Generative AI with Diffusion Models

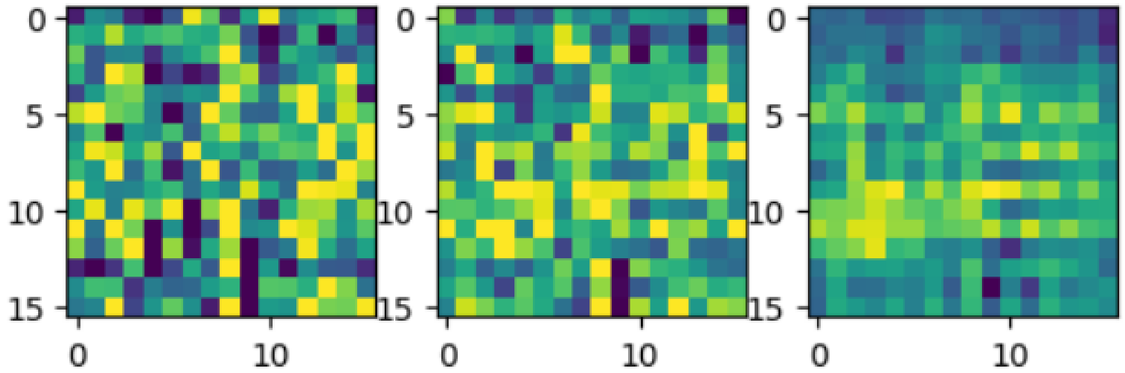
Part 3: Optimizations

Agenda

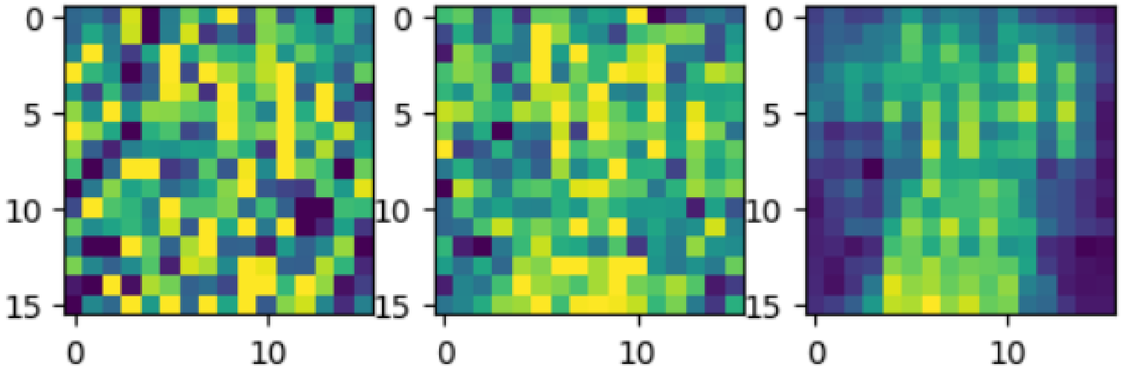
- Part 1: From U-Nets to Diffusion
- Part 2: Denoising Diffusion Probabilistic Models
- Part 3: Optimizations
- Part 4: Classifier-Free Diffusion Guidance
- Part 5: CLIP
- Part 6: Wrap-up & Assessment

The Checkerboard Problem

The Checkerboard Problem



Shoe?

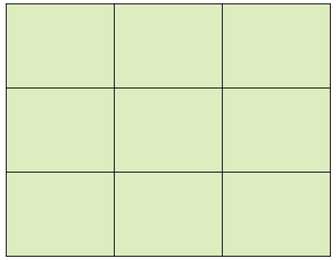


Shirt?

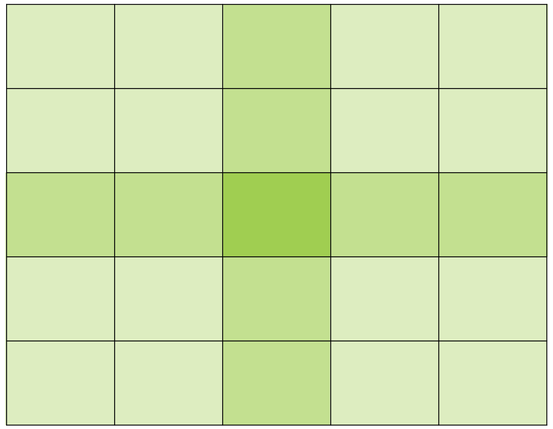
The Checkerboard Problem

The Impact of Stride

Kernel Size = 3



Stride = 2

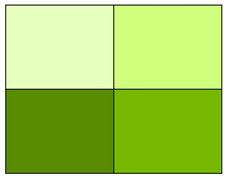


A cozy green plaid blanket, fairy tale drawing

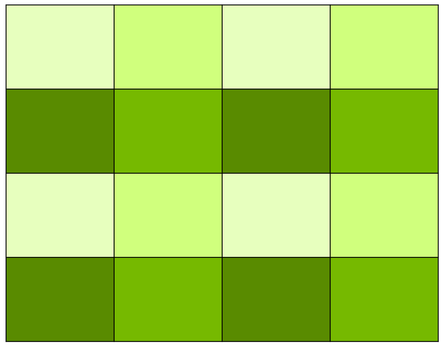
The Checkerboard Problem

The Impact of Stride

Kernel Size = 2



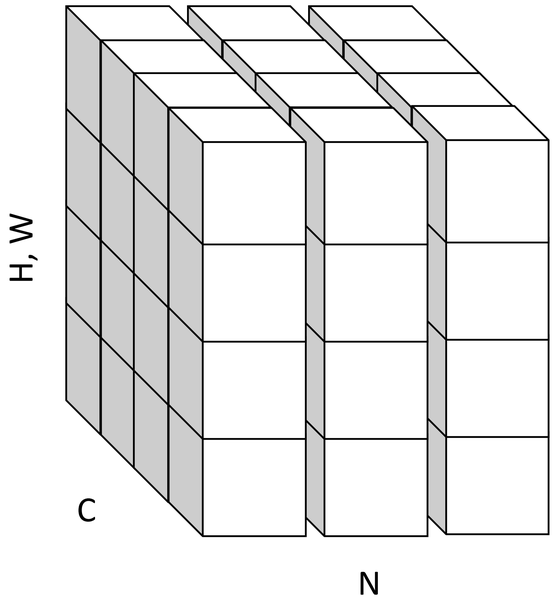
Stride = 2



Group Normalization

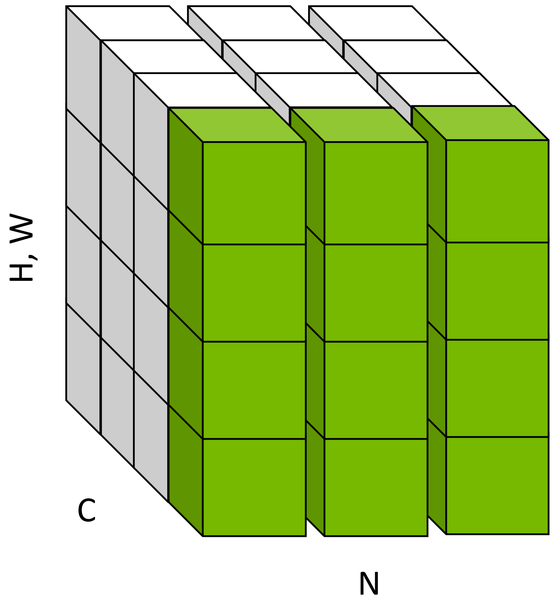
Group Normalization

Batch Normalization Review



Group Normalization

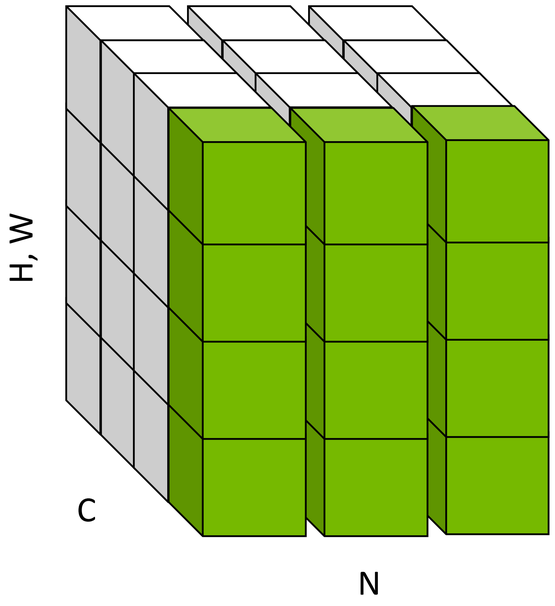
Batch Normalization Review



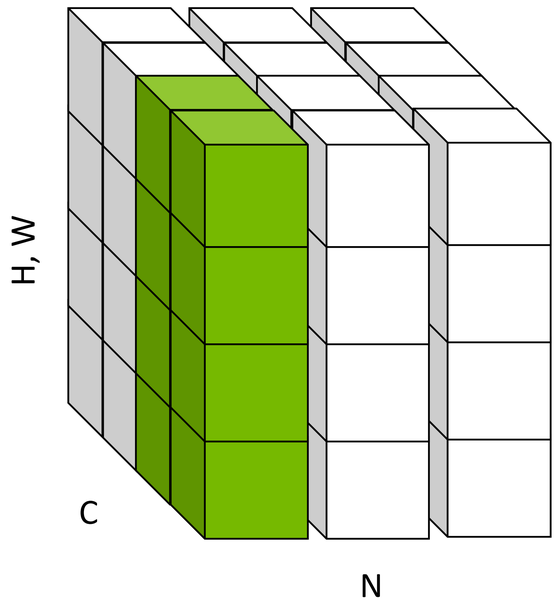
Batch Normalization

Group Normalization

Types of Group Normalization



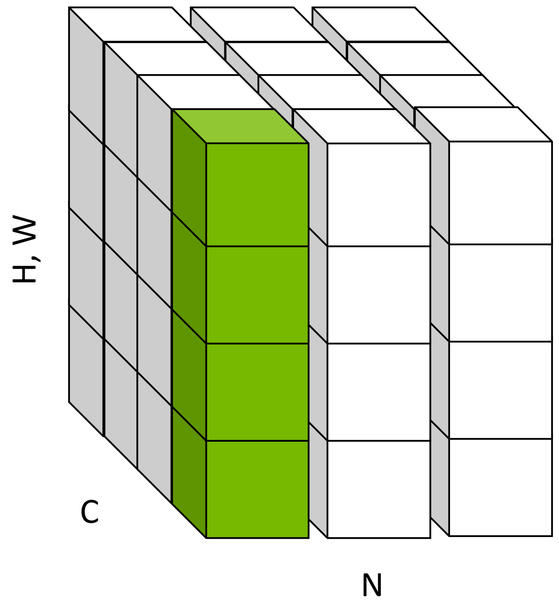
Batch Normalization



Group Normalization

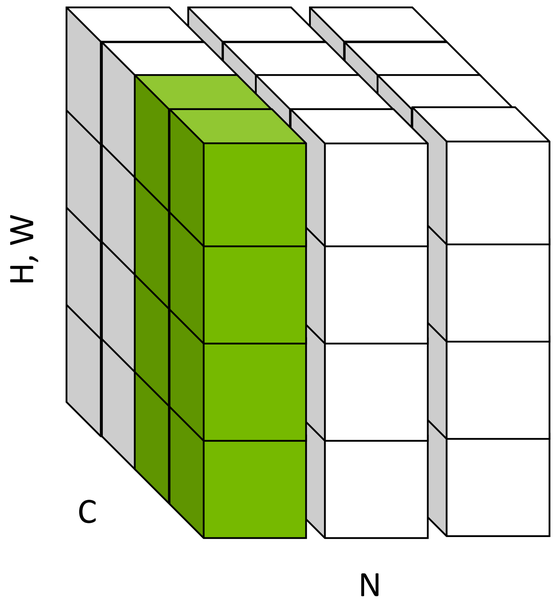
Group Normalization

Types of Group Normalization



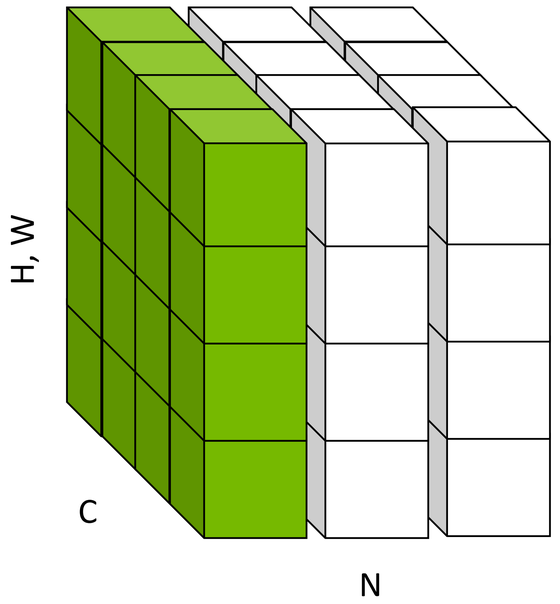
Instance Normalization

Group Size = 1



Group Normalization

Group Size = 2

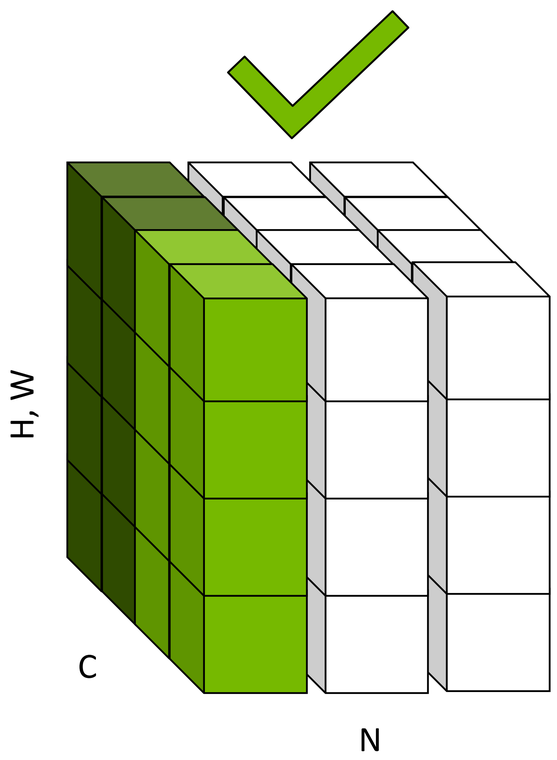


Layer Normalization

Group Size = All

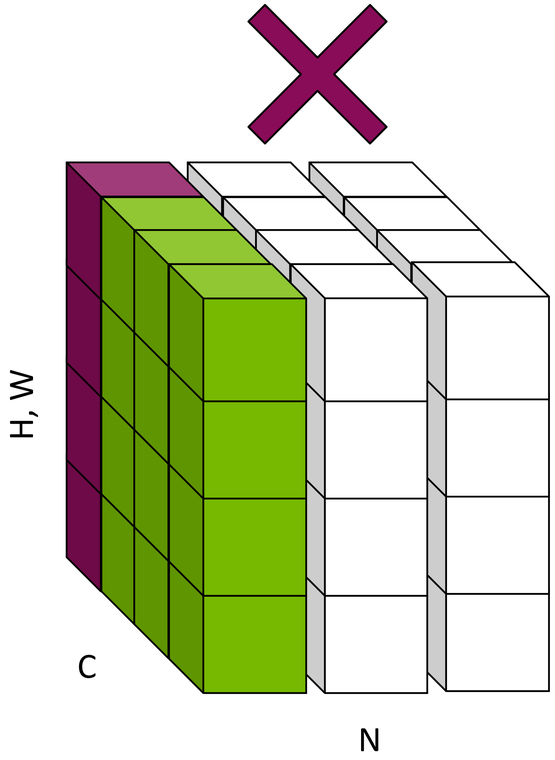
Group Normalization

Types of Group Normalization



Group Normalization

Group Size = 2



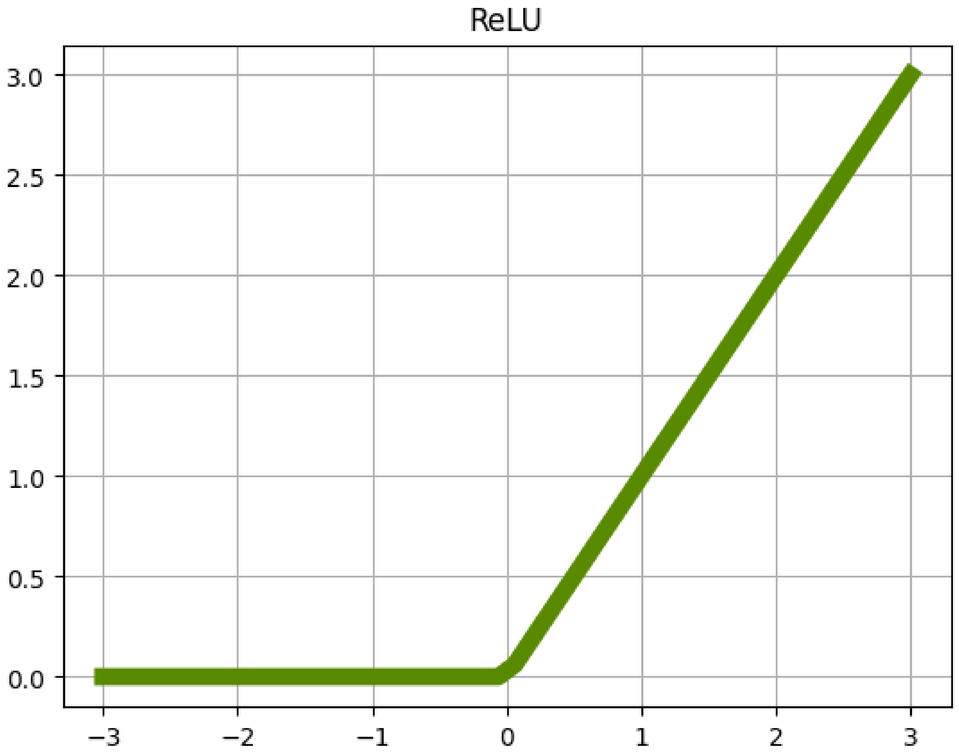
Group Normalization

Group Size = 3

Gaussian Error Linear Unit (GELU)

GELU

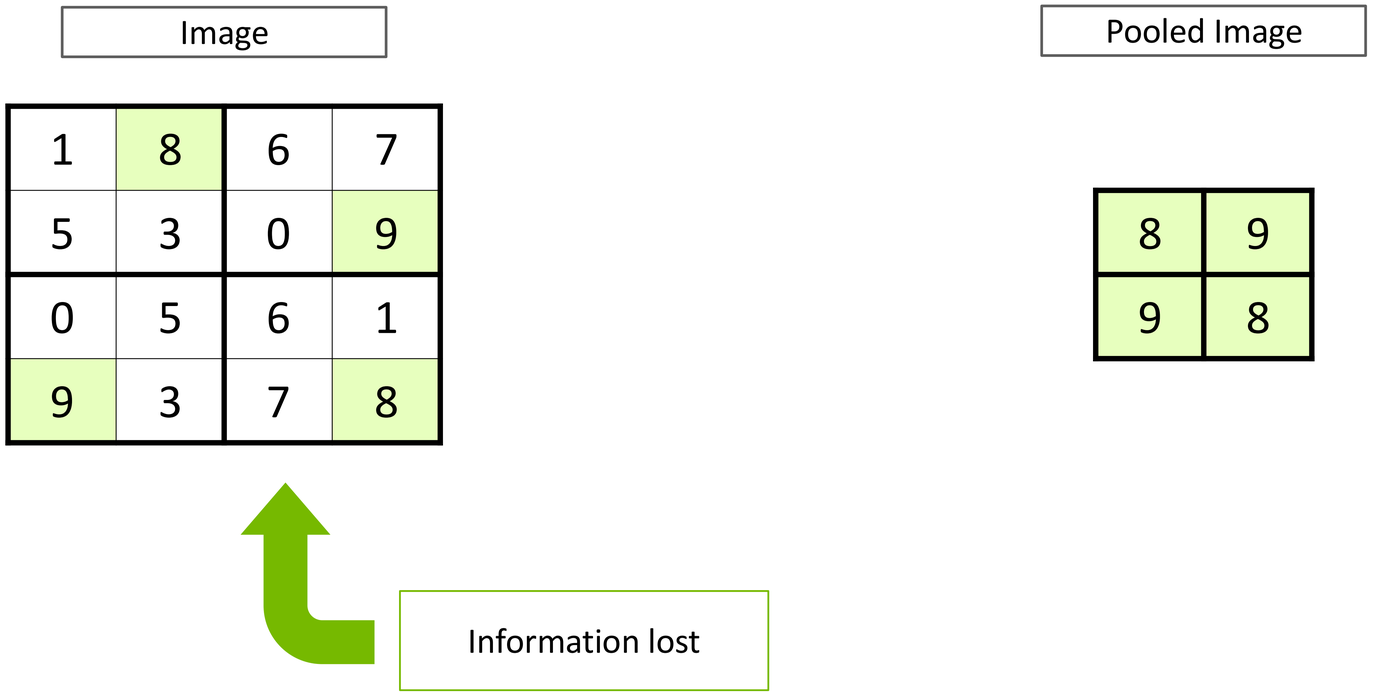
Gaussian Error Linear Unit



Rearrange Pooling

Pooling

Max Pooling Review

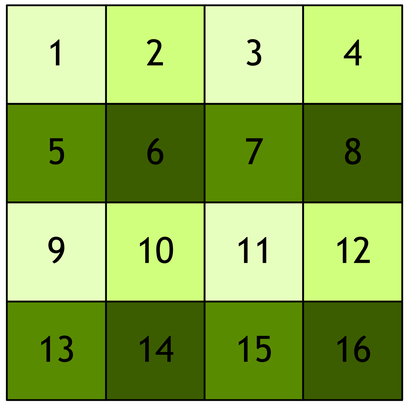


Einops

Better Dimension Manipulation

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

Cut image into strips and stack



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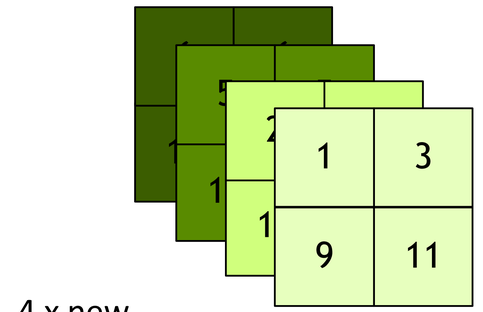


4 x new Channels

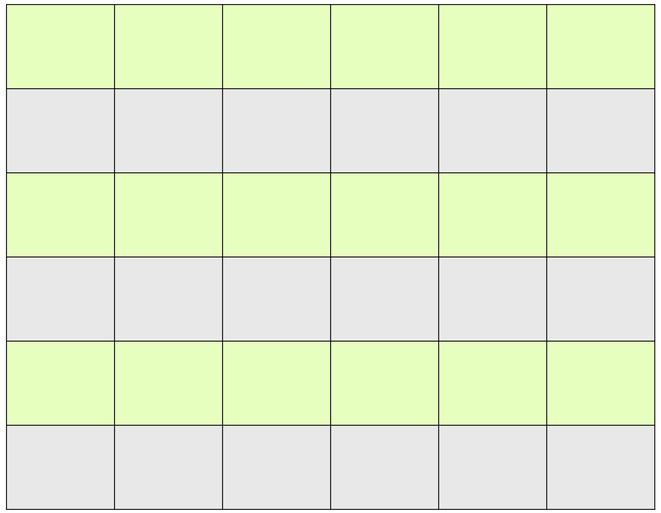
$^1/_2$ Height

$^1/_2$ Width

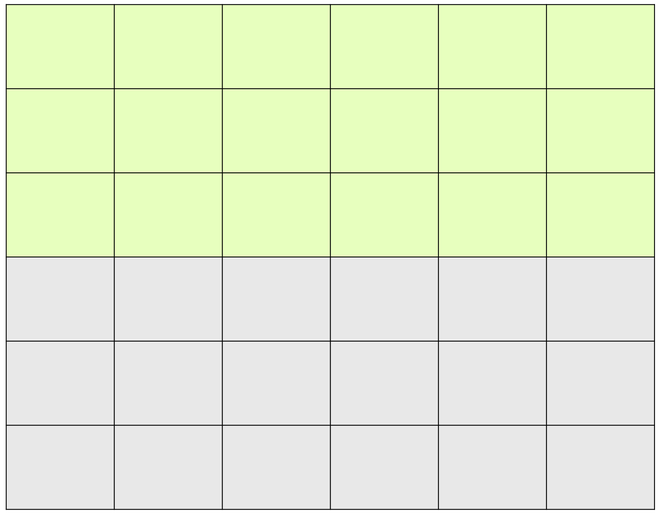
Einops

Order Matters

```
Rearrange(
  "c (h p1) w -> (c p1) h w", p1=2
)
```



```
Rearrange(
  "c (p1 h) w -> (c p1) h w", p1=2
)
```



Sinusoidal Position Embeddings

Time as a Sequence

How to Represent Time as Discrete Steps?

t

0	1	2	3	4	5	6	7	8	9	…

As a one-hot encoding?

t = 7

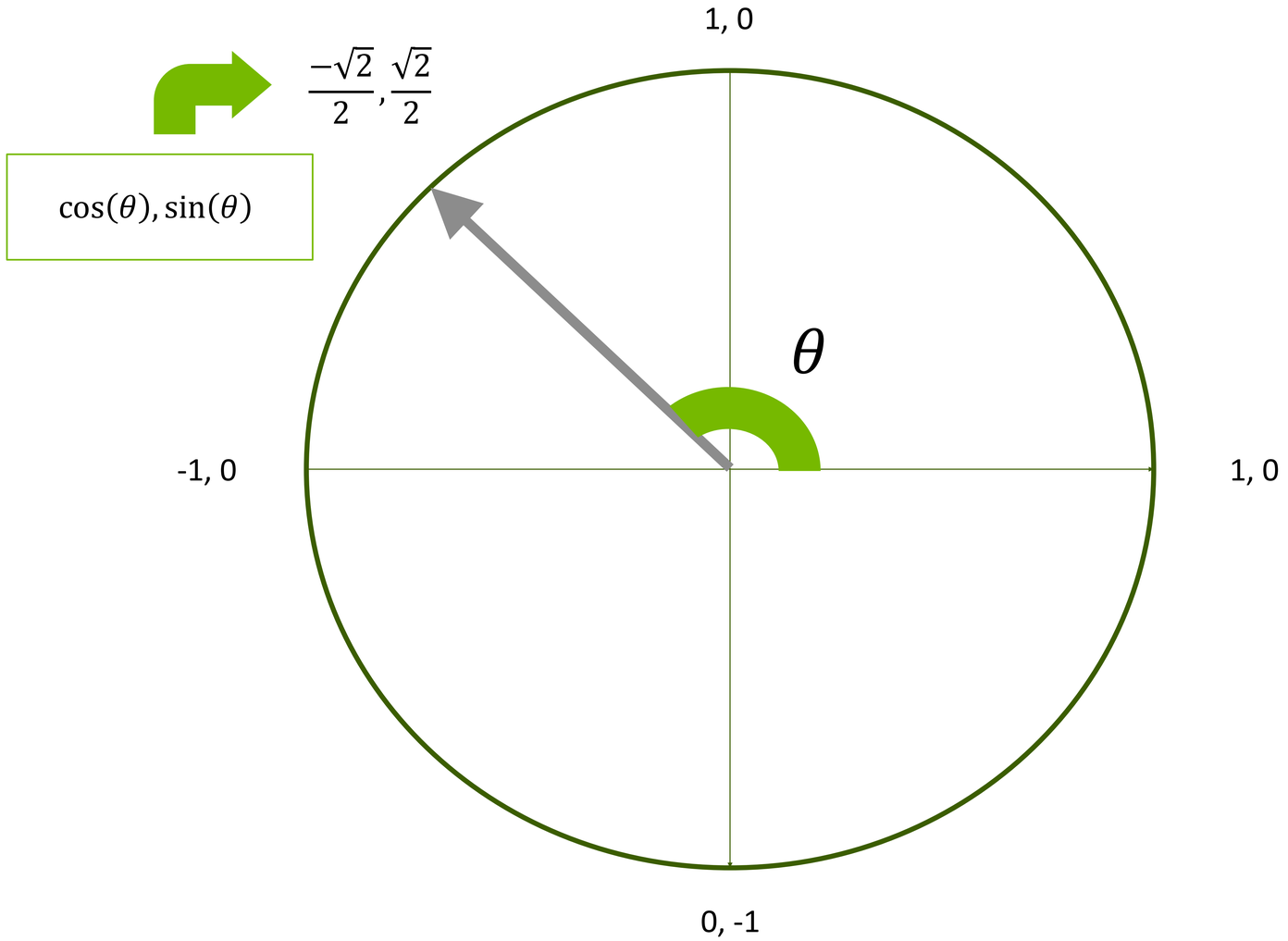
0	0	0	0	0	0	0	1	0	0	…

As binary?

0	0	0	0	0	0	0	0	1	1	…
0	0	0	0	1	1	1	1	0	0	…
0	0	1	1	0	0	1	1	0	0	…
0	1	0	1	0	1	0	1	0	1	…

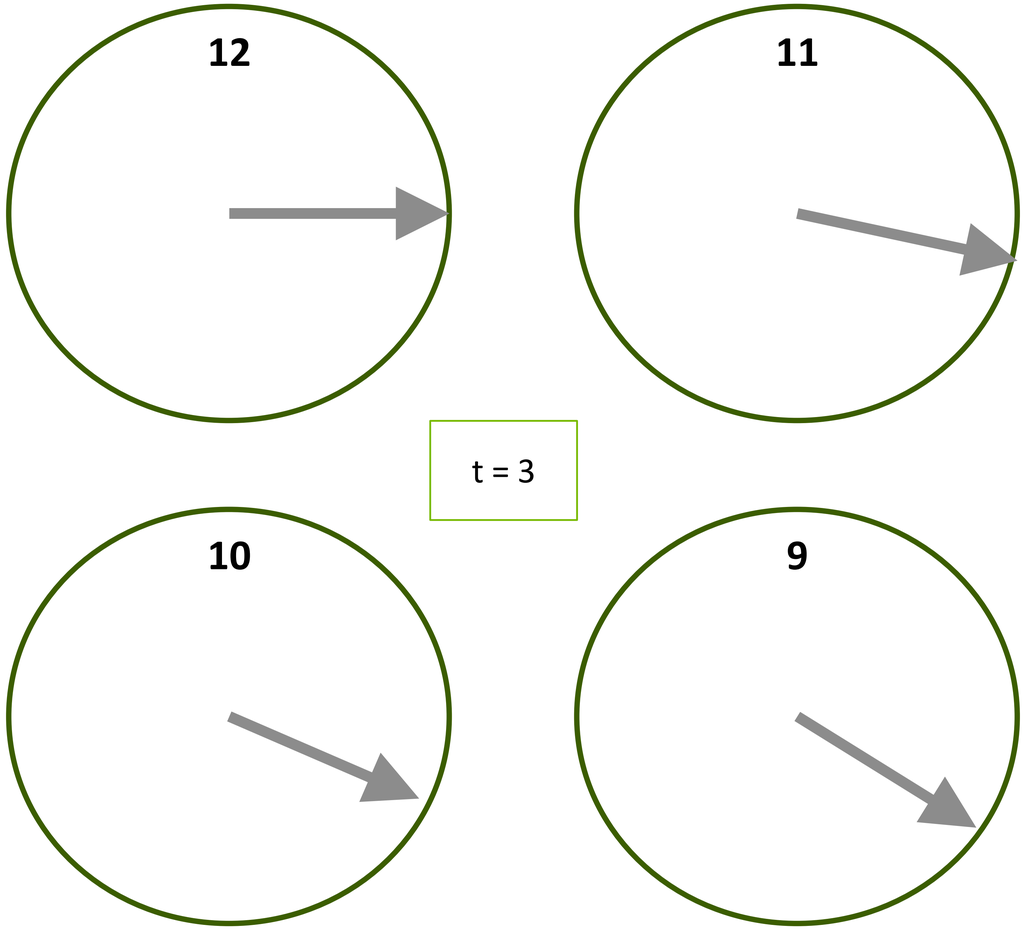
Time as a Sequence

As a Unit Circle?



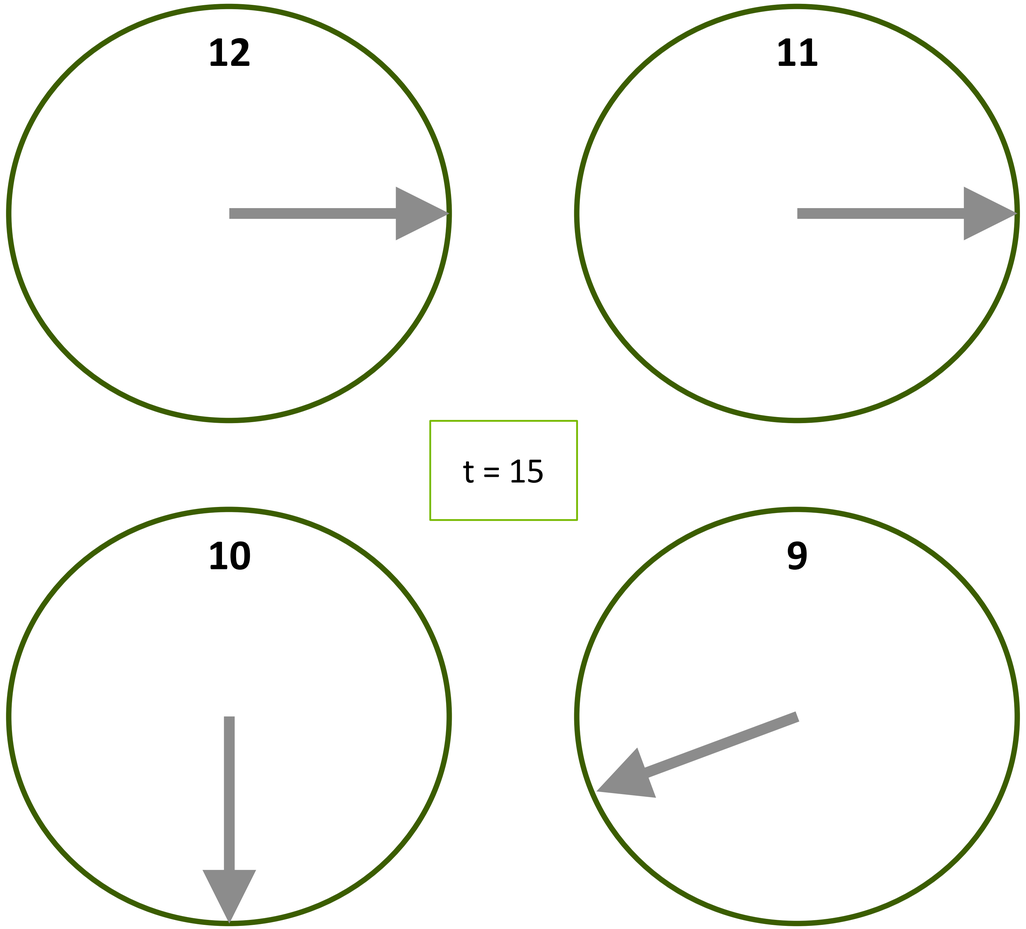
Time as a Sequence

As Unit Circles?



Time as a Sequence

As Unit Circles?

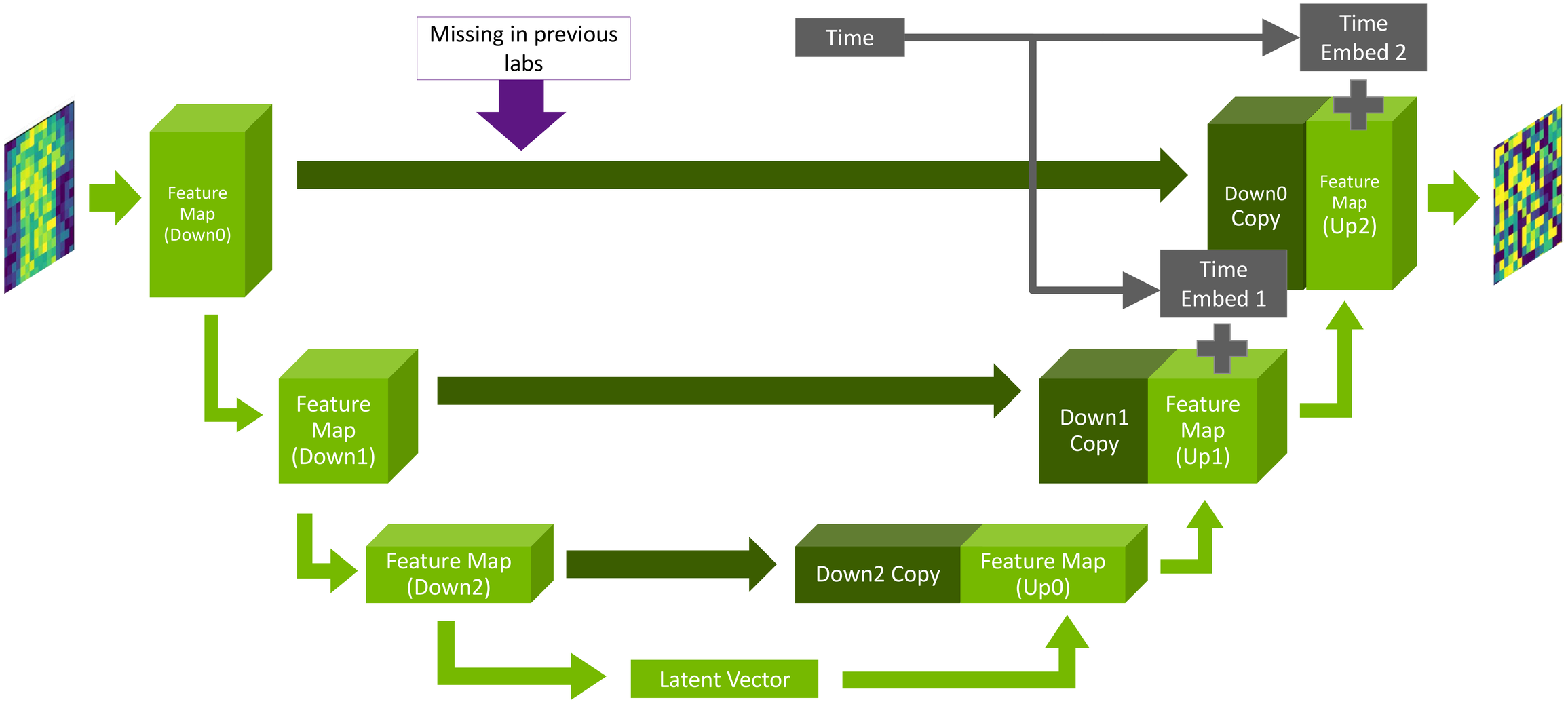


A bunch of abstract clocks with different numbers on them

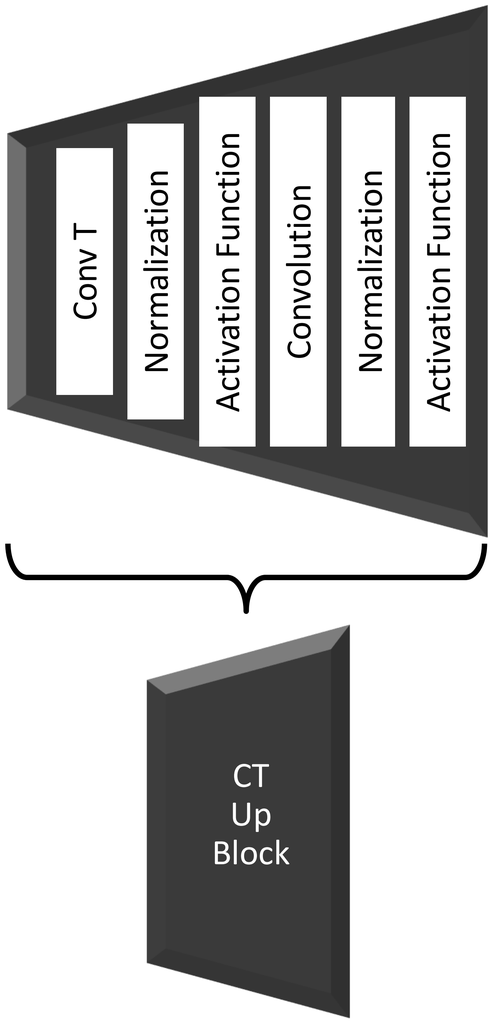
Deeper Networks

The U-Net Architecture

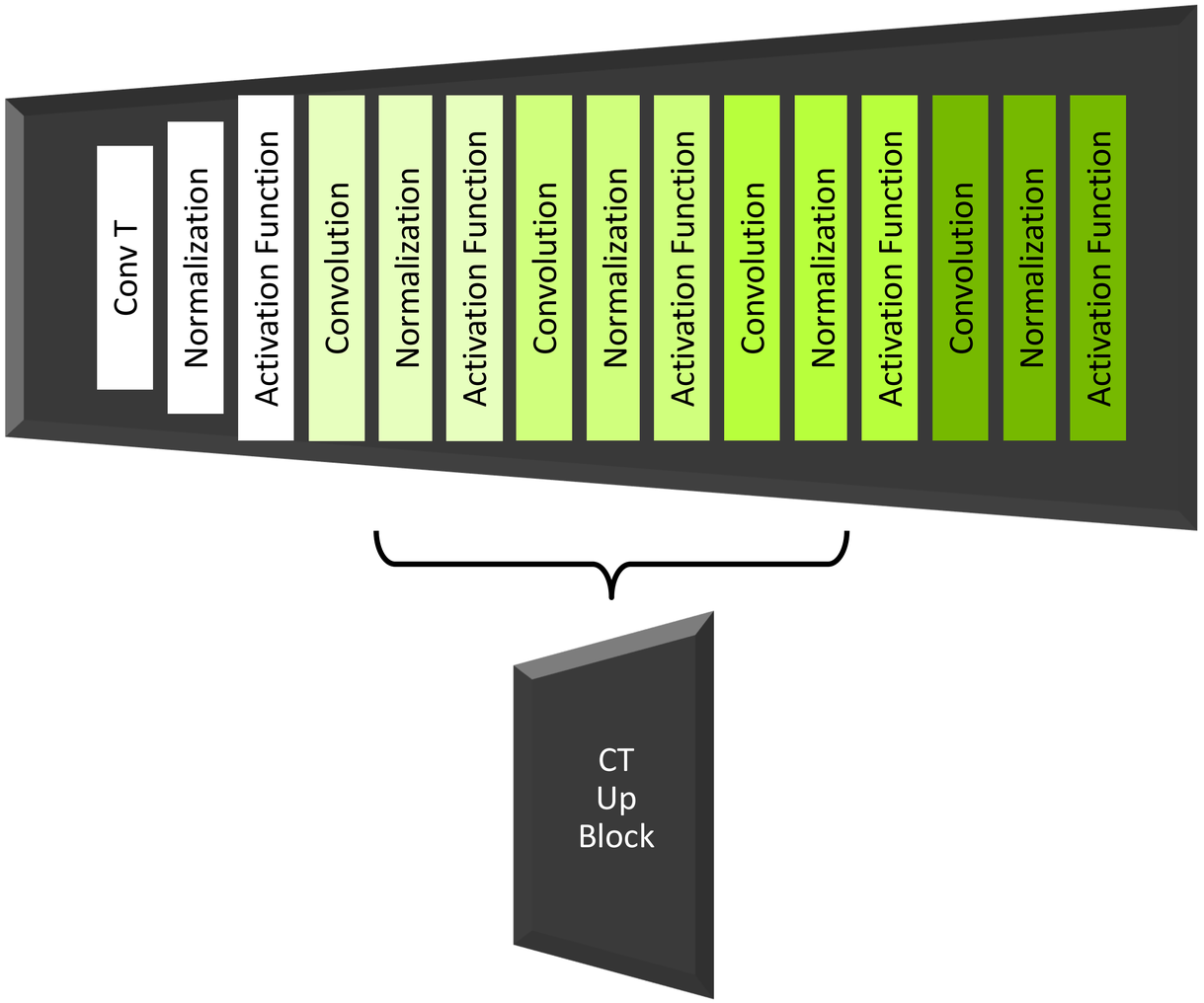
Adding Time



Adding Depth



Adding Depth



Let’s get started!