Neural Style Transfer Quiz Questions

Yashila Bordag
Division of Computing, Data Science, and Society
Department of Classics
University of California, Berkeley
Berkeley, CA 94720
yashila.bordag@berkeley.edu

William Brandon
Department of Computer Science
Department of Mathematics
University of California, Berkeley
Berkeley, CA 94720
williambrandon@berkeley.edu

Wangda Lei
Department of Computer Science
University of California, Berkeley
Berkeley, CA 94720
radarlwd@berkeley.edu

Let us consider the content loss function presented in the lecture notes and that we used in the assignment:

$$L^l_{content}(\vec{p}, \vec{x}) = \frac{1}{2} \sum_{i,j} (F^l_{ij} - P^l_{ij})^2 \tag{1}$$

$$L_{content}(\vec{p}, \vec{x}) = \sum_{l \in L} L^l_{content}(\vec{p}, \vec{x}) \tag{2}$$

1. What do we use the content loss defined by (1) and (2) for?

2. Calculate the partial derivative of the layer content loss with respect to the activation F^l_{ij}.

3. Now calculate the partial derivative of the total content loss with respect to the activation F^l_{ij}, using your answer from the last part.

Now let us consider the style loss function presented in the lecture notes and the that we used in the assignment. This loss is markedly different from the content loss defined earlier, as it involves both a Gram matrix and an expectation:

$$G^l_{ij} = \sum_k F^l_{ik} F^l_{jk}, \tag{3}$$

$$E_l = \frac{1}{4N_l^2 M_l^2} \sum_{i,j} (G^l_{ij} - A^l_{ij})^2 \tag{4}$$

$$L_{style}(\vec{a}, \vec{x}) = \sum_{l \in L} w_l E_l \tag{5}$$

4. What do we use the style loss defined by (3), (4), and (5) for?

Now we give you the partial derivative of the expectation with respect to the activation F^l_{ij}:

$$\frac{\partial E_l}{\partial F^l_{ij}} = \frac{1}{N_l^2 M_l^2} (F^l)^T (G^l - A^l), \tag{6}$$

5. Now using the derivative of the expectation with respect to F^l_{ij} given above, calculate the partial derivative of the total style loss with respect to the activation F^l_{ij}.

Now recall the total loss function:

$$L_{total}(\vec{p}, \vec{a}, \vec{x}) = \alpha L_{content}(\vec{p}, \vec{x}) + \beta L_{style}(\vec{a}, \vec{x}) \tag{7}$$

6. Finally, using problems 3. and 5. calculate the partial derivative of the total loss with respect to the activation F^l_{ij}.

Recall the basic gradient descent step:

$$w^{t+1} = w^t + \eta_t \nabla Loss, \tag{8}$$

7. Now using your answer from problem 6. write the update step for F^l_{ij} with update weight η and image $\vec{x}$.

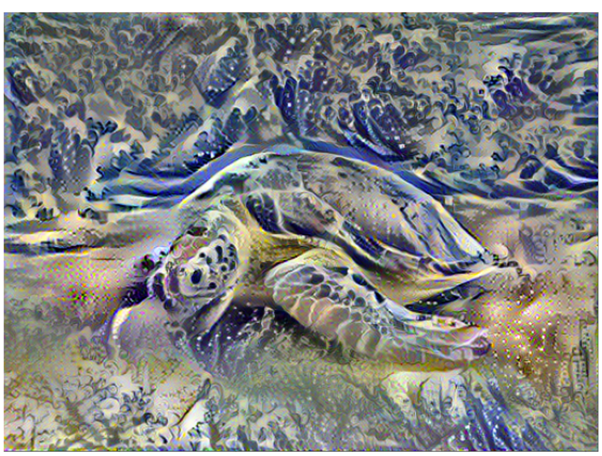
8. Given a pretrained image classification model based on a convolutional neural network architecture, how do we extract the raw content and style features from an image? You don't need to describe how we measure similarity using those features.

9. True or false: Obtaining a model suitable for running the Neural Style Transfer algorithm requires training on a large dataset of triples of the form (content image, style image, combined style-transferred image). Explain your answer.

10. True or false: A Neural Style Transfer model can transfer style from a style source image that was not in its training data set. Explain your answer.

11. At what steps in the Neural Style Transfer algorithm do we use the content source image?

12. Both of the following images were generated by applying Neural Style Transfer to a content source image consisting of a photograph of a sea turtle, using style information from the woodblock print The Great Wave off Kanagawa. One of the images was generated using the first 3 layers of a pretrained convolutional neural network (CNN) to extract style features, while the other image was generated using the first 5 layers of the same network for style features. Which of the two images was generated using 3 layers, and which was generated using 5? Justify your answer.



References

[1] Gatys, L. A., Ecker, A. S., Bethge, M. et al. "A neural algorithm of artistic style." arXiv preprint, 2015, `https://arxiv.org/abs/1508.06576`.

[2] Simonyan, K., Zisserman, A. "Very Deep Convolutional Networks for Large-Scale Image Recognition." arXiv preprint, 2015, https://arxiv.org/pdf/1409.1556.

[3] Yuan, R. "Neural Style Transfer: Creating Art with Deep Learning using tf.keras and eager execution." Medium, 3, Aug. 2018, https://medium.com/tensorflow/neural-style-transfer-creating-art-with-deep-learning-using-tf-keras-and-eager-execution-7d541ac31398.

[4] "Neural style transfer." TensorFlow.org, 2020, https://www.tensorflow.org/tutorials/generative/style_transfer.