CS229: Machine Learning
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Dan Boneh, Andrew Ng

It's Your Life. Make It Colorful!

Old Image De-noising and Auto Colorization Using Lin. Reg., MLP, and CNN

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Motivation

- **De-noising** and **Auto-colorization**
  I. Old images of friends and family members
  II. Low-resolution surveillance camera images
  III. Historic film footages

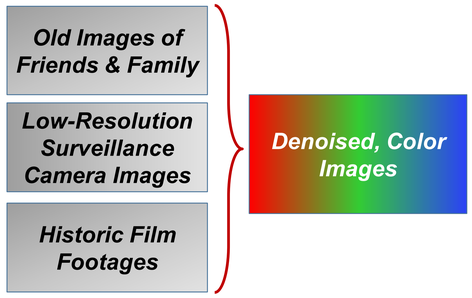


Fig. 1. Application of our motivation

Dataset Generation

- CIFAR-10 (Due to hardware limitations)
- 60000 32×32 RGB images
  I. Converted to greyscale images
  II. Introduced 15% salt & pepper noise
  III. 70% training set, 30% test set

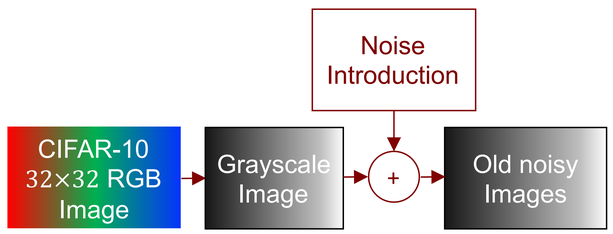


Fig. 2. Generation of old and noisy images

Methodology

- **De-noising**
  I. Linear Regression & Noise Detector
    - Least-squares loss (LSL)
- **Colorization**
  I. Multi-layer Perceptron (MLP)
    - LSL without regularization
    - LSL with L2 regularization
  II. Convolutional Neural Network (CNN)
    - MSE loss
    - MSE + cross entropy loss
    - Integration of transfer learning (resnet)

Network Architecture

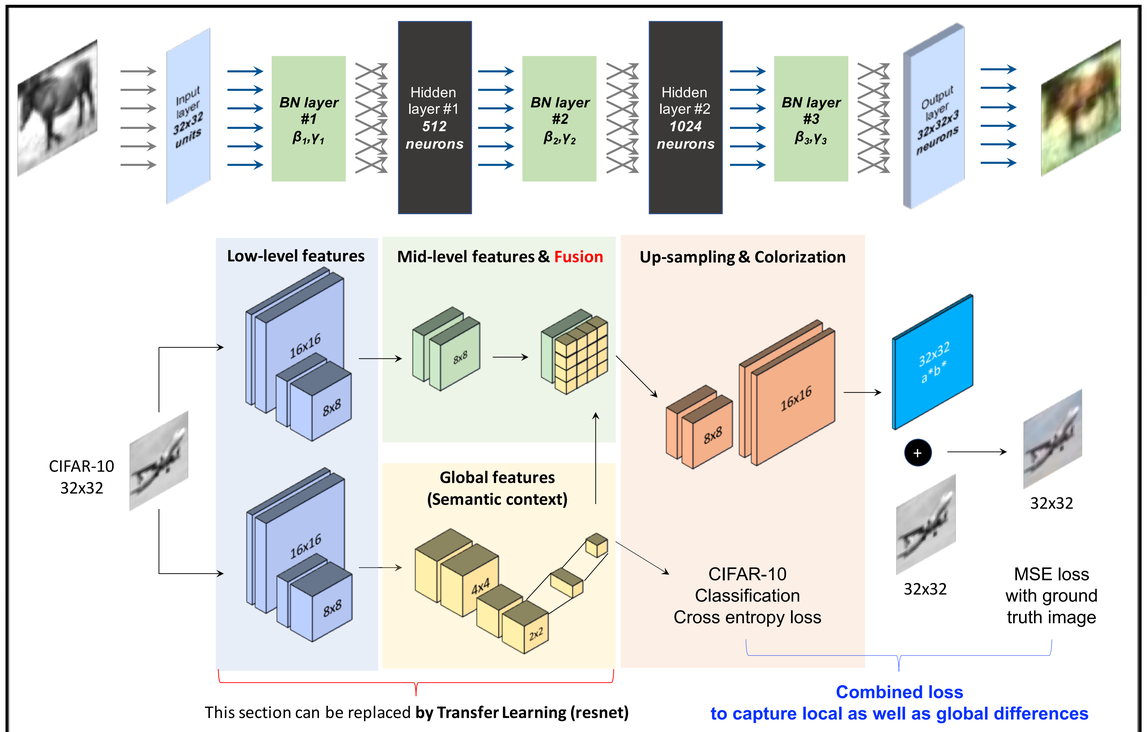
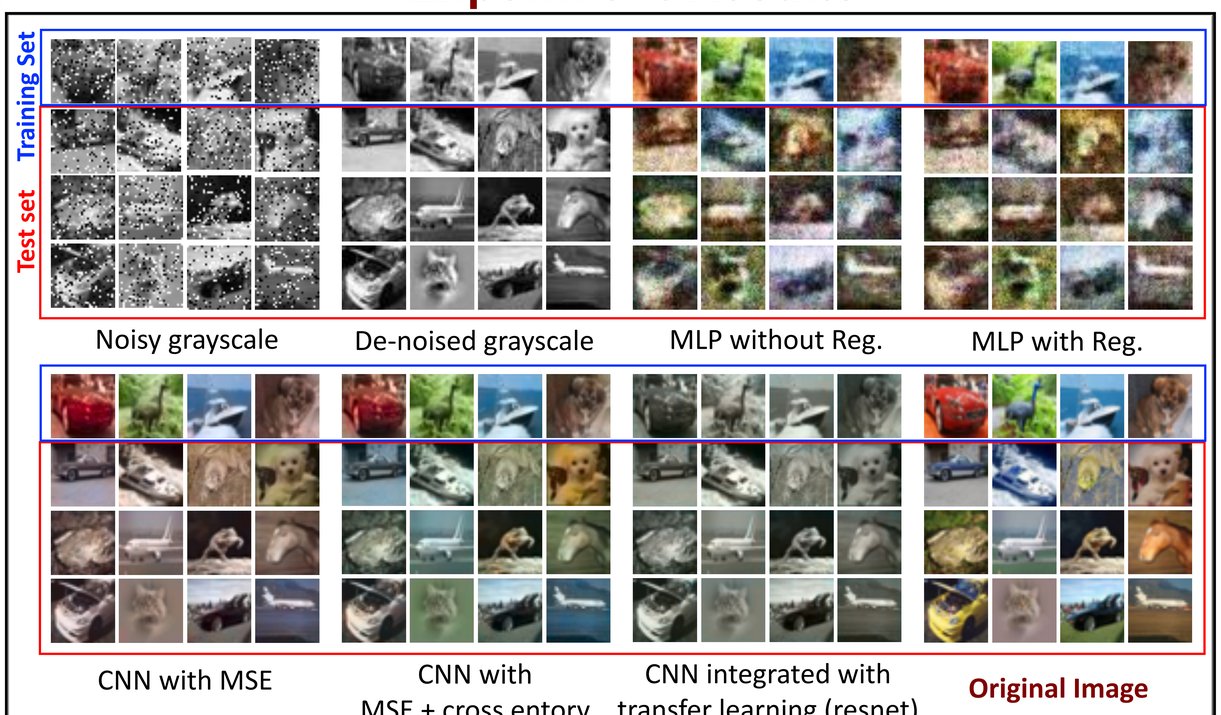


Fig. 3. Implemented MLP and CNN architecture, MLP (top) and CNN (bottom)

Experiment Results



Loss in CNN

Total loss: $L(y^{color}, y^{class})$

$$\underbrace{\|y^{output} - y^{truth}\|^2}_{\text{Image}} + \alpha \underbrace{\left(y^{true\ class} - \log\left(\sum_i e^{\hat{y}_i^{softmax\ output}}\right)\right)}_{\text{Classification}}$$

Fig. 4. Total combined loss that captures semantic info.

Error Analysis

Method	Avg. Squared Error
Lin. Reg. (De-noising)	0.12 %
MLP without Reg.	3.41 %
MLP with Reg.	3.30 %
CNN (MSE)	0.69%
CNN (MSE + CE)	0.61%
CNN (Transfer Leaning)	0.72 %

Fig. 5. Average squared error of the methods used

Conclusions

- Without noise-detection, linear regression performs poorly in removing noise
- MLP is an over-parameterized model
  - Adding more layers exacerbates the problem
  - L2-regularization doesn't help much
- CNN never restores original images
- However, CNN fused with global features extraction greatly improve adding semantic info.

Future Work

- Add image segmentation, e.g. super pixel algorithms for better semantic understanding
- Implement CNN model on bigger dataset
- Improve the transfer learning CNN model

References

[1] https://www.cs.toronto.edu/~kriz/cifar.html
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[3] Iizuka, et al. ACM Trans. Graph. 35, 4, Article 110, 2016
[4] Ioffe and Szegedy, In 32nd International Conference on Machine Learning, Lille, France, 2015
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