Autoencoder and Rate Distortion Theory

Soma Mbadiwe Information Theory | December 12, 2019 | WVU

Autoencoder: Quick Overview



Rate Distortion, Mutual Information ... and all that hazy stuff

 $R(D) = R^{(I)}(D) = \min_{p(\hat{x}|x): \sum_{(x,\hat{x})} p(x)p(\hat{x}|x)d(x,\hat{x}) \le D}$ $I(X; \hat{X})$

Conjecture: the min of $I(X; \hat{X})$ is always such that the conditional probability constraint (that given sum up there) = D.

I(X;Y)

Χ



In Picture: Prof. Wole Soyinka; the first African Nobel laurate.



Distortion measures used

- Mean Square Error (MSE) $MSE = \frac{1}{N} \sum_{i=1}^{N} (Y_i - \hat{Y}_i)^2$
- Root Mean Square Error (RMSE) $RMSE = \sqrt{MSE}$
 - Itakura-Saito distance $d_{IS} = \sum_{i} \left(\frac{p_i}{q_i} - \ln \frac{p_i}{q_i} - 1 \right)$
- I-divergence

$$I(\boldsymbol{p}||\boldsymbol{q}) = \sum_{i} p_{i} \ln \frac{p_{i}}{q_{i}} - \sum_{i} (p_{i} - q_{i})$$

Data Used

Dataset

- Cars Dataset (16,185 images of 196 classes of cars.)
- https://ai.stanford.edu/~jkrause/cars/car_dataset.html
- Original Image size
 - > 224 x 224 x 3 (~588Kb on a 64bit machine)







Distortion measure: MSE. Bottleneck: 7 x 7 x 512. Reduction: 6x



Image Reconstructions for different distance measures at different epochs.

Bottleneck: $7 \times 7 \times 512$

Reduction: 6x



Image
Reconstructions
for different
distance
measures at
different epochs.

epoch BEST

Bottleneck: 7 x 7 x 512

Reduction: 6x



Pushing it further:

Let's try x12 reduction (Bottleneck: 7x7x256)



Loss vs Epoch plot for different distance measures.

Bottleneck: $7 \times 7 \times 256$

Reduction: 12x



Distortion measure: MSE. Bottleneck: 7 x 7 x 256. Reduction: 12x. 30 Epochs





Image Reconstructions for different distance measures at different epochs.

Bottleneck: 7 x 7 x 256

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Trained for 30 epochs





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Trained for 30 epochs

Pushing it even further:

Let's try x24 reduction (Bottleneck: 7x7x256)

Additional Resources

Code and additional information available at https://github.com/smbadiwe/Autoencoder