The effect of image enhancement algorithms on convolutional neural networks

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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.
Methodology

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

\[ \phi \in \{0, \ldots, 2^H - 1\} \quad (1) \]

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

\[ \hat{\phi} = \text{floor} \left( \frac{1}{b} \phi + \frac{1}{2} \right) = \text{floor} \left( \frac{1}{b} \phi + \frac{1}{2} \right) \quad (2) \]

- A quantization Error is produced due to rescale process:

\[ E = \left| b \cdot \hat{\phi} - \phi \right| = \left| b \cdot \text{floor} \left( \frac{1}{b} \phi + \frac{1}{2} \right) - \phi \right| \quad (3) \]
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 chosen randomly from the ILSVRC2012 Validation Dataset

Bright Scale is swept from 1 to 10
Experimental Results

**Bright**

- Image 328
  - ILSVRC2012 Validation Dataset
  - HE
  - GC ($\gamma=0.5$)
  - CLAHE ClipLimit=10.0,tileGrid=5x5
  - $b = 1$

**Dark**

- Image 5944
  - ILSVRC2012 Validation Dataset
  - HE
  - GC ($\gamma=0.5$)
  - CLAHE ClipLimit=10.0,tileGrid=5x5
  - $b = 6$
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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