SegFormer Model - a Transformer based framework for semantic segmentation.

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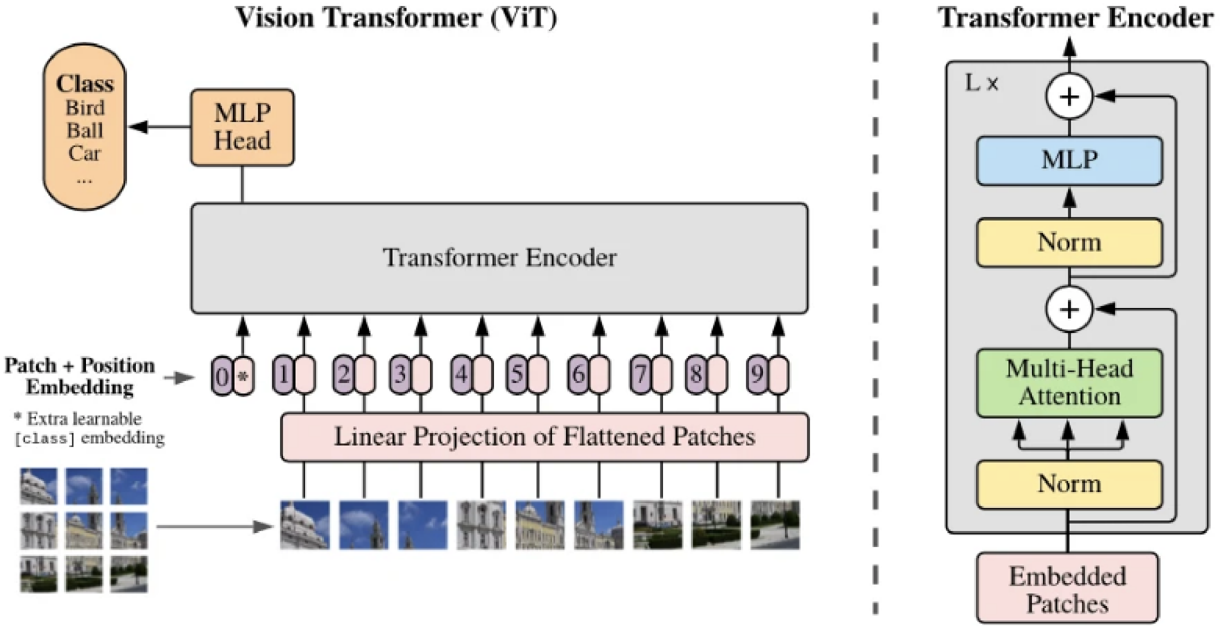
Content:

- Vision Transformer
- Segforer Model:
  - Encoder
  - Decoder

Vision Transformer

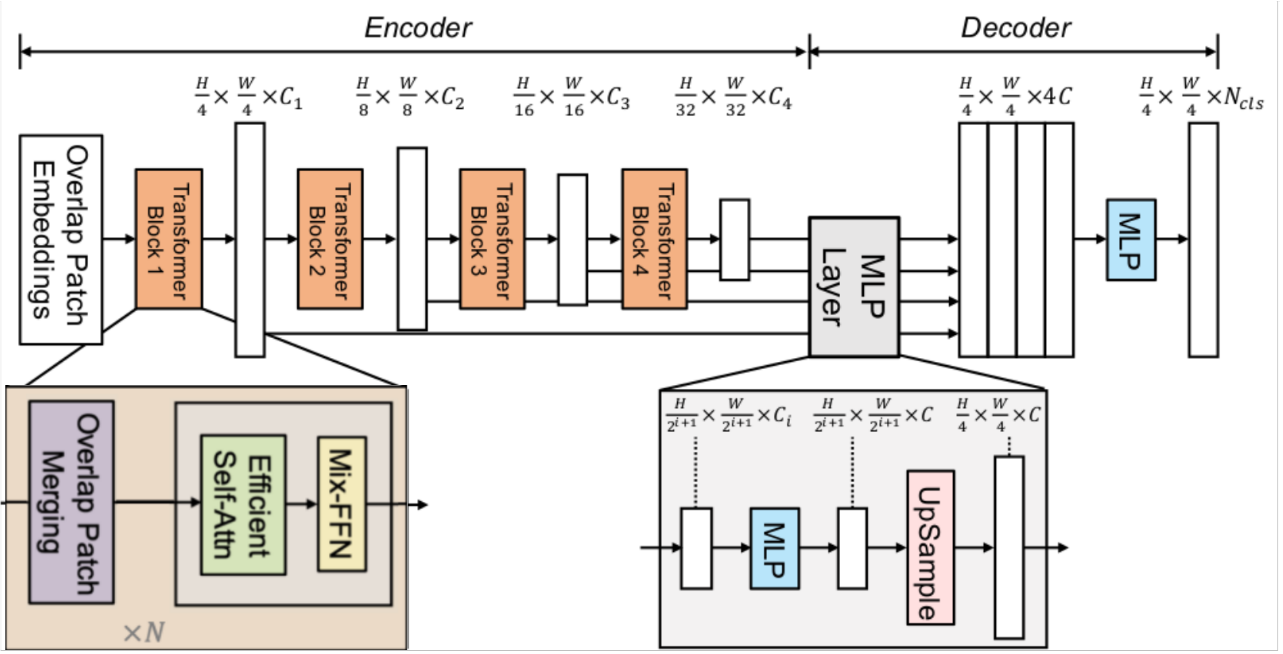


Vision Transformer ViT Architecture – Source

- Split an image into patches
- Flatten the patches
- Linear embeddings from the flattened patches
- Add positional embeddings
- Feed the sequence into transformer encoder
- Using multi layer perceptron MLP to get classification head

Vision Transformer

- ViT understands the local and global features
- CNN focus on the local features
- ViT has a higher precision rate on a large dataset



Encoder
Decoder
$\frac{H}{4}\times\frac{W}{4}\times C_1$
$\frac{H}{8}\times\frac{W}{8}\times C_2$
$\frac{H}{16}\times\frac{W}{16}\times C_3$
$\frac{H}{32}\times\frac{W}{32}\times C_4$
$\frac{H}{4}\times\frac{W}{4}\times 4C$
$\frac{H}{4}\times\frac{W}{4}\times N_{cls}$
Overlap Patch Embeddings
Transformer Block 1
Transformer Block 2
Transformer Block 3
Transformer Block 4
MLP Layer
MLP
Overlap Patch Merging
Efficient Self-Attn
Mix-FFN
$\times N$
$\frac{H}{2^{i+1}}\times\frac{W}{2^{i+1}}\times C_i$
$\frac{H}{2^{i+1}}\times\frac{W}{2^{i+1}}\times C$
$\frac{H}{4}\times\frac{W}{4}\times C$
MLP
UpSample

Segforer Model

SegFormer has the following notable points:

- Encoder: Mix Transformer (MiT) that extracts coarse and fine features
- Decoder: MLP network to directly fuse the multi-level features of the encoder part and predicts the semantic segmentation mask

Encoder

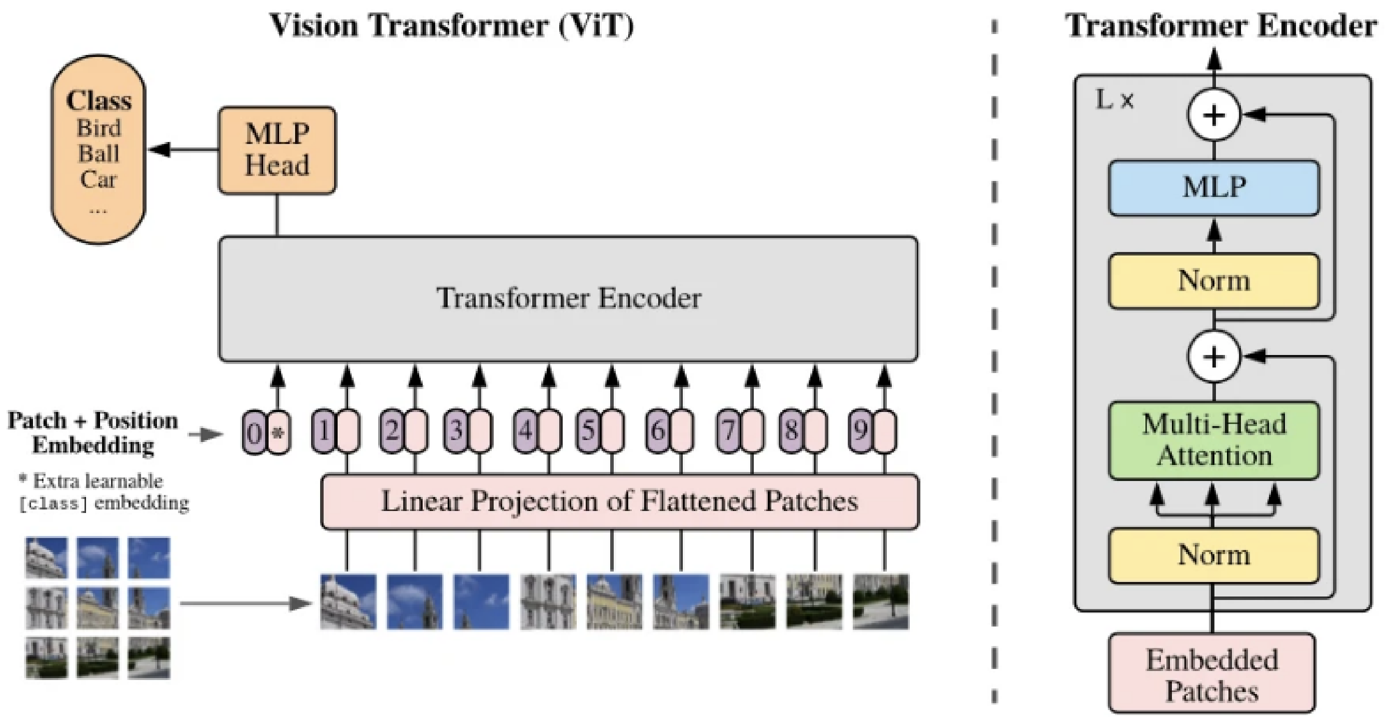
Hierarchical Feature Representation

- ViT that can only generate a single-resolution feature
- MiT generate multi-level features (MiT have 4 Transformer layers)

Overlapped Patch Merging

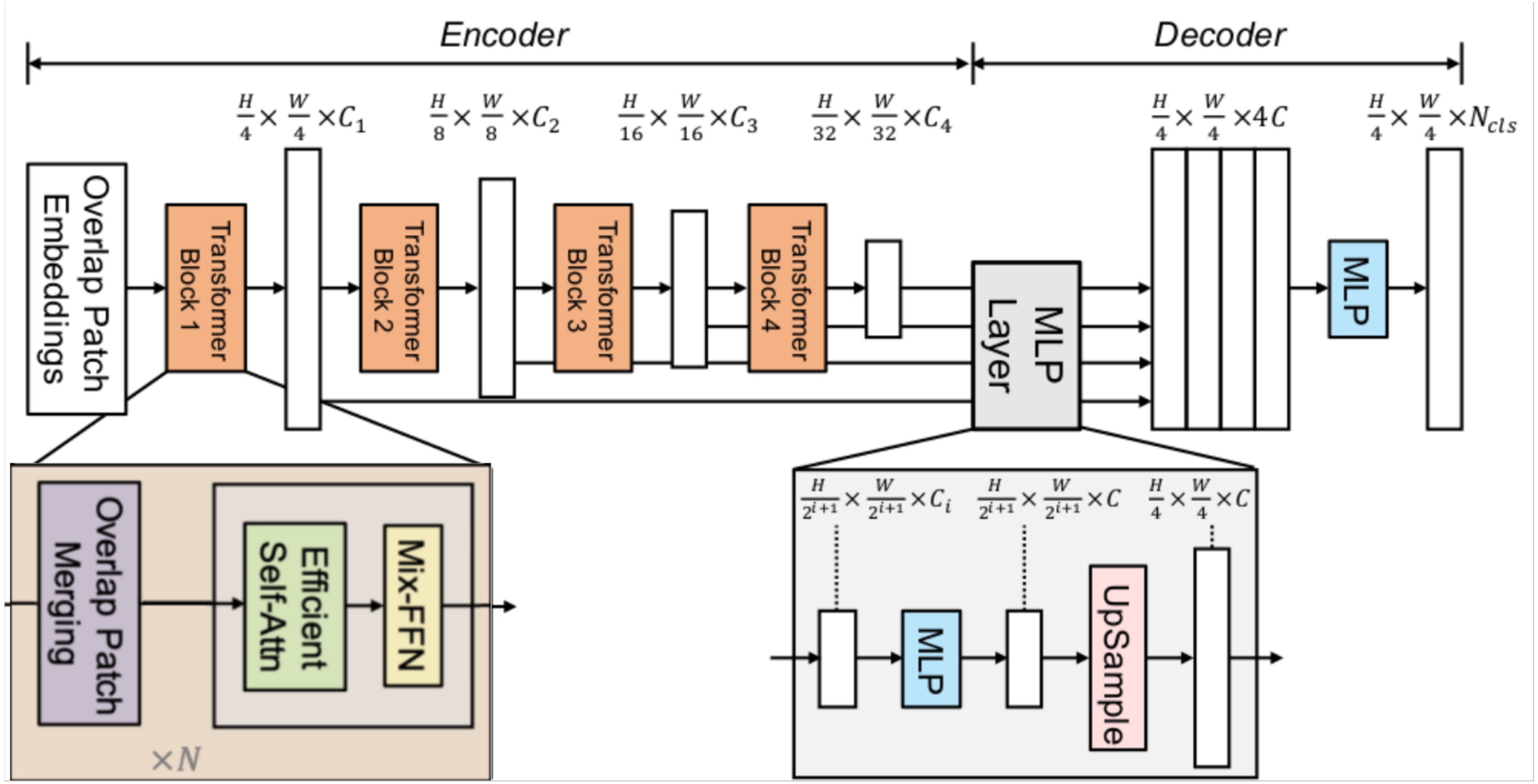
- In ViT, a image input is splitted into **partition** patches.
- Mix Transformer, a image input is splitted into **overlapping** patches.

ViT model



Vision Transformer ViT Architecture – Source

Segformer model


Encoder
Decoder
$\frac{H}{4}\times\frac{W}{4}\times C_1$
$\frac{H}{8}\times\frac{W}{8}\times C_2$
$\frac{H}{16}\times\frac{W}{16}\times C_3$
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$\frac{H}{4}\times\frac{W}{4}\times N_{cls}$
Overlap Patch Embeddings
Transformer Block 1
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MLP Layer
MLP
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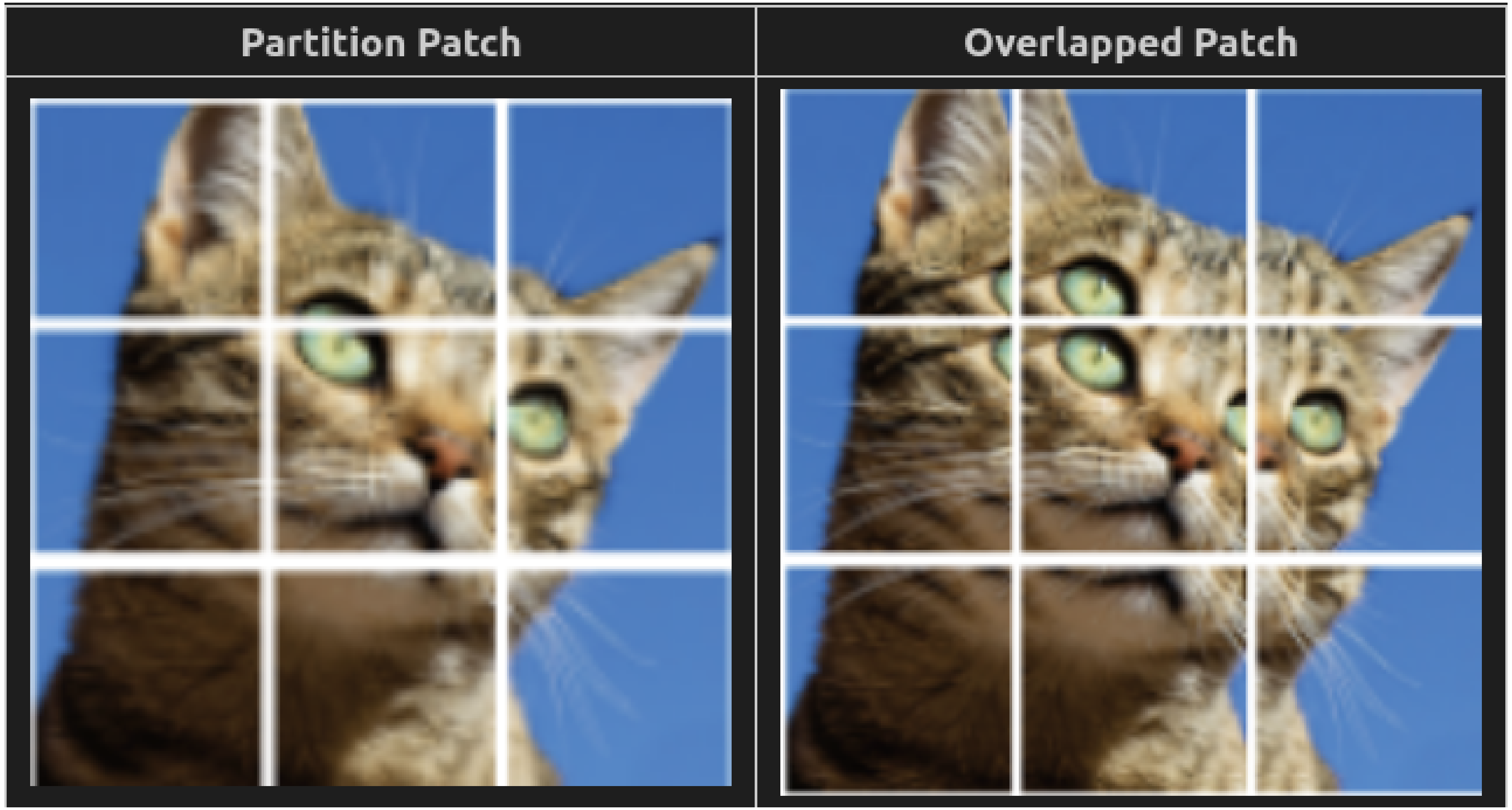
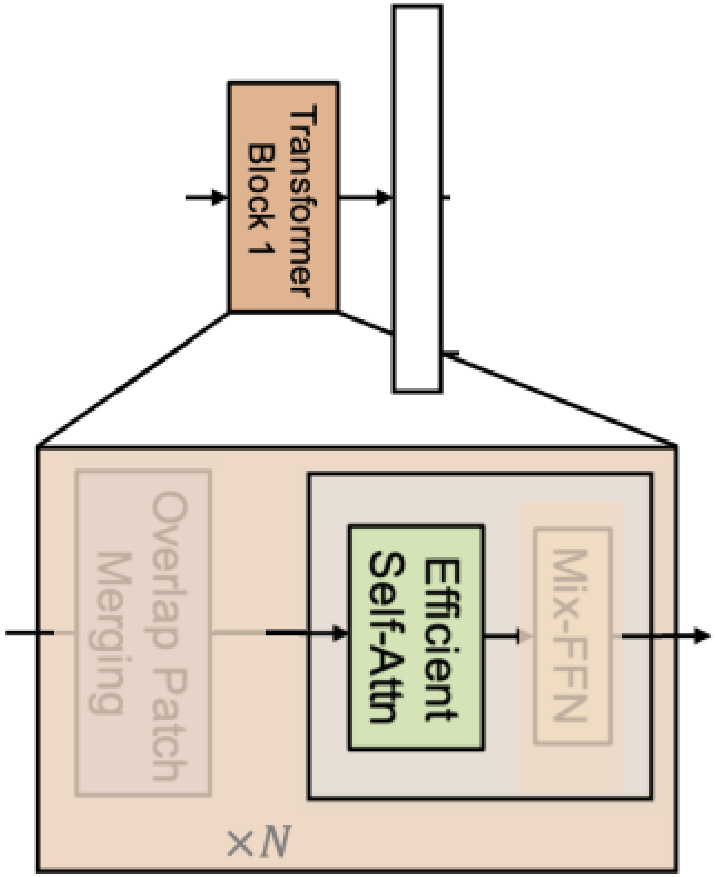
Efficient Self-Attn
Mix-FFN
×N
$\frac{H}{2^{i+1}}\times\frac{W}{2^{i+1}}\times C_i$
$\frac{H}{2^{i+1}}\times\frac{W}{2^{i+1}}\times C$
$\frac{H}{4}\times\frac{W}{4}\times C$
MLP
UpSample

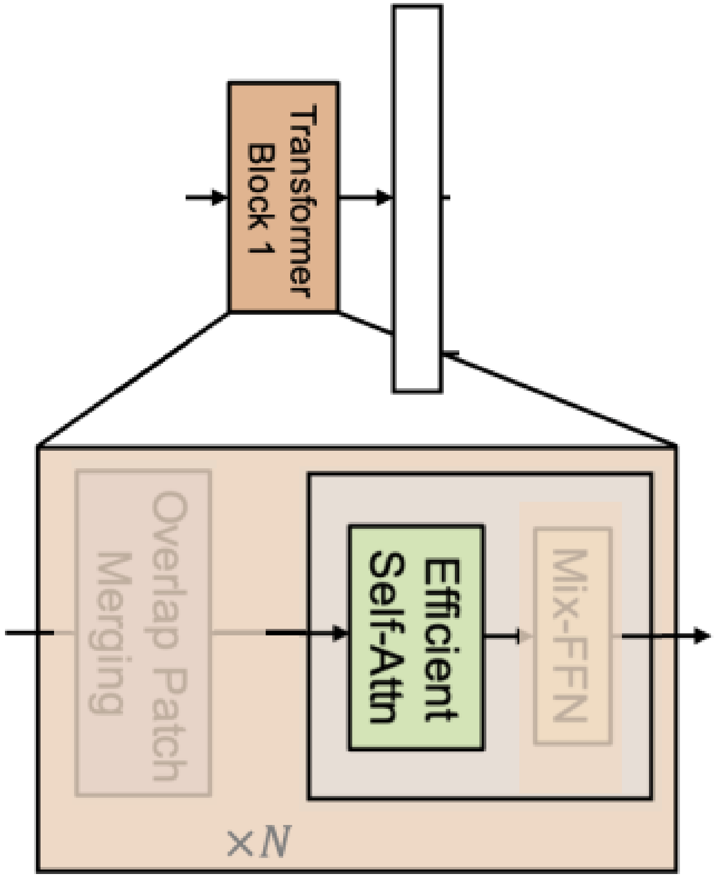
Segformer model





Encoder

- ViT uses Multi Head Attn (Computation of $O((H \times W)^2)$)
- MiT uses Efficient Self Attn (Computation of $O((H \times W)^2/R)$)



Encoder

- ViT uses MLP
- MiT uses

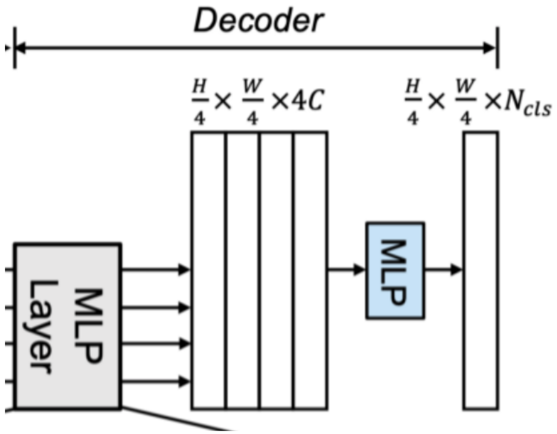
$$x_{out} = MLP(GELU(CONV_{3\times3}(MLP(x_{in})))) + x_{in}$$

- MLP = nn.Linear(dim, num_classes) (or Dense Layer)

it's called Mix because it mixes information using the 3x3 conv

Decoder

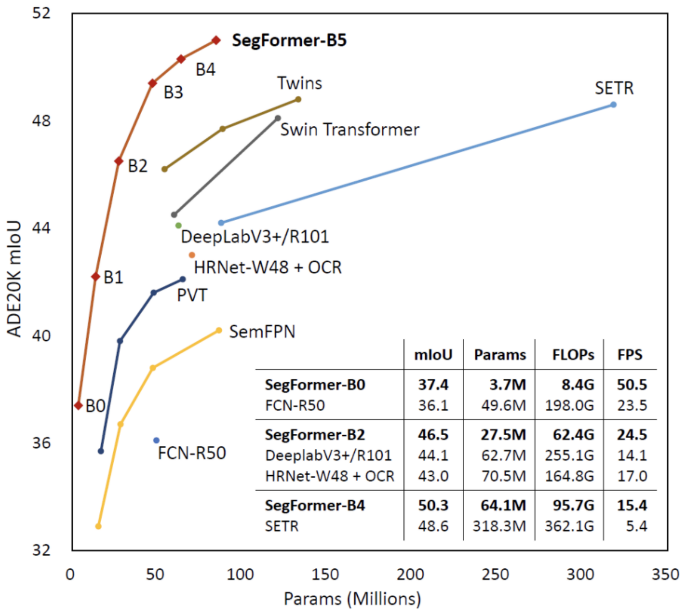
Because Encoder is quite good, then to avoid the overfitting, we use a MLPs to fuse the features of the encoder and predict the semantic segmentation mask.


Decoder
$\frac{H}{4} \times \frac{W}{4} \times 4C$
$\frac{H}{4} \times \frac{W}{4} \times N_{cls}$
MLP Layer
MLP

A MLP of decoder part

```
class SegFormerDecoderBlock(nn.Sequential):
    def __init__(self, in_channels: int, out_channels: int, scale_factor: int = 2):
        super().__init__(
            nn.UpsamplingBilinear2d(scale_factor=scale_factor),
            nn.Conv2d(in_channels, out_channels, kernel_size=1),
        )
```

performance of Segformer



	mIoU	Params	FLOPs	FPS
SegFormer-B0	**37.4**	**3.7M**	**8.4G**	**50.5**
FCN-R50	36.1	49.6M	198.0G	23.5
SegFormer-B2	**46.5**	**27.5M**	**62.4G**	**24.5**
DeeplabV3+/R101	44.1	62.7M	255.1G	14.1
HRNet-W48 + OCR	43.0	70.5M	164.8G	17.0
SegFormer-B4	**50.3**	**64.1M**	**95.7G**	**15.4**
SETR	48.6	318.3M	362.1G	5.4

Figure 1: Performance of SegFormer-B0 to SegFormer-B5.

Segformer works well on a large dataset.

References

- SegFormer: A Transformer-based Framework for Semantic Segmentation
- Training the Segformer model by using Pytorch Lightning and HuggingFace
- Usage of TensorFlow based SegFormer in hugs transformers