SD-Layer: Stain Deconvolutional layer for CNNs in Medical Microscopic Imaging



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This poster presents a stain deconvolutional layer affixed at the front of a CNN. It transforms training on RGB intensities to training on stain absorption quantities.

Key Idea

Staining chemicals combine linearly in the optical density (OD) colorspace according to the Beer Lambert's law [1].

-Beer Lambert's Law-

The Imaging model (1)



| | Model Architectures | Accuracy (%) | F-Score (%) |
|--|---------------------|-----------------|----------------|
| | AlexNet | 87.9 | 88.12 |
| | T-CNN [3] | 92.48 | 92.7 |
| | AlexNet + SD-Layer | 88.5 | 88.32 |
| | T-CNN + SD-Layer | 93.2 | 93.08 |
| Table 1 : 5-fold cross validated performance of SD-Layer | | | |

- 2. Performance of frozen v/s trainable stain vector S.
 - Trainable S outperforms frozen S by a large margin





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absorbance of stain 'i' in channel 'c'

The optical density (OD) colorspace (2)

OD colorspace intensity at location 'p' and channel 'c' $O(p,c) = -\log \frac{I(p,c)}{I_{o,c}} = \sum_{i=1}^{N} Q(p,i) S(i,c)$

In Matrix Notation (3)

 $O = Q \qquad S$ $[MN \times 3] \qquad [MN \times 3] \qquad [3 \times 3]$

Key Insight

Fig 3: Test accuracy v/s epochs, evaluated on a single fold

- 3. Effect of Initialization of S on performance
 - SVD based initialization [2] works best



Fig 4: Test accuracy v/s epochs, for difference initializations.

References

[1] Ruifrok, Arnout C., and Dennis A. Johnston. "Quantification of histochemical staining by color deconvolution." *Analytical and* **Fig 5:** The left column is an example image of a lymphoblast. (a) is the original image, (b)-(d) are stain deconvolved images using stain vector obtained through SVD, (e)-(g) are the stain deconvolved images using stain vector after training

Matrix multiplication can be viewed equivalently as a convolution between rows and columns of the multiplying matrices.



quantitative cytology and histology 23.4 (2001): 291-299.

[2] Macenko, Marc, et al. "A method for normalizing histology slides for quantitative analysis." *Biomedical Imaging: From Nano to Macro, 2009. ISBI'09. IEEE International Symposium on.* IEEE, 2009.

[3] Andrearczyk, Vincent, and Paul F. Whelan. "Using filter banks in convolutional neural networks for texture classification." *Pattern Recognition Letters* 84 (2016): 63-69. T-CNN + SD-Layer for 300 epochs. The right column are corresponding images for an example lymphocyte.

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