Why BN is not used in Transformer

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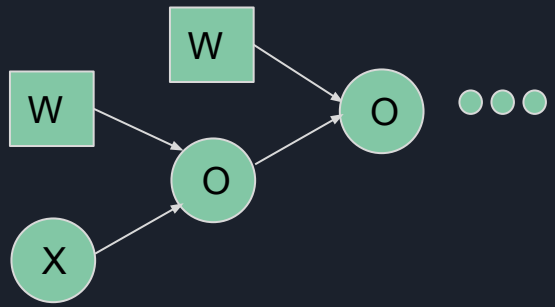
Introduction

1. Vanishing or exploding gradient Problem

2. How to solve
   - sigmoid -> relu,
   - skip connection
   - careful parameter init
   - batchnorm
   etc…

Introduction

1. DNN은 input(x)과 weight(w)가 recursive하게 계속 곱해지는 구조
   W의 값이 1보다 크면 발산하고, 1보다 작으면 최종 output이 0으로 수렴하는 문제 발생
2. scale의 값을 1에 가깝게 하기 위한 다양한 initialization 방법들이 제안됨
   (matrix norm, principle eigen value to 1
   by circular theorem, need to select randomly by mean and variance constraints,
   variance is by inputs size, output size(for forward, backward stable)
3. Batcnorm은 output에 대해 normalization을 해주는 방식의 다른 대안을 제시함



Batchnorm

1. 1D, 2D, 3D
   channel 단위 normalization, re-scaling in image
   2*dim (scale, bias)의 parameter,
   test시 moving average(mean, variance)
   Internal covariance shift -> (how does batchnorm help optimization)
   frozen batchnorm
   learning rate vs batch size
   set batch statistic on non linear point

2. Without Batchnorm(NFNet)
   poor in small batch size
   discrepancy between the behaviour of the model during training and at inference
   batch normalization breaks the independence during training

Batchnorm

1. loss landscape visualization
   select two axis, make grid,
   get loss by all test set, visualize
2. it seemed easy but difficult, Why??

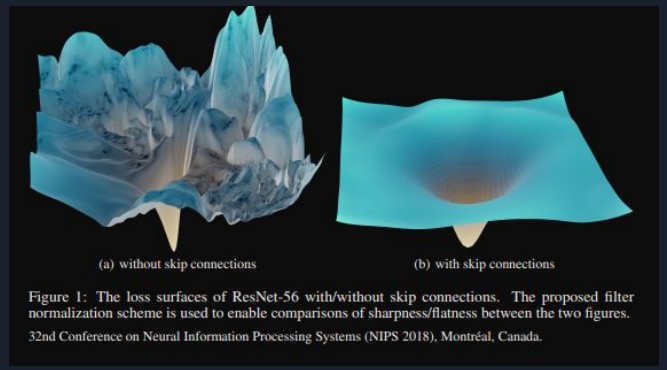
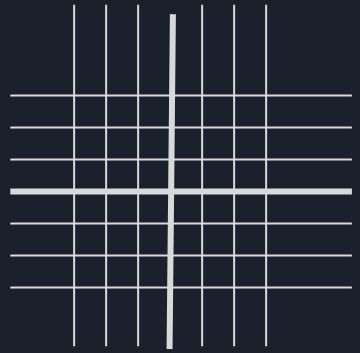


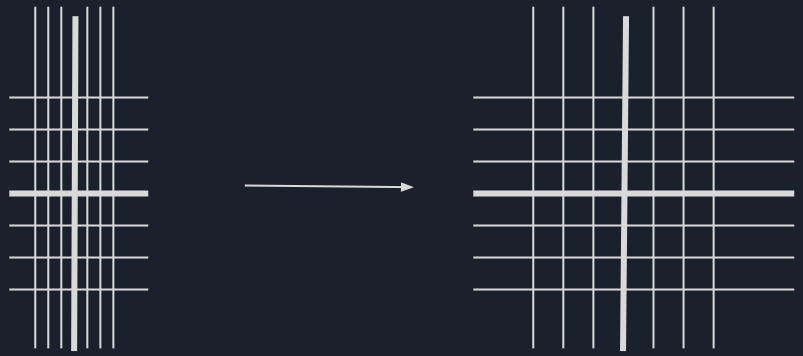
Figure 1: The loss surfaces of ResNet-56 with/without skip connections. The proposed filter normalization scheme is used to enable comparisons of sharpness/flatness between the two figures.
32nd Conference on Neural Information Processing Systems (NIPS 2018), Montréal, Canada.



https://arxiv.org/pdf/1712.09913.pdf

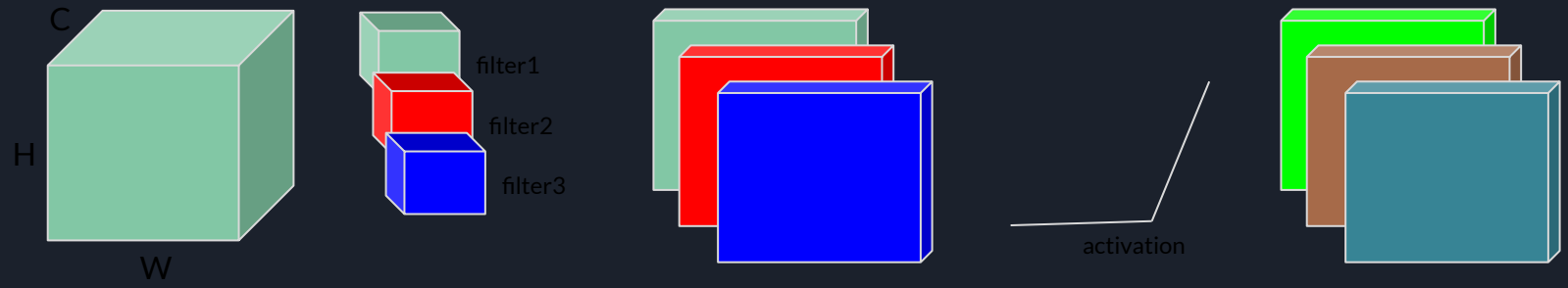
Batchnorm

1. its not euclidean space, big scale eats small scale
   need to make scale to be equally
   which unit to scale -> filter wise normalization



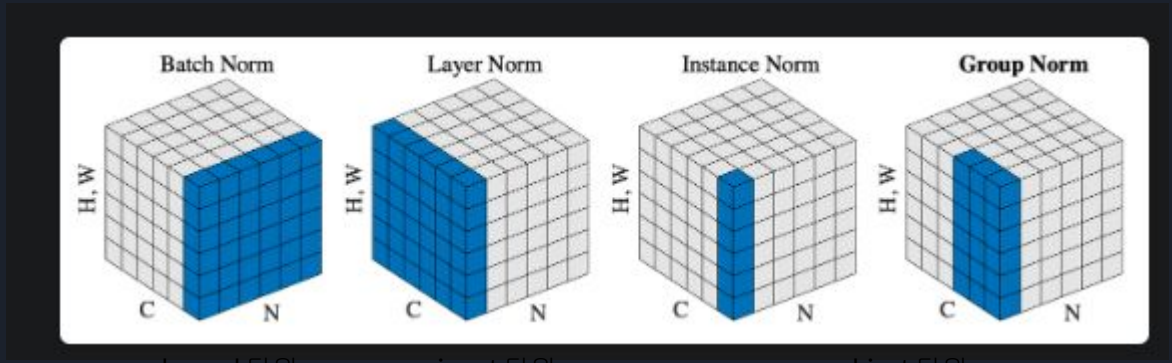
Batchnorm

1. How about using filter wise normalization in training??
   it seemed to be difficult direct on weight, how about using on feature map?
   This is Batchnorm,
   normalize each filter, and gave scale
   (각 필터를 normalization후 중요 필터에 가중치, bias를 적절히 주자)



Batchnorm

1. LayerNorm은 input image
   instance or group norm의 경우 object 단위의 normalization을 한다고 볼수 있을 듯,
   task에 맞게 적절한 normalization이 필요하다.



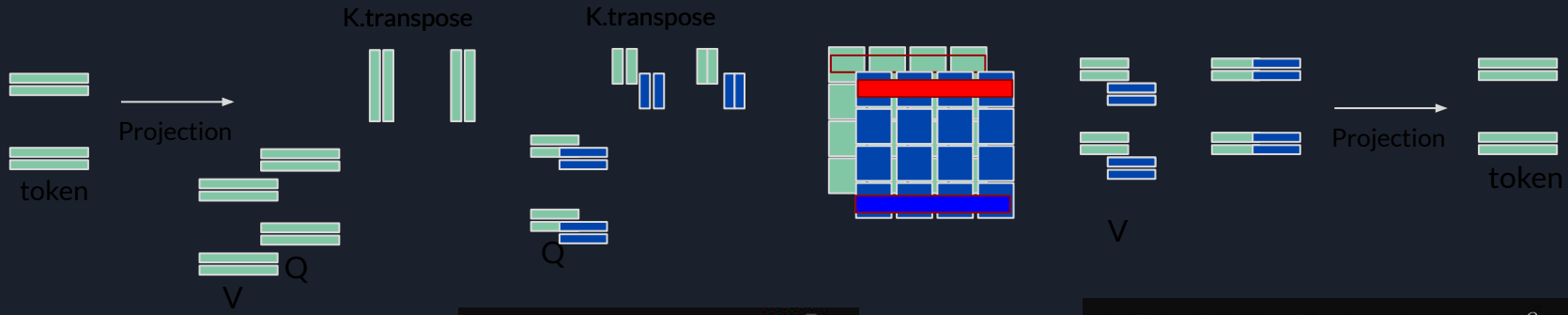
channel 단위 input 단위 object 단위

Transformer

1. Why BatchNorm is not used in Transformer
   sequencial한 data에서 leakage등이 발생할 수 있음
   (cheating)
2. But Lots of data, random sampling, is it really problem?
3. view of filter wise normalization

Transformer

- attention
  - re-encoding, dynamic convolution, long range dependency
    soft filter, trainable projection matrix
  - complexity, weak inductive bias

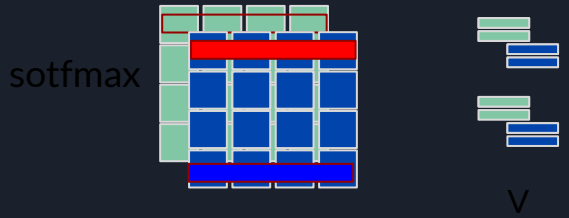


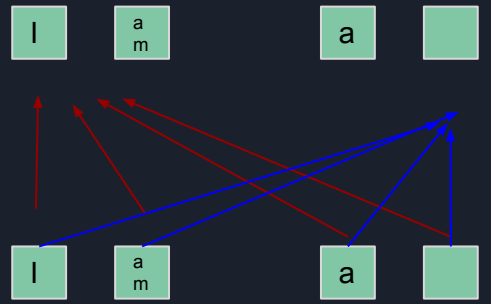
$$\text{Attention}(Q, K, V) = \text{softmax}(\frac{QK^T}{\sqrt{d_k}})V$$

$$\text{MultiHead}(Q, K, V) = \text{Concat}(\text{head}_1, ..., \text{head}_h)W^O$$
$$\text{where head}_i = \text{Attention}(QW_i^Q, KW_i^K, VW_i^V)$$

Transformer

1. weight is already normalized by softmax,
   it seem that batchnorm is not fit to transformer(layer norm is better)
   But how about value?





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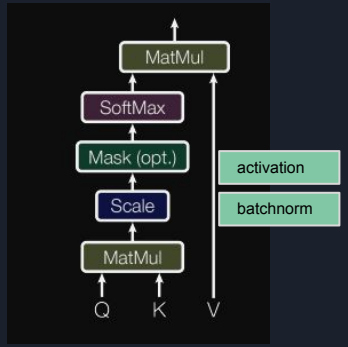
Transformer

Linear projection is like a convolution of full window size
Batchnorm 1d per channel wise
give activation(기존 addition, GELU in mlp)
attention map을 학습하기 오랜 시간이 걸림, direct로 value쪽에서 의미 있는 feature 뽑아내 보자.

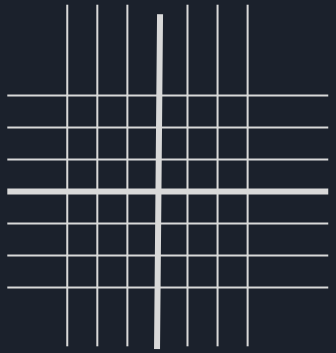


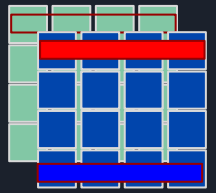
Results

1. Imagenet 1k,
   SGD with momentum 0.9, weith decay 1e-4
   step LR(0.1 decay per 30 epoch)
2. training 내내 val acc가 2~3% 정도 항상 높은 경향을 보임
3. vit의 경우 imagenet 1k보다 큰 dataset으로 테스트 필요

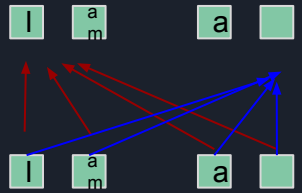
Previous	New
Acc@1 53.784 Acc@5 77.266	Acc@1 56.340 Acc@5 79.732

Thank you !!





V



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