The effect of image enhancement algorithms on convolutional neural networks

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Outline

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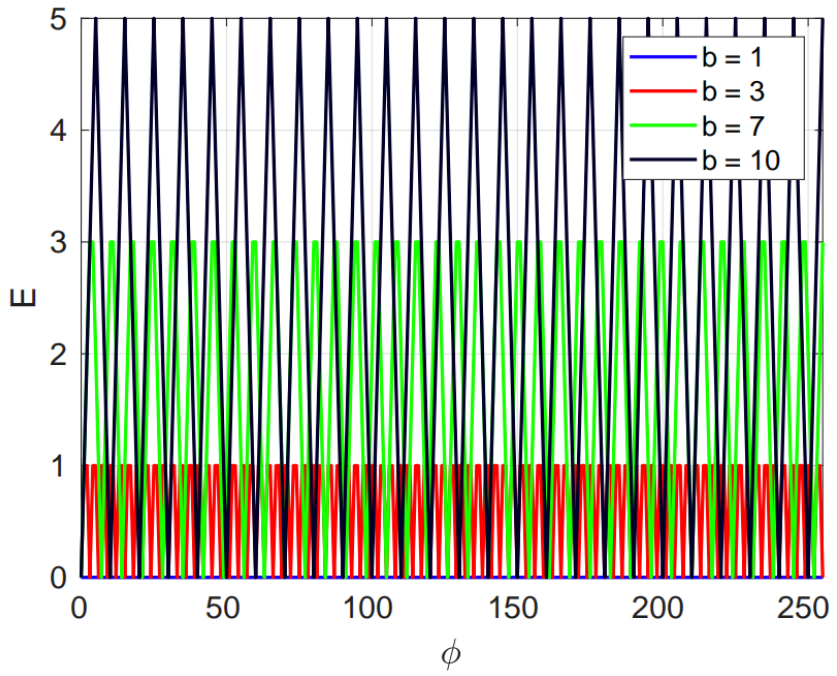
Introduction

- Convolutional Neural Networks (CNNs) are deep neural networks that combine convolutional with subsampling layers
- CNNs are used broadly in several disciplines
- They are more used in computer vision applications
- Image Quality has a high impact on the CNN performance
- Low Brightness degrades the CNN performance
- Four Well-Known Contrast Enhancement Techniques are applied in this work to improve Accuracy

Original Image

Dark Image

Methodology



- Original Image pixel is encoded with an integer inside the next range of values:

$$\phi \in \{0, \ldots, 2^H - 1\} \qquad (1)$$

- Image brightness is controlled by an integer scale factor called as **Bright Scale (b) following the next expression:**

$$\hat{\phi} = \text{floor}\left(\tilde{\phi} + \frac{1}{2}\right) = \text{floor}\left(\frac{1}{b}\phi + \frac{1}{2}\right) \qquad (2)$$

- A quantization Error is produced due to rescale process:

$$E = \left|b \cdot \hat{\phi} - \phi\right| = \left|b \cdot \text{floor}\left(\frac{1}{b}\phi + \frac{1}{2}\right) - \phi\right| \qquad (3)$$

Experimental Results

- Three well-known CNNs are used: AlexNet, GoogleNet and ResNet-50 implemented in Python with Torchvision (a package of PyTorch)
- Four contrast enhancement algorithms are used in the experiments: Gamma Correction (**GC**), Logarithm Transformation (**LT**), Histogram Equalization (**HE**) and Contrast-Limited Adaptive Histogram Equalization (**CLAHE**)
- Each Accuracy-1 point is calculated through 1000 images choosen randomly from the ILSVRC2012 Validation Dataset
- Bright Scale is swept from 1 to 10

Experimental Results

Bright

HE

Image 328
ILSVRC2012
Validation Dataset

b = 1

LT

GC
(γ=0.5)

CLAHE
ClipLimit=10.0,tileGrid=5x5

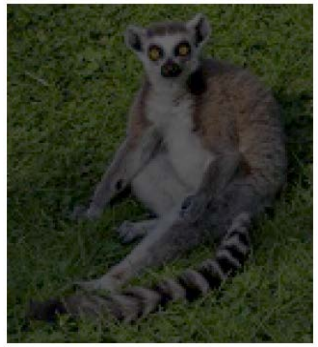
Dark

HE

Image 5944
ILSVRC2012
Validation Dataset

b = 6

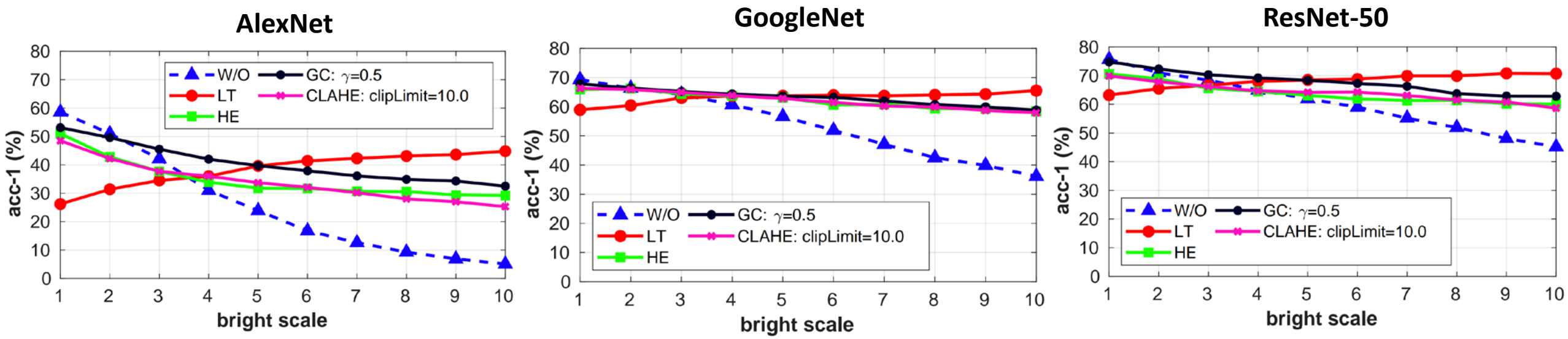
LT



GC
(γ=0.5)

CLAHE
ClipLimit=10.0,tileGrid=5x5

Experimental Results



- Good improvement of Accuracy (acc-1) for dark images
- Accuracy-1 boost around 40% for AlexNet when b = 10
- The best algorithm for dark images is LT
- The best algorithm for bright images is GC

Conclusions

- Four well-known contrast enhancement algorithms have been proposed to improve the accuracy of CNNs when illumination is low: HE, CLAHE, GC and LT
- The four algorithms improve the accuracy for dark images
- LT is the best algorithm for dark images, but it presents some issues for brighter ones
- The other algorithms: GC, HE and CLAHE are more robust than LT for a wider range of brightness

Thank you for your attention!

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