

IHC Style Transfer to H&E Stained Histological Images

By:-

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Outline

Objective

Types of staining

What is neural style transfer

Cost functions

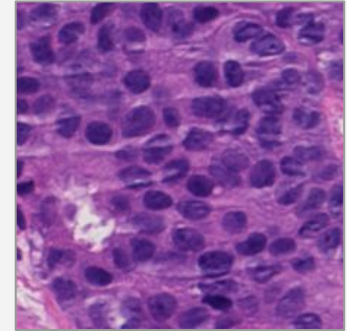
Results

Hematoxylin and Eosin (H&E) and Immunohistochemistry(IHC) Stains

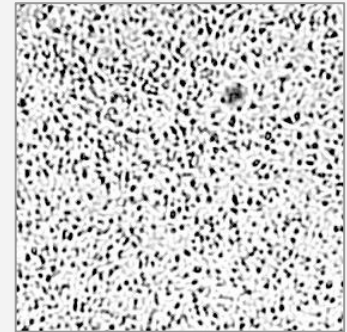
Staining is used to enhance contrast in samples, generally at the microscopic level. Stains and dyes are frequently used in histology (the study of tissue under the microscope).

Haematoxylin stains cell nuclei blue, while eosin stains cytoplasm, connective tissue and other extracellular substances pink or red. Eosin is strongly absorbed by red blood cells, colouring them bright red.

Immunohistochemistry involves the process of selectively identifying antigens (proteins) in cells of a tissue section by exploiting the principle of antibodies binding specifically to antigens in biological tissues



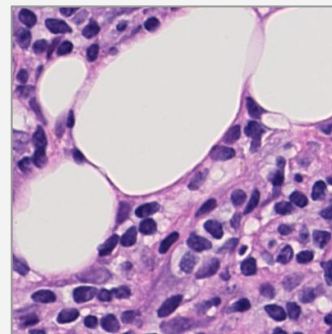
H&E stained tissue of Lymph node follicle region



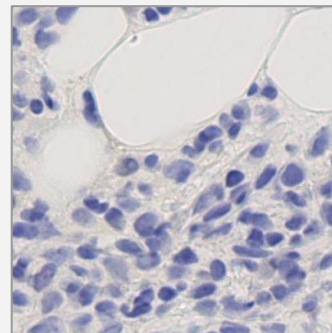
IHC stained tissue of mouse brain-slice

Hematoxylin and Eosin (H&E) and Immunohistochemistry(IHC) Stains

Staining Method	Approximate Commercial Cost Per Slide
Routine H&E staining	\$7
IHC Staining	\$38
Double IHC Staining	\$76
IHC Work-up	\$800



H&E



IHC stained tissue of mouse brain

Data Courtesy: Robert H. Lurie Comprehensive Cancer Center of Northwestern University

<http://sites.cancer.northwestern.edu/pathcore/pricing.cfm>

Neural Style Transfer



Neural Style Transfer

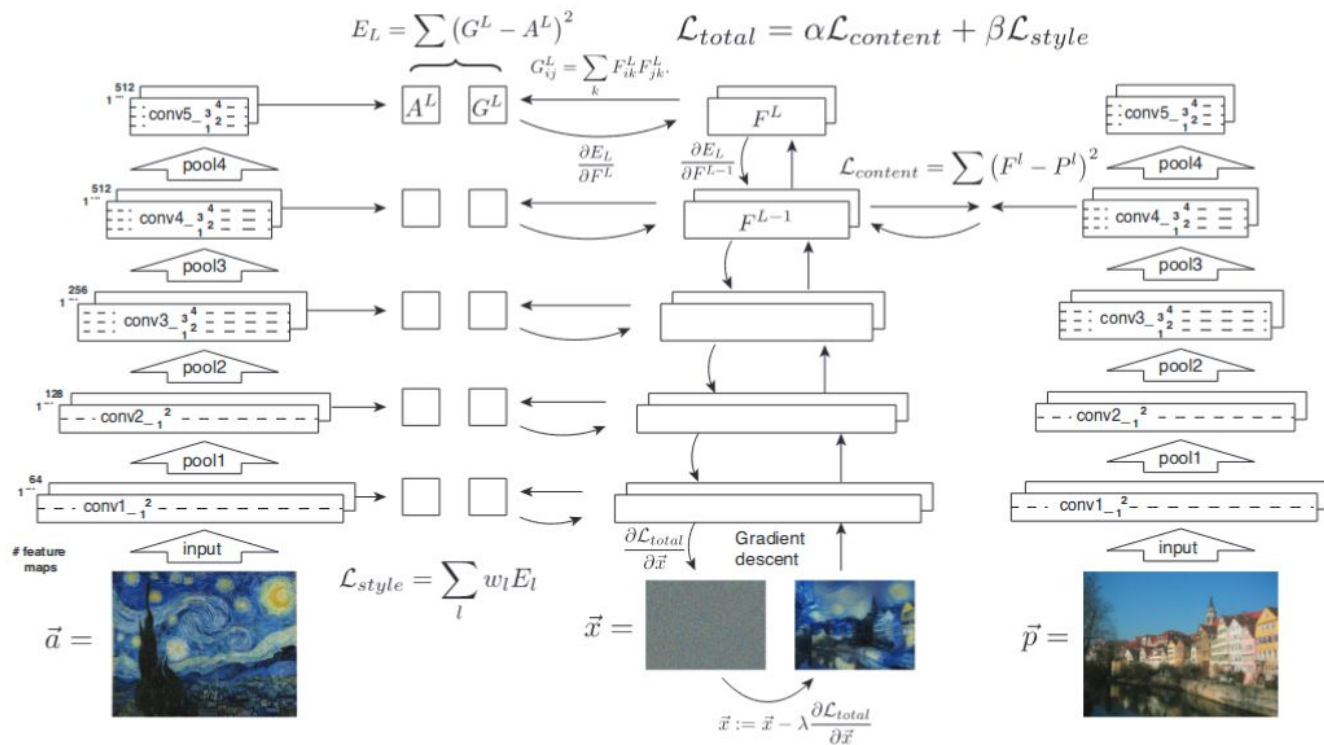


Image Ref. L. A. Gatys, A. S. Ecker and M. Bethge, "Image Style Transfer Using Convolutional Neural Networks,"

Style Transfer

1) Content Loss:

To calculate the content loss, we take the feature representation of only one of the layers.

E.g. VGG19 architecture : l th convolutional layer

$$\mathcal{L}(C, G, l) = 1/2 \sum (L_l(G) - L_l(C))^2$$

where $L_l(x)$ represents feature matrix of image x at output of layer l

Style Transfer

2) Style Loss:

To calculate style loss we first compute the Gram Matrices of outputs of different layers for style and generated images

$$\mathcal{L}_{\text{GM}}(S, G) = (1/4N_l^2M_l^2) \sum (GM_l(G) - GM_l(S))^2$$

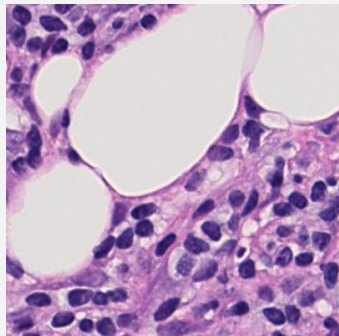
where $GM_l(x)$ represents Gram matrix of image x at output of layer l

While computing style loss we use multiple activation layers, that gives flexibility of assigning different weights to each sub loss provided by different layers

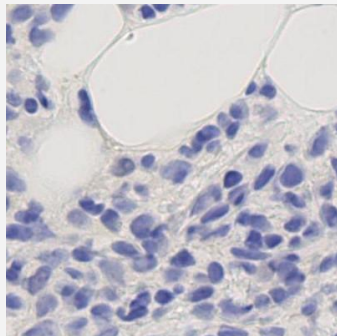
$$\mathcal{L}_{\text{style}}(S, G) = \sum w_i * \mathcal{L}_{\text{GM}}(S, G, i)$$

where i runs from 0 to L i.e number of layer included

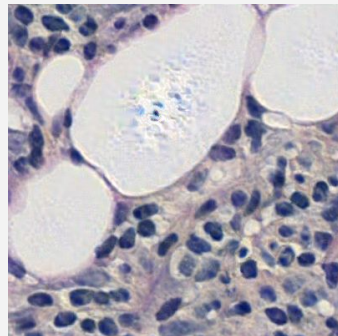
Style Transfer



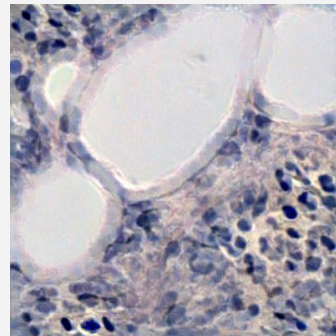
H & E stained patch



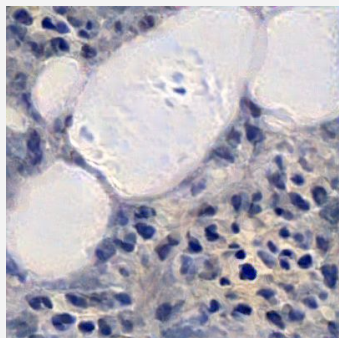
Groundtruth IHC



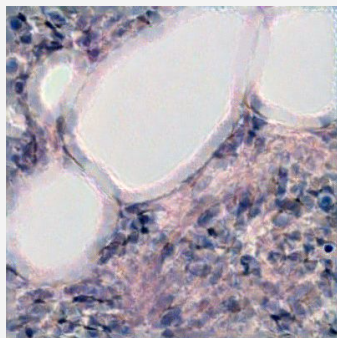
Low content loss



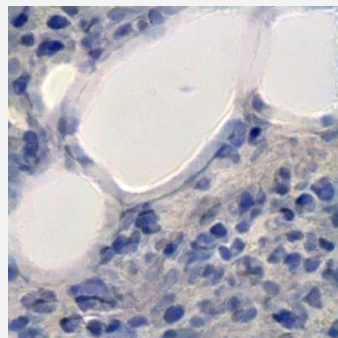
High style loss



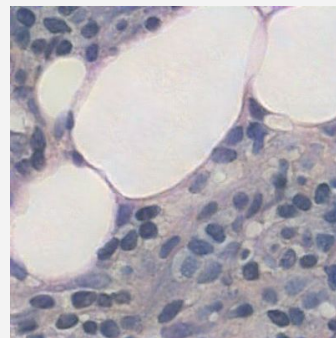
mae Loss



content loss at
higher layers



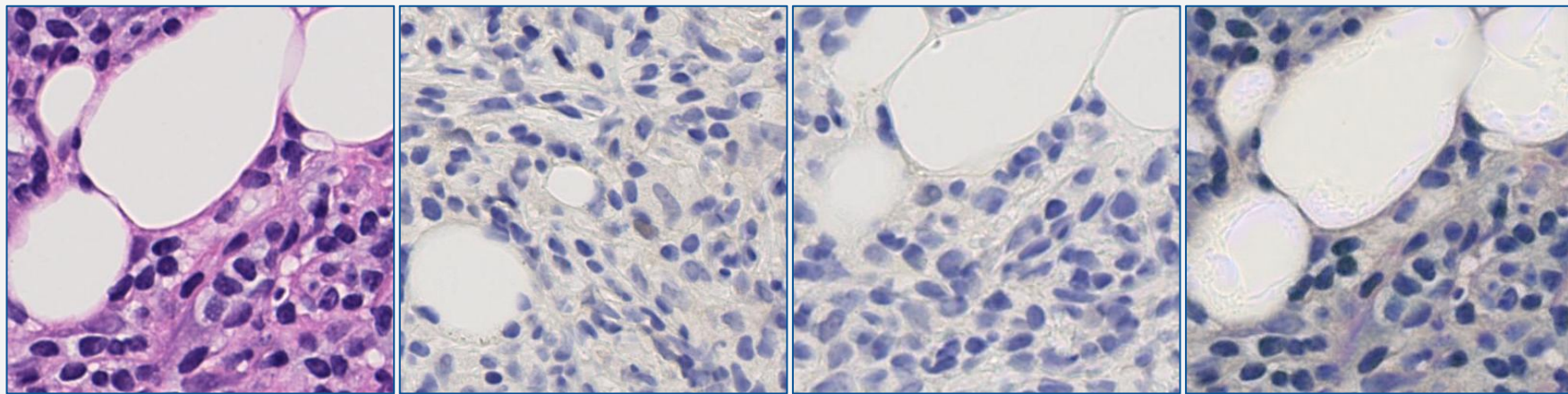
High weight to
higher layers



best result

Results

Patch 1



HnE

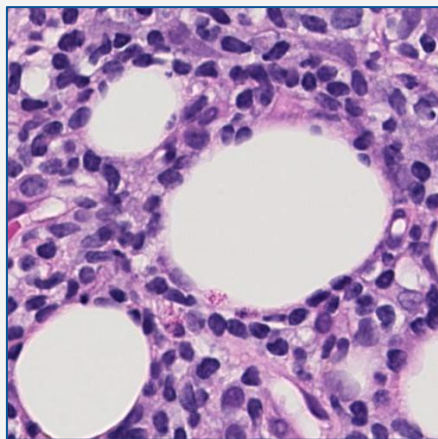
Style Image

Real IHC

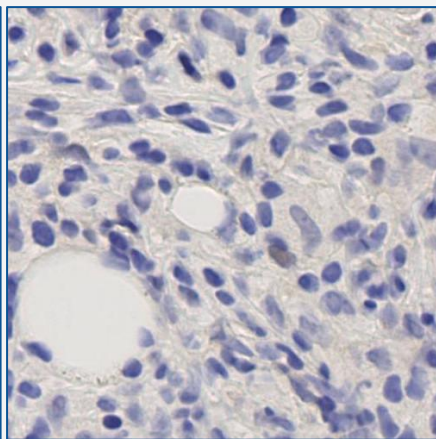
Style Transferred

Results

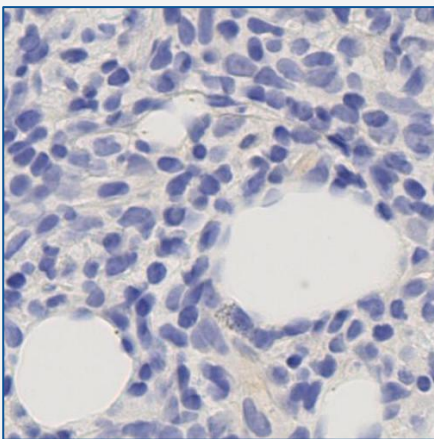
Patch 2



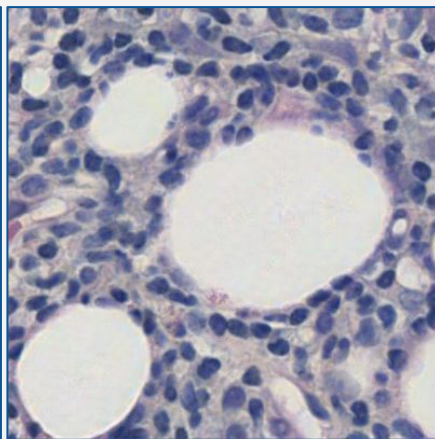
HnE



Style Image



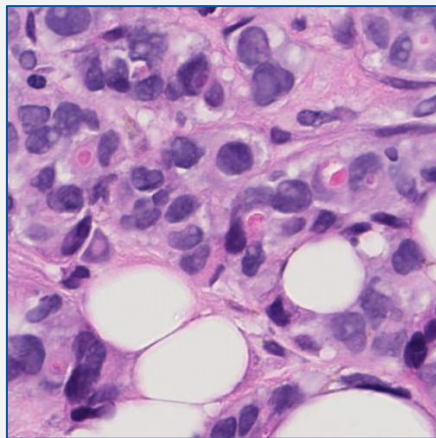
Real IHC



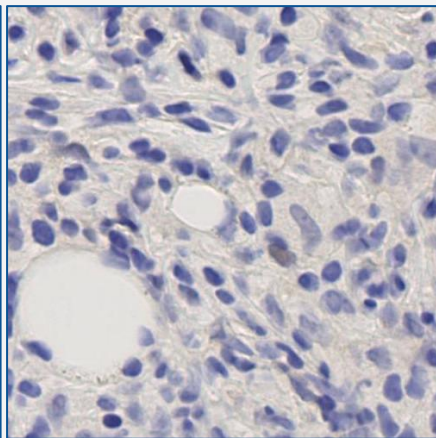
Style Transferred

Results

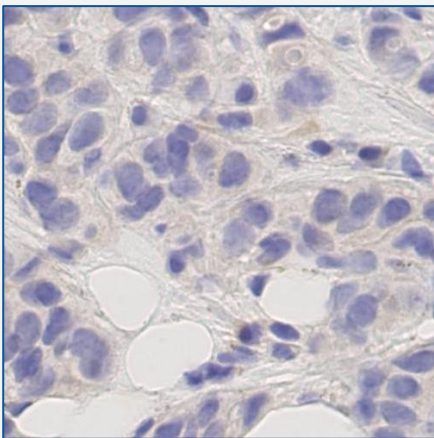
Patch 3



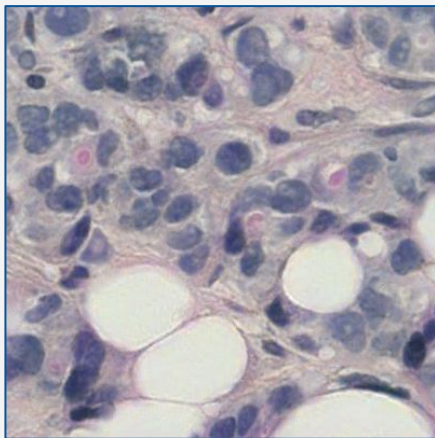
HnE



Style Image



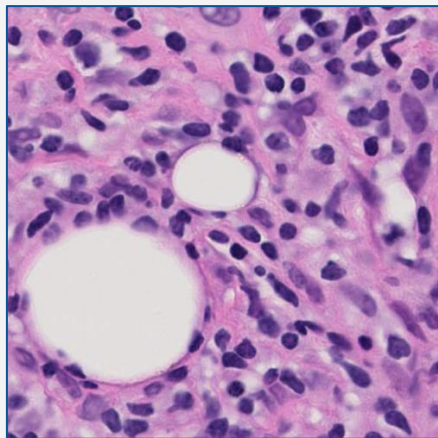
Real IHC



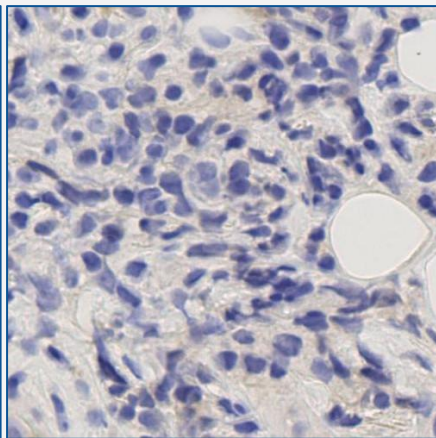
Style Transferred

Results

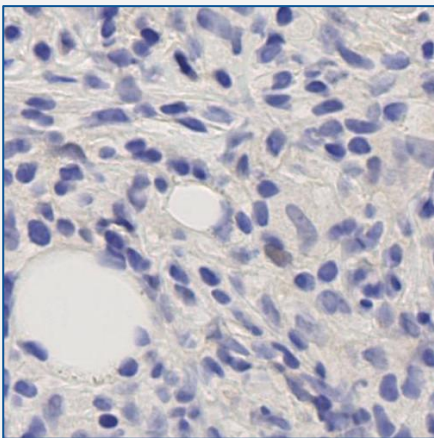
Patch 4



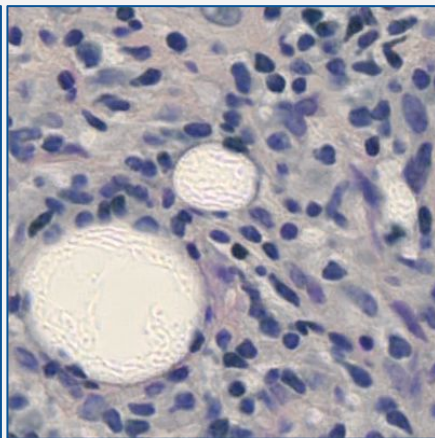
HnE



Style Image



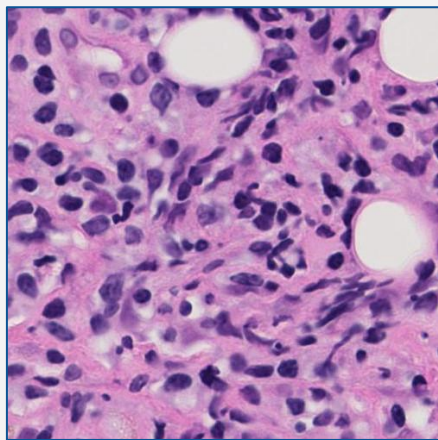
Real IHC



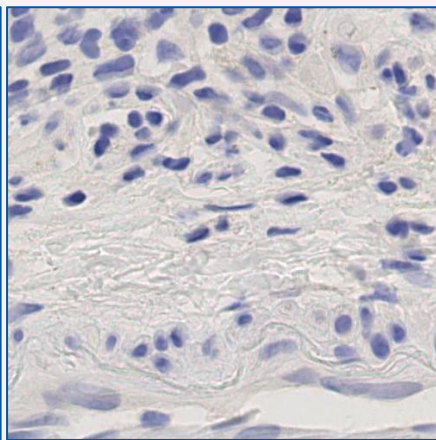
Style Transferred

Results

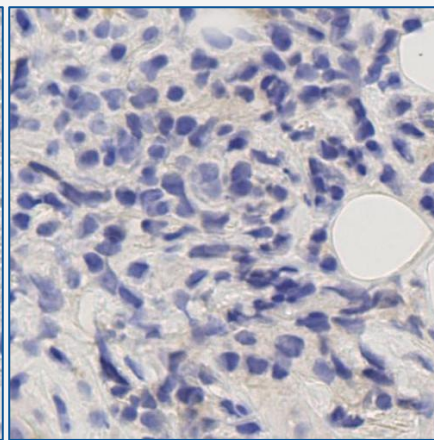
Patch 5



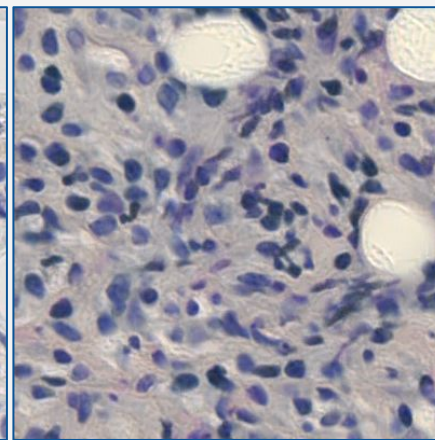
HnE



Style Image



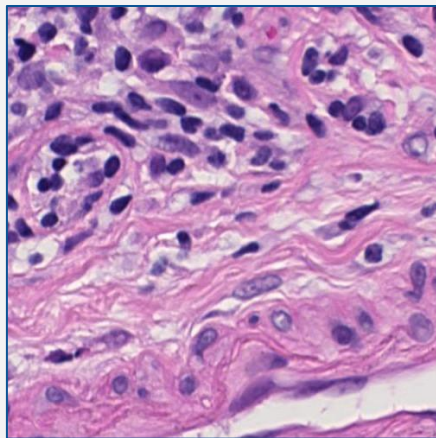
Real IHC



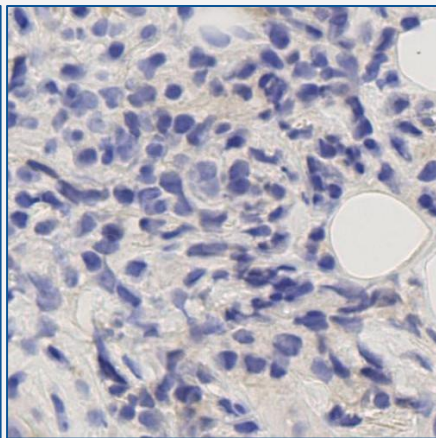
Style Transferred

Results

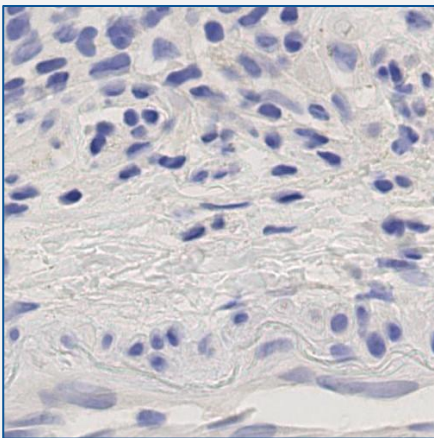
Patch 6



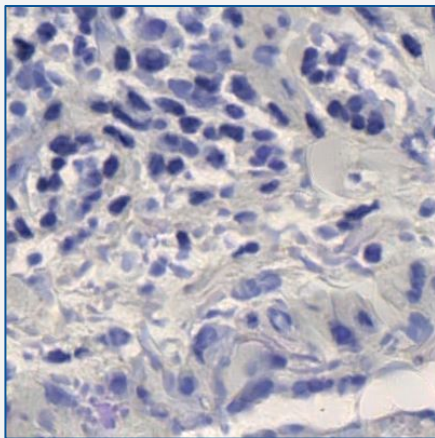
HnE



Style Image

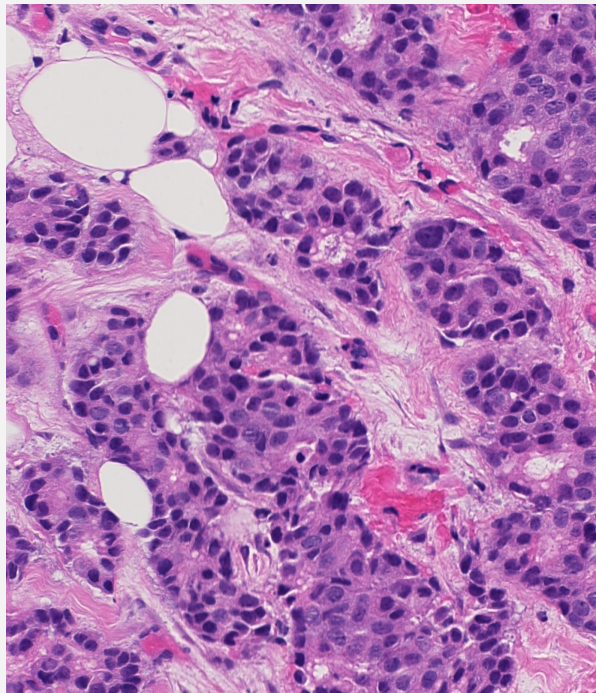


Real IHC

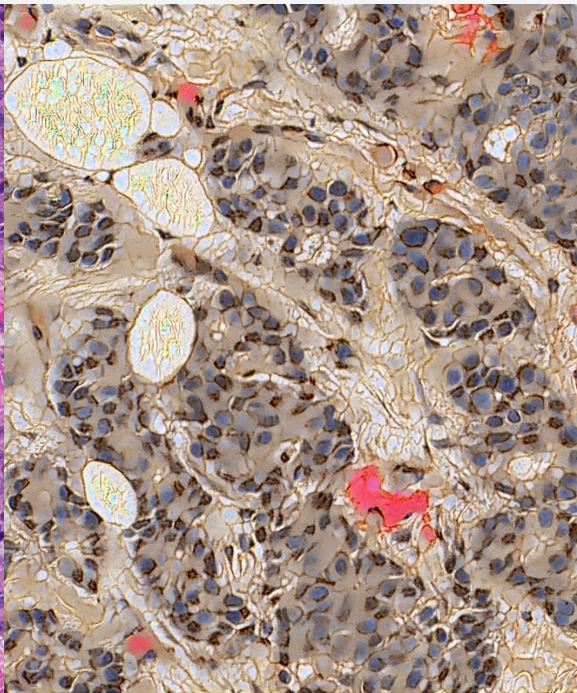


Style Transferred

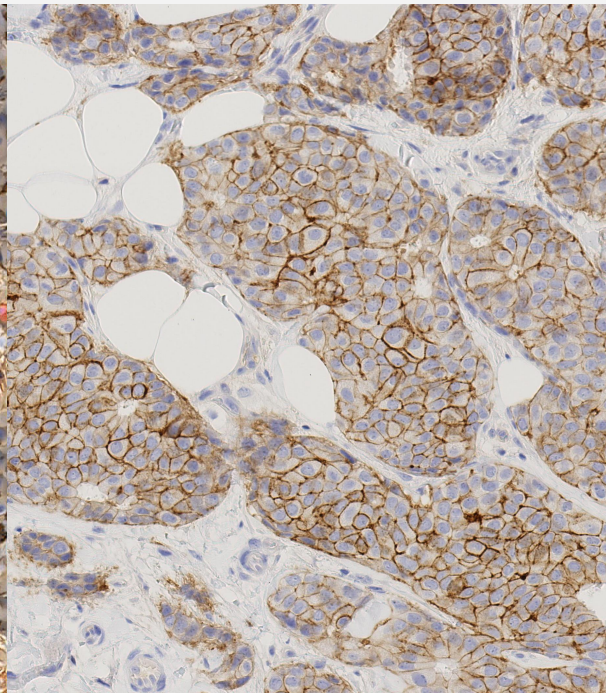
Results



HnE



Style Transferred



Actual IHC

Conclusion and Future work

Designing new loss functions which can help preserve the structure of medical images as content and structure is too important in medical images might improve the results.

Using the CNNs pre-trained on medical image data rather than natural images might improve the results.

Thank you !

References

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doi: 10.1109/CVPR.2016.265
URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7780634&isnumber=7780329>
2. Y. Jing, Y. Yang, Z. Feng, J. Ye, Y. Yu and M. Song, "Neural Style Transfer: A Review," in *IEEE Transactions on Visualization and Computer Graphics*.
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