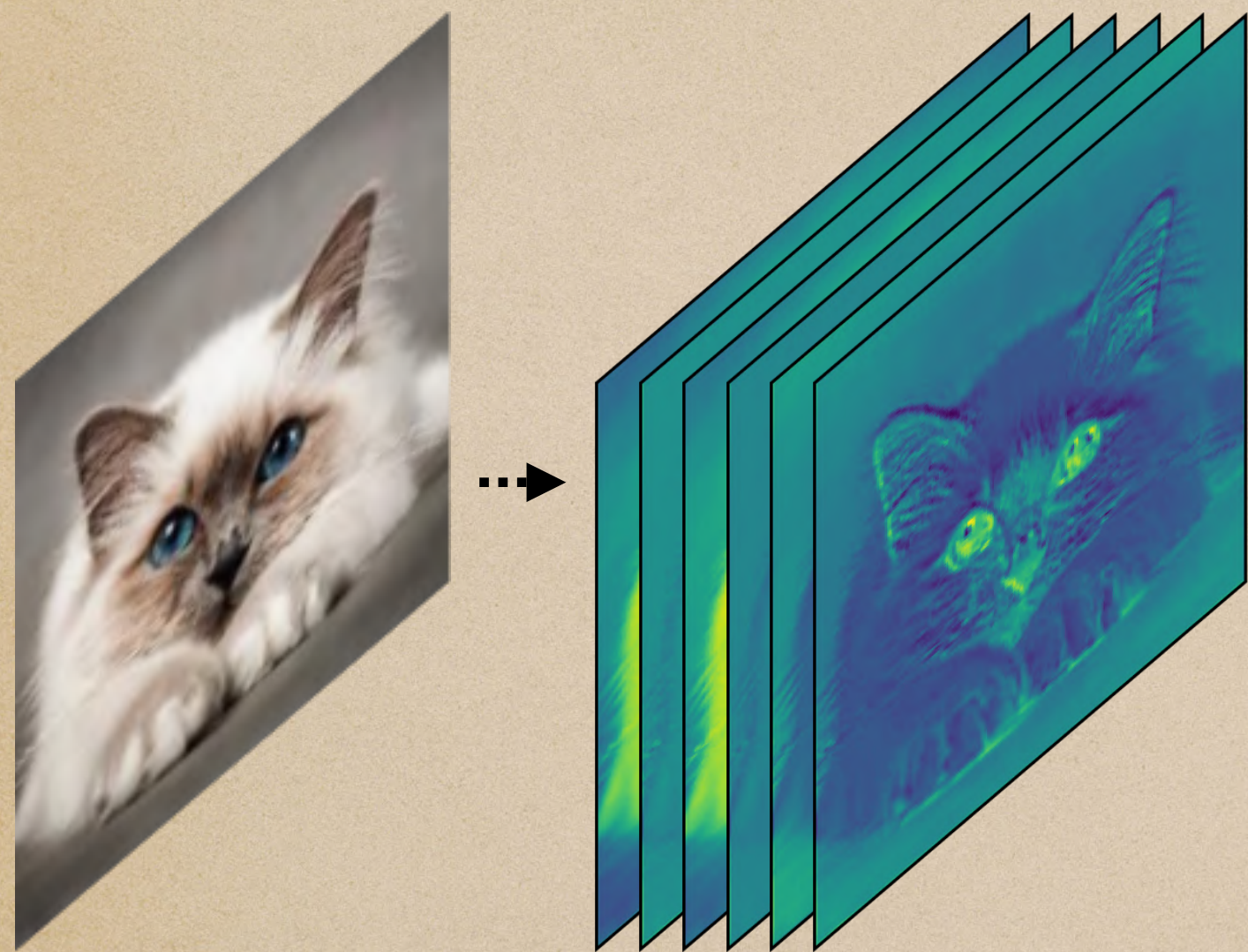
$X \in \mathbb{R}^{B \times C \times H \times W}$

H: Height
W: Width

C: Channel

B: Batch

Moments:

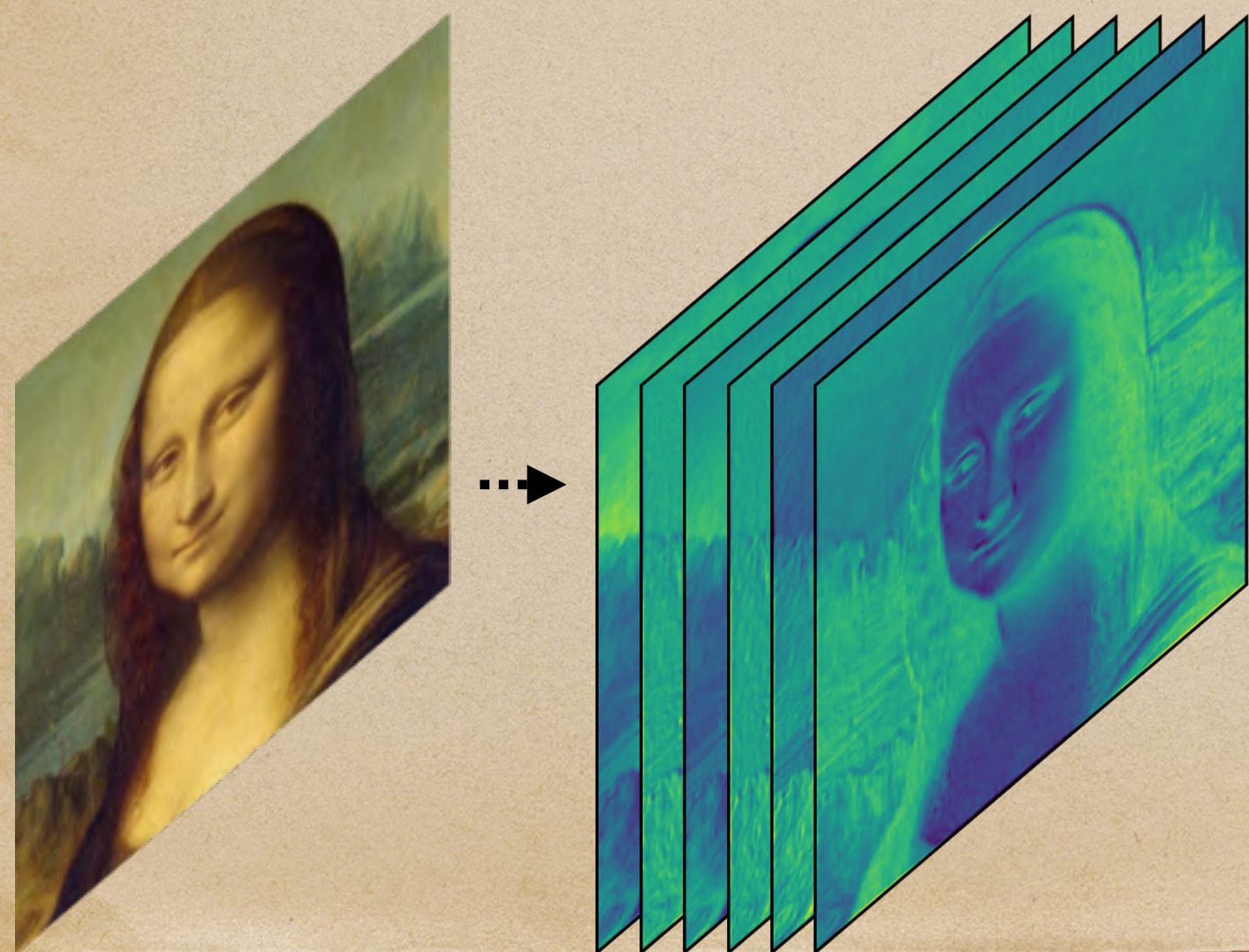$$\mu_{b,h,w} = \frac{1}{C} \sum_{c=1}^{C} X_{b,c,h,w}$$

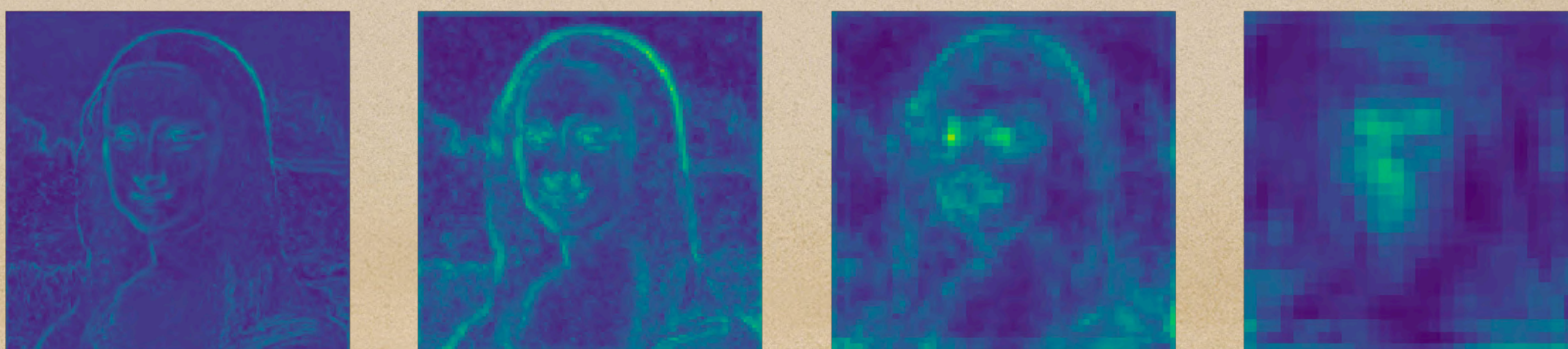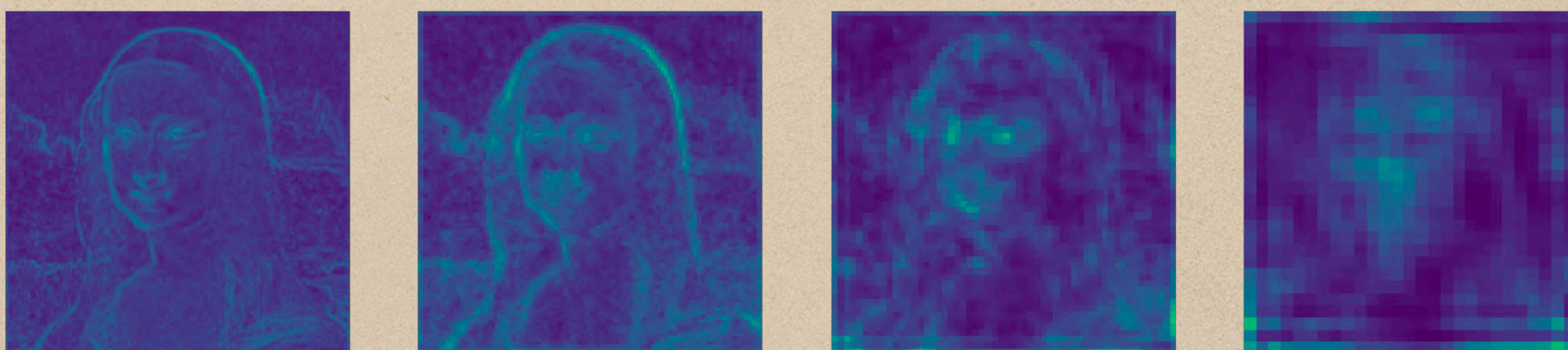$$\sigma_{b,h,w} = \sqrt{\frac{1}{C} \sum_{c=1}^{C} \left(X_{b,c,h,w} - \mu_{b,h,w} \right)^2}$$

Moments in PONO

Early layer ⟶ Deeper Layer

$\rightarrow \mu$

$\rightarrow \sigma$

$\rightarrow \mu$

$\rightarrow \sigma$
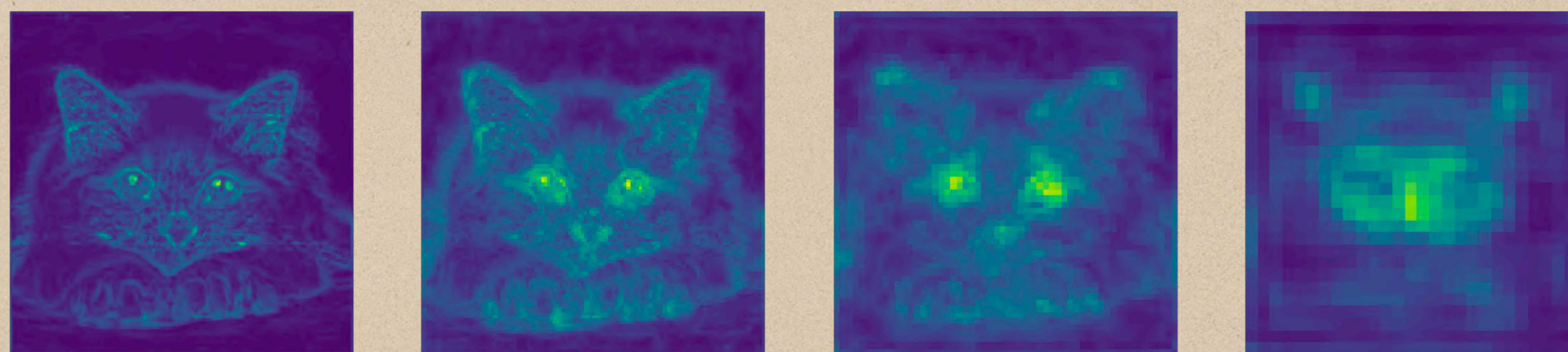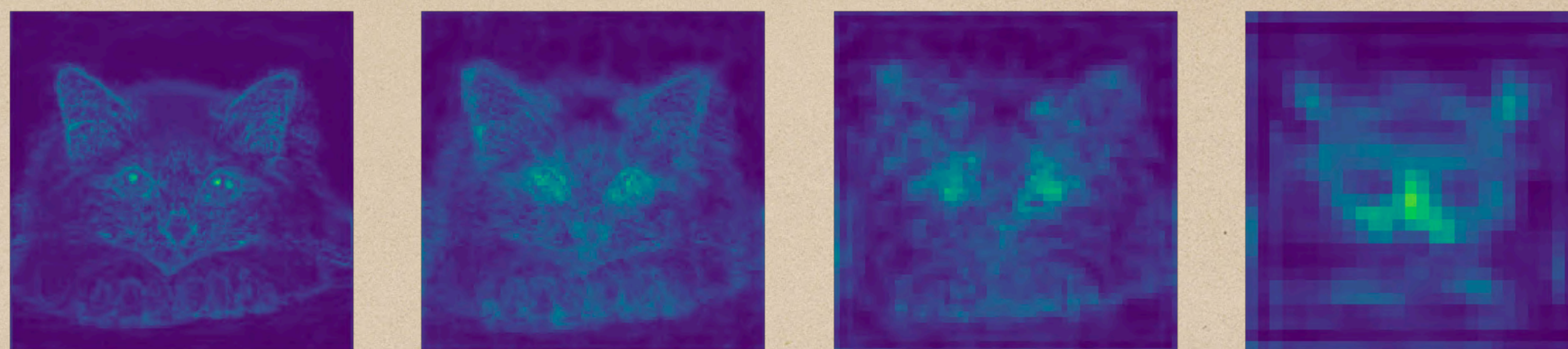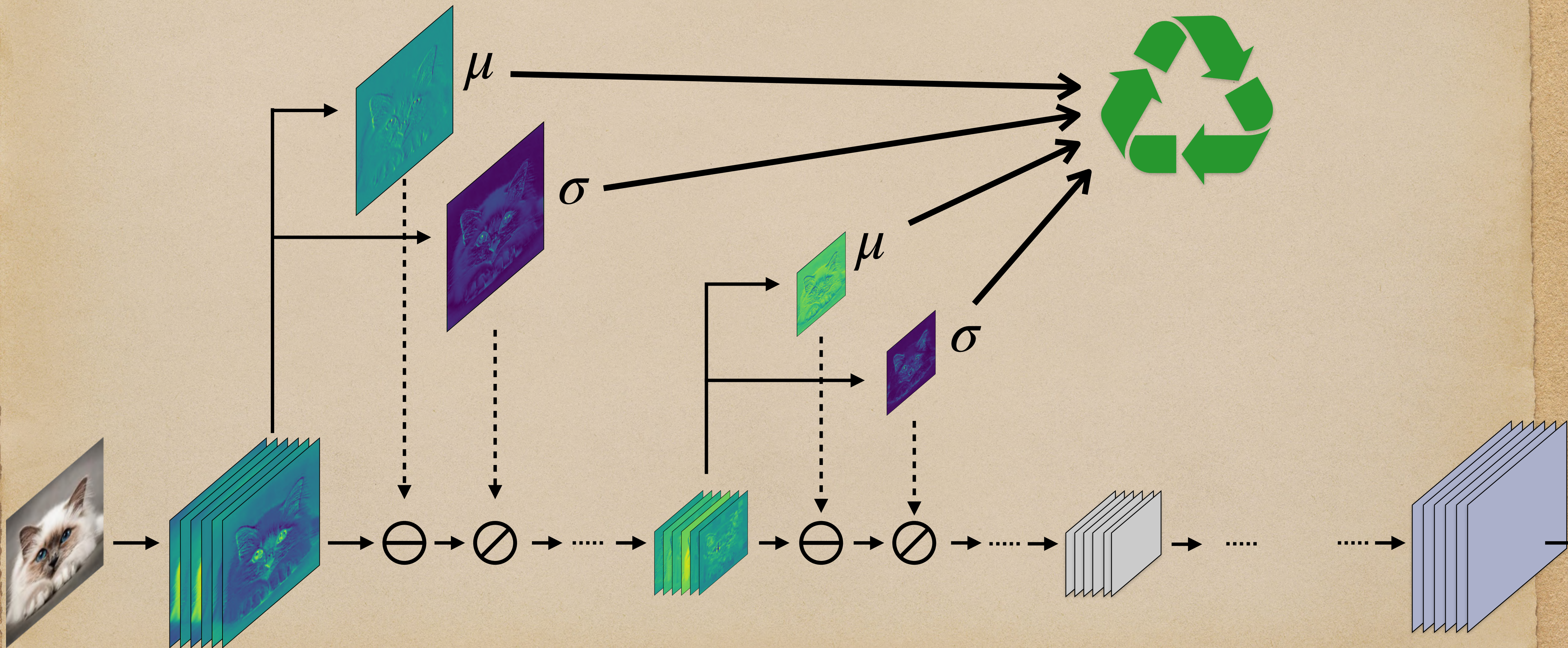
PONO
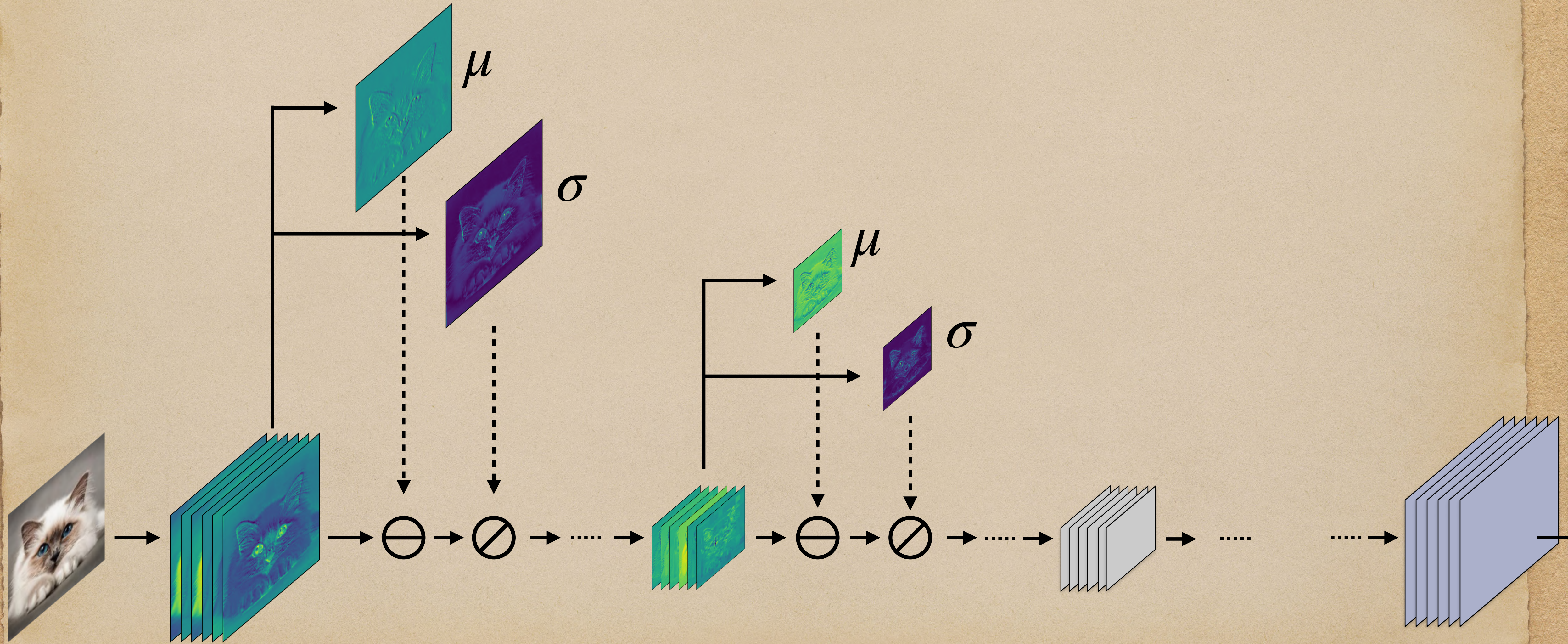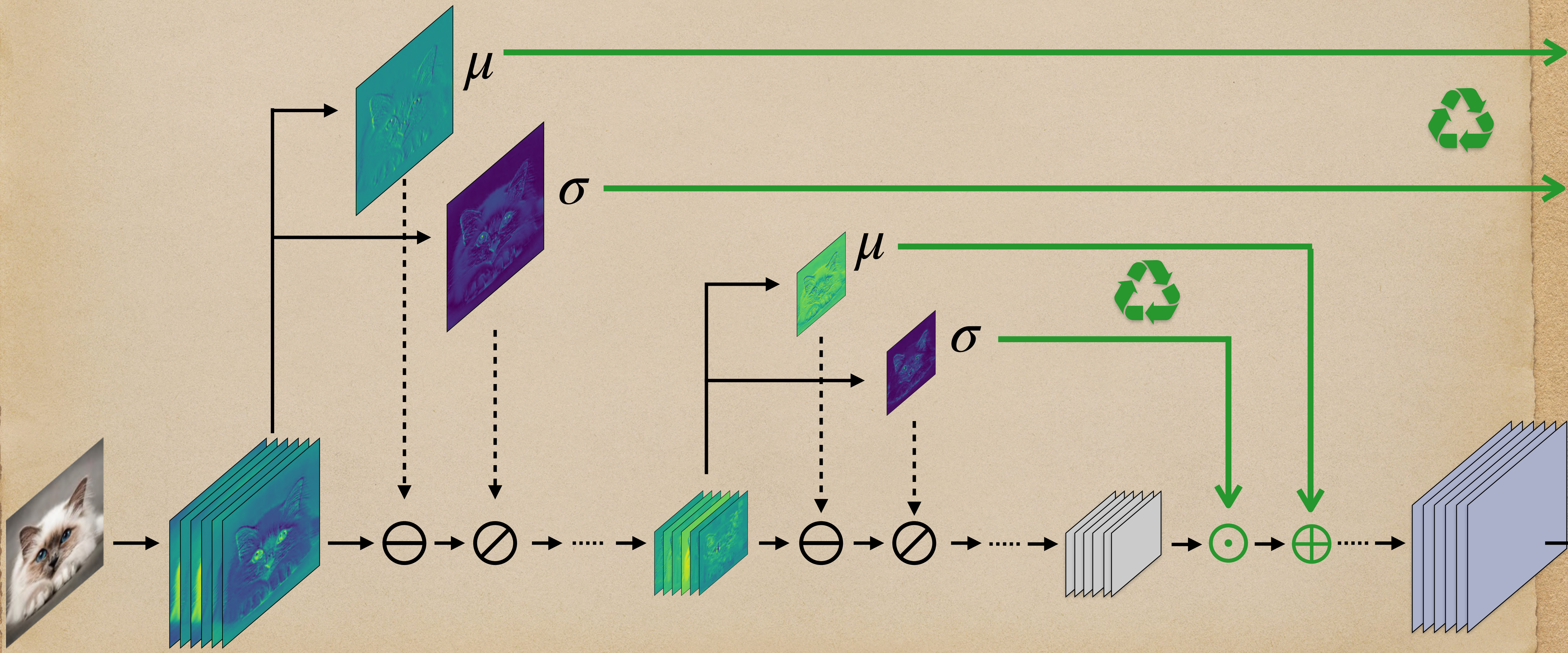
Moments = Trash ?
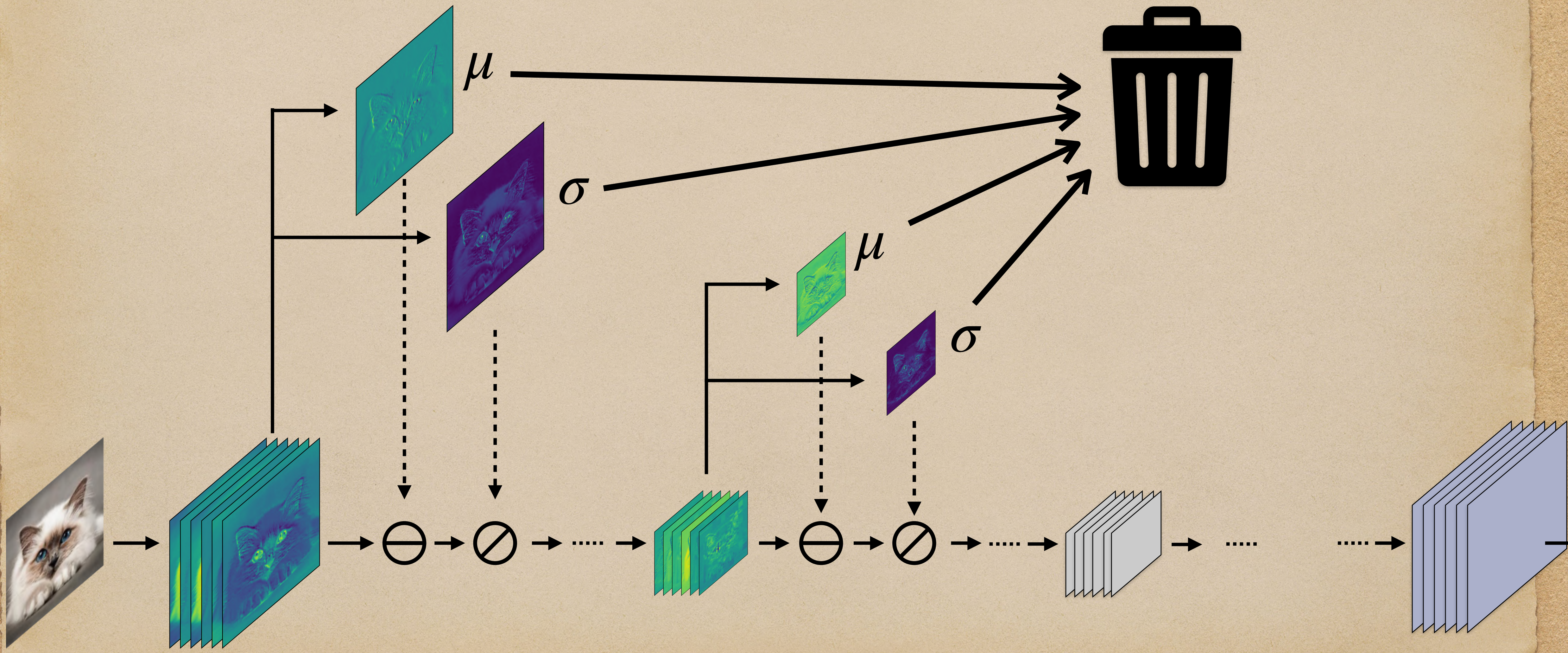
Moments ≠ Trash

Moment Shortcut (MS)

Moment Shortcut (MS) + PONO = PONO-MS

Image Translation
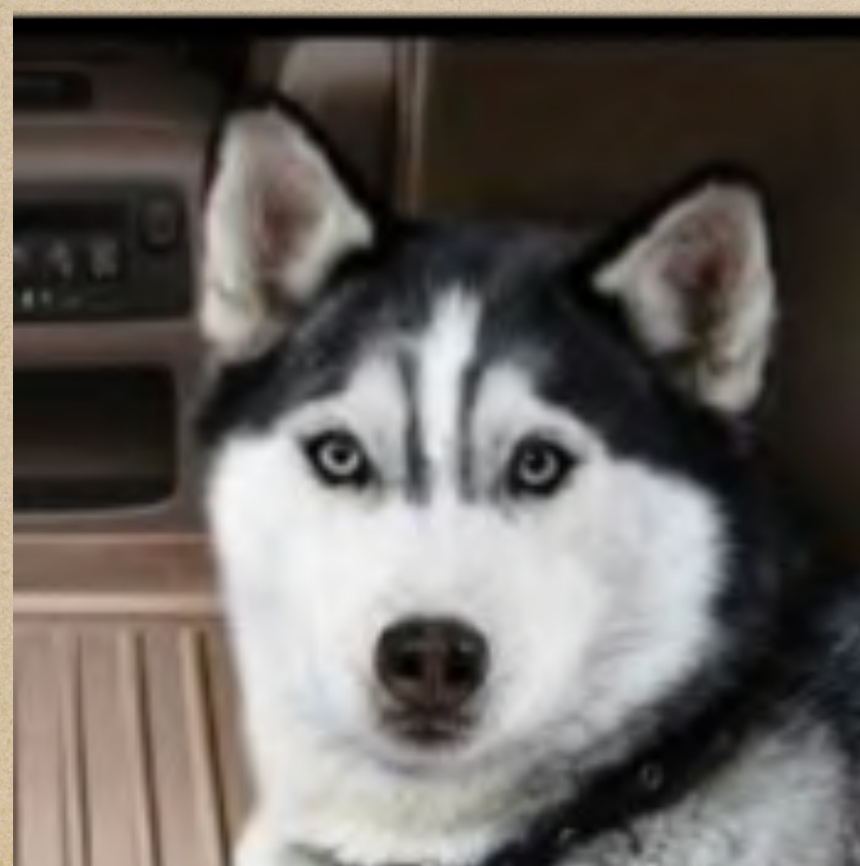
Without PONO-MS
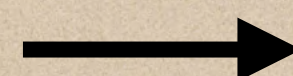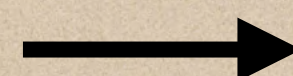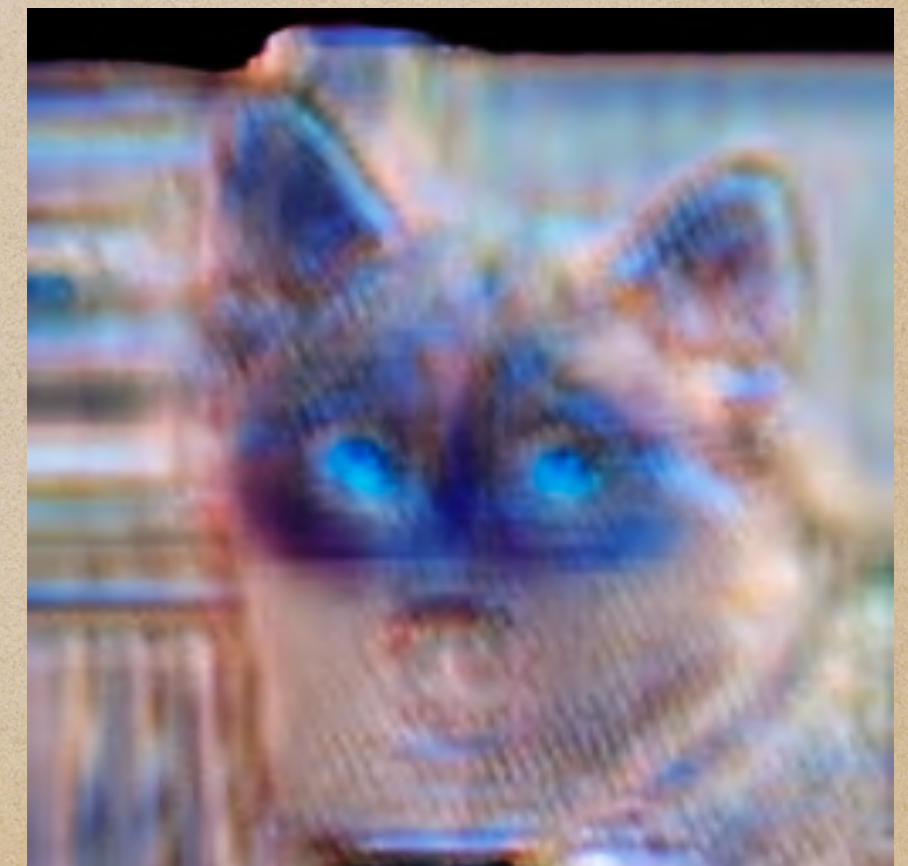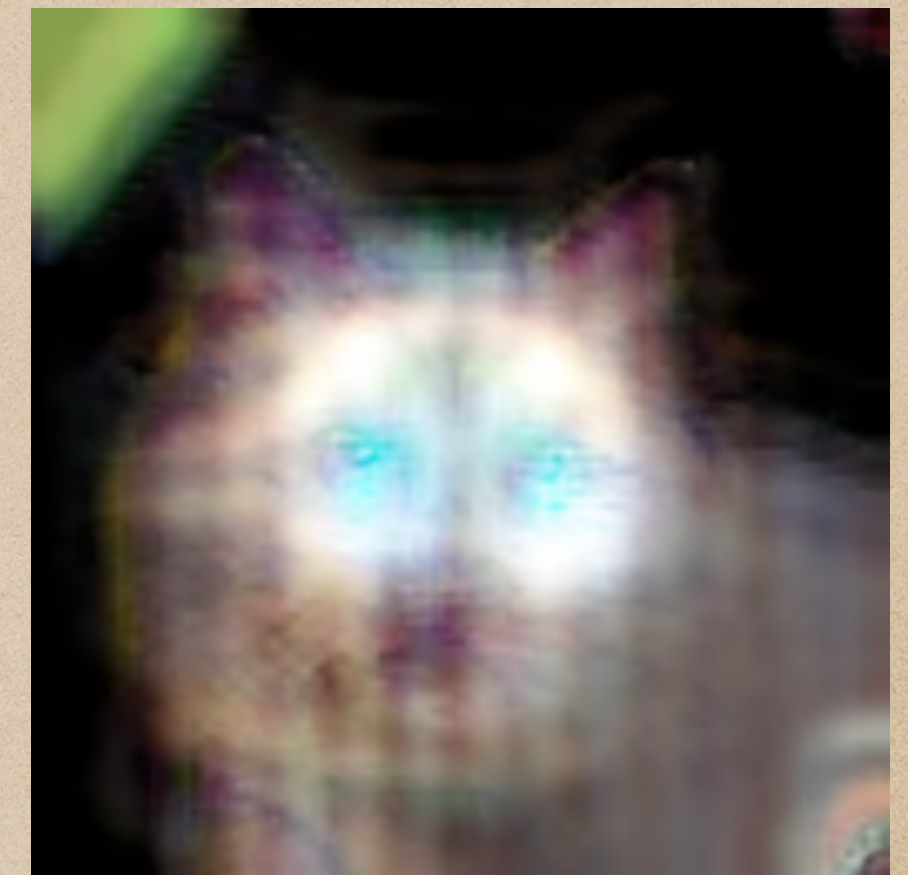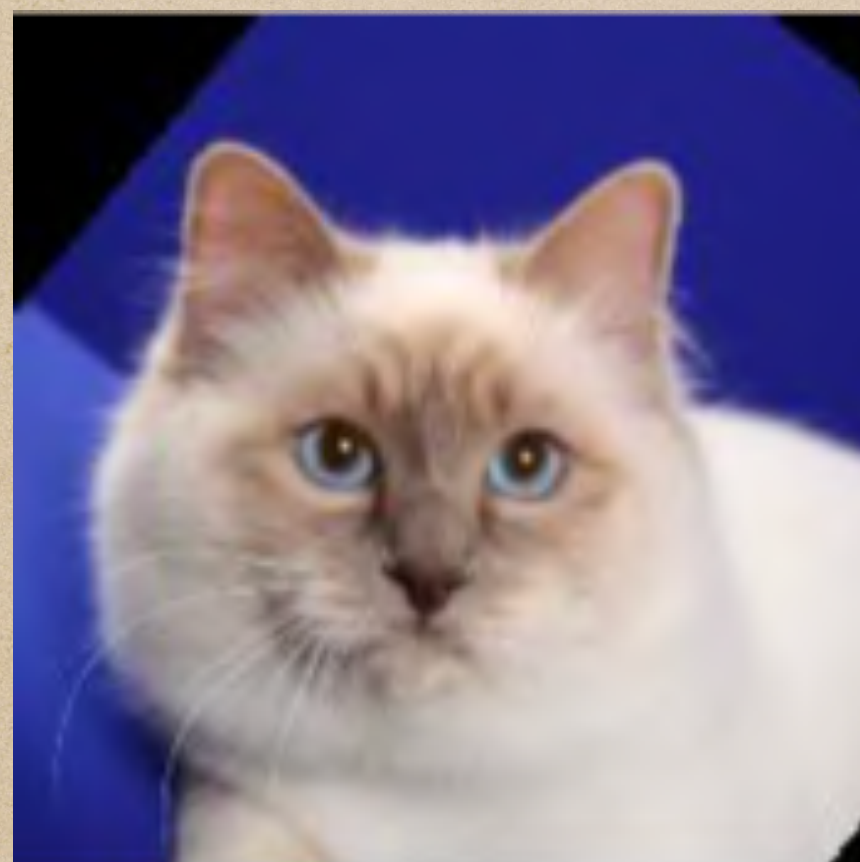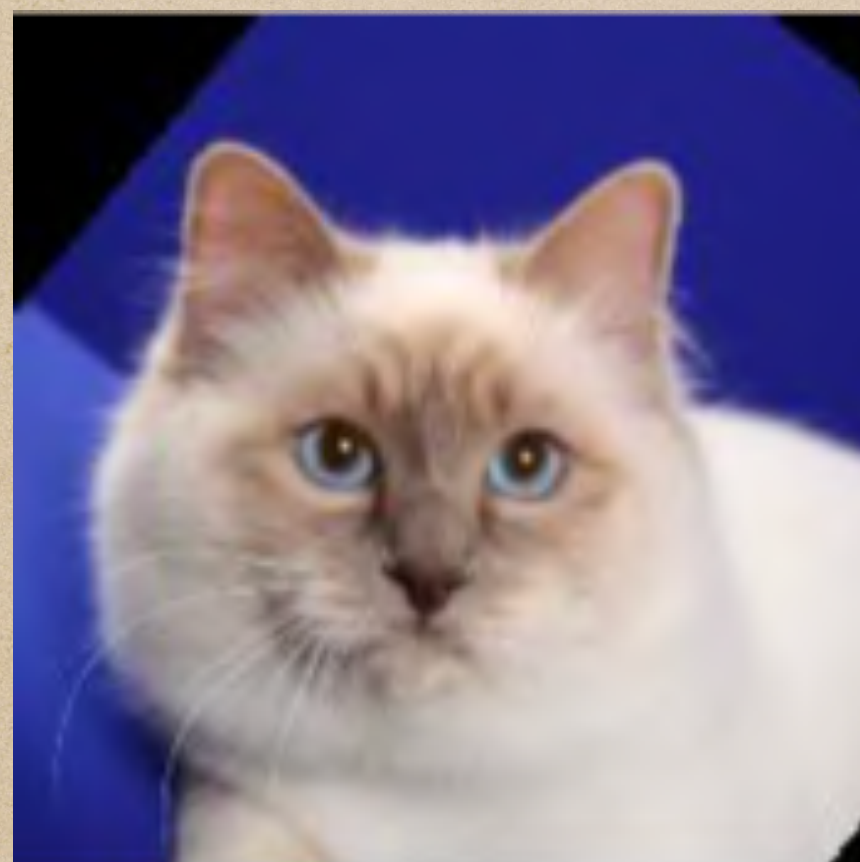
Class

Pose

?

Class

Pose

?

Dataset Source:https://github.com/HsinYingLee/DRIT Model Source: https://github.com/NVlabs/MUNIT

Image Translation

Dataset Source:https://github.com/HsinYingLee/DRIT Model Source: https://github.com/NVlabs/MUNIT
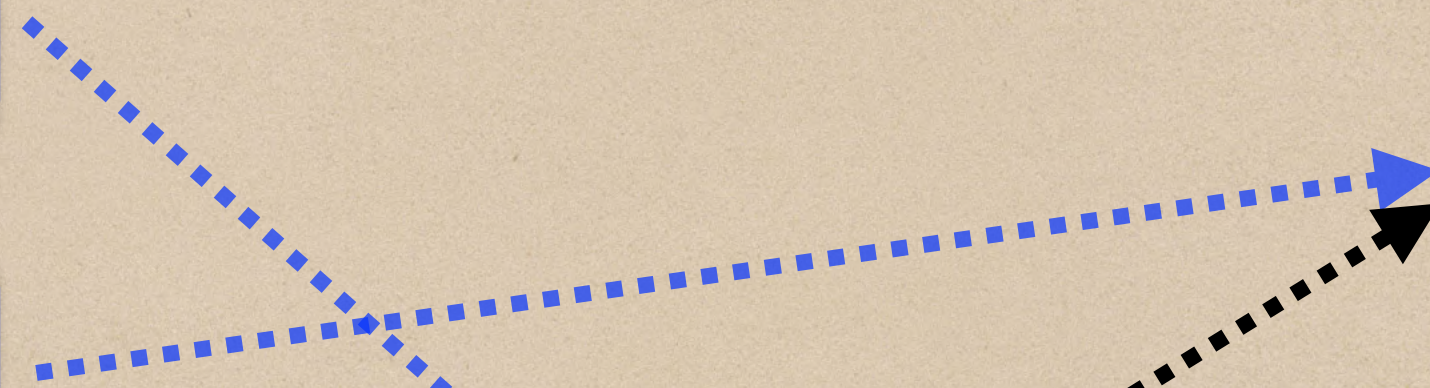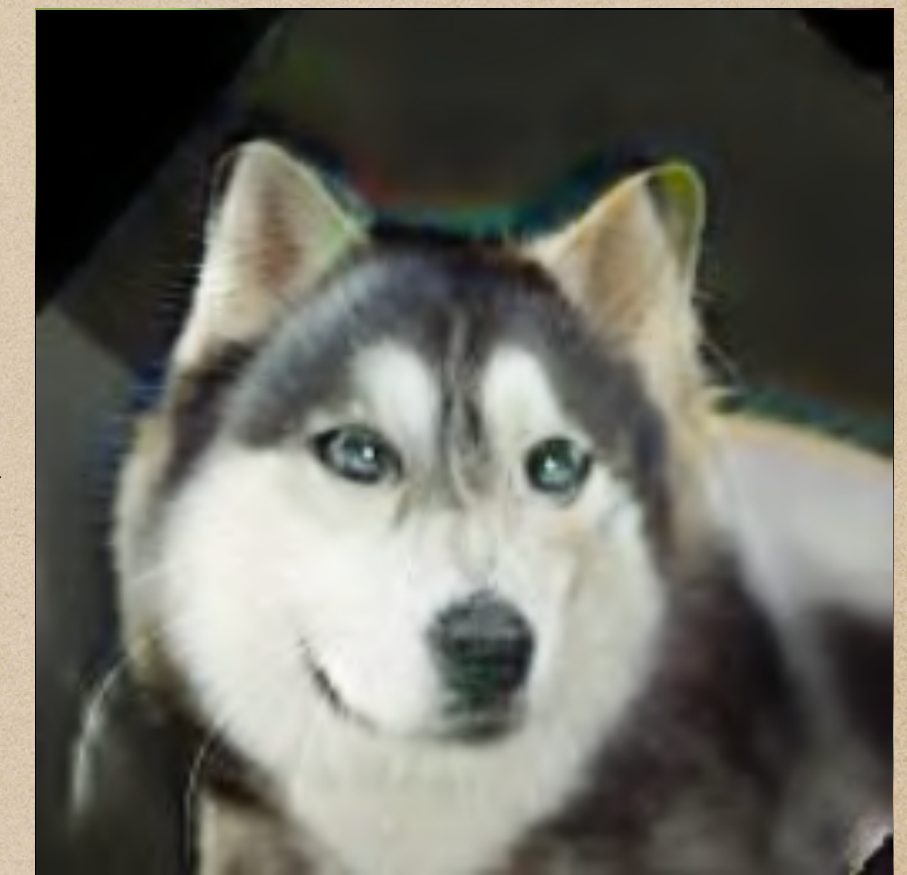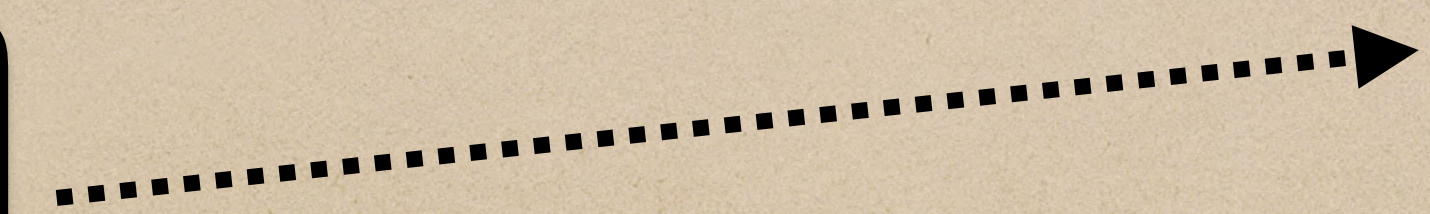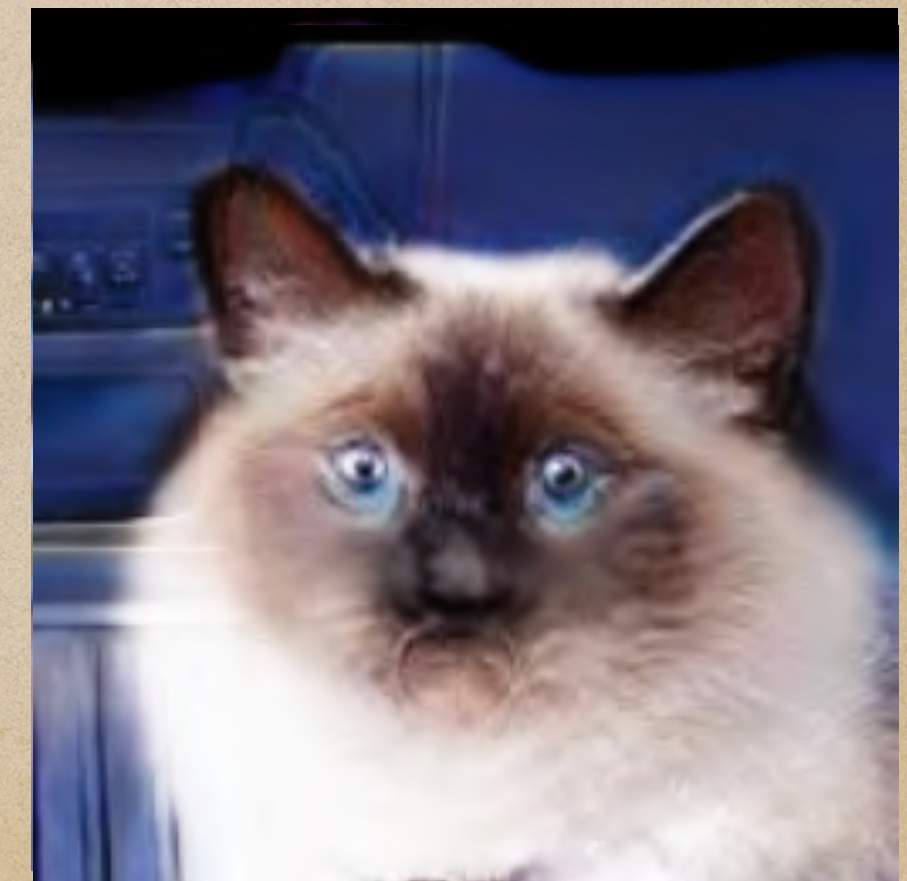
Image Translation

With PONO-MS

Class

Pose
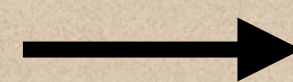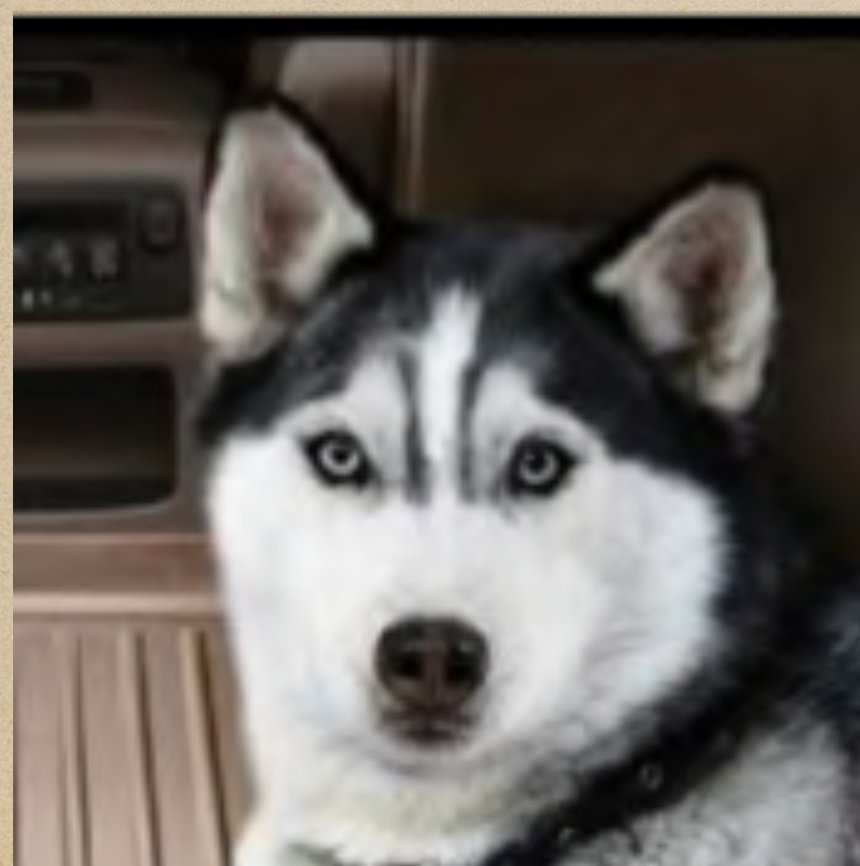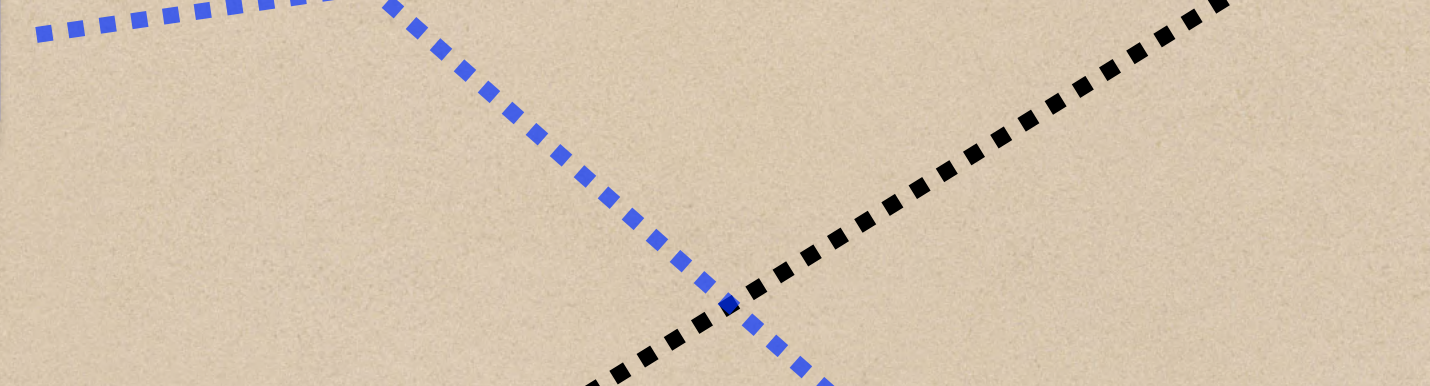
Class

Pose

Come to our poster for more details!
East Exhibition Hall B + C #147