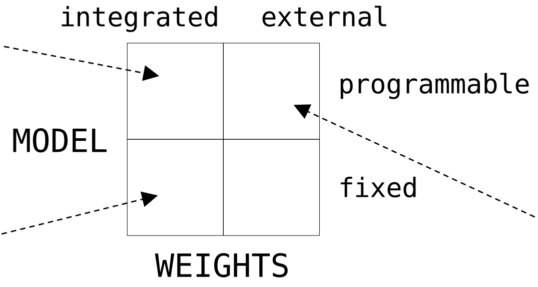
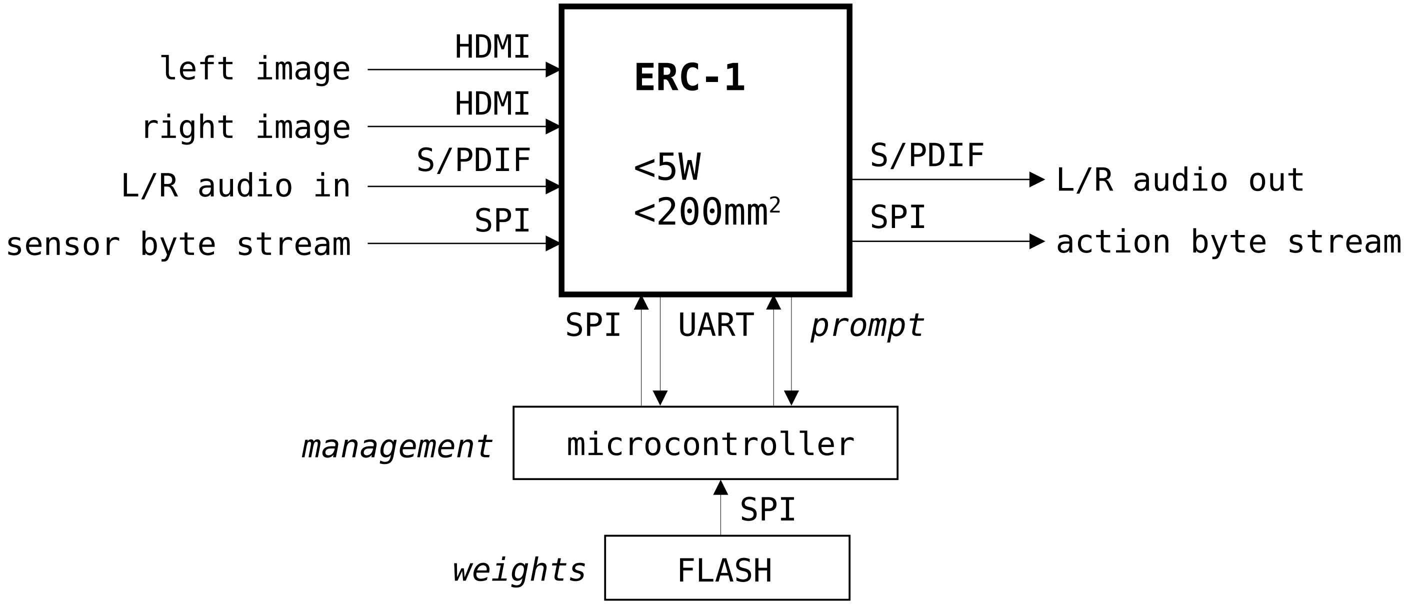
**Inference accelerator**
Cerebras
Groq

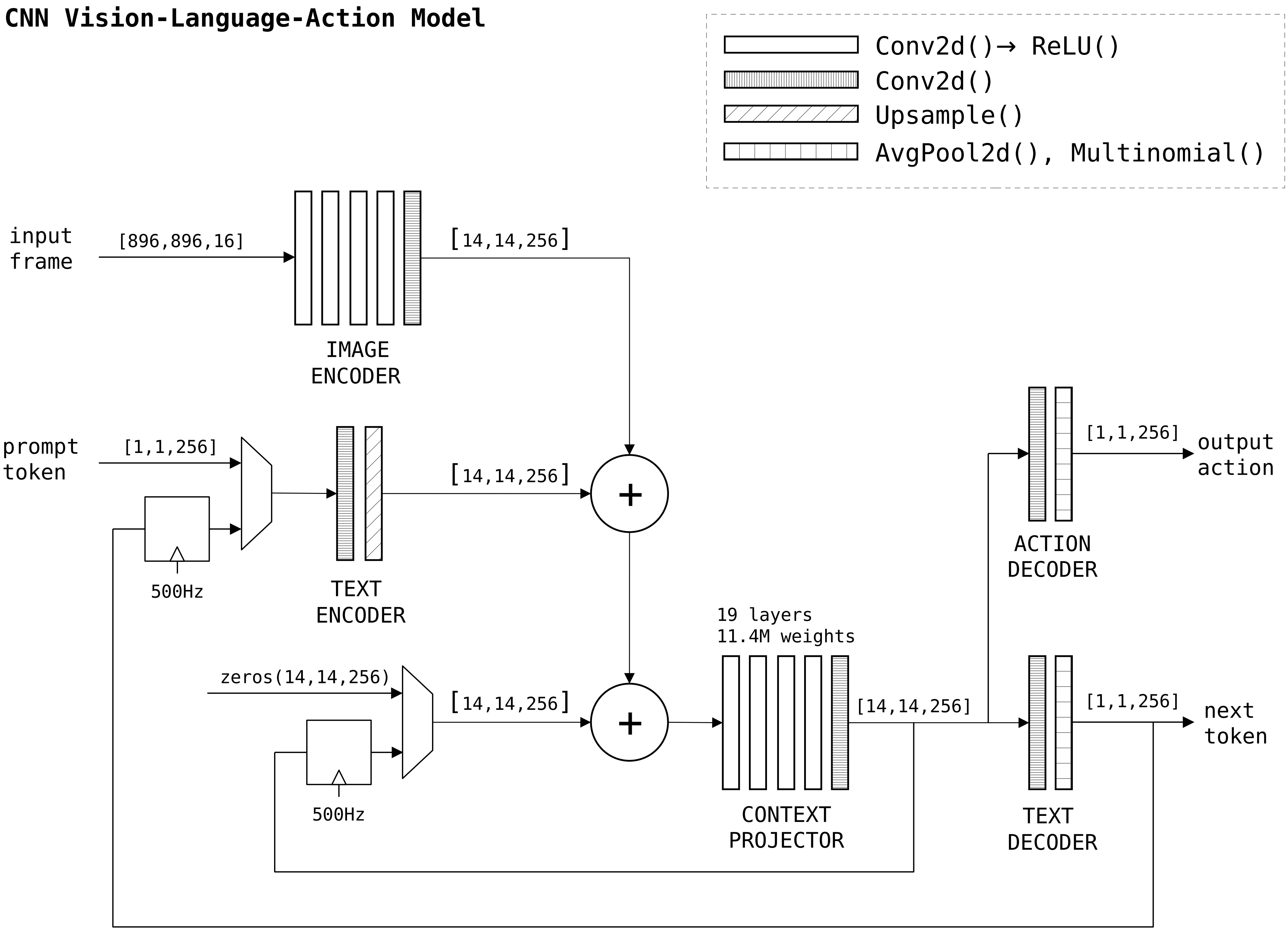


**Embedded AI**
integrated SRAM weights
fixed model
no software stack, weights only

**AI accelerator (GPU)**
external DRAM weights
programmable model
Pytorch software stack

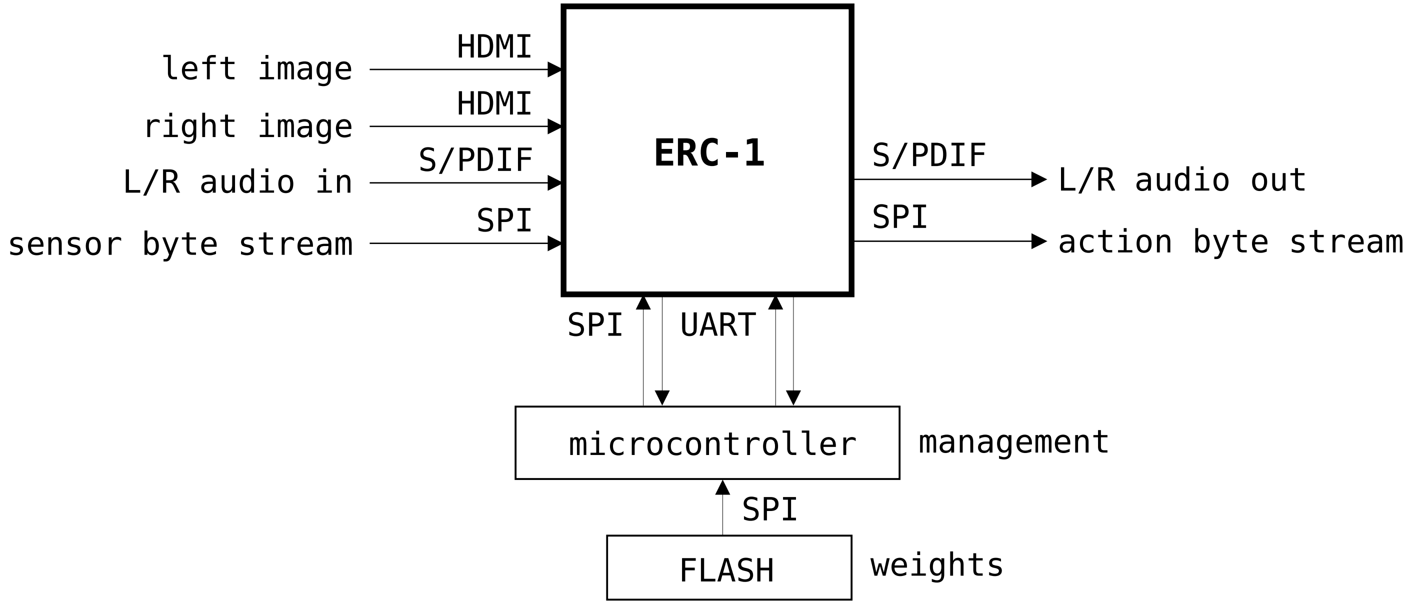
**Embedded Robot Controller**
Autonomous robots
Interactive signage
Nuclear fusion reactors




CNN Vision-Language-Action Model
Conv2d()→ ReLU()
Conv2d()
Upsample()
AvgPool2d(), Multinomial()
input frame
[896,896,16]
IMAGE ENCODER
[14,14,256]
prompt token
[1,1,256]
500Hz
TEXT ENCODER
[14,14,256]
+
zeros(14,14,256)
500Hz
[14,14,256]
+
19 layers
11.4M weights
CONTEXT PROJECTOR
[14,14,256]
ACTION DECODER
[1,1,256]
output action
TEXT DECODER
[1,1,256]
next token

# BACKUP

**Embedded Robot Controller**
Autonomous robots
Interactive signage
Nuclear fusion reactors



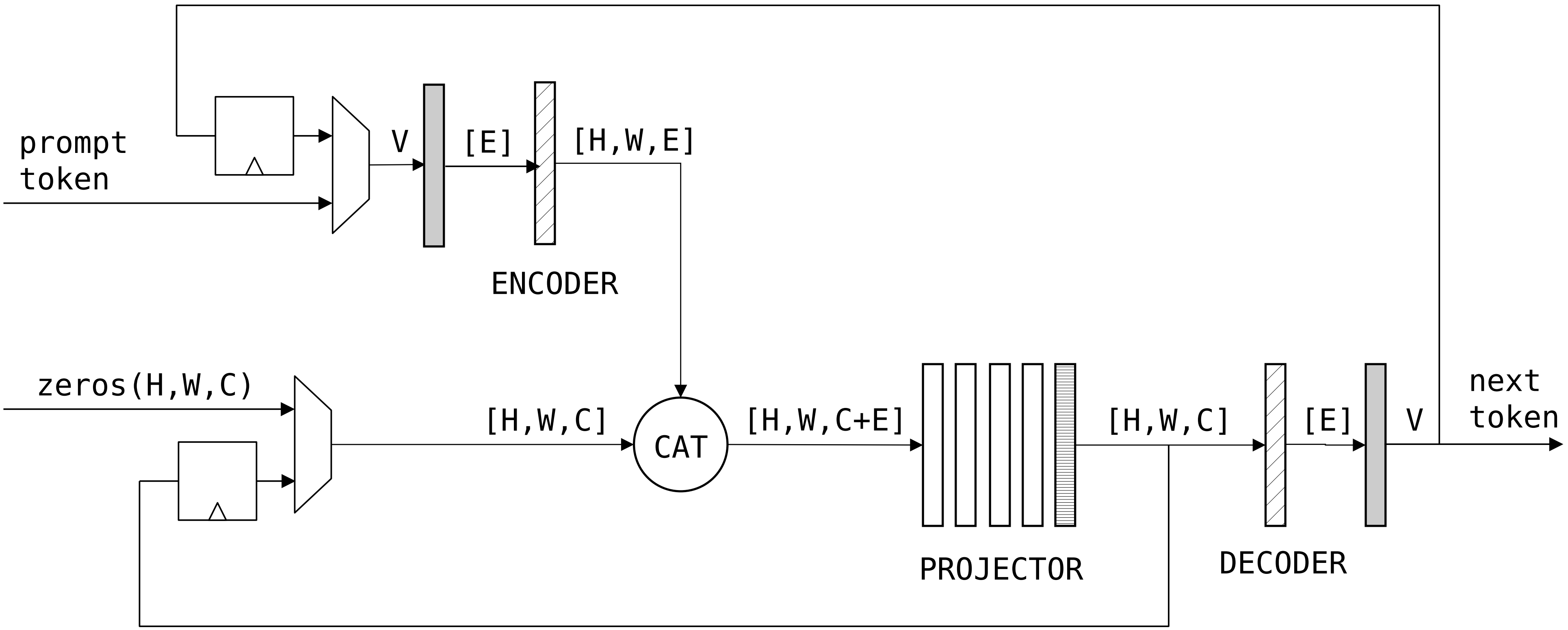
**hardened components**
integrated SRAM/ROM weights
fixed model

⟺

**AI accelerator**
external DRAM weights
programmable model

| MODEL \ WEIGHTS | integrated | external |
|---|---|---|
| programmable | | |
| fixed | | |

**CNN Language Model**



▭ Conv2d()→ ReLU()

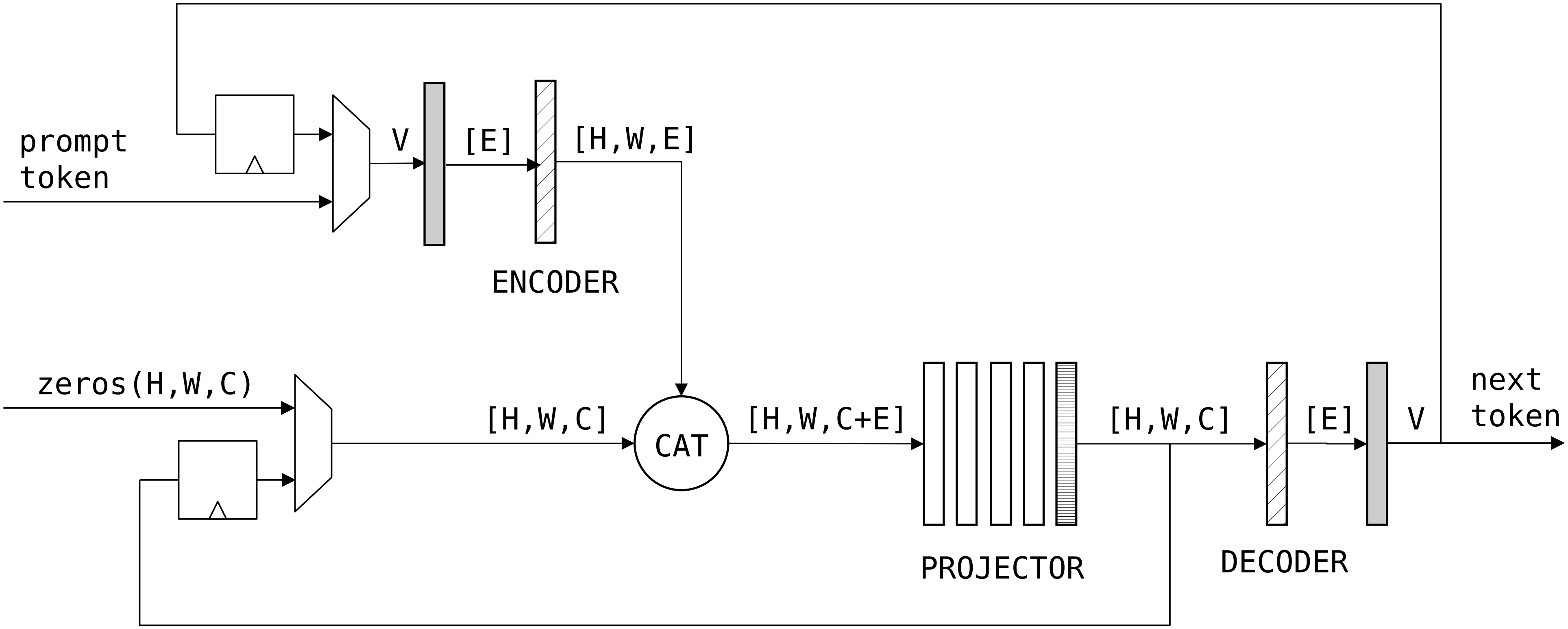
▥ Conv2d()

▨ Upsample(), AvgPool2d()

■ FROZEN

| | |
|---|---|
| V | 50257 |
| E | 256 |
| C | 512 |
| H,W | 8,8 |

## CNN Language Model



▭ Conv2d()→ ReLU()

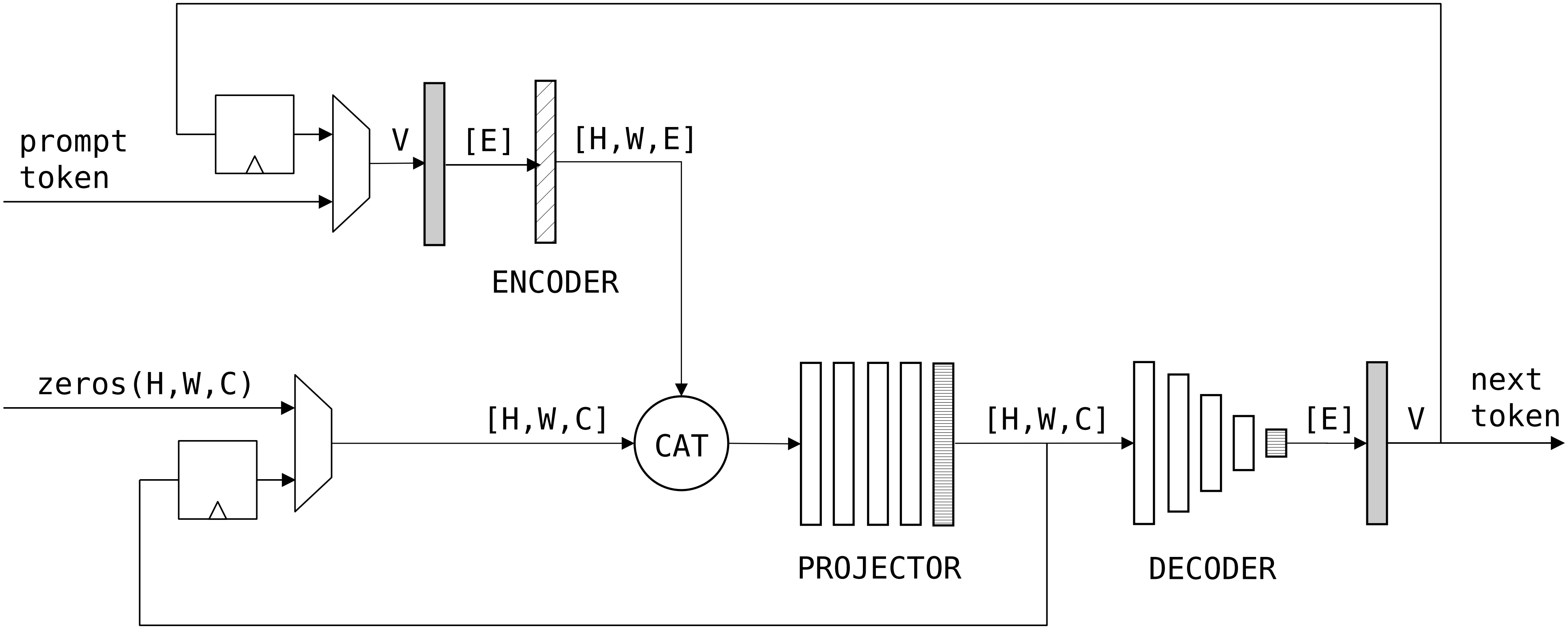
▥ Conv2d()

▨ Upsample(), AvgPool2d()

■ FROZEN

| | |
|---|---|
| V | 50257 |
| E | 256 |
| C | 512 |
| H,W | 8,8 |

## CNN Language Model



□ Conv2d()→ ReLU()

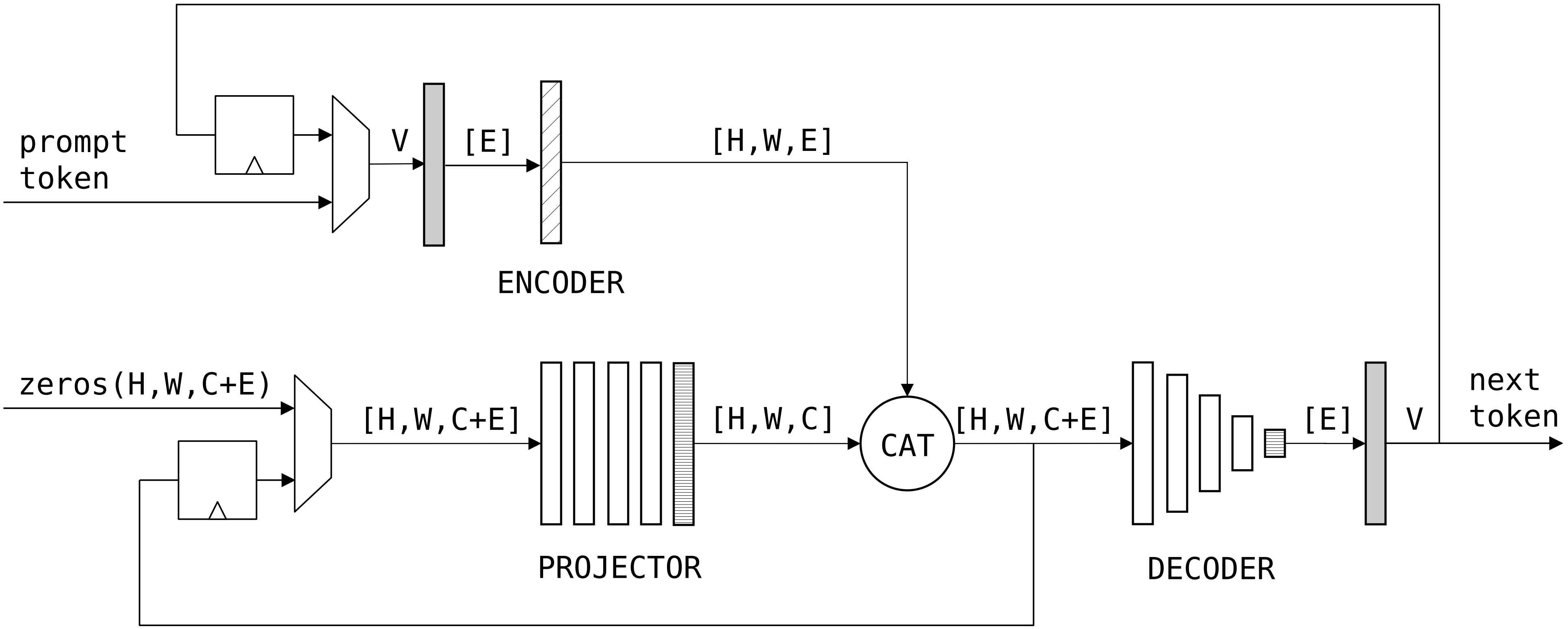
▥ Conv2d()

▨ Upsample()

▒ FROZEN

| | |
|---|---|
| E | 256 |
| V | 50257 |
| C | 256 |
| H,W | 14,14 |

## CNN Language Model



□ Conv2d()→ ReLU()

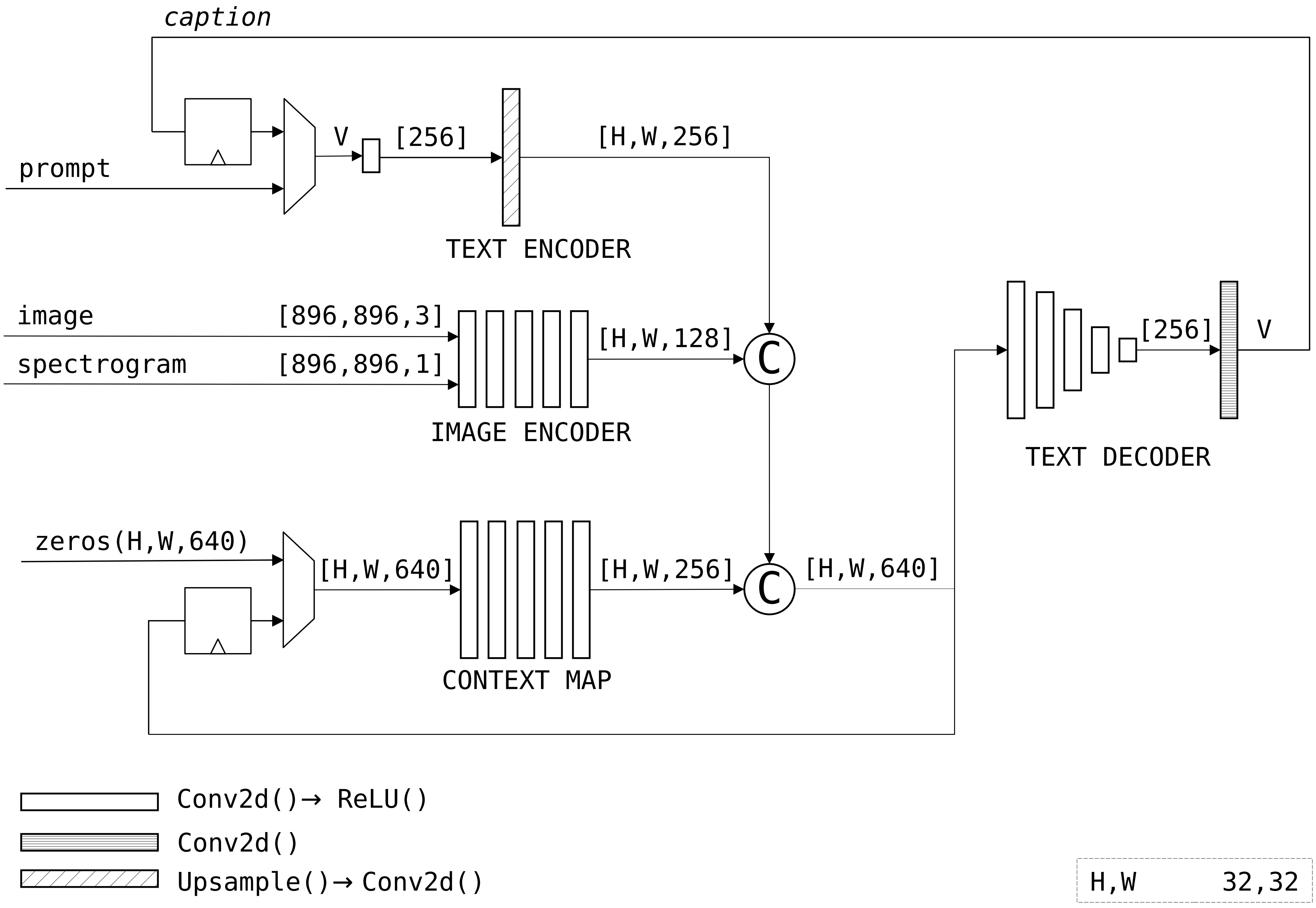
▥ Conv2d()

▨ Upsample()

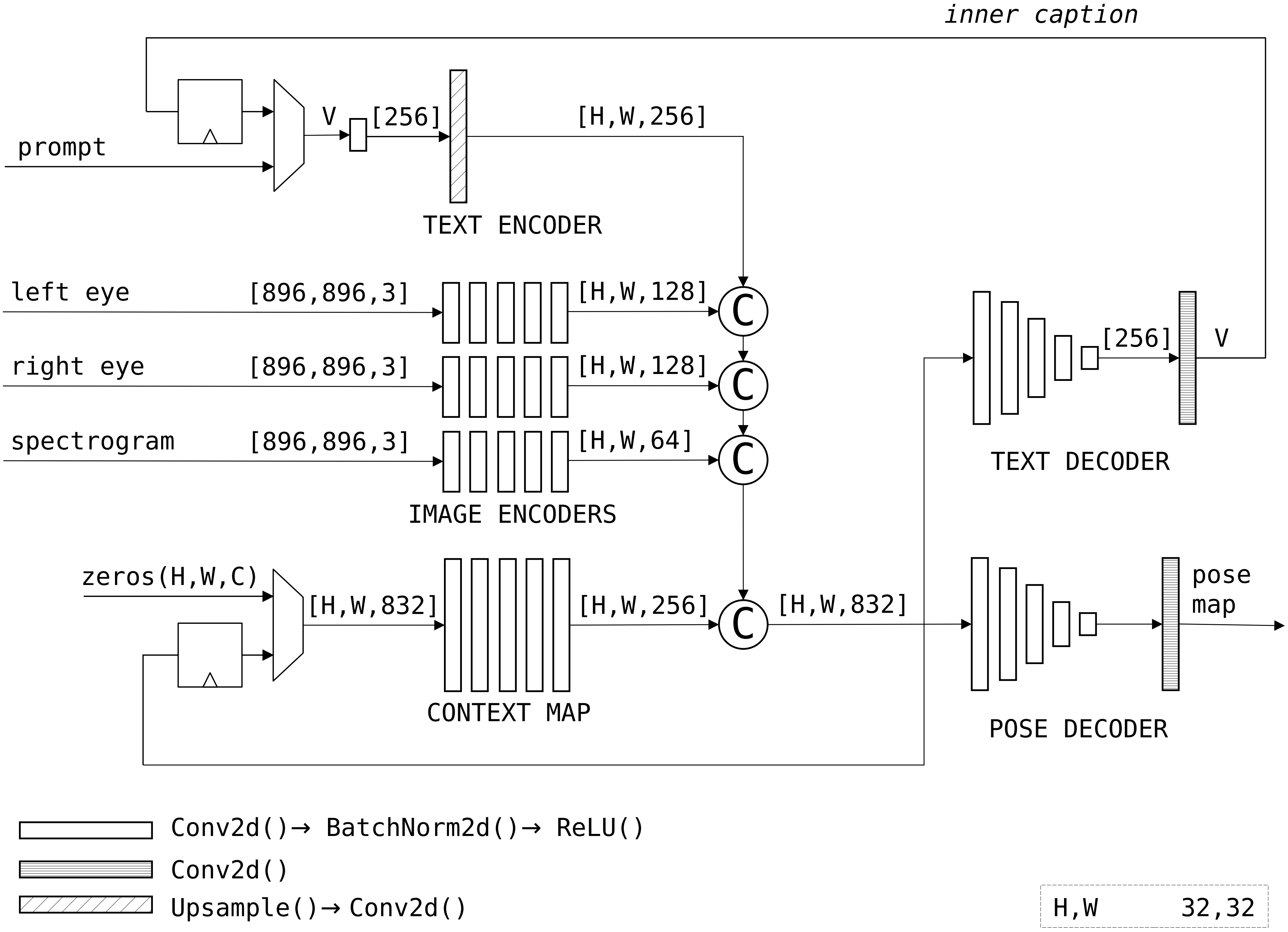
■ FROZEN

| | |
|---|---|
| E | 256 |
| V | 50257 |
| C | 256 |
| H,W | 14,14 |

## CNN Vision-Language Model



**CNN Perception-Language-Action Model**



**PHASE 1:**
CNN Perception-Language-Action model (CNN-PLA), running on GPU
>20fps, <100ms latency, <400W

**PHASE 2:**
CNN-PLA model running on FPGA
>100fps, <15ms latency, <100W

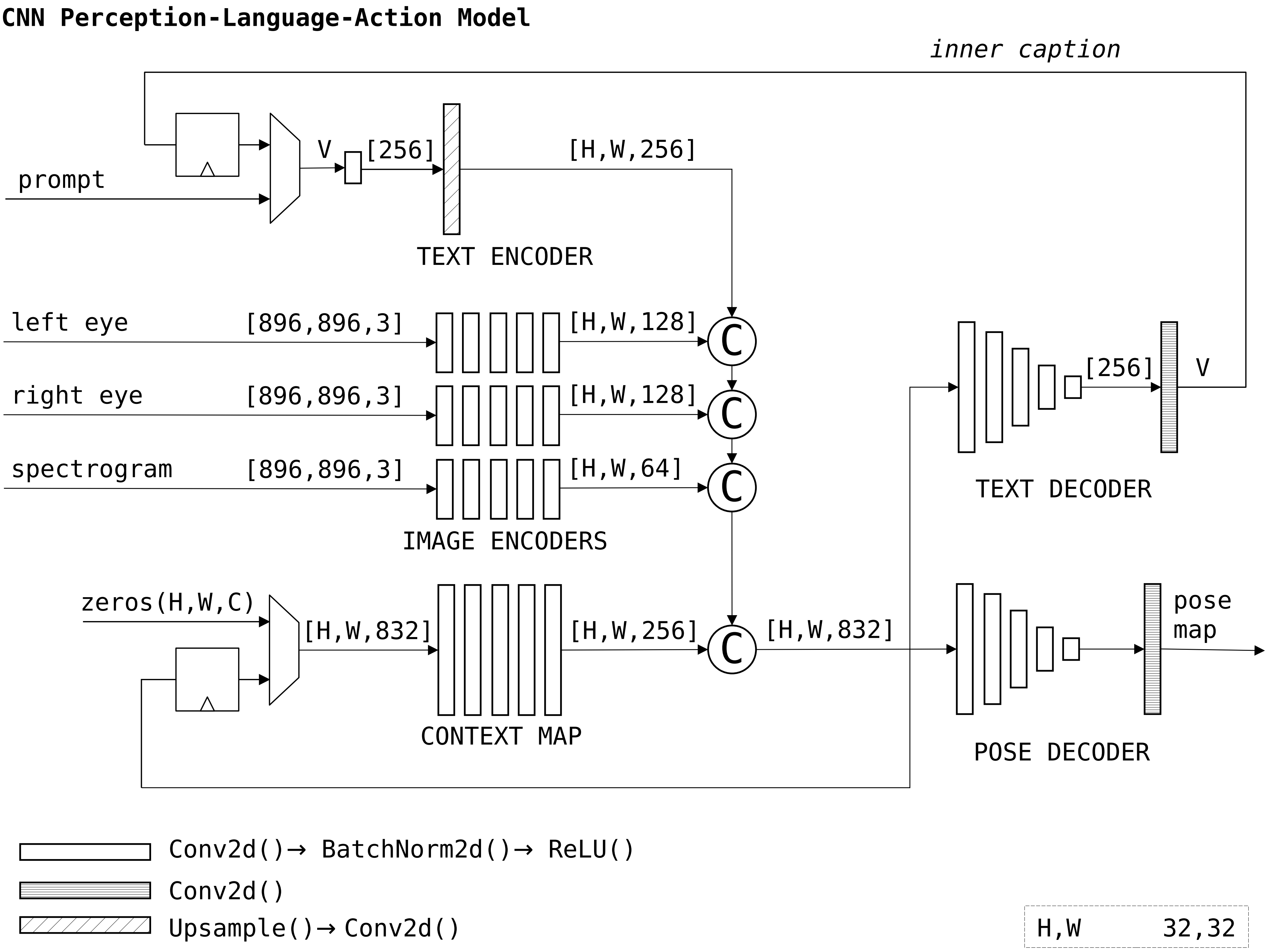
**PHASE 3:**
CNN-PLA model running on ASIC at >300fps, <5ms latency, <10W

Seated humanoid :
1-DoF spine
2-DoF shoulder
2-DoF neck
6-DoF arms
6-DoF hands

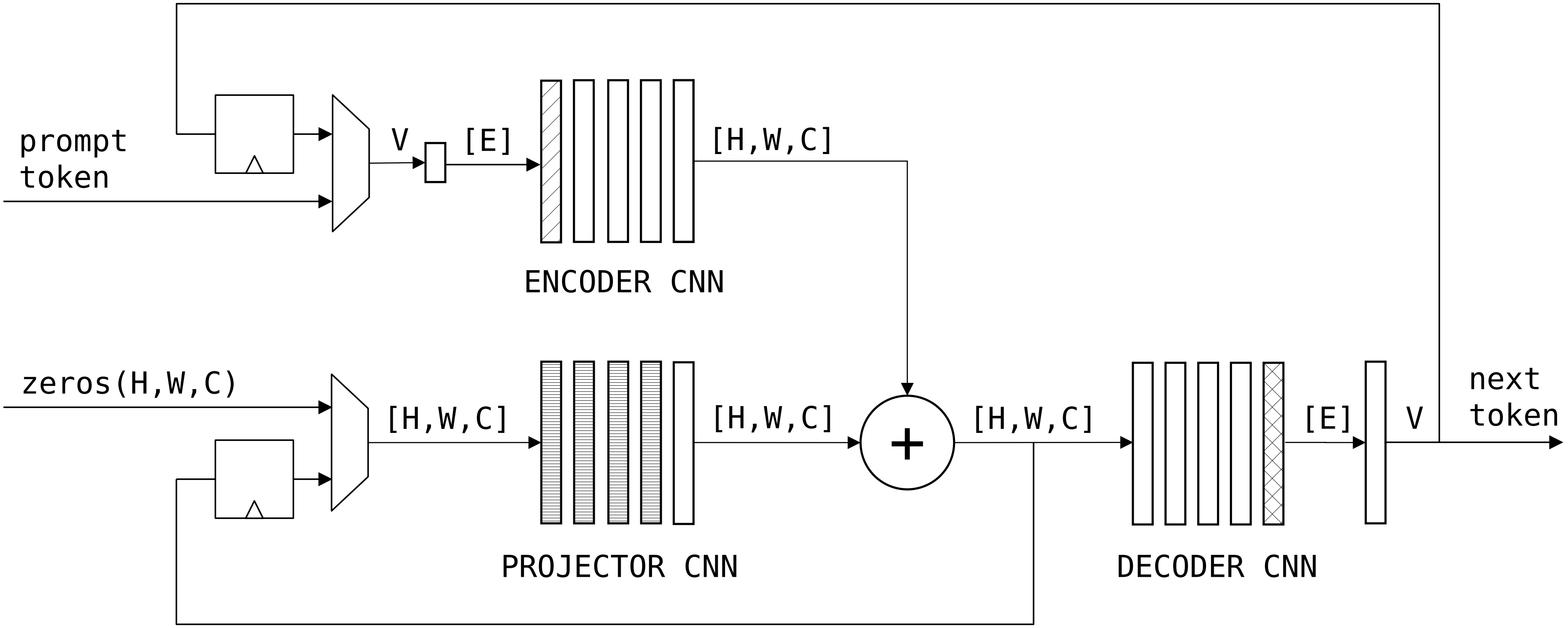
Data collection :
VR teleoperated
spine/shoulder : swivel chair with up/down control
neck : VR gyroscope
arms/hands : TBD

ROBOT
896x896 RGB at 120Hz, left and right eye
896x896 spectrogram at 120Hz, audio and tactile signals
29-DoF target pose at 120Hz

TELEOPERATOR
transcribed verbal commentary at 120 characters/s
synthetically captioned using open source VL model, 1 character/frame


CNN Perception-Language-Action Model
inner caption
V
[256]
[H,W,256]
prompt
TEXT ENCODER
left eye
[896,896,3]
[H,W,128]
right eye
[896,896,3]
[H,W,128]
spectrogram
[896,896,3]
[H,W,64]
IMAGE ENCODERS
C
C
C
C
[256]
V
TEXT DECODER
zeros(H,W,C)
[H,W,832]
[H,W,256]
[H,W,832]
CONTEXT MAP
pose
map
POSE DECODER
Conv2d()→ BatchNorm2d()→ ReLU()
Conv2d()
Upsample()→ Conv2d()
H,W 32,32

## CNN Language Model



▥ Conv2d()→ ReLU()

□ Conv2d()

▨ Upsample()

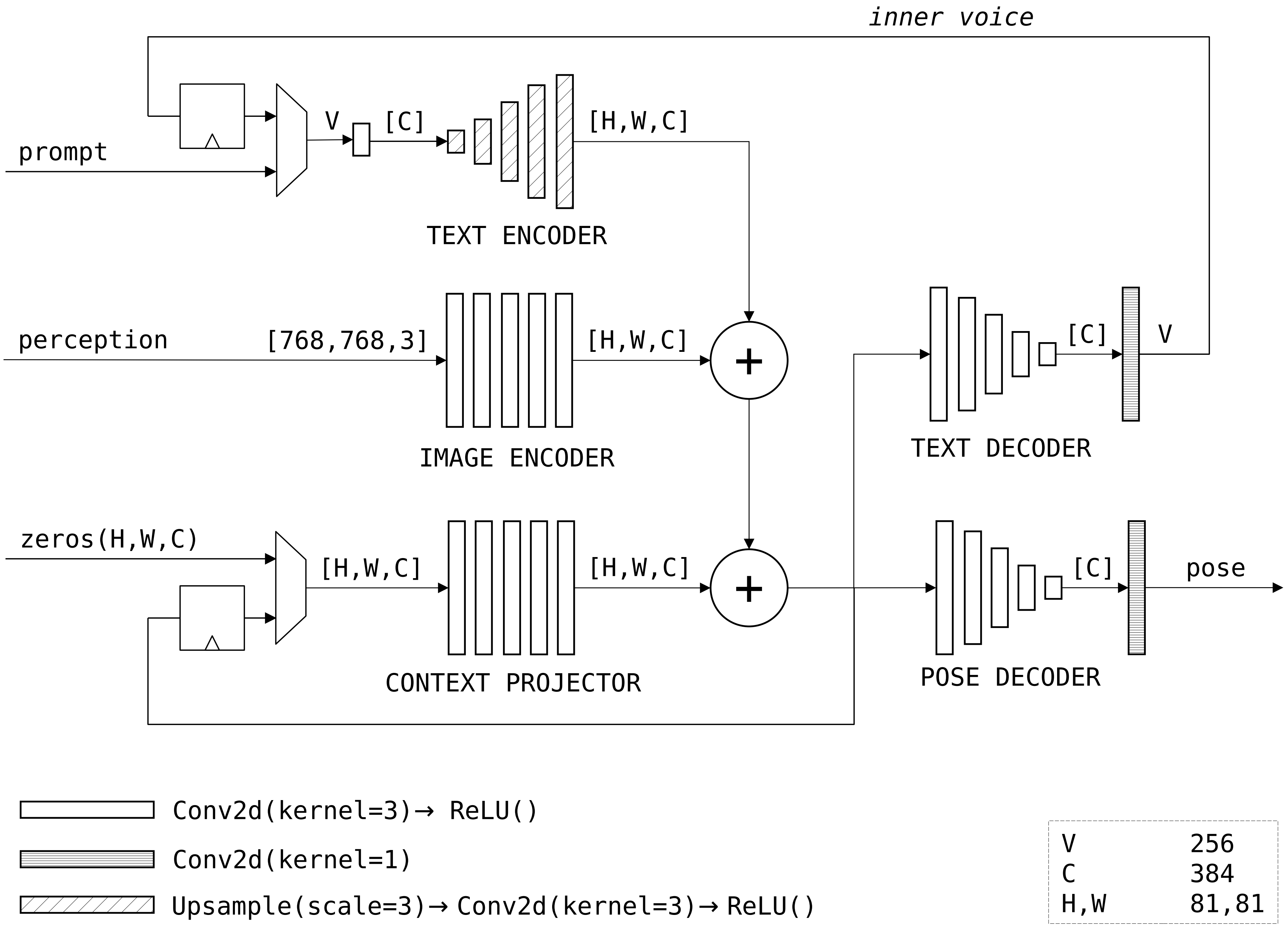
▩ AvgPool()

| | |
|---|---|
| E | 256 |
| V | 50257 |
| C | 384 |
| H,W | 14,14 |

## Devices

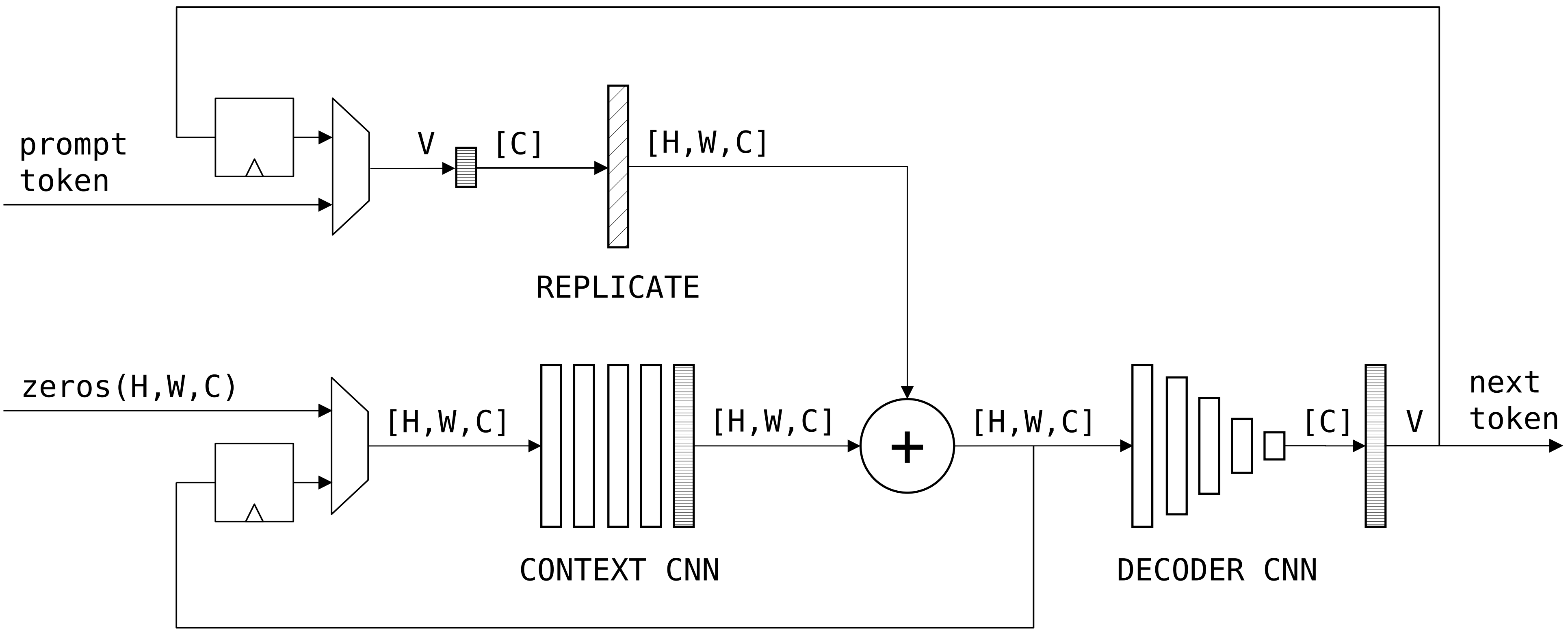
- TE256A : Token Encoder, vocab_size=256, ASCII
- TD256A : Token Decoder, vocab_size=256, ASCII
- CP384V : Context Projector, n_embd=384, VGG
- IE384R : Image Encoder, n_embd=384, Resnet
- TD
-

alt = lite-base-resnet-xeno



| | |
|---|---|
| V | 256 |
| C | 384 |
| H,W | 81,81 |

alt2



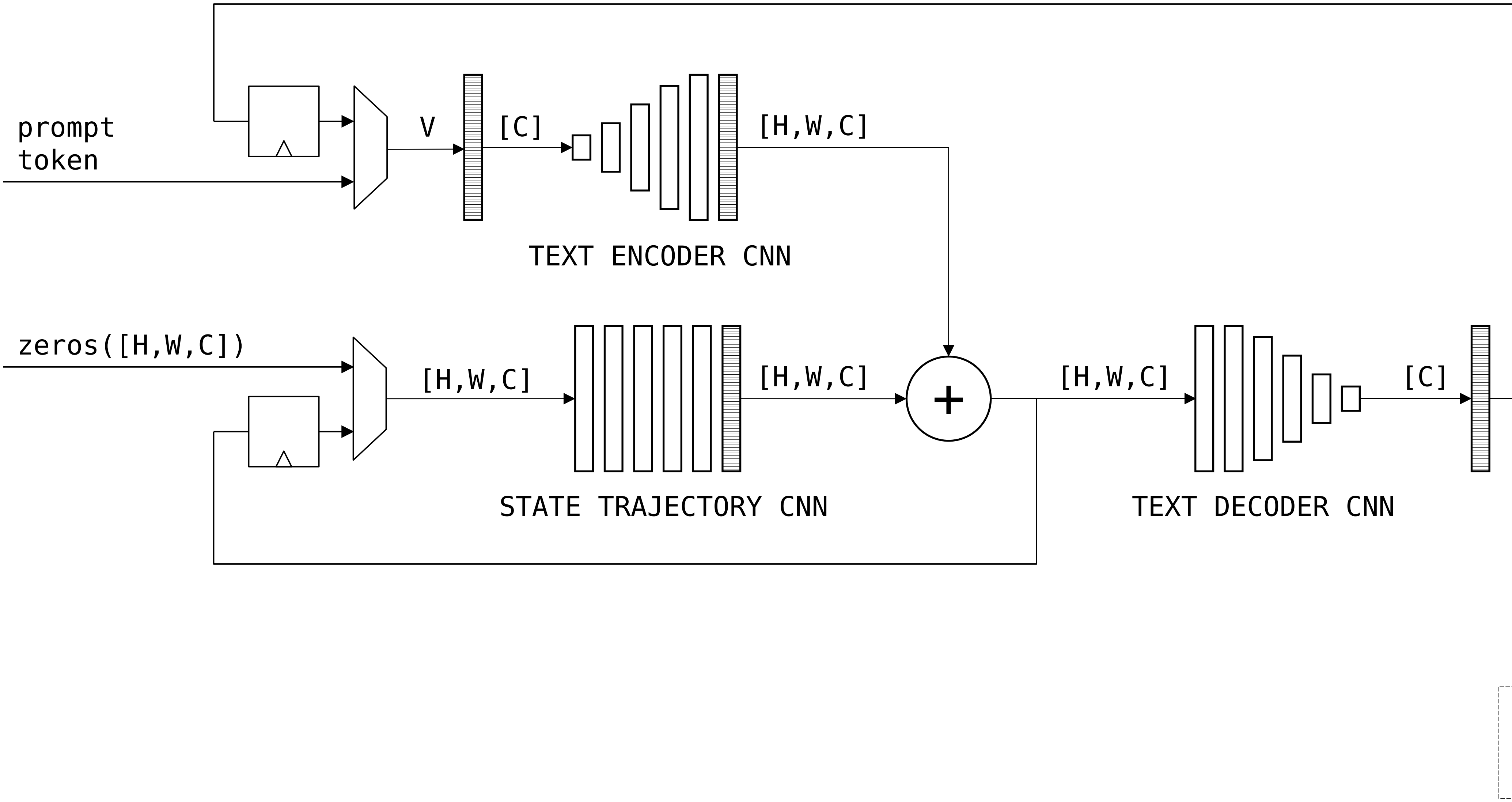
□ Conv2d(kernel=3)→ BatchNorm2d()→ ReLU()

▤ Conv2d(kernel=1)

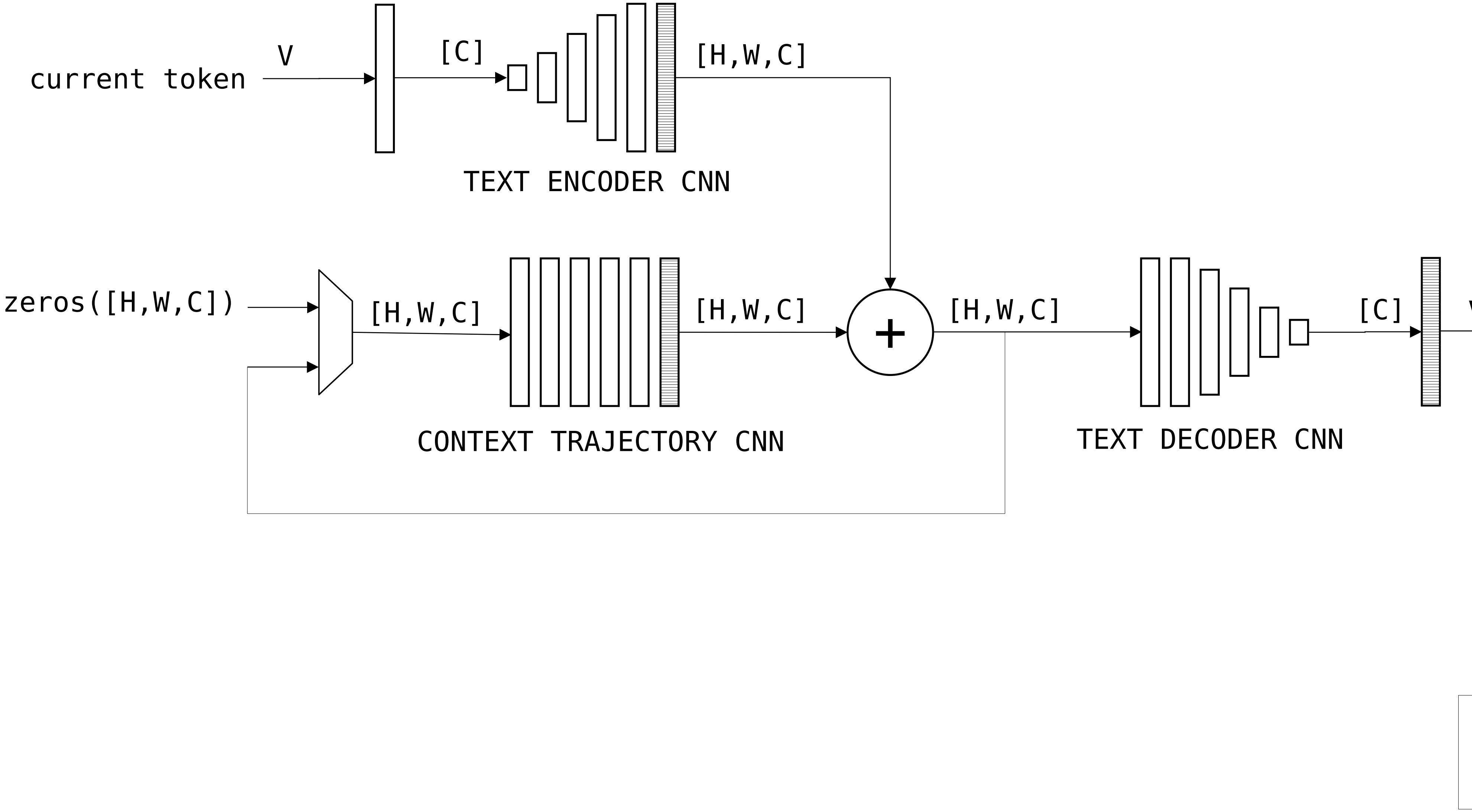
▨ Upsample()

| | |
|---|---|
| V | 256 |
| C | 384 |
| H,W | 81,81 |

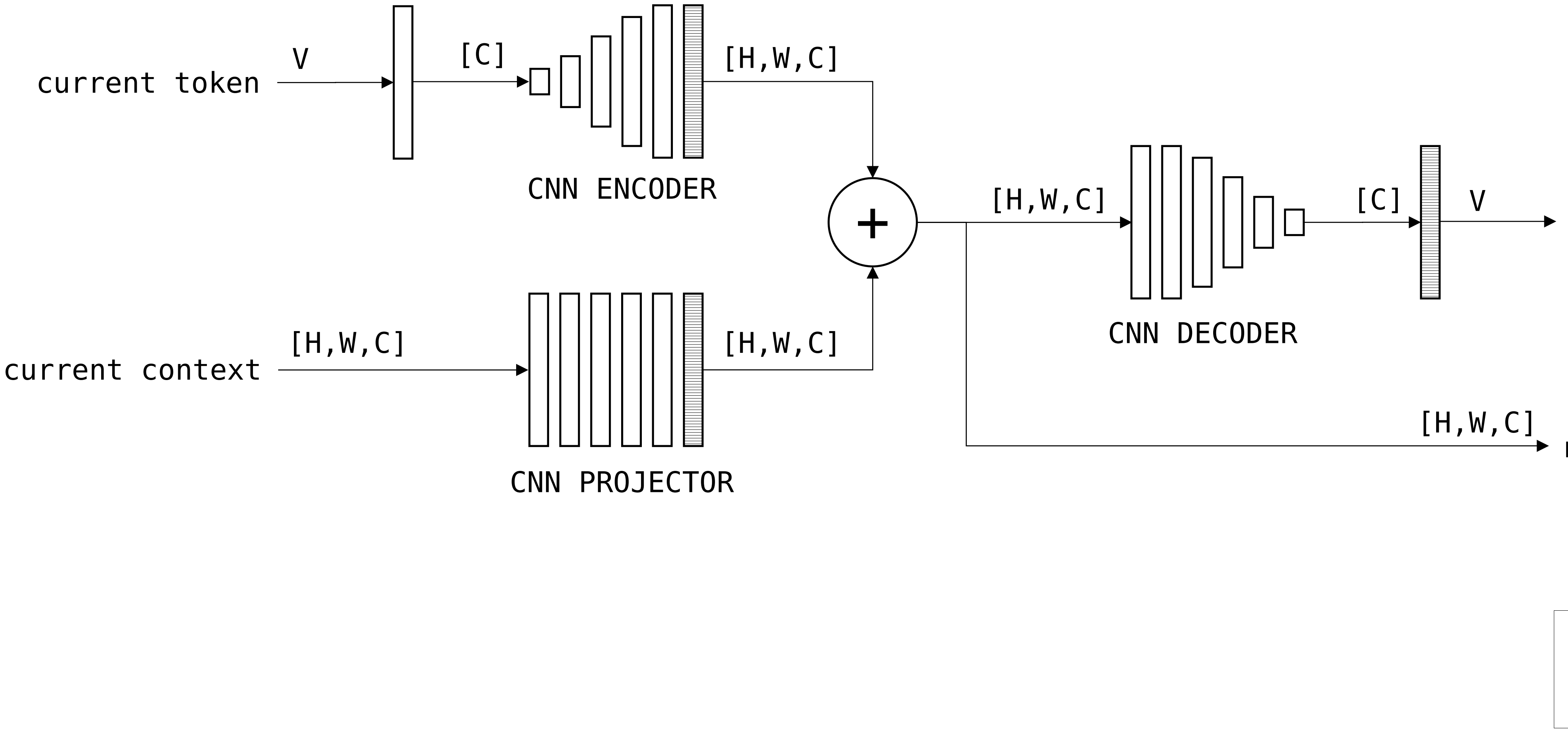
alt1


prompt
token
V
[C]
[H,W,C]
TEXT ENCODER CNN
zeros([H,W,C])
[H,W,C]
[H,W,C]
+
STATE TRAJECTORY CNN
[H,W,C]
[C]
TEXT DECODER CNN

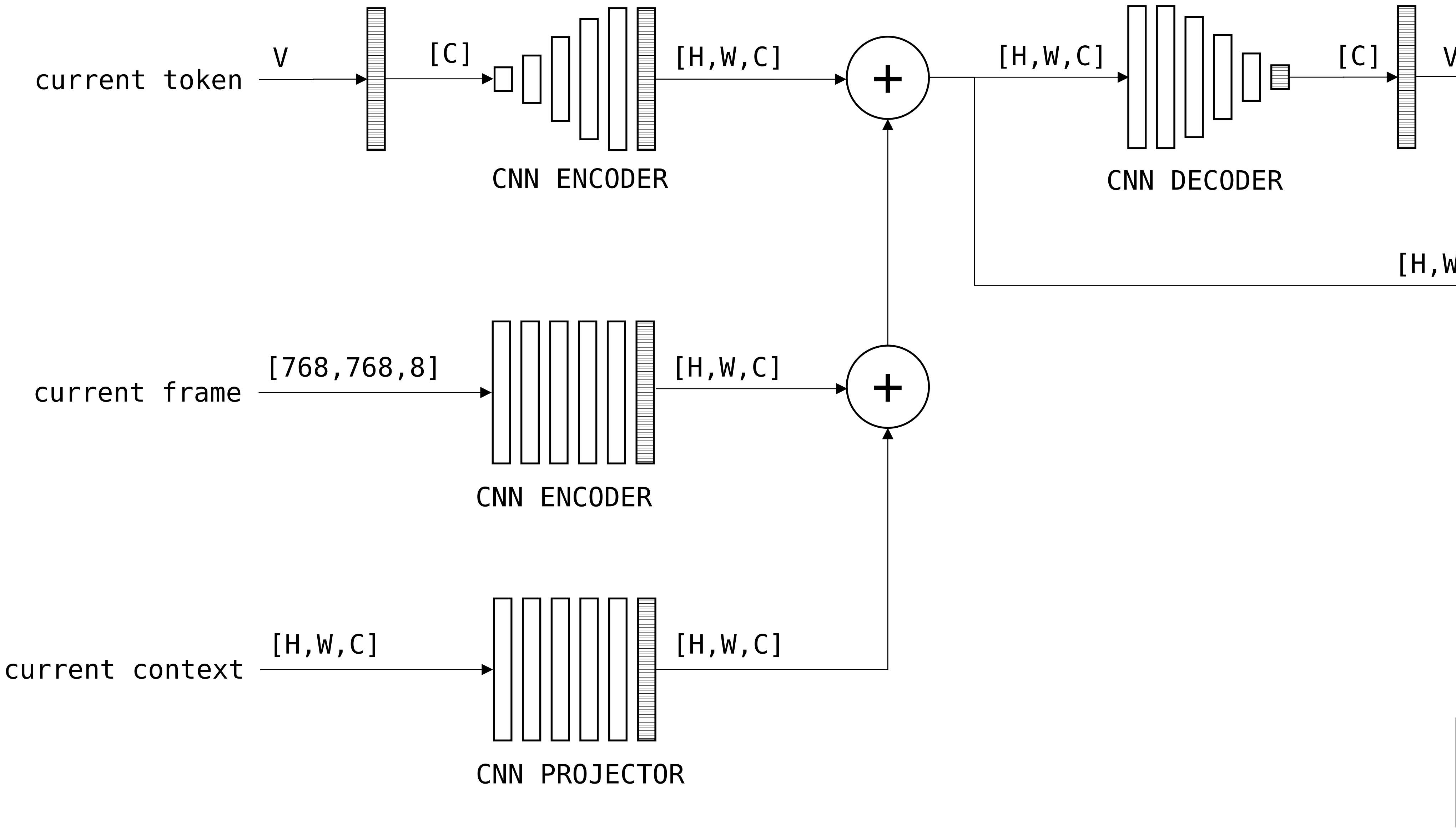
alt1


current token
V
[C]
[H,W,C]
TEXT ENCODER CNN
zeros([H,W,C])
[H,W,C]
[H,W,C]
+
[H,W,C]
CONTEXT TRAJECTORY CNN
TEXT DECODER CNN
[C]

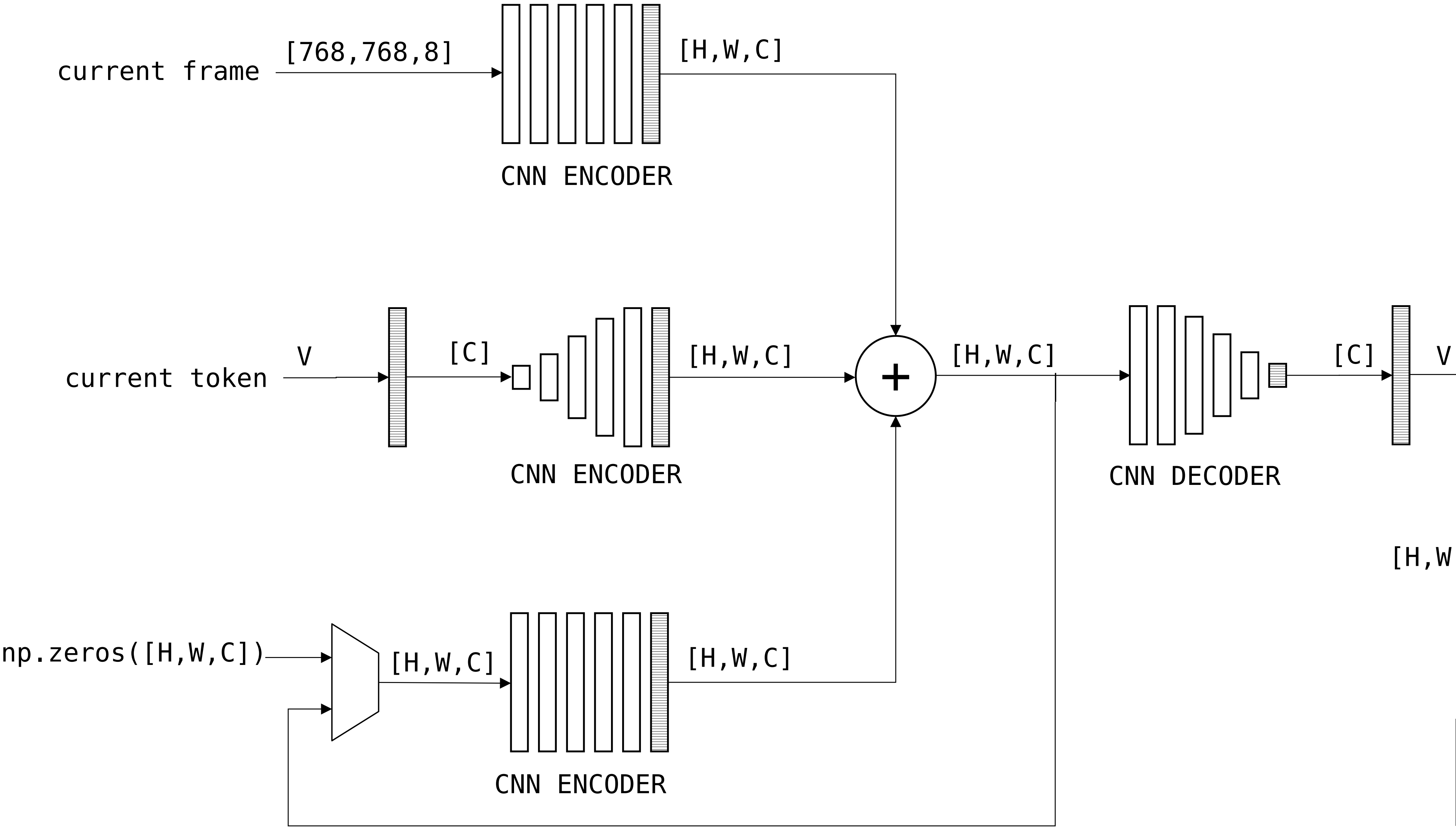
alt1


current token
V
[C]
CNN ENCODER
[H,W,C]
+
current context
[H,W,C]
CNN PROJECTOR
[H,W,C]
[H,W,C]
CNN DECODER
[C]
V
[H,W,C]

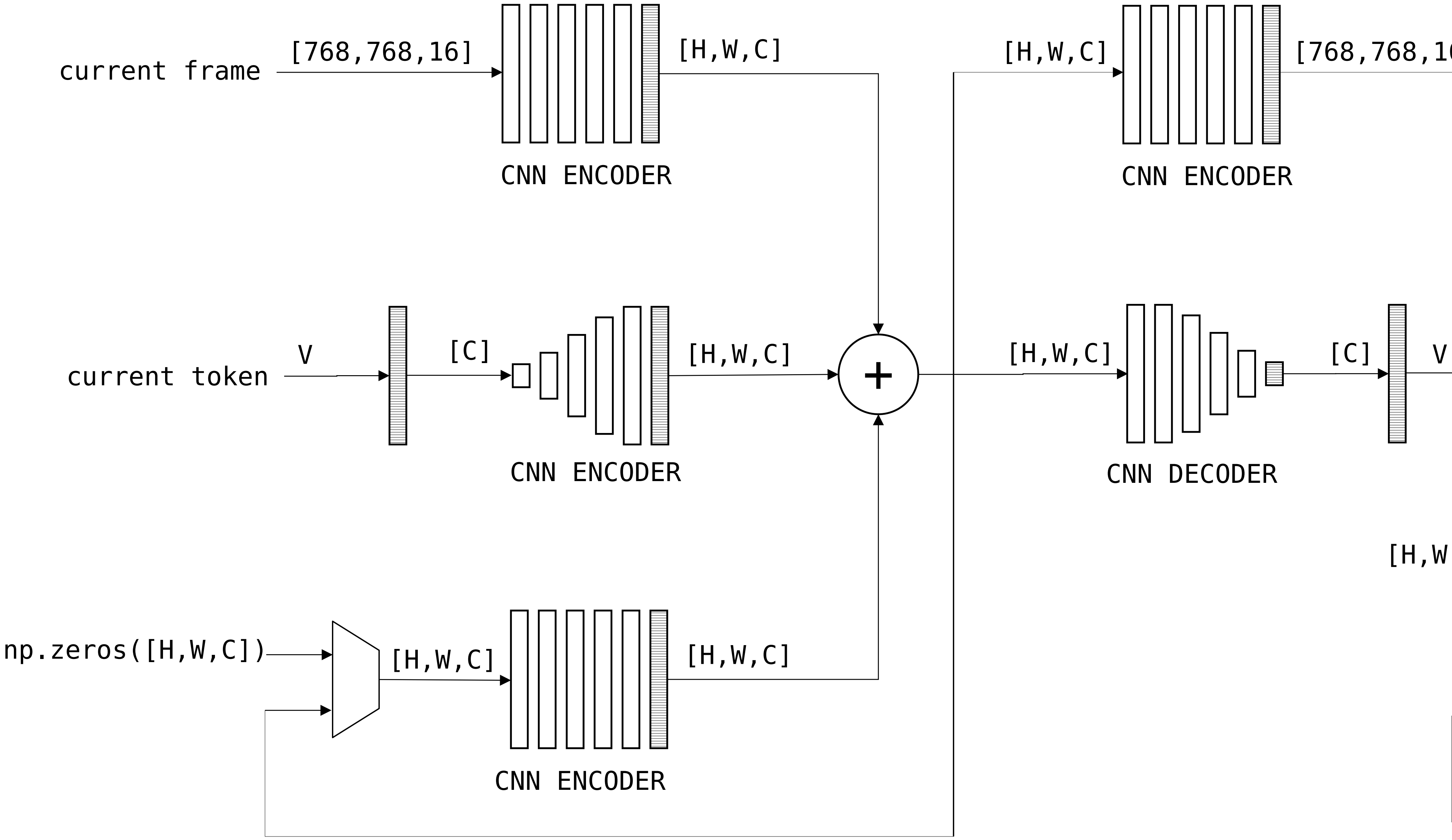
multimodal alt1



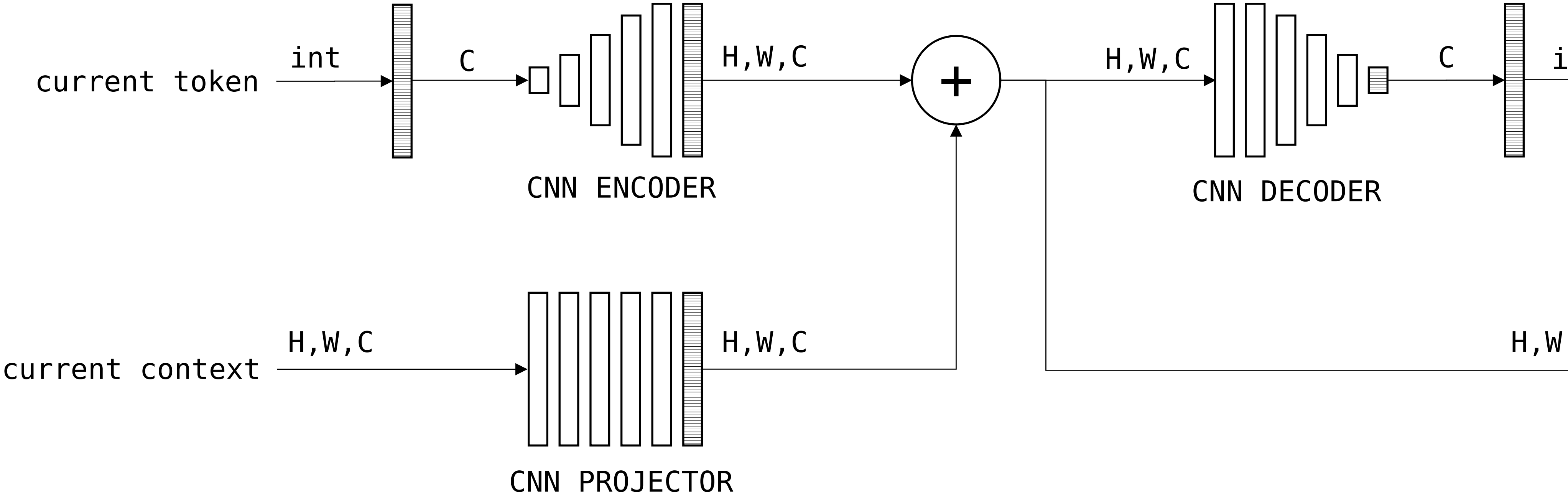
multimodal alt1

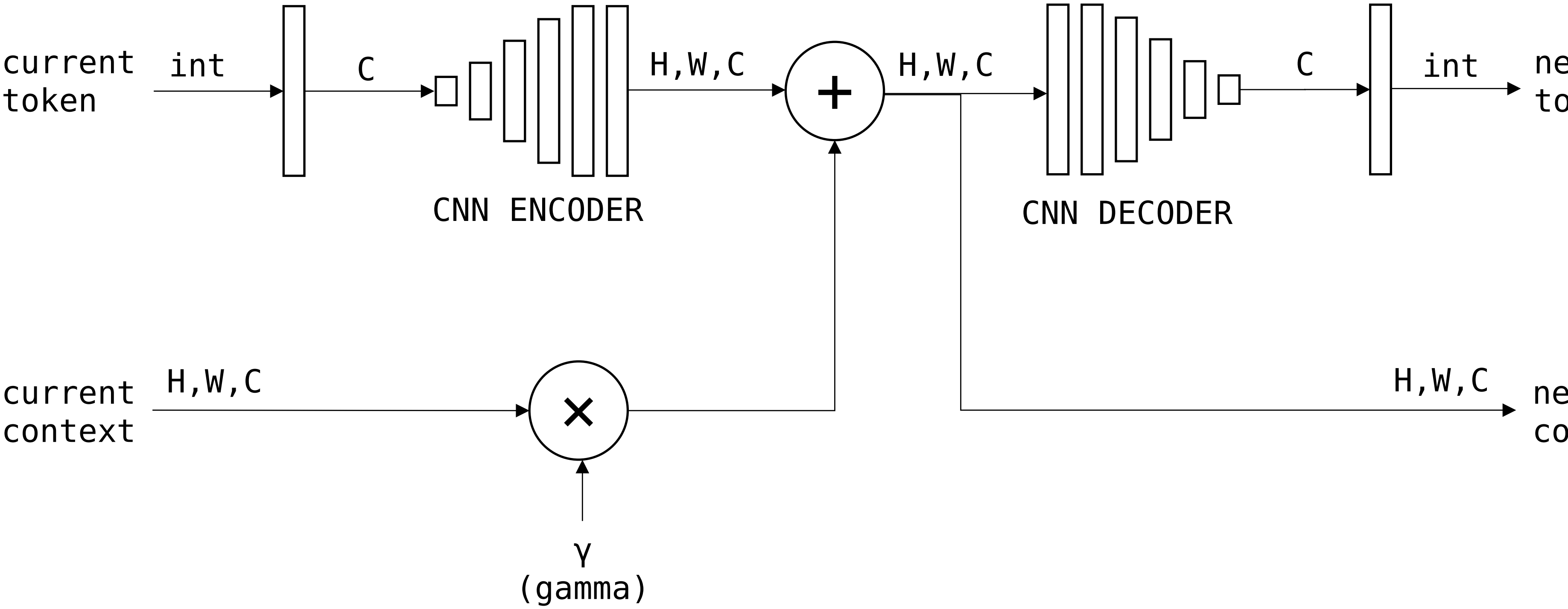


multimodal alt1

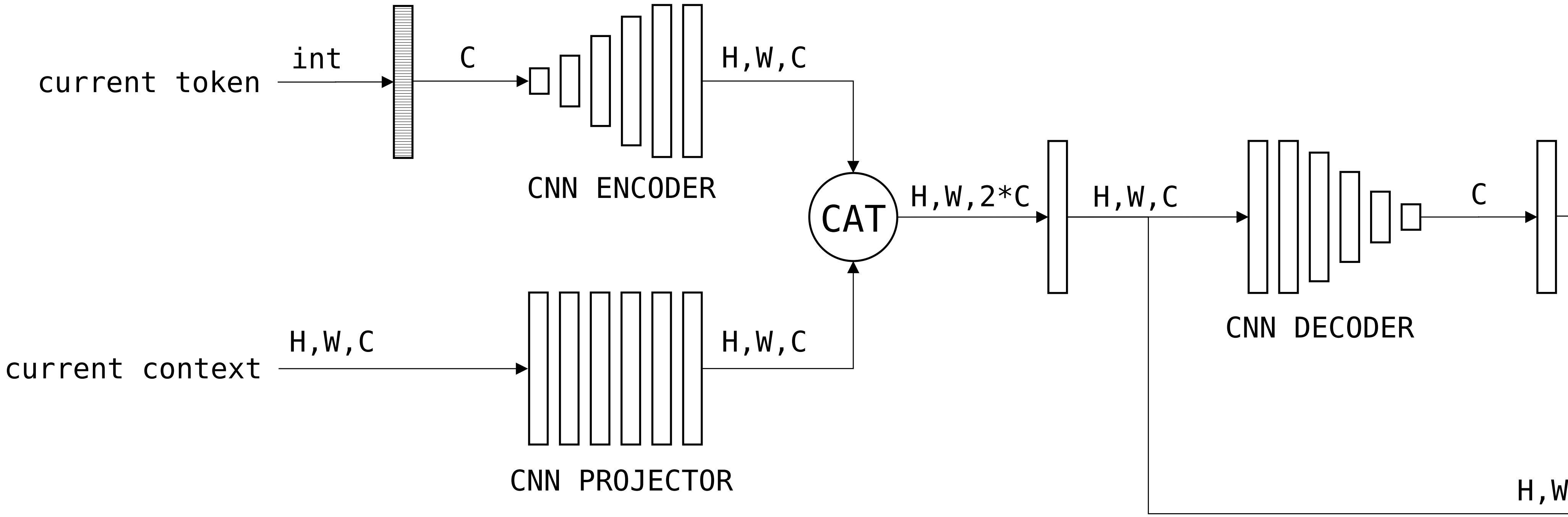


alt1

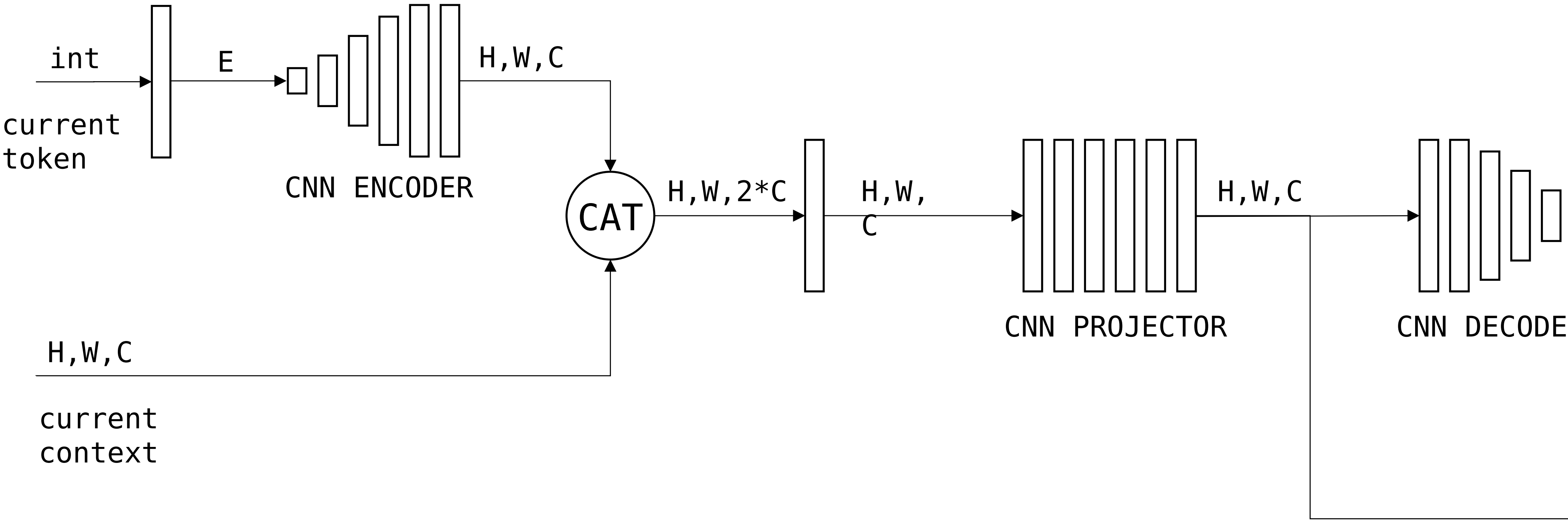

current token
int
C
CNN ENCODER
H,W,C
+
H,W,C
CNN DECODER
C
i
current context
H,W,C
CNN PROJECTOR
H,W,C
H,W

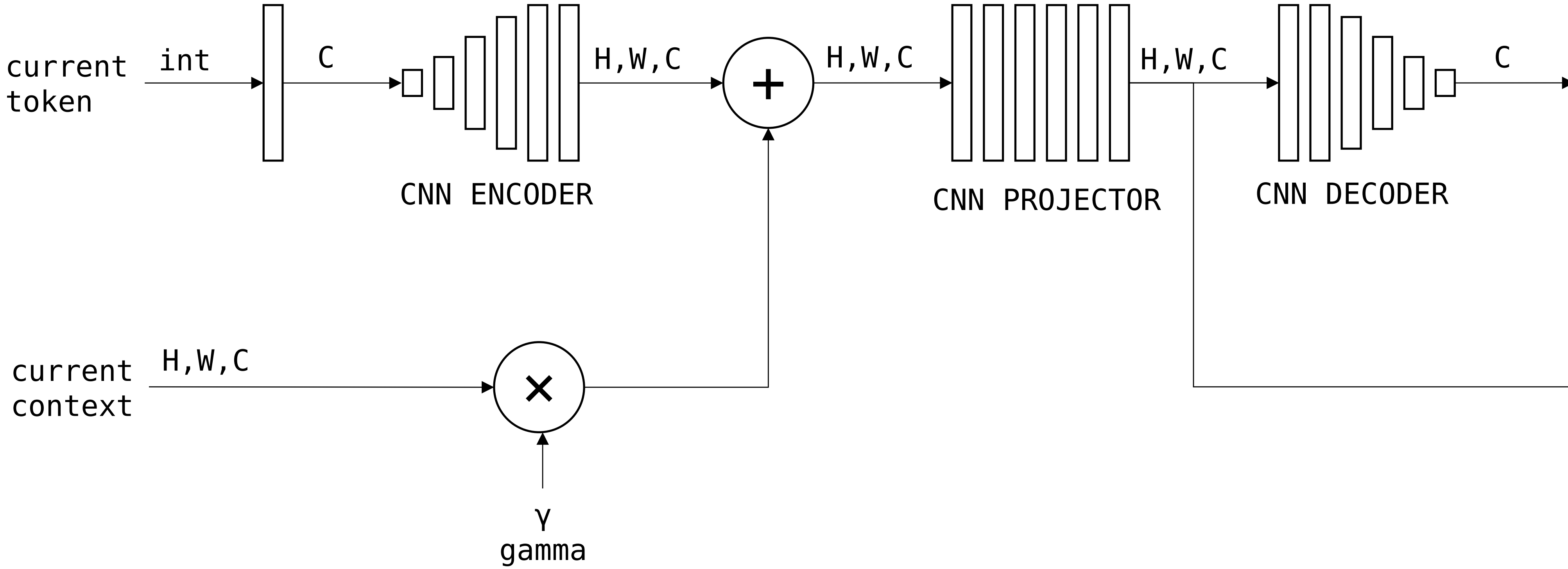

current
token
int
C
CNN ENCODER
H,W,C
+
H,W,C
CNN DECODER
C
int
ne
to
current
context
H,W,C
×
γ
(gamma)
H,W,C
ne
co

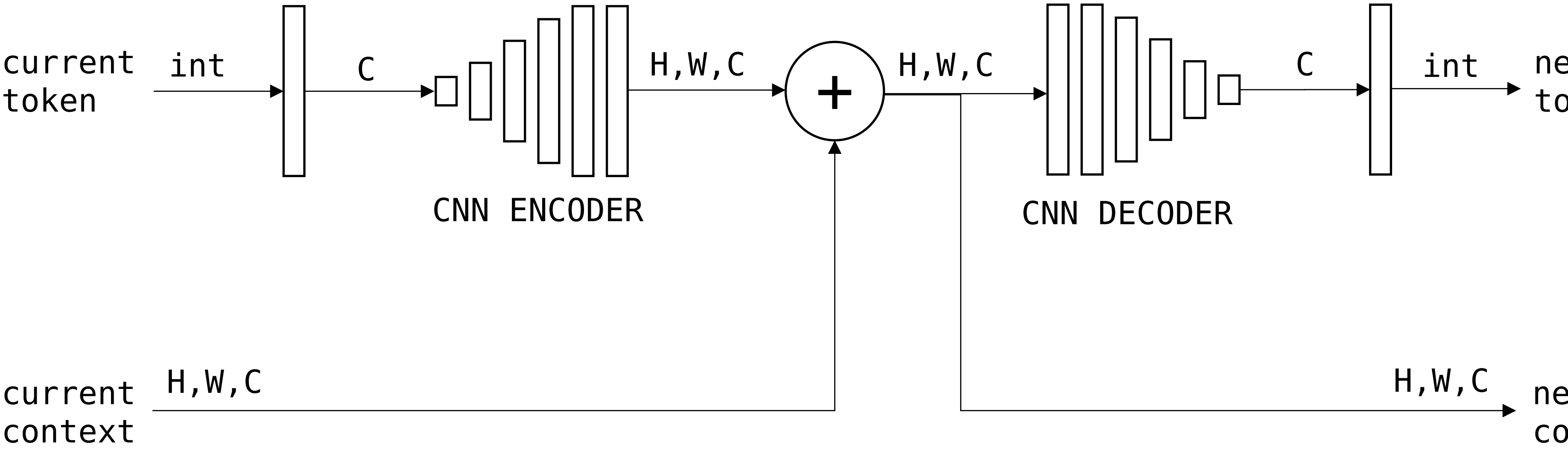
alt2

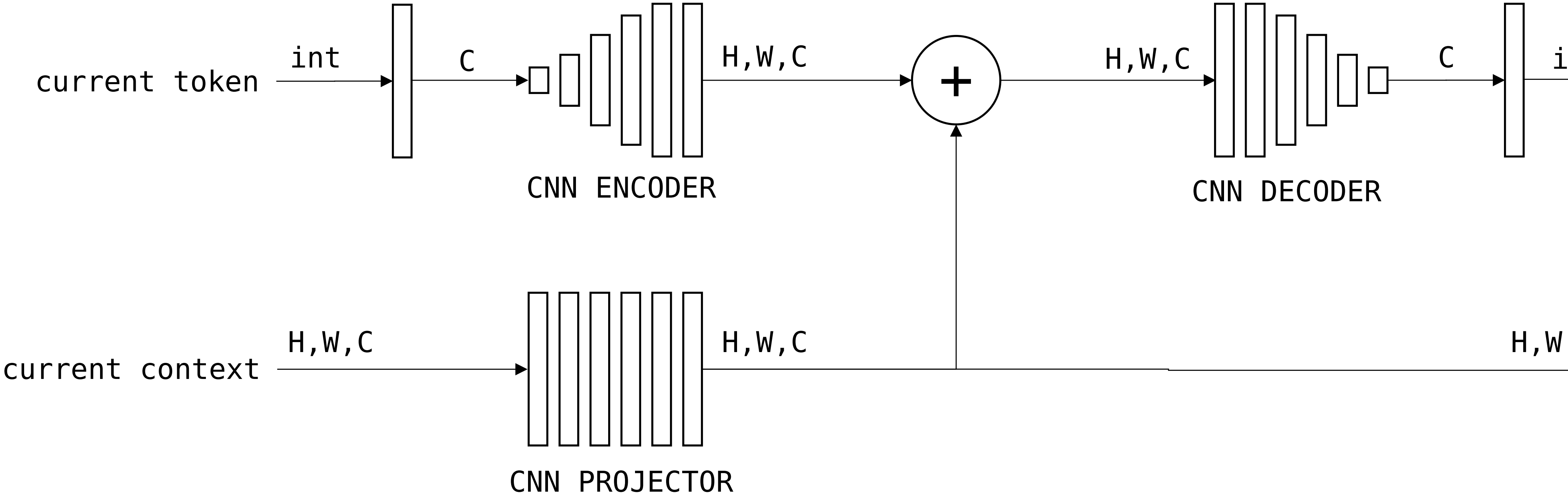

current token
int
C
CNN ENCODER
H,W,C
CAT
current context
H,W,C
CNN PROJECTOR
H,W,C
H,W,2*C
H,W,C
CNN DECODER
C
H,W

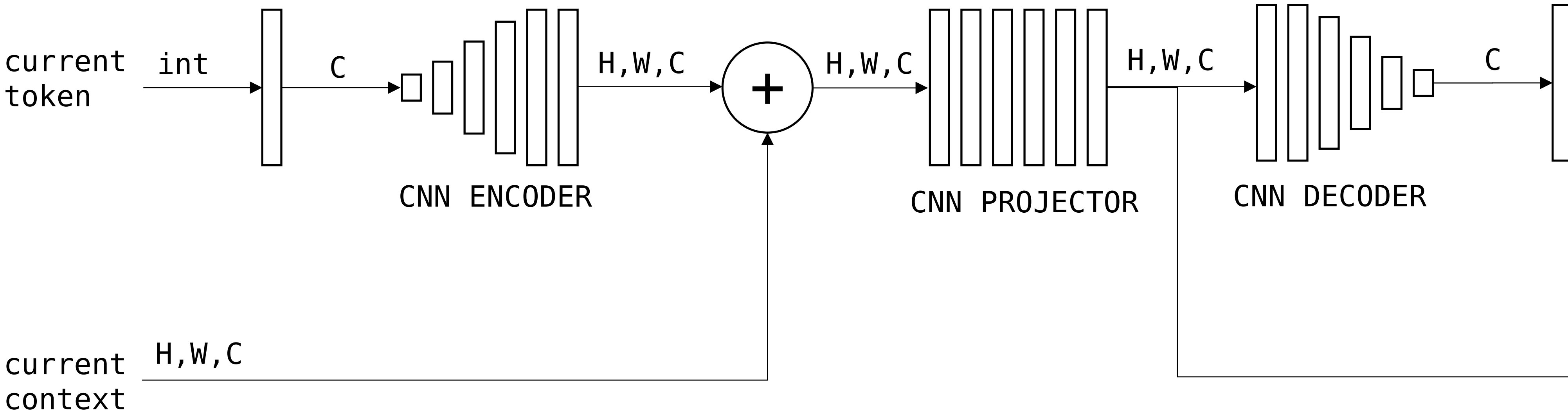
alt3

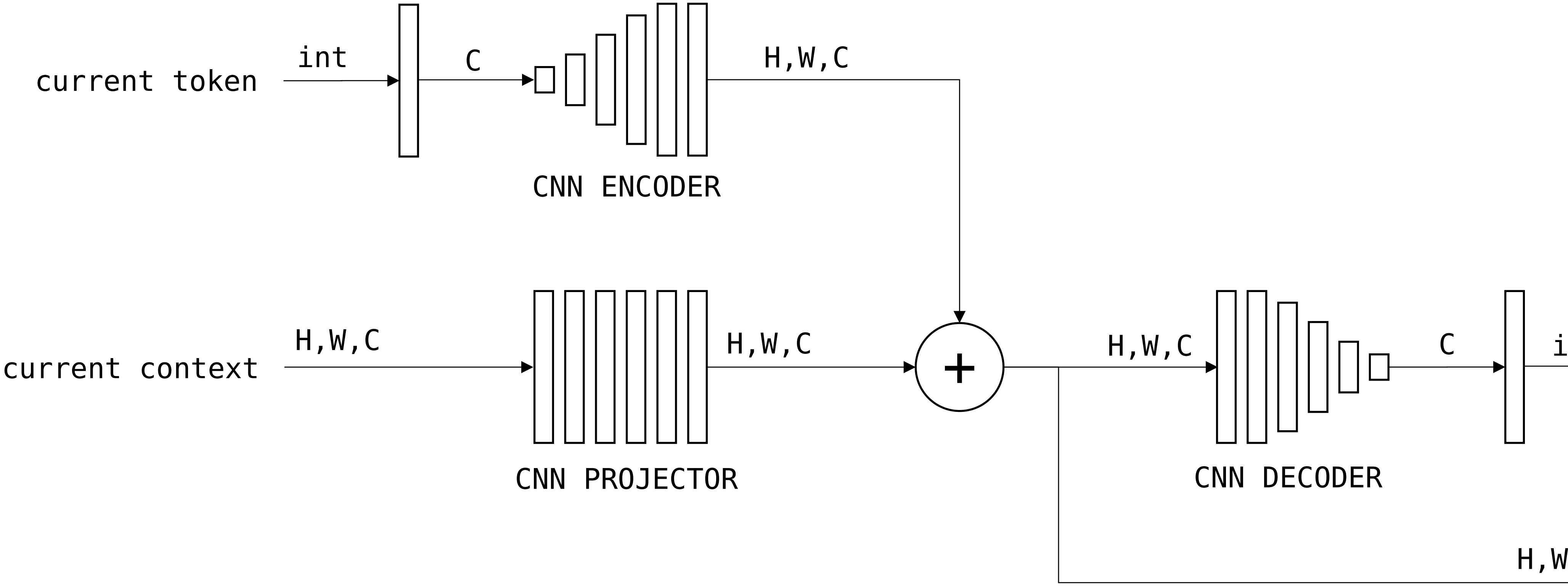

int
current
token
E
H,W,C
CNN ENCODER
CAT
H,W,2*C
H,W,
C
CNN PROJECTOR
H,W,C
CNN DECODE
H,W,C
current
context


current token
int
C
CNN ENCODER
H,W,C
+
H,W,C
CNN PROJECTOR
H,W,C
CNN DECODER
C
current context
H,W,C
×
γ
gamma


current token
int
C
CNN ENCODER
H,W,C
+
H,W,C
CNN DECODER
C
int
ne to
current context
H,W,C
H,W,C
ne co


current token
int
C
H,W,C
+
H,W,C
C
i
CNN ENCODER
CNN DECODER
current context
H,W,C
H,W,C
H,W
CNN PROJECTOR


current token
int
C
CNN ENCODER
H,W,C
+
H,W,C
CNN PROJECTOR
H,W,C
CNN DECODER
C
current context
H,W,C


current token
int
C
CNN ENCODER
H,W,C
current context
H,W,C
CNN PROJECTOR
H,W,C
+
H,W,C
CNN DECODER
C
i
H,W