Maximizing Feature Extraction in Deep Neural Networks for Transfer Learning

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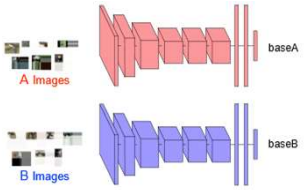
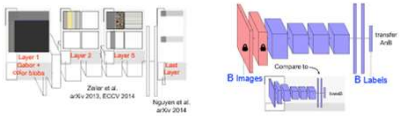
Introduction



Training on multiple datasets:
- We can train separate models for the separate data-sets
- Performance may be reduced when there is not enough training examples for data-set B.



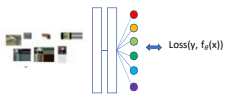
- Instead, pre-train on dataset A:
  - Initialize first few layers with weights from A
  - Randomly initialize remaining layers
  - Reduce learning rate and "fine tune" on dataset B
- This improves accuracy on dataset B **[1, 4]**

Methods

We would like to extract more features from A to increase fine-tuning performance on B.

Idea is to pose a harder problem to the network

- Given dataset **A** with data (x, y) where y∈ C={1, 2,…,N}, e.g. **{1,2,3,4,5,6}**.



References

[1] J. Yosinski, J. Clune, Y. Bengio, and H. Lipson, "How transferable are features in deep neural networks?," in *Advances in Neural Information Processing Systems 27*, Z. Ghahramani, M. Welling, C. Cortes, N. D. Lawrence, and K. Q. Weinberger, Eds. Curran Associates, Inc., 2014, pp. 3320–3328.
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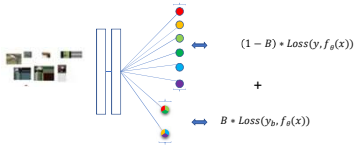
[6] W. Yang, *pytorch-classification: Classification with PyTorch*. 2017.
[7] *vision: Datasets, Transforms and Models specific to Computer Vision*. pytorch, 2017.

Methods – con't

- **Randomly** partition C into 2 equal seized subsets, e.g. c0=**{1,3,4}**, c1=**{2,5,6}**
- New labels $y_b(y) = \begin{cases} 0, if\ y \in c_0 \\ 1, otherwise \end{cases}$



- New dataset **A'** (x, y, y_b(y))
- New loss $(1-B) * Loss(y, f_{\theta(x)}) + B * Loss(y_b, f_{\theta(x)})$

- Train the network on dataset **A'**, then
  - Initialize new network with weights from A' and remove binary layer, educe learning rate.
  - Reset final classification layer, use normal learning rate.
  - Train for reduced number of epochs on **B**

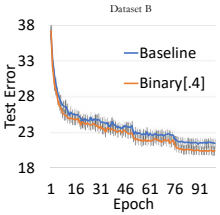
Intuition: instead of finding minimum features for classification (e.g. sphere is ball, rectangle is box), find features that relate classes to each other.

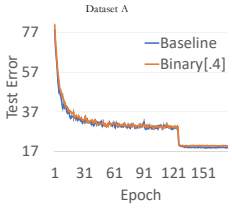
Results

Dataset:
- CIFAR-100, 32X32, 100 classes, 500 images/class for train, 100 images/class for test
- 50/50 split for A, B

Network:
- DenseNet-BC (L=100, k=12), only 0.8M

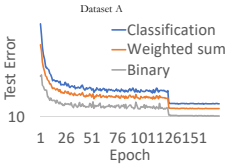
Regime:
- Train on A for 175 epochs with or without binary layer, fine-tune on B for 100 epochs (early stopping)



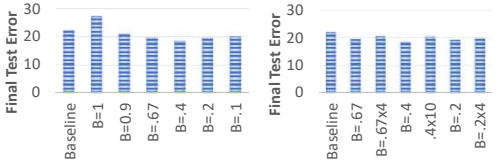


Results - con't

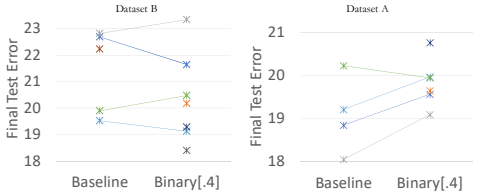
- Test error for classification and binary layers are smoothly converging



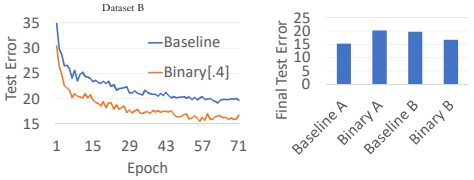
Binary layer in A improved performance on B
- Weight of binary loss affected performance
- More binary layers is worse than one binary layer



- Binary classifier generally **reduces** the test error on dataset B at the cost of an **increase** in test error on dataset A.

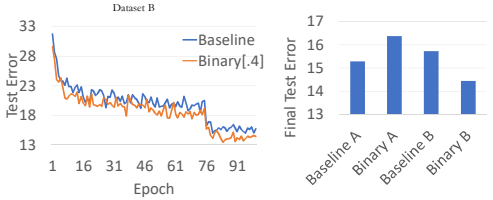


- **WideResNet** (WRN-28-10 (drop 0.3), 36.48M) on **CIFAR-100**
- Train 112 epochs on A, fine-tune 71 epochs on B
- we observe an even greater performance increase

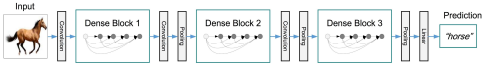


Results - con't / Discussion

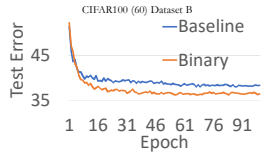
- Using a **DenseNet** (DenseNet-121 (k=32), 8M) on **ImageNet-100** we also observe a performance improvement



- There is a dependency on class **split**
- There's **always** tradeoff between **reduced** performance on A with **improved** performance on B
- Larger network (ResNet) has greater improvement, suggesting network needs sufficient **capacity**. Perhaps the DenseNet used is too small.



- Multiple binary layers reduces performance, suggesting there may not be nice minima for multiple layers
- Transferring out of domain from CIFAR-100 to CIFAR-10 or SVHN showed no improvement.
- Reducing CIFAR-100 to 60 images/class showed some improvement, but error was high and variable at different classes sizes



Conclusions / Future Work

- Observed improvement on multiple architectures and datasets with a binary layer
- Use larger and better optimized network
- Increase number of replications to verify result is not random