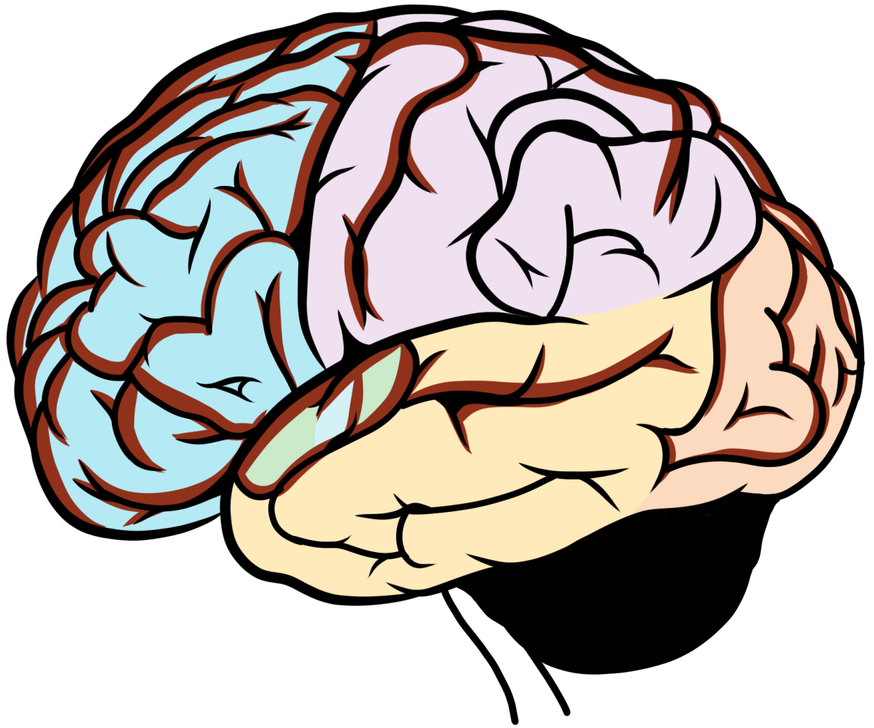
PMLDL. X-Net

Anna Boronina

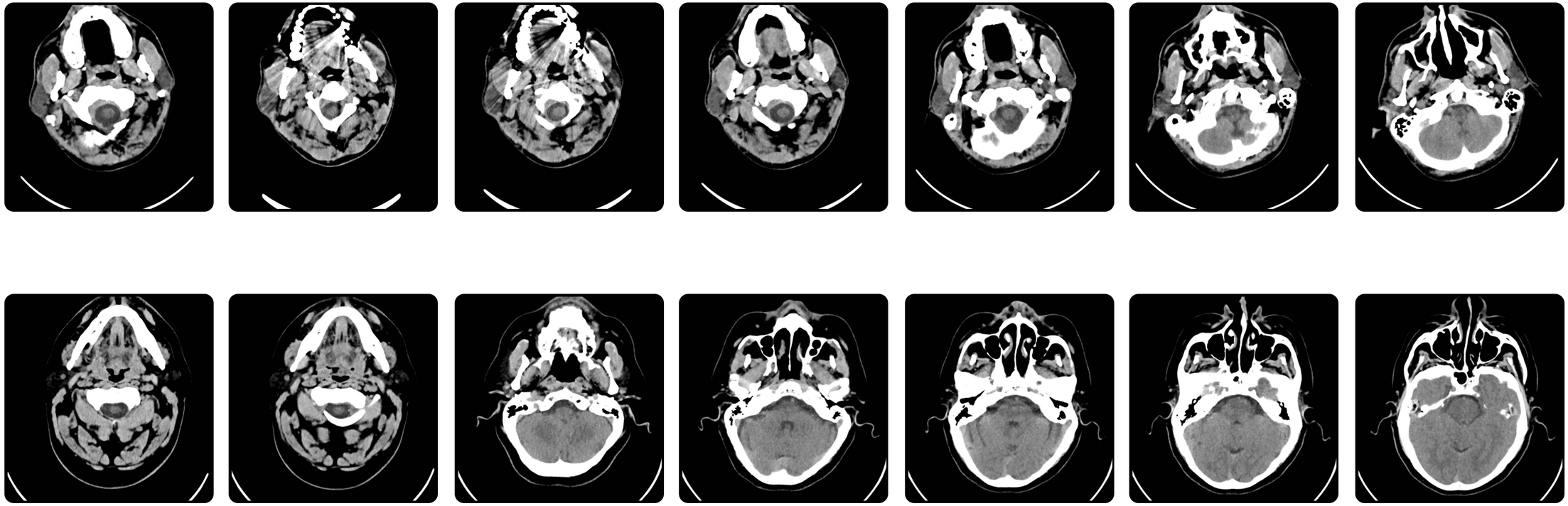
What is a brain stroke (ru: инсульт)?

Brain stroke occurs when the blood supply to part(s) of one’s brain is interrupted or reduced.



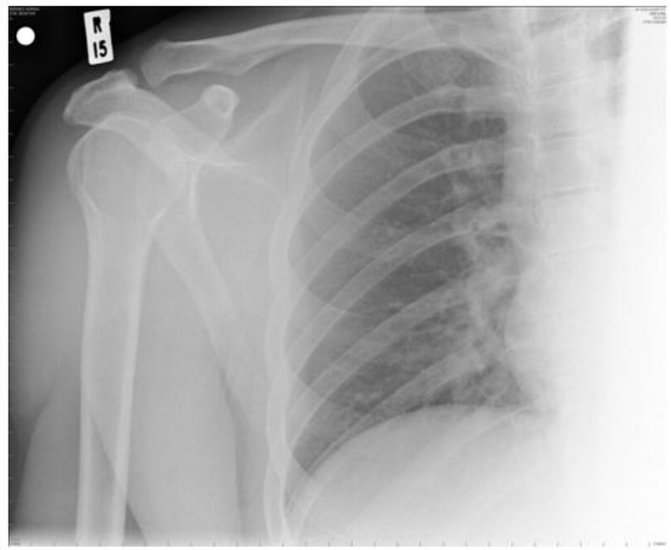
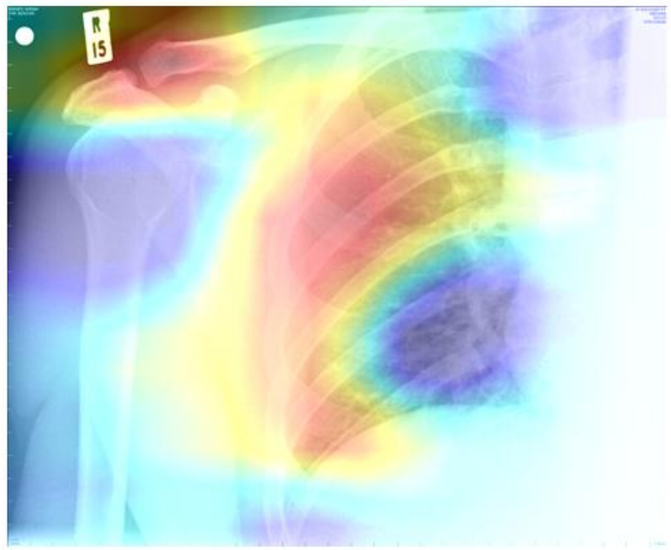
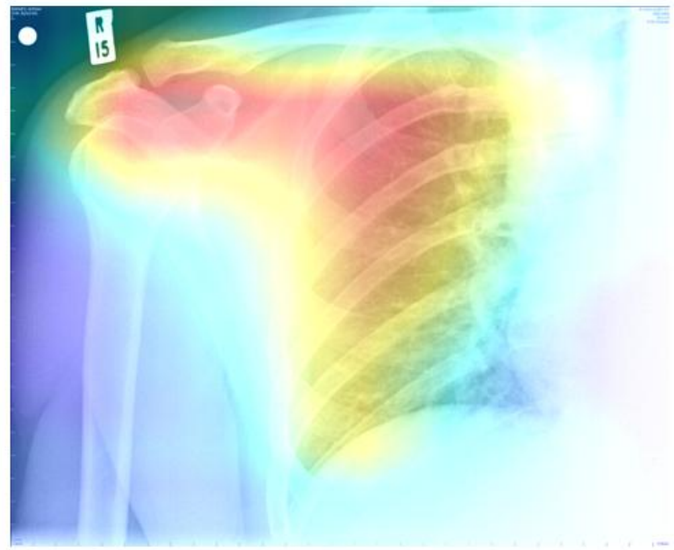
Problems

- sometimes even doctors cannot spot a brain stroke
- sometimes there is a sequence of MRI scans which should be processed together
- **healthy** VS **stroke**:



DL applications

- use Deep Learning model as a complementary tool
- use methods that explain model’s decisions
  - GradCam
  - GradCam++
  - LIME
  - ...

X-Net Paper: Qi *et. al*

International Conference on Medical Image Computing and Computer-Assisted Intervention

MICCAI 2019: Medical Image Computing and Computer Assisted Intervention – MICCAI 2019 pp 247-255 | Cite as

X-Net: Brain Stroke Lesion Segmentation Based on Depthwise Separable Convolution and Long-Range Dependencies

Authors | Authors and affiliations

Kehan Qi, Hao Yang, Cheng Li, Zaiyi Liu, Meiyun Wang, Qiegen Liu, Shanshan Wang

Conference paper

First Online: 10 October 2019

Part of the Lecture Notes in Computer Science book series (LNCS, volume 11766)

Previous attempts

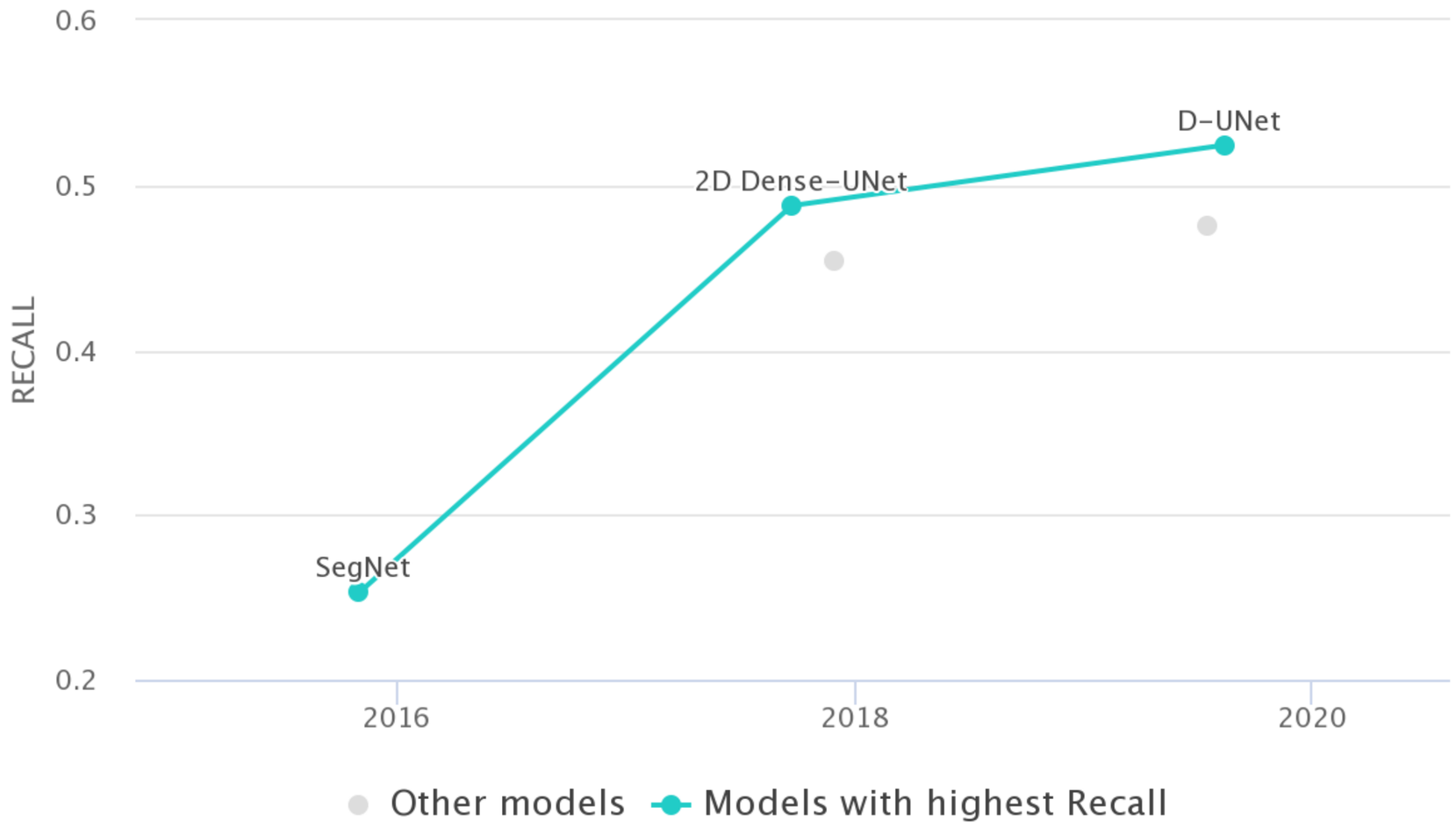
- **SegNet** - symmetrical convolutional autoencoder
- **UNet** - originally, non-residual convolutional network with "crop-and-concat"
- **2D Dense Unet** - residual dense network

Their problems according to Qi *et. al*

- heavy network parameters
- cannot capture long-range dependencies

Benchmark - ATLAS Dataset

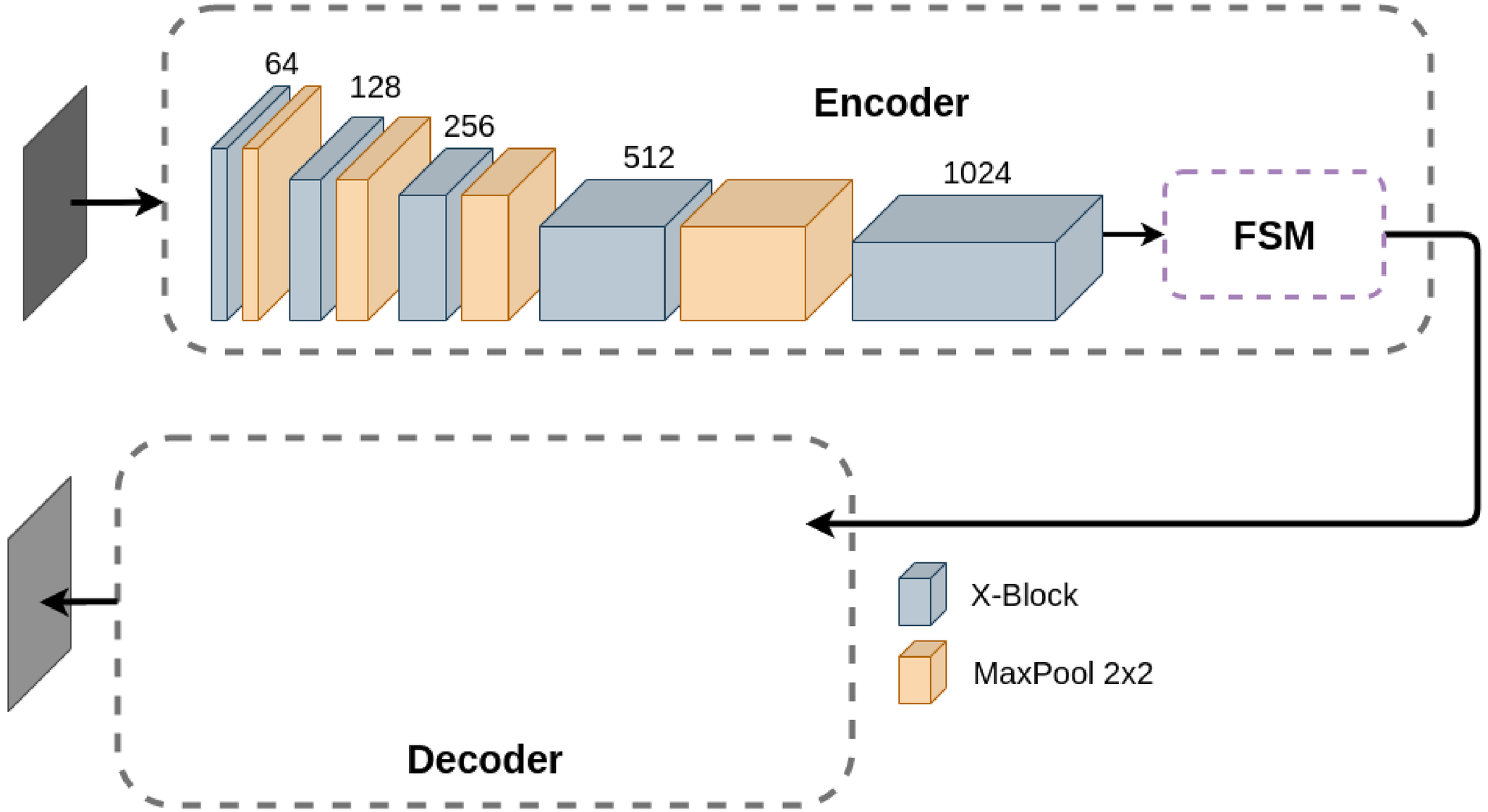
Recall: How many relevant items are retrieved?



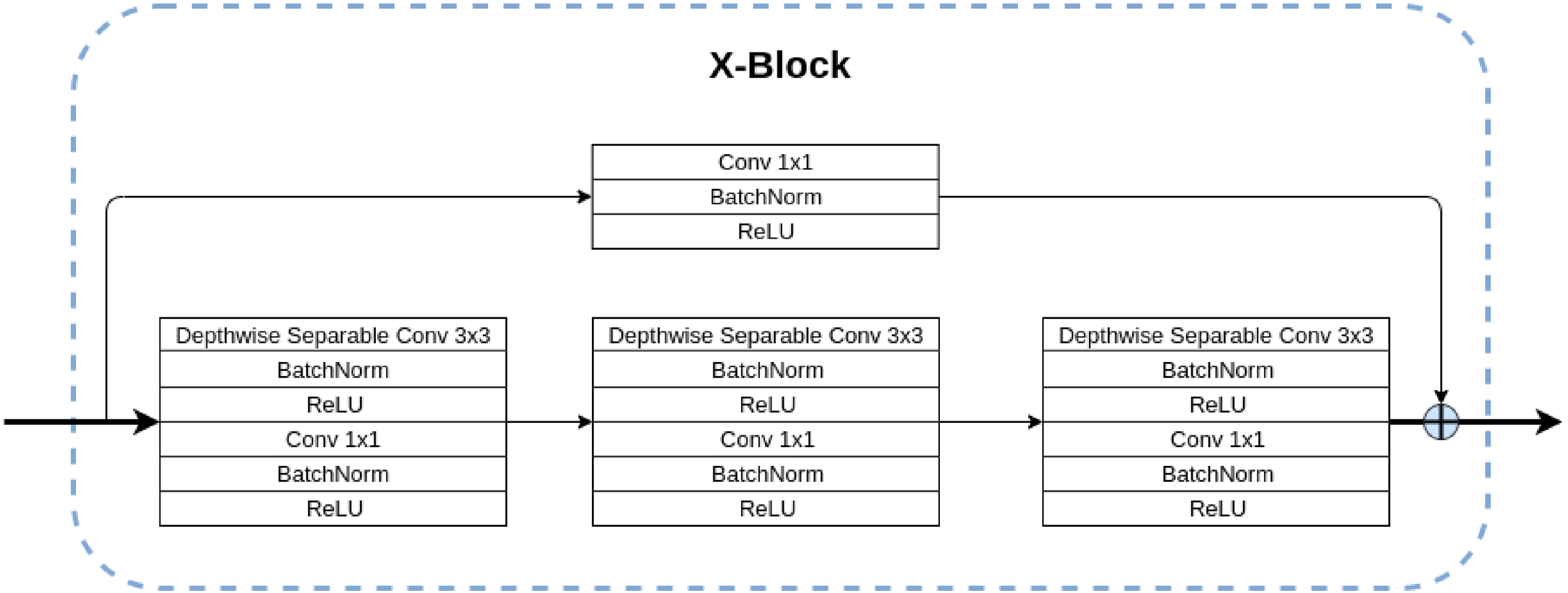
Solution proposed by Qi *et. al*

- reduce number of parameters
  - **separable convolution**
    - it is efficient
    - gives better segmentation results
  - **basic upsampling**
- Feature Similarity Module (**FSM**) to capture long-range dependencies
- **skip-and-concat** to solve vanishing gradient problem and overfitting

Architecture. Encoder



Encoder. XBlock



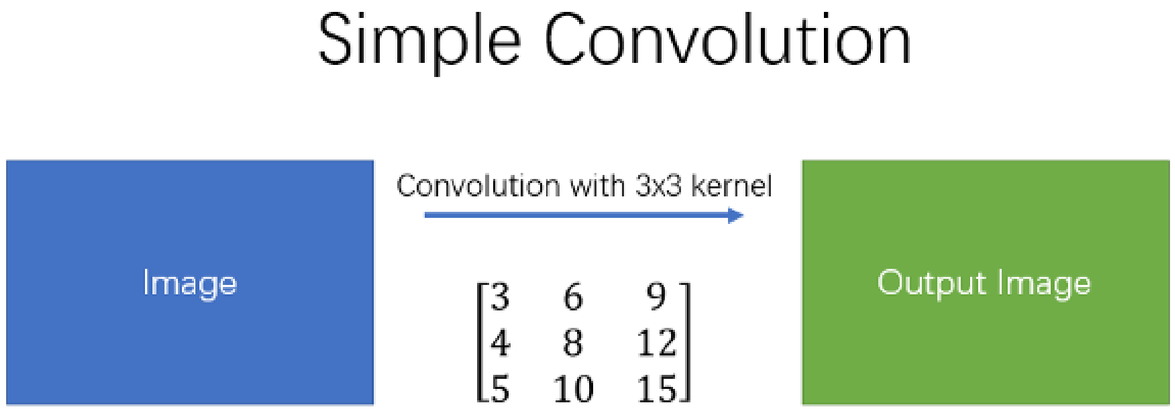
Encoder. X-Block. Separable Convolution

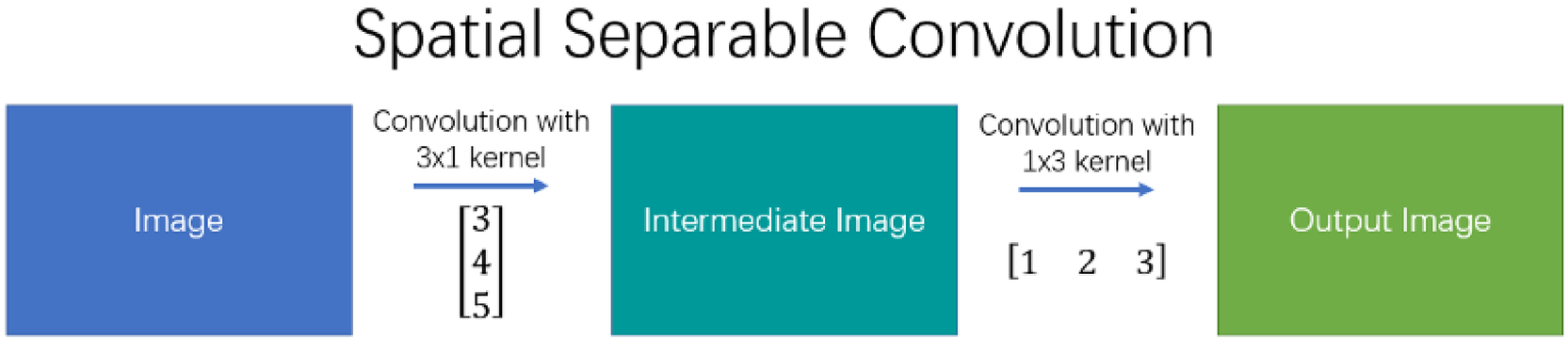
Separating a 3x3 kernel spatially

$$\begin{bmatrix} 3 & 6 & 9 \\ 4 & 8 & 12 \\ 5 & 10 & 15 \end{bmatrix} = \begin{bmatrix} 3 \\ 4 \\ 5 \end{bmatrix} \times \begin{bmatrix} 1 & 2 & 3 \end{bmatrix}$$

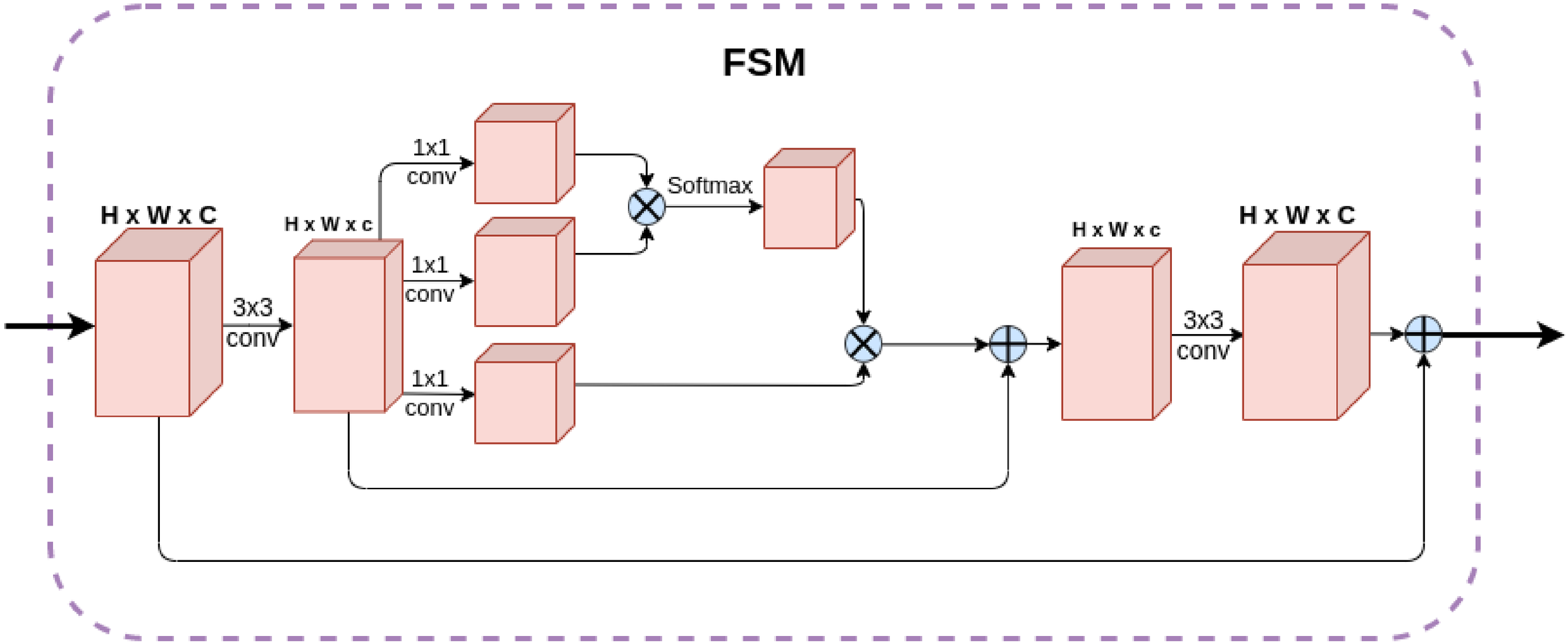
Encoder. X-Block. Separable Convolution

Separable Convolution can enhance efficiency and decrease overfitting without significantly reducing effectiveness

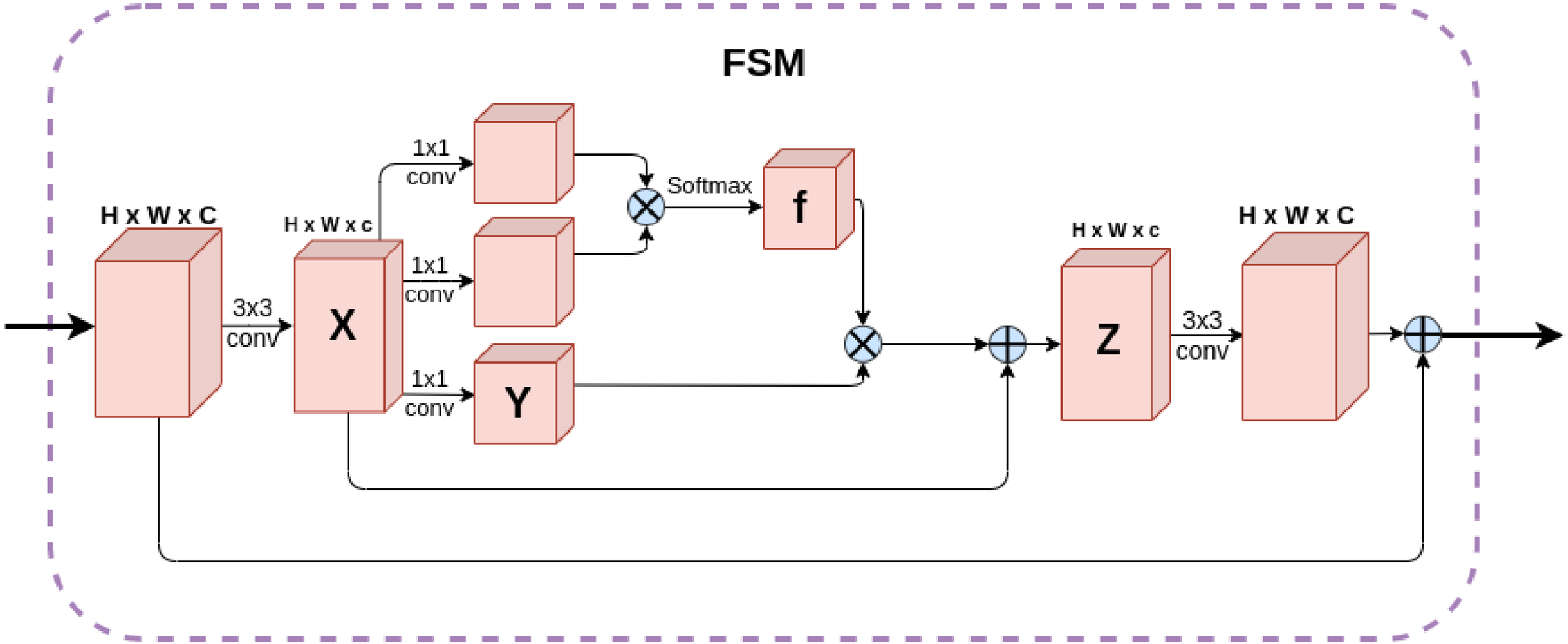




Encoder. FSM

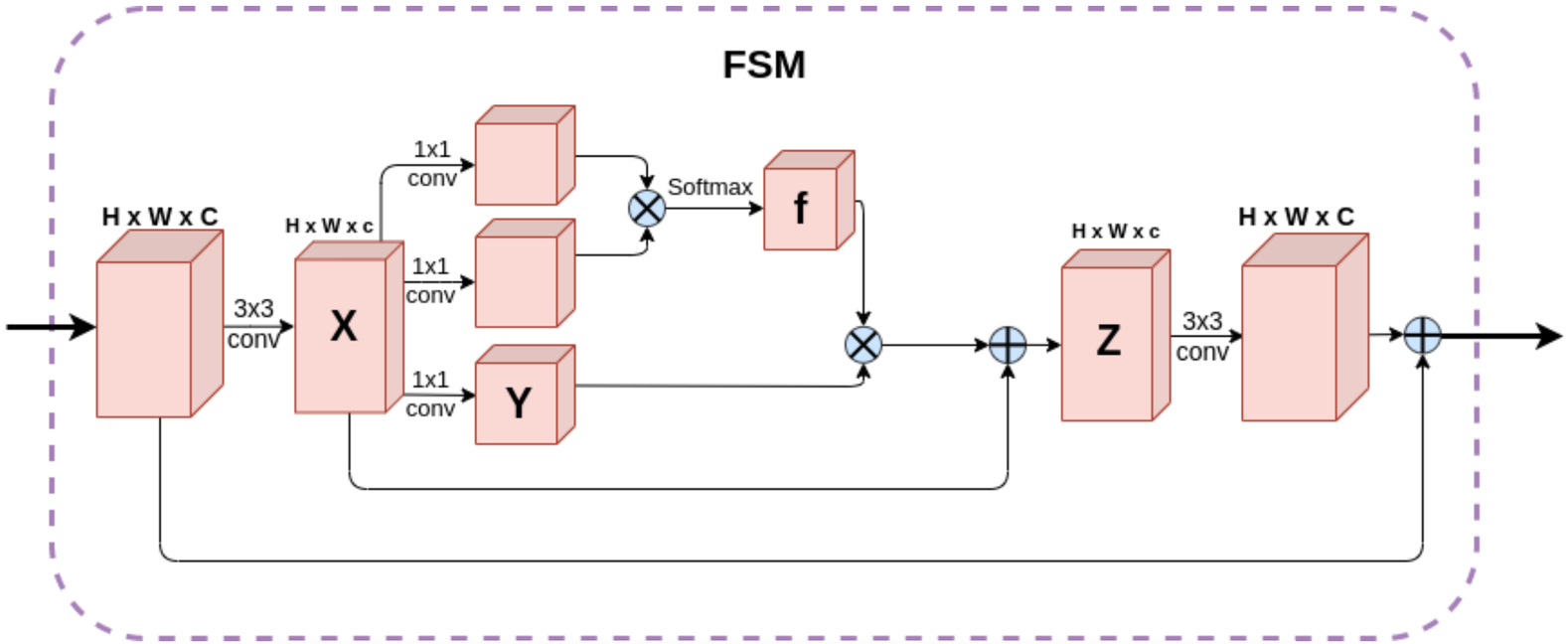

FSM
H x W x C
3x3
conv
H x W x c
1x1
conv
1x1
conv
1x1
conv
Softmax
H x W x c
3x3
conv
H x W x C

Encoder. FSM


FSM
H x W x C
3x3
conv
H x W x c
X
1x1
conv
1x1
conv
1x1
conv
Y
Softmax
f
H x W x c
Z
3x3
conv
H x W x C

Encoder. FSM

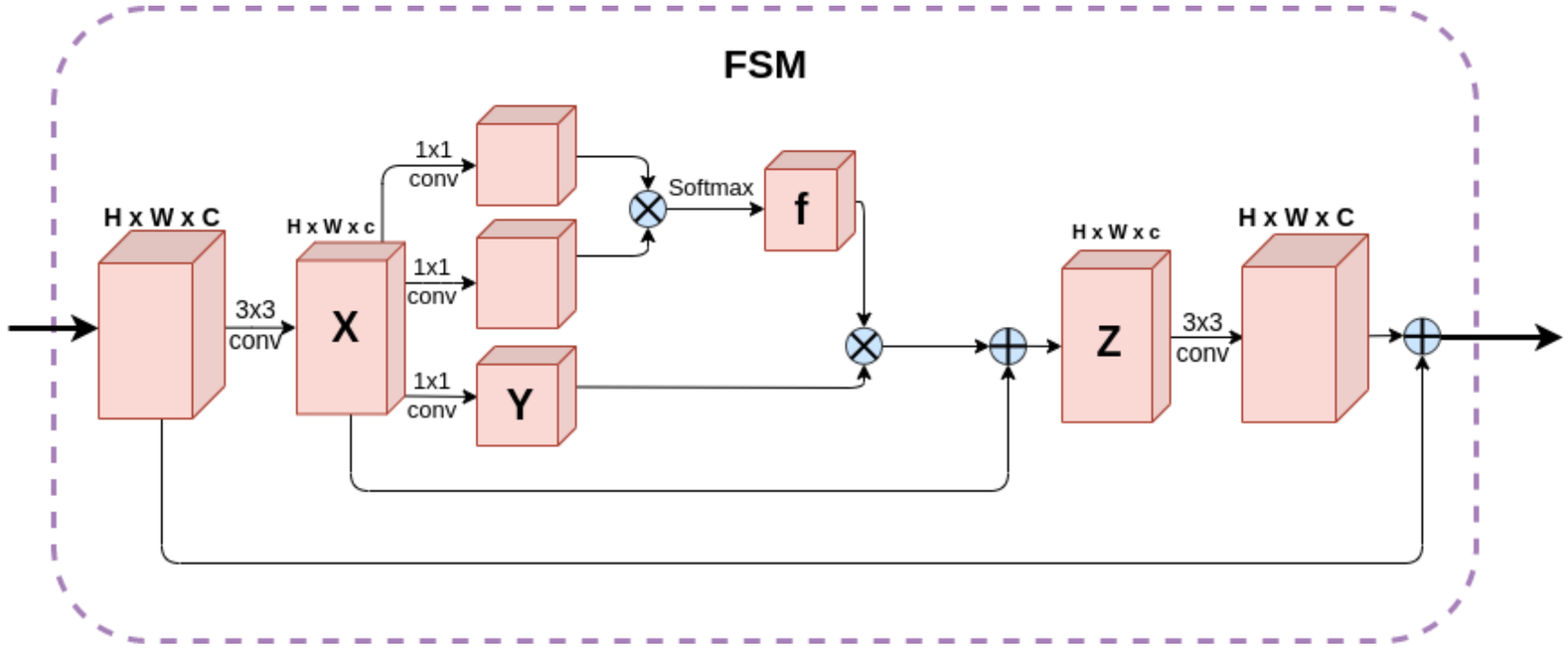
Z = relationship feature + original feature



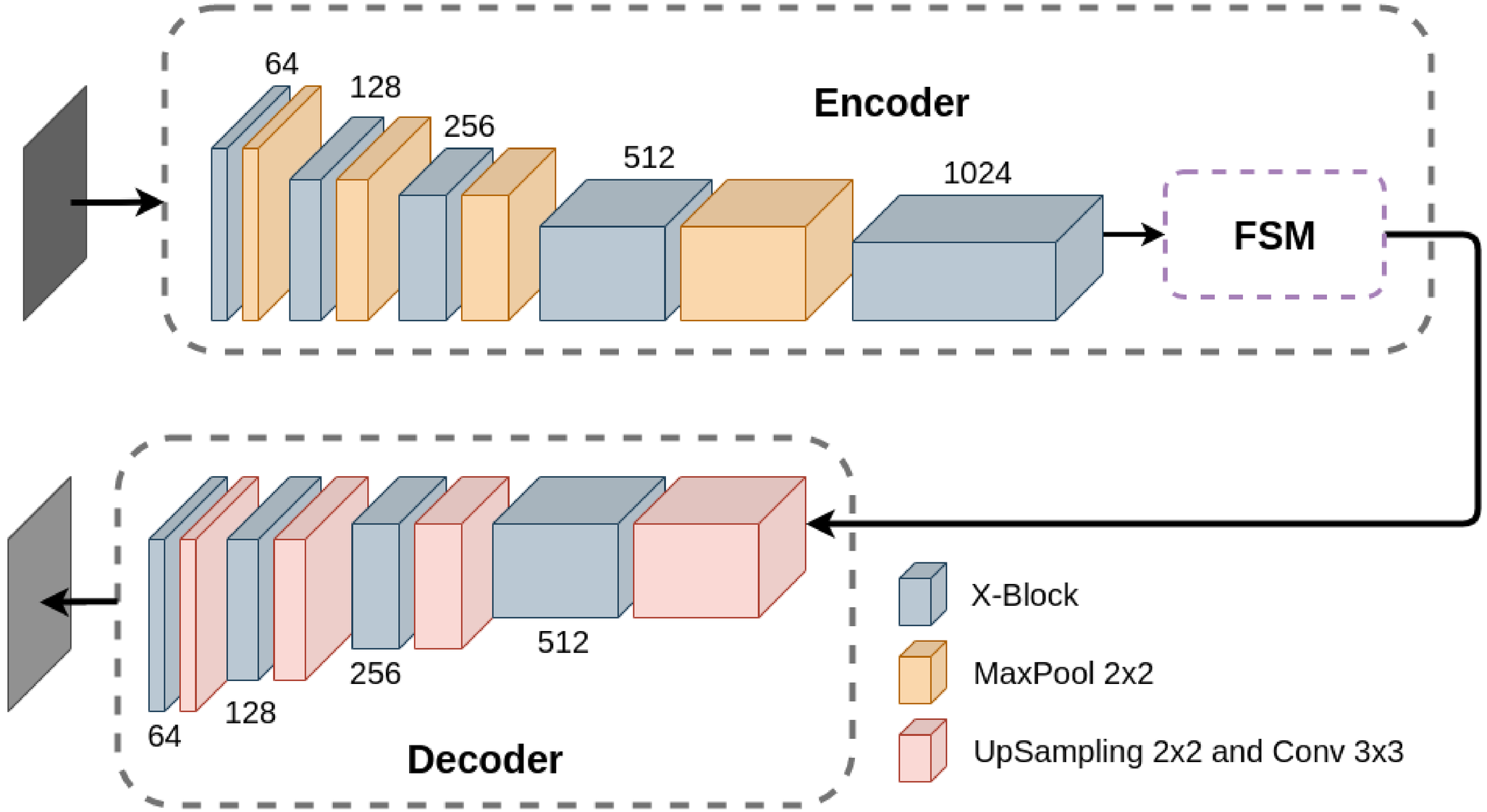
$$Z_i = \sum_{j=1}^{N} f(x_i, x_j) Y_j + X_i$$

Encoder. FSM

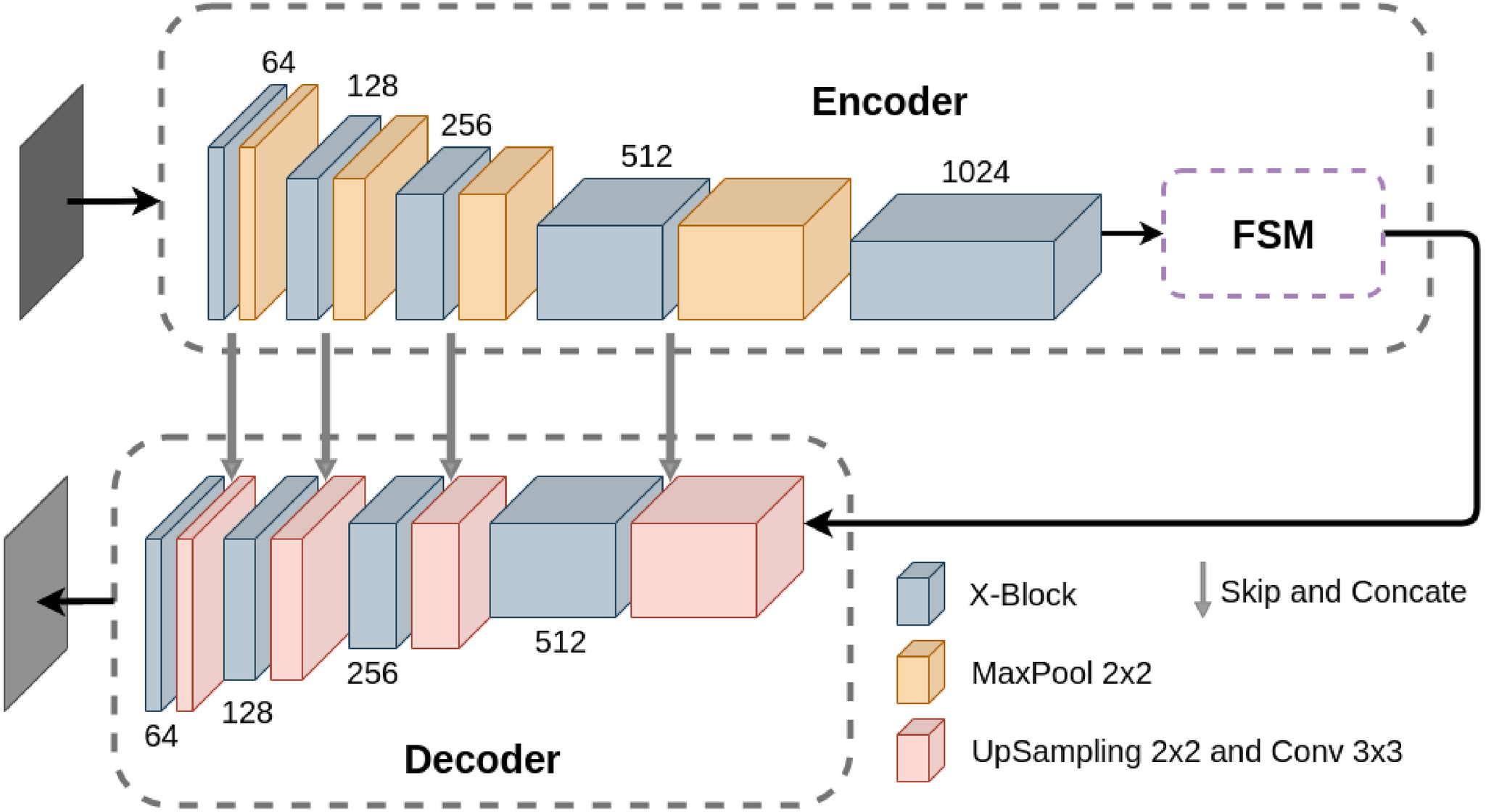
1. FSM is a non-local operation for capturing long-range dependencies by learning a relationship between any two positions of a feature map
2. FSM has a reduced number of training parameters (thanks to separable convolution)
3. Can be plugged into any model



Architecture. Decoder



Final Architecture. Skip-and-concate



A bit more information

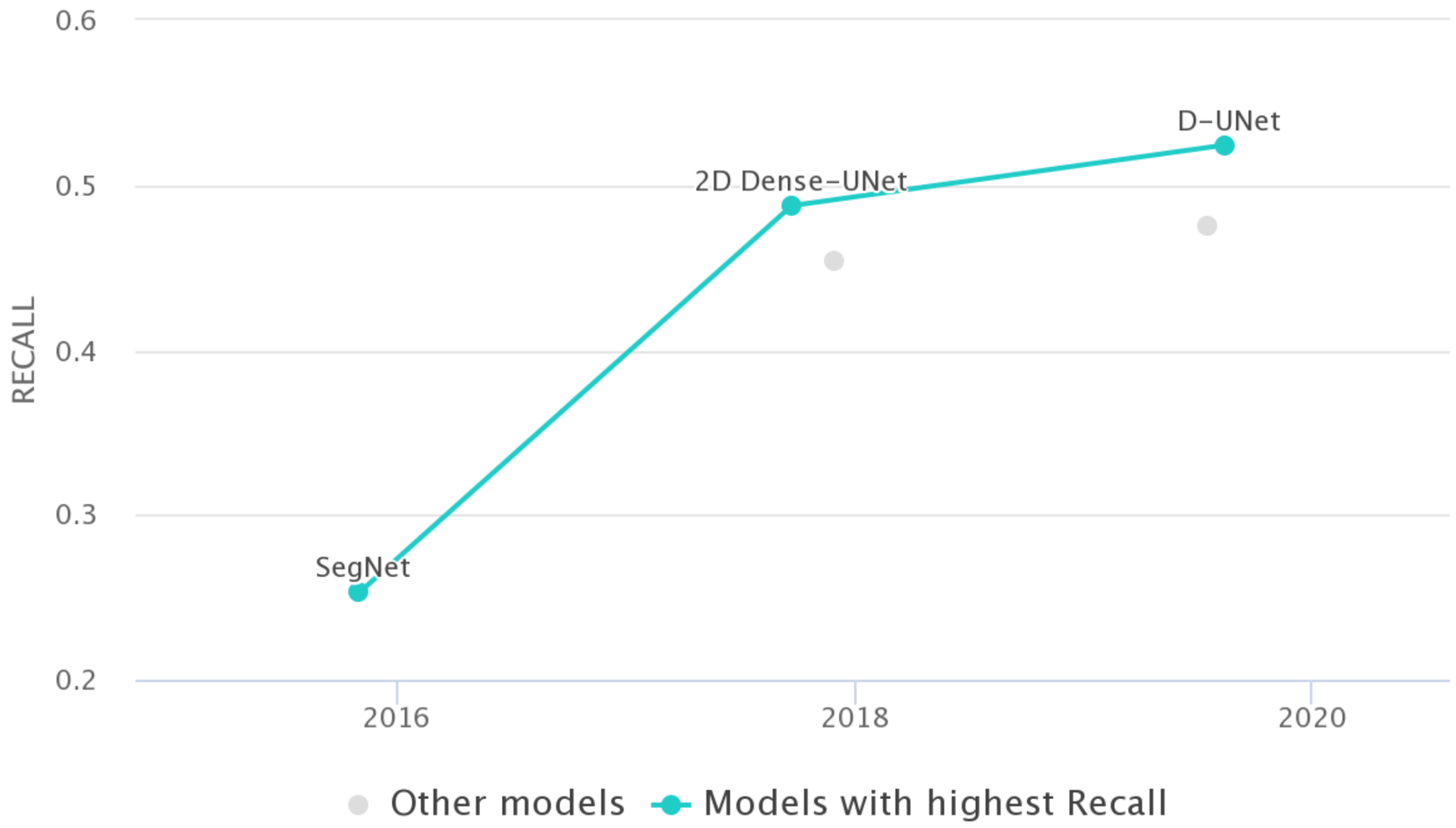
Optimizer: Adam, lr=0.001

Loss Function: Dice + Cross Entropy losses

Batch Size: 8

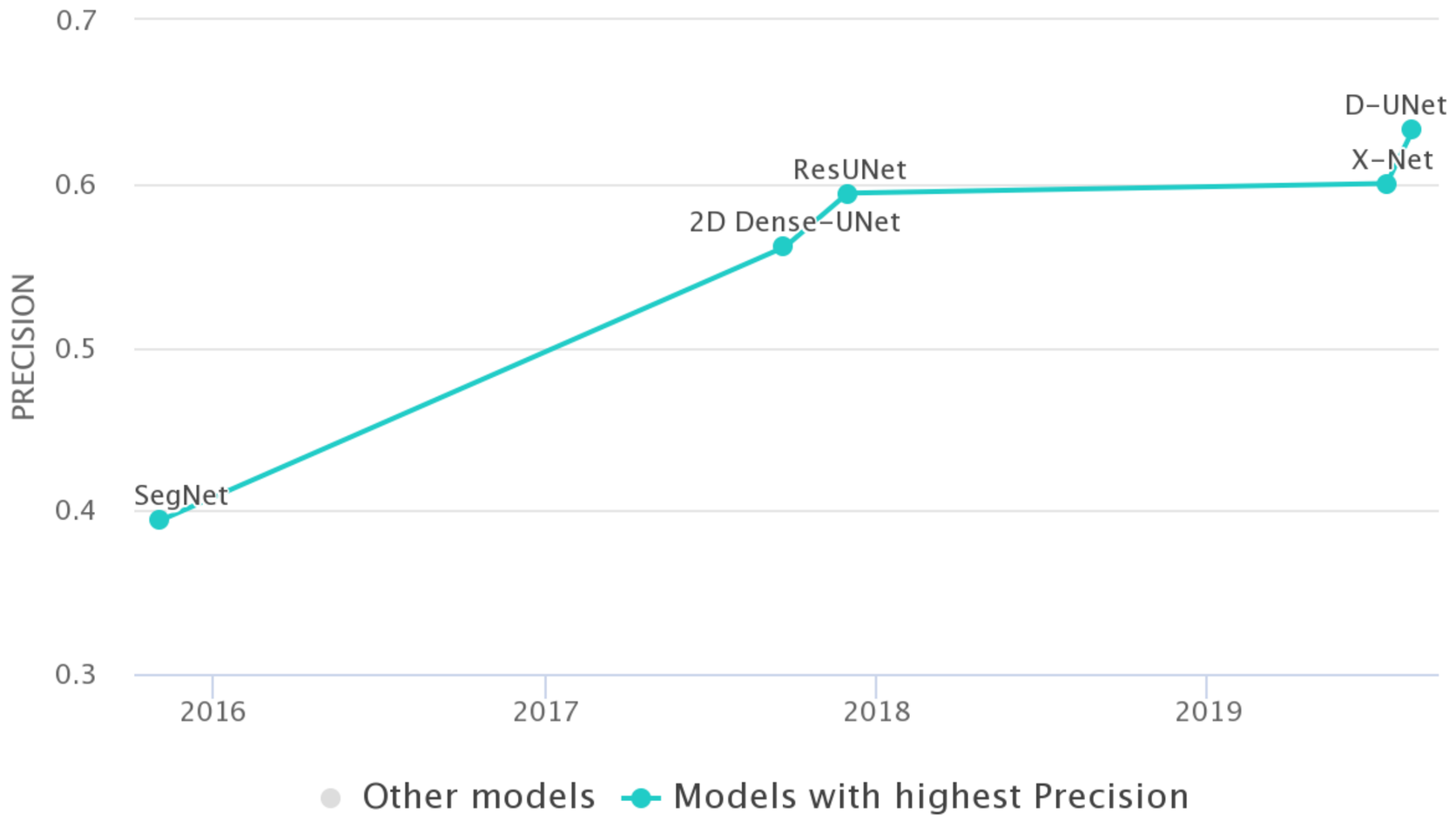
Benchmark - ATLAS dataset

Recall: How many relevant items are retrieved?



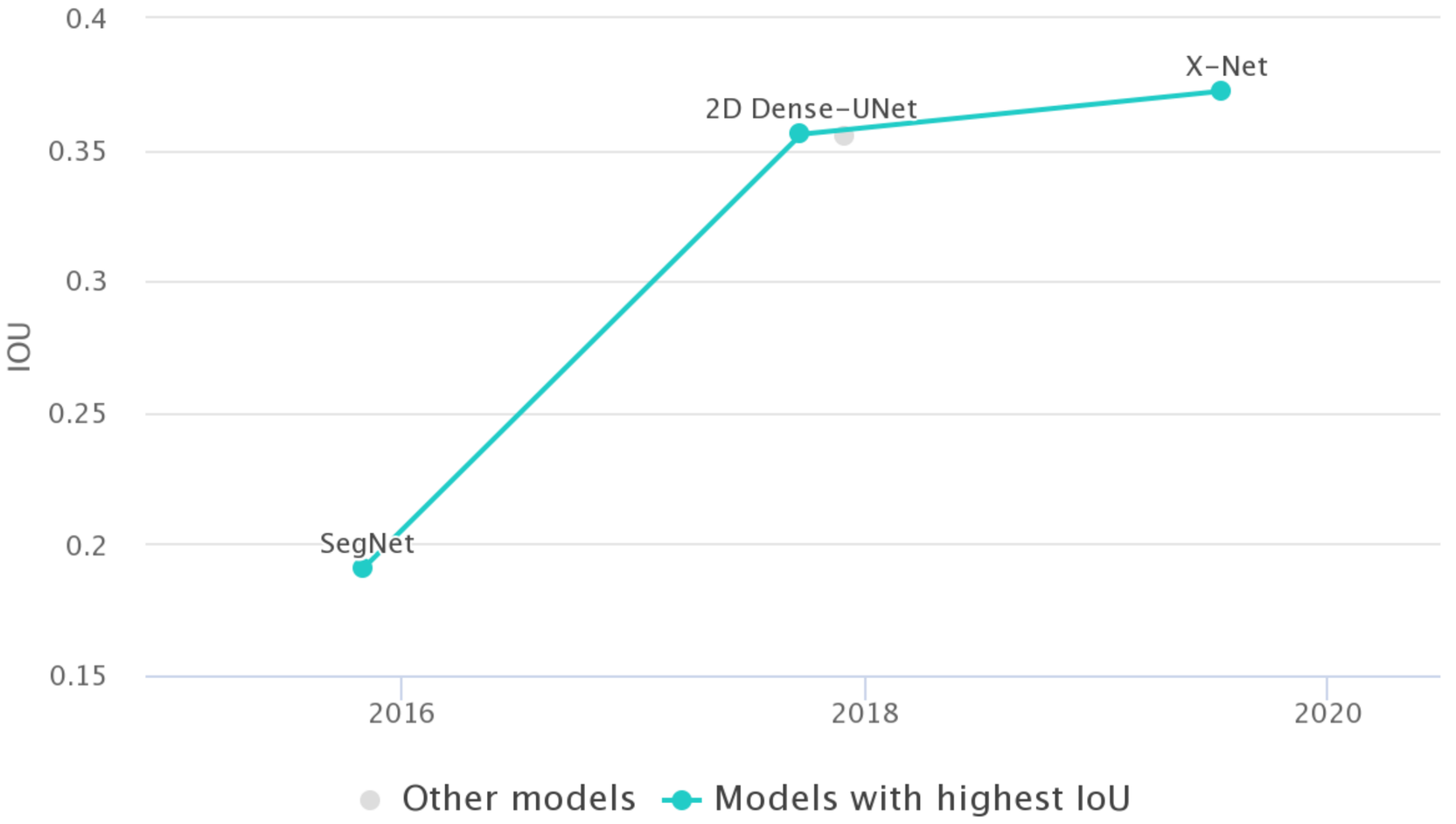
Benchmark - ATLAS dataset

Precision: How many retrieved items are relevant?



Benchmark - ATLAS dataset

IoU: What is the % of overlap between ground-truth segment and predicted segment?



The authors’ results

Method	IoU	# parameters
2D Dense-UNet	0.35	50.0M
U-Net	0.34	34.5M
SegNet	0.35	29.5M
X-Net	**0.37**	**15.1M**

Small conclusion

- reduce number of parameters
  - **separable convolution**
  - **basic upsampling**
- Feature Similarity Module (**FSM**) to capture long-range dependencies
- **skip-and-concat** to solve vanishing gradient problem and overfitting