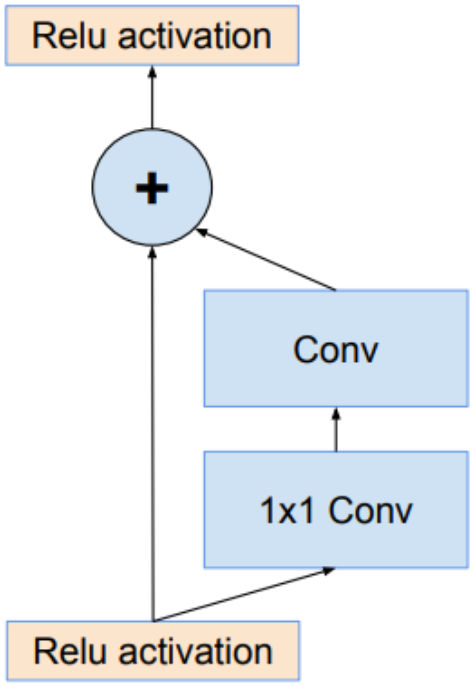
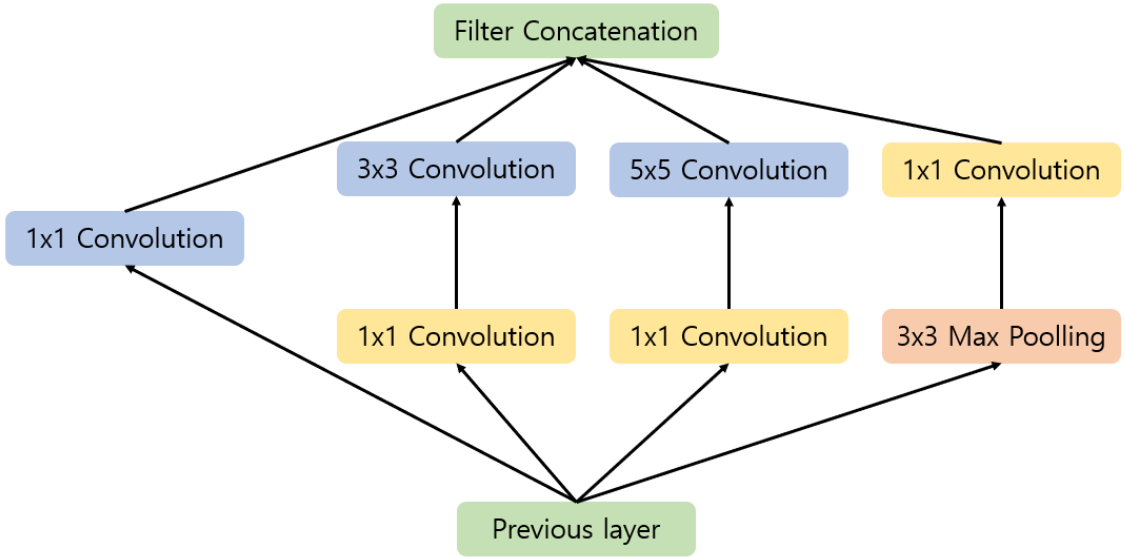
Inception-v4, Inception-ResNet and the Impact of Residual Connections on Learning (CVPR 2016)

- **연구동기:**
  Residual connection + Inception architecture => Any benefit?
  (Inception의 계산 효율성 유지 + residual block 이점)
  residual Inception model, non-residual Inception model
  + **activation scaling**의 Very Wide Residual Inception Network 학습 안정화

Residual Block



Inception module



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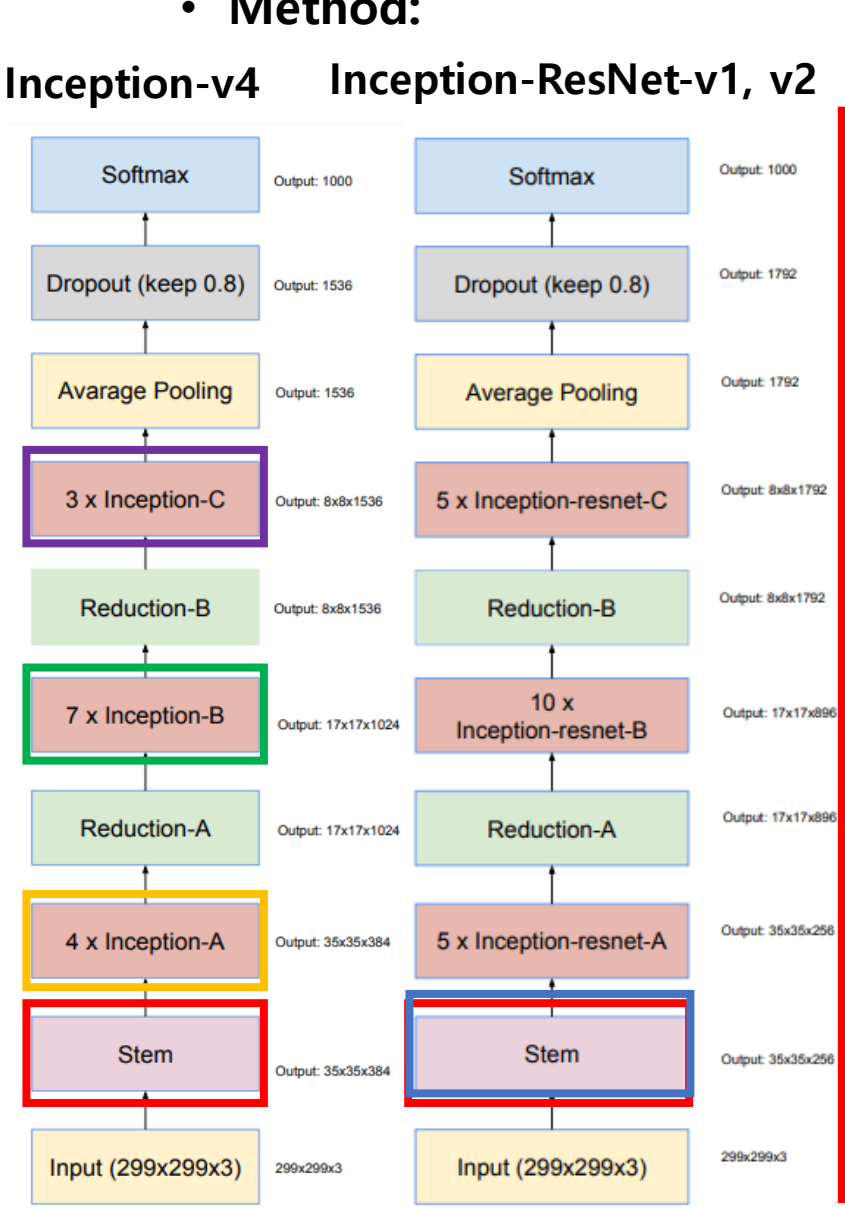
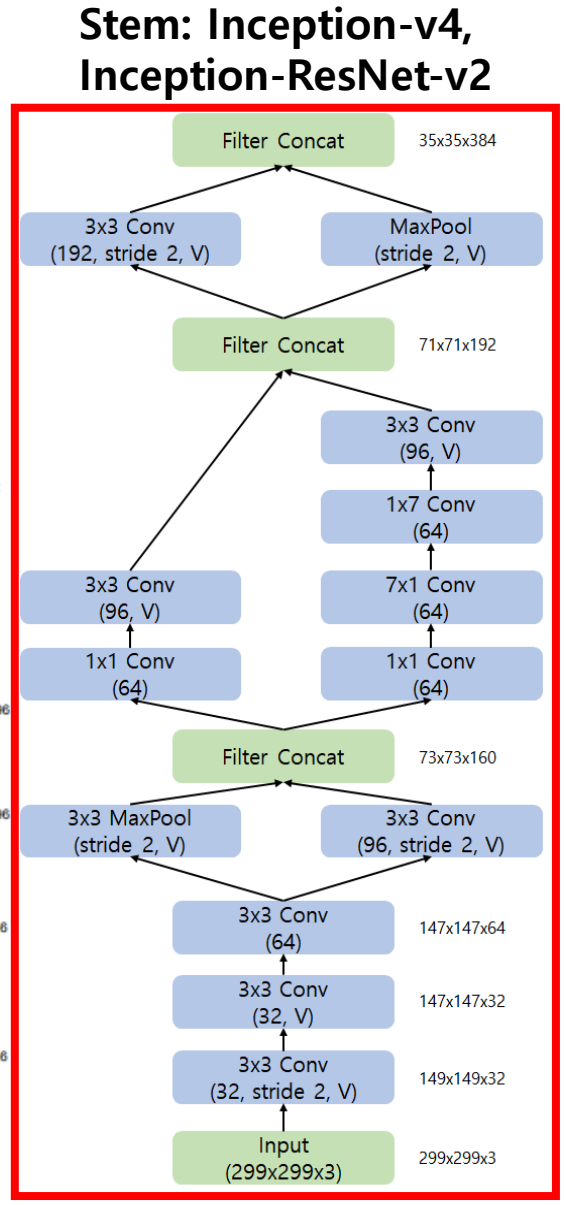
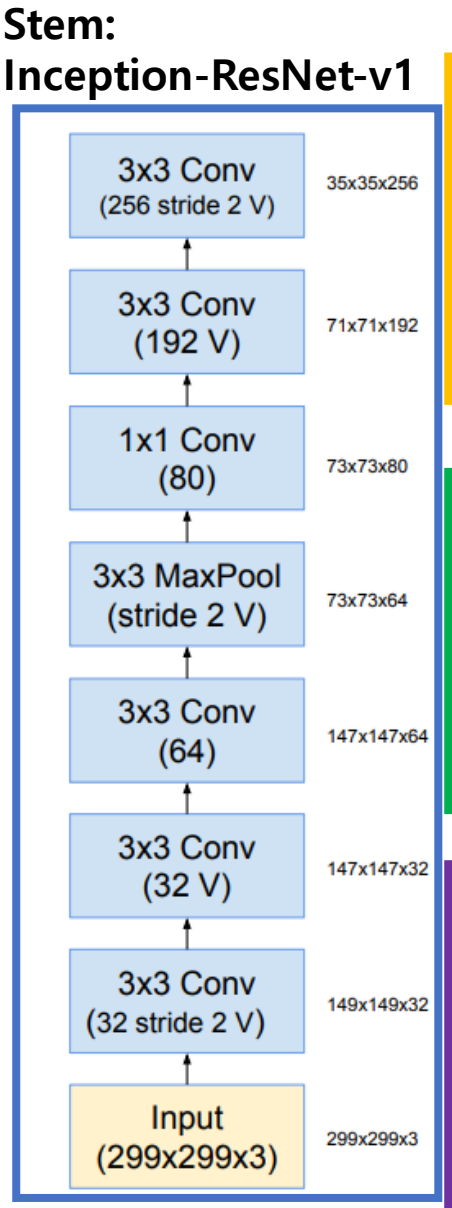
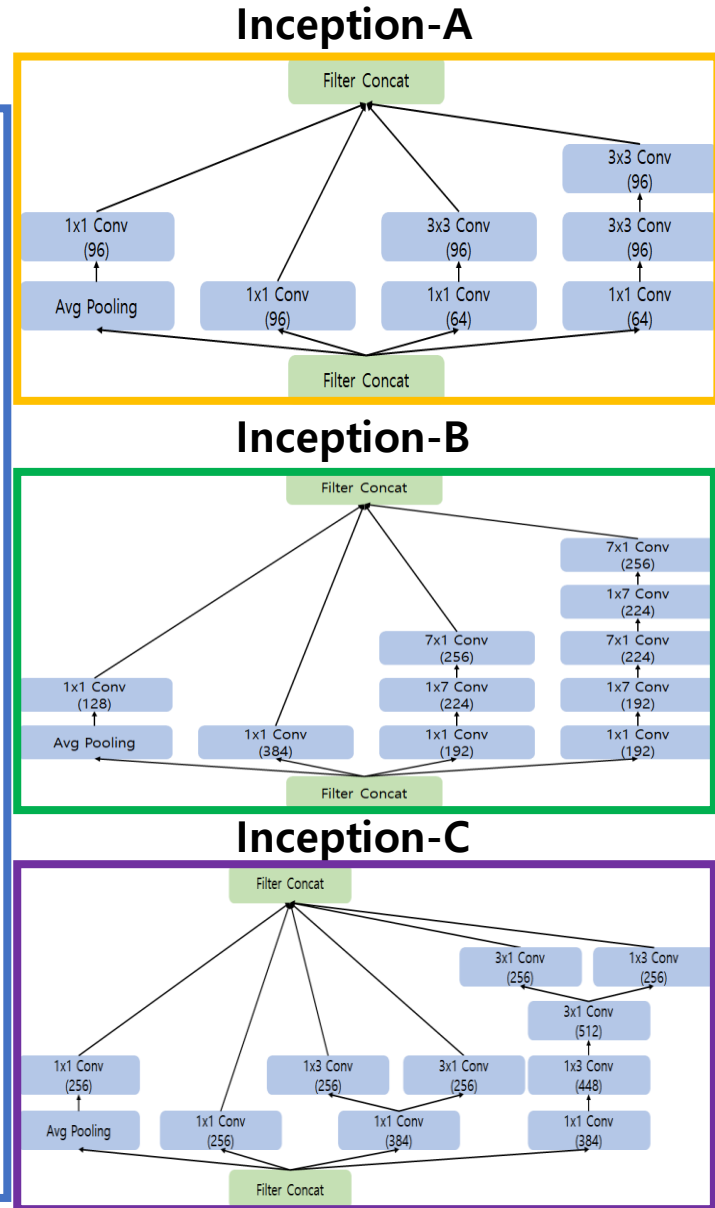
- **Method:**









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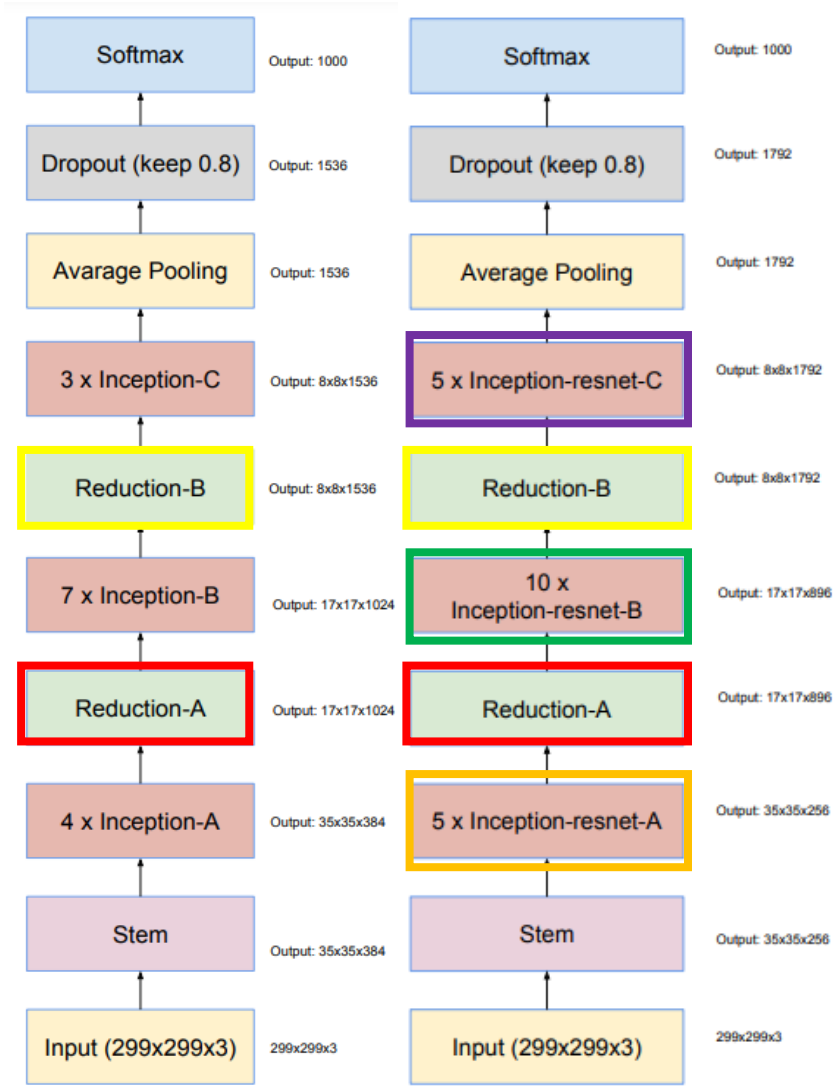
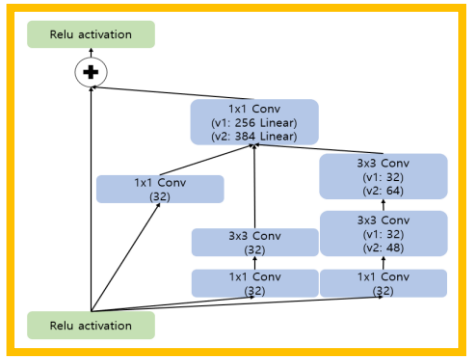
- **Method:**

Inception-v4

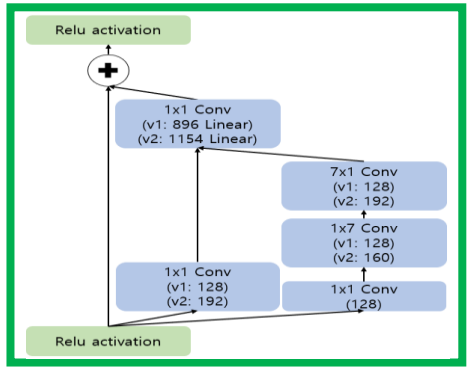


Inception-ResNet-v1, v2

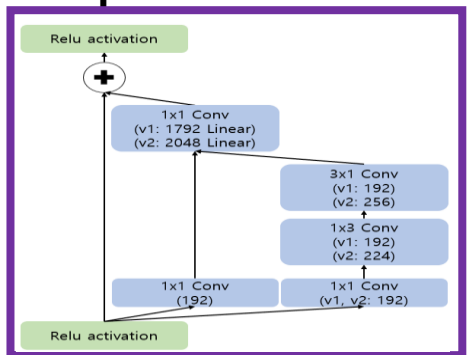
Inception-ResNet-A



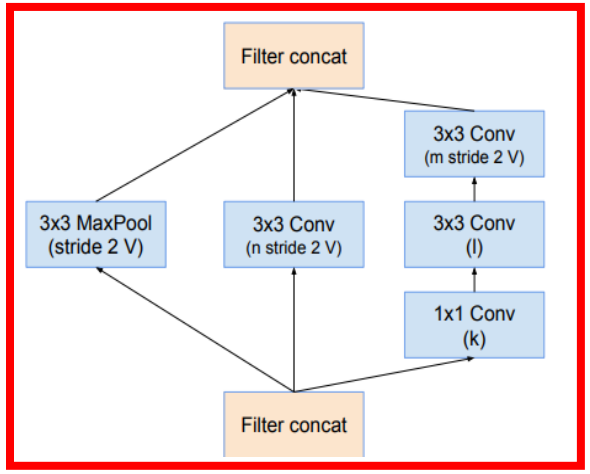
Inception-ResNet-B



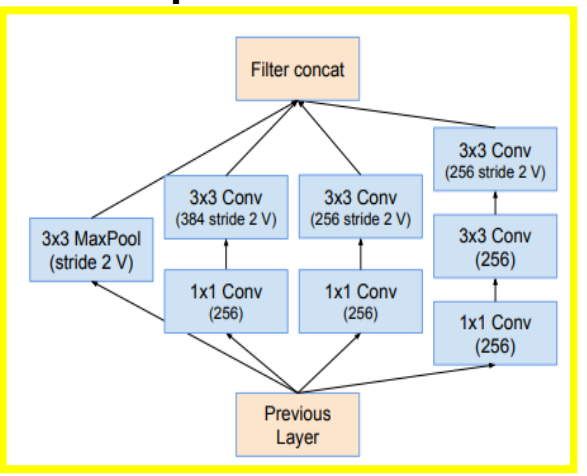
Inception-ResNet-C



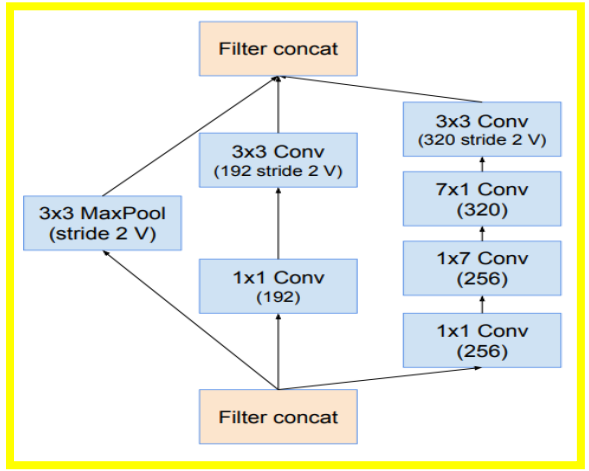
Reduction-A



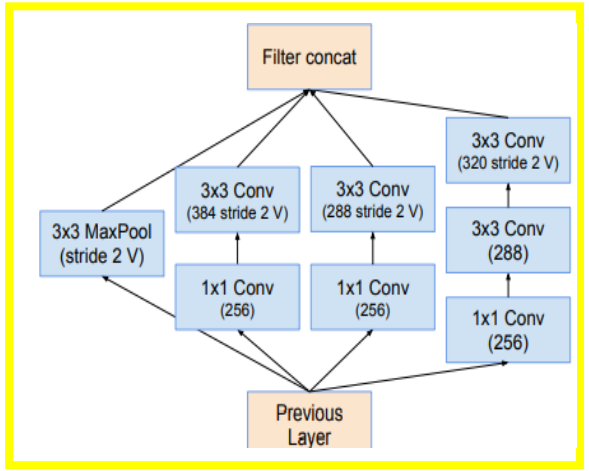
Reduction-B: Inception-ResNet-v1



Reduction-B: Inception-v4



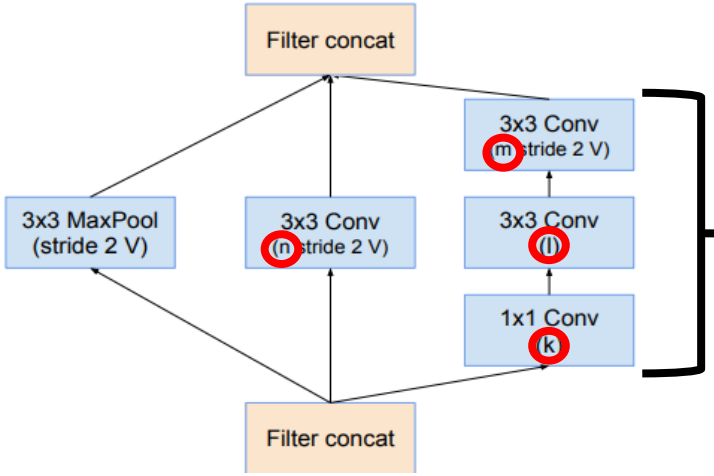
Reduction-B: Inception-ResNet-v2



Inception-v4, Inception-ResNet and the Impact of Residual Connections on Learning (CVPR 2016)

- **Method:**
  Inception-ResNet-v1: Inception-v3와 유사한 계산비용을 가진 하이브리드 버전
  Inception-ResNet-v2: Recognition 성능이 크게 향상된 계산 비용이 많이 드는 하이브리드 버전
  Inception-v4: Inception-ResNet-v2와 동일한 recognition 성능을 가진 Non-residual, pure Inception 버전
  Residual Inception Blocks: 연산할 **파라미터 수를 줄이기** 위해 1x1 Conv를 먼저 진행 → 입력 차원 수 ↓
  Activation Scaling: 잔차(Residual)를 Scaling해 **학습의 안정성**을 높임.

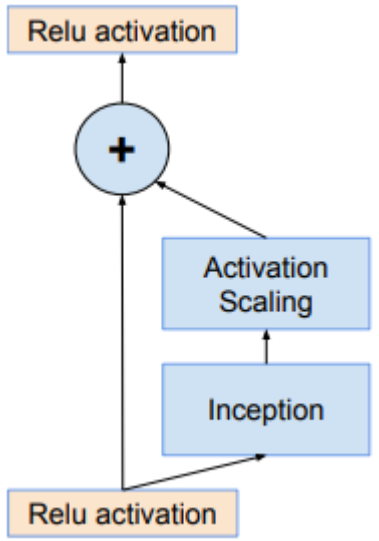
Reduction-A



Number of filters of the Reduction-A

Network	k	l	m	n
Inception-v4	192	224	256	384
Inception-ResNet-v1	192	192	256	384
Inception-ResNet-v2	256	256	384	384

Activation Scaling

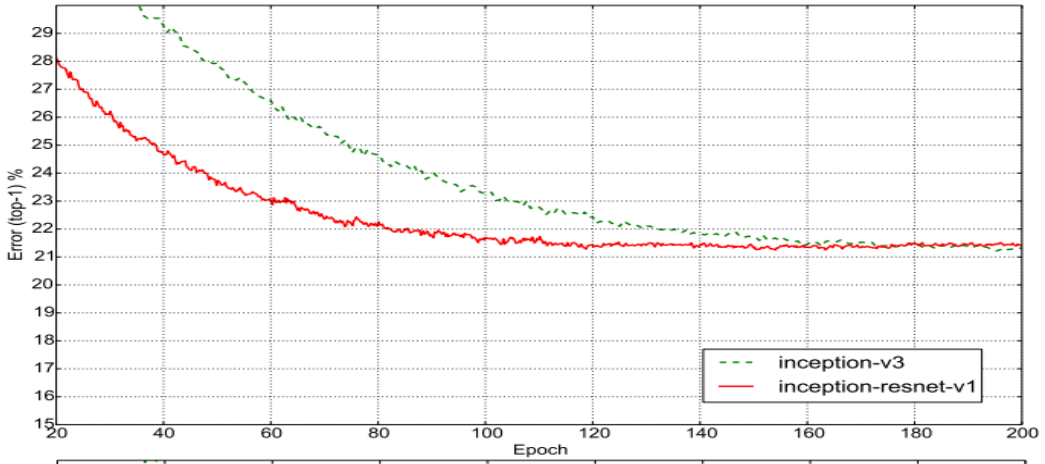


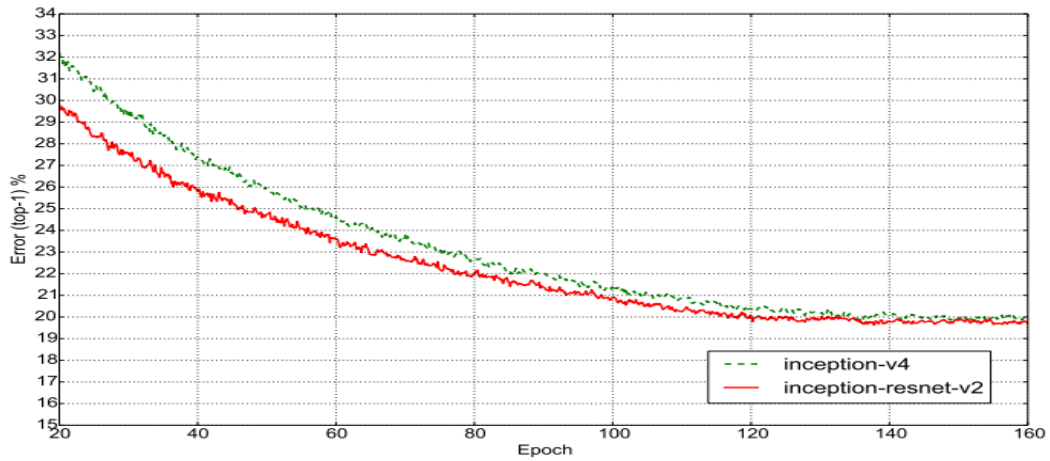
Scaling Factor: 0.1 ~ 0.3
General Scaling Factor: 0.1

Inception-v4, Inception-ResNet and the Impact of Residual Connections on Learning (CVPR 2016)

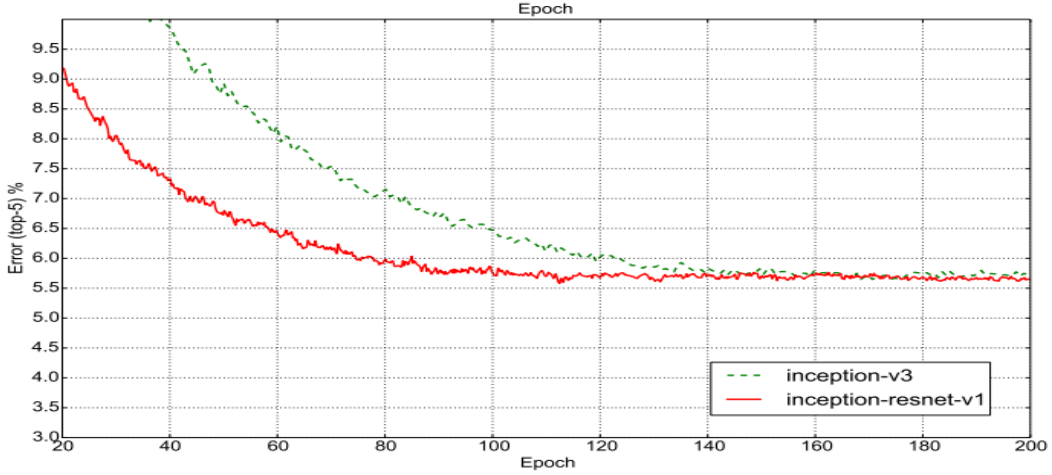
- **Experiment:**
  Residual connection의 도입으로 Inception 구조의 학습속도가 향상되고, 기존의 성능을 능가한다.
  (계산 효율성 유지 + 학습 속도 향상)
  Top-1, -5 error measured on a single crop on the non-blacklist images of the ILSVRC-2012 validation set (Inception-v3 vs Inception-ResNet-v1), (Inception-v4 vs Inception-ResNet-v2)

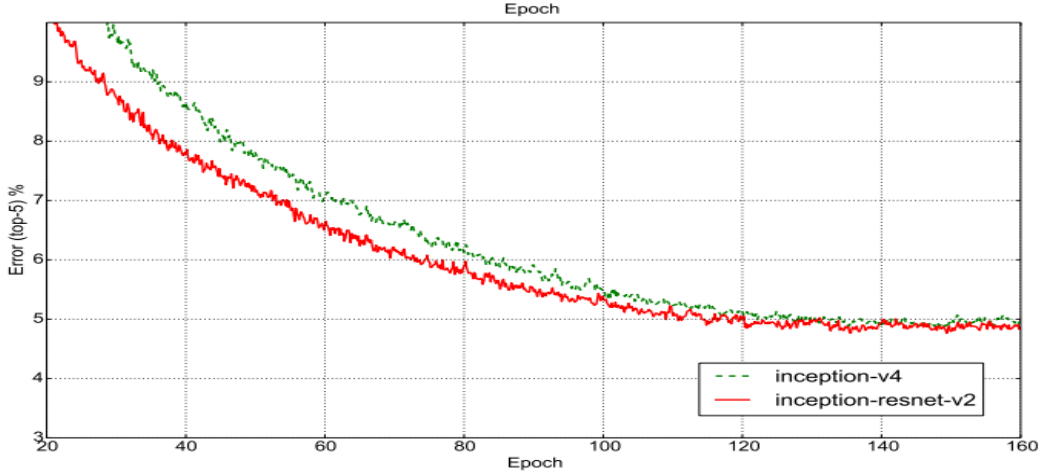
Top-1





Top-5





Inception-v4, Inception-ResNet and the Impact of Residual Connections on Learning (CVPR 2016)

- **Experiment:**
  Residual connection의 도입으로 Inception 구조의 학습속도가 향상되고, 기존의 성능을 능가한다.
  (계산 효율성 유지 + 학습 속도 향상)

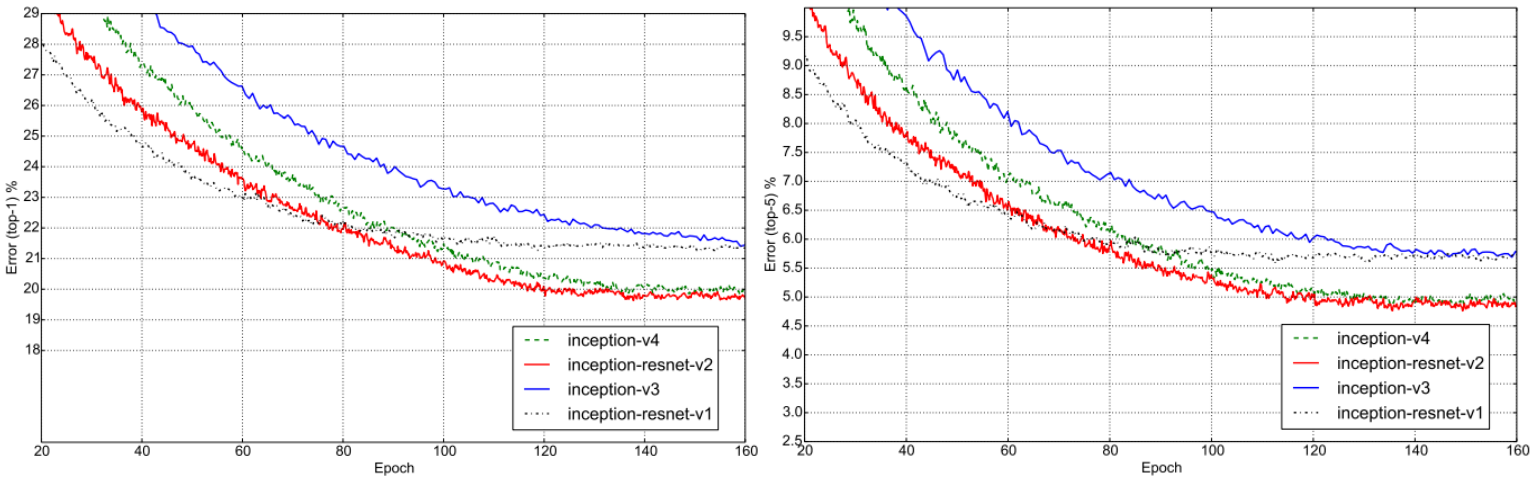
Top-1, -5 error on the non-blacklisted subset of the validation set of ILSVRC 2012.

Network	Top-1 Error	Top-5 Error
BN-Inception [6]	25.2%	7.8%
Inception-v3 [15]	21.2%	5.6%
Inception-ResNet-v1	21.3%	5.5%
Inception-v4	20.0%	5.0%
Inception-ResNet-v2	19.9%	4.9%

Ensemble results on all 50000 images of the validation set of ILSVRC 2012

Network	Models	Top-1 Error	Top-5 Error
ResNet-151 [5]	6	–	3.6%
Inception-v3 [15]	4	17.3%	3.6%
Inception-v4 + 3× Inception-ResNet-v2	4	16.5%	3.1%

Top-1, -5 error evolution of all four models (Single model, crop)



Inception-v4, Inception-ResNet and the Impact of Residual Connections on Learning (CVPR 2016)

- **Experiment:**
  실험에서 residual connection의 유무에 상관없이 모든 이전 네트워크 성능을 능가하는 모습을 보였다.
  (**Inception-v4**)

Evaluation of various number of crop on all 50000 images of the validation set of ILSVRC 2012

Network	Crops	Top-1 Error	Top-5 Error
ResNet-151 [5]	10	21.4%	5.7%
Inception-v3 [15]	12	19.8%	4.6%
Inception-ResNet-v1	12	19.8%	4.6%
Inception-v4	12	18.7%	4.2%
Inception-ResNet-v2	12	18.7%	4.1%

Network	Crops	Top-1 Error	Top-5 Error
ResNet-151 [5]	dense	19.4%	4.5%
Inception-v3 [15]	144	18.9%	4.3%
Inception-ResNet-v1	144	18.8%	4.3%
Inception-v4	144	17.7%	3.8%
Inception-ResNet-v2	144	17.8%	3.7%