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Image Pre-Transformation for Recognition-Aware Image Compression

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Introduction

Images with high compression ratios degrade deep neural network (DNN) recognition accuracy

- ✓ DNNs automatically obtain a feature extraction mechanism and selectively **extract high frequency features** of images (e.g. Gabor like edge)
- ✓ Lossy image compression **discards the high frequency information** and often brings coding artifacts (e.g. block-shaped distortions, mosquito noises)

Our Goal : Prevent the DNN recognition accuracy degradation due to lossy compression

Basic Ideas

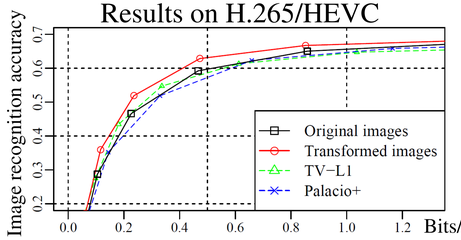
Increasing spatial correlation for reduce bitrates while maintaining accuracy using image pre-transformation

- ✓ Our method pre-transforms images before lossy compression
- ✓ Related work [Palacio+, CVPR18]
  - Their model pre-transform in images that gave them higher accuracy than the original one
  - The encoder-decoder (ED) model is learnt with the backpropagated loss of DNNs

Results

- ✓ **Higher accuracy** than some benchmarks in highly compressed situation
- ✓ **Good BD-Rate(Accuracy) gain** on various encoders

Results on H.265/HEVC



	Palacio+	TV-L1 [Le Guen, IPOL14]	Ours
JPEG	+3.7%	+0.4%	**-11.9%**
JPEG2000	+15.9%	+1.3%	**-17.8%**
HEVC	+9.5%	-3.9%	**-21.5%**

BD-Rate(Accuracy) on each encoder

	w/o TV	w/ TV
w/o bypass	+9.5%	-14.7%
w/ bypass	+4.2%	**-21.5% (Ours)**

Ablation results of our methods on HEVC

Experimental Conditions
Task: ImageNet classification problem
Network: VGG-16 [Simonyan & Zisserman, ICLR15]
QPs selection for BD-Rate: 4points under 1.0bpp
Hyper-parameter: $\lambda = 1.0$

Conclusion

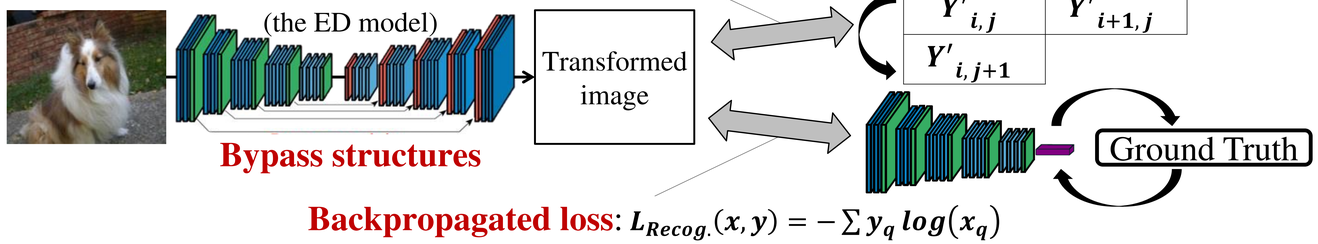
Our image pre-transformation model can prevent the DNN accuracy degradation due to compression on various encoders

- Our method can apply for JPEG and JPEG2000 directly, in contrast previous works [Choi & Bajic, ICASSP18] [Galteri+, ICPR18]
- Future works: further improve the loss functions and investigate our method's impact on recognition performance that humans can achieve

Our Method

- ✓ Proposed model is learnt with total variation loss and backpropagated loss
  $Loss = L_{Recog.}(x, y) + \lambda \cdot L_{TV}(Y')$ * λ: Hyper-parameter
  - Total variation (TV) loss has the effect of increasing the spatial correlation
  - Because it is **not differentiable** that directly calculate bitrate, we focus on the **spatial correlation** of images
- ✓ Our model is the ED model with bypass structures
  - Bypass structures can prevent degradation problem of DNN [He+, CVPR16] and make it possible to utilize local image features

TV loss: $L_{TV}(Y') = \sum \left(\left| Y'_{i+1,j} - Y'_{i,j} \right|^2 + \left| Y'_{i,j+1} - Y'_{i,j} \right|^2 \right)$



Backpropagated loss: $L_{Recog.}(x, y) = -\sum y_q \, log(x_q)$