Trainable Spectrally Initializable Matrix Transformations in CNNs

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Key Contributions

Proof-of-concept and implementation for a novel architectural component, which leverages **trainable linear matrix transformation module**

→ *can perform global transformation*

PyTorch based **open-source** implementations as a pip installable python package[1] and integrated into the DeepDIVA[2] deep learning framework

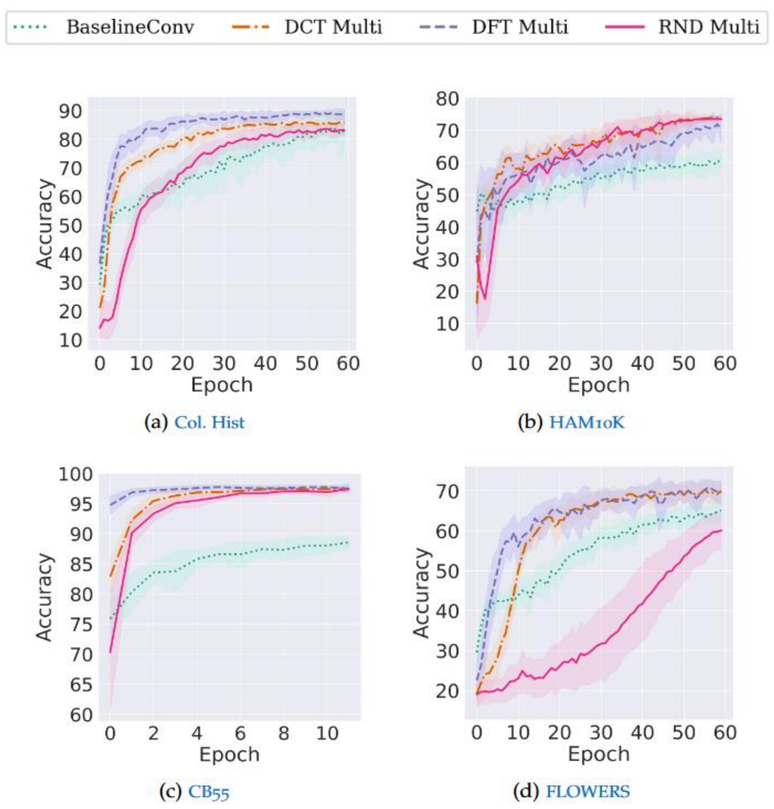
→ *enabling full reproducibility of experiments*

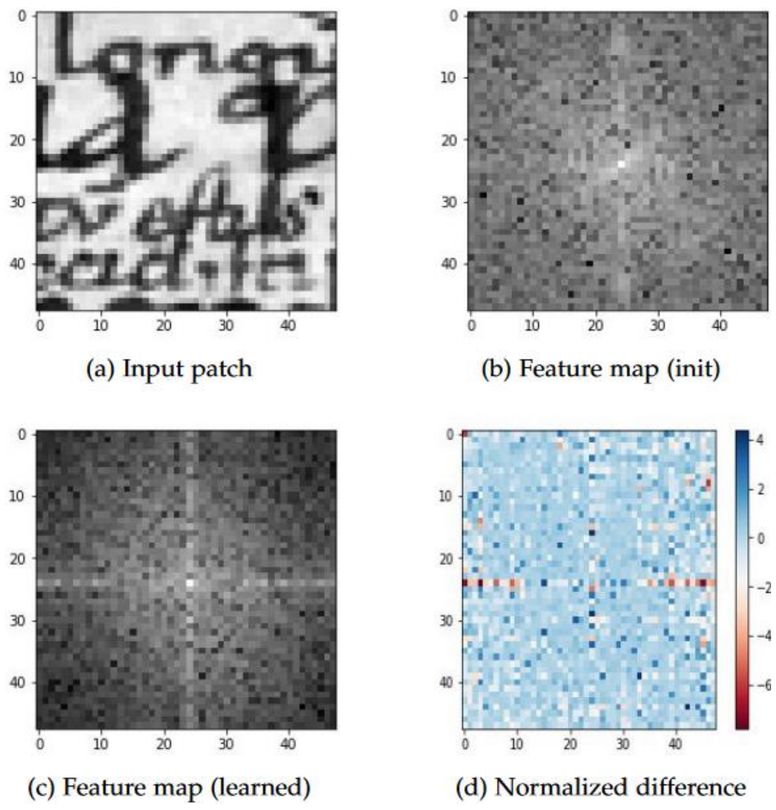
Why Should One Care?

Vanilla CNN **struggle** at applying global transformations (e.g., translation, rotation, scaling, …) and are **biased** towards texture for object recognition.

Global transformations are **useful** for texture analysis

Experimental Analysis





Proposed Module

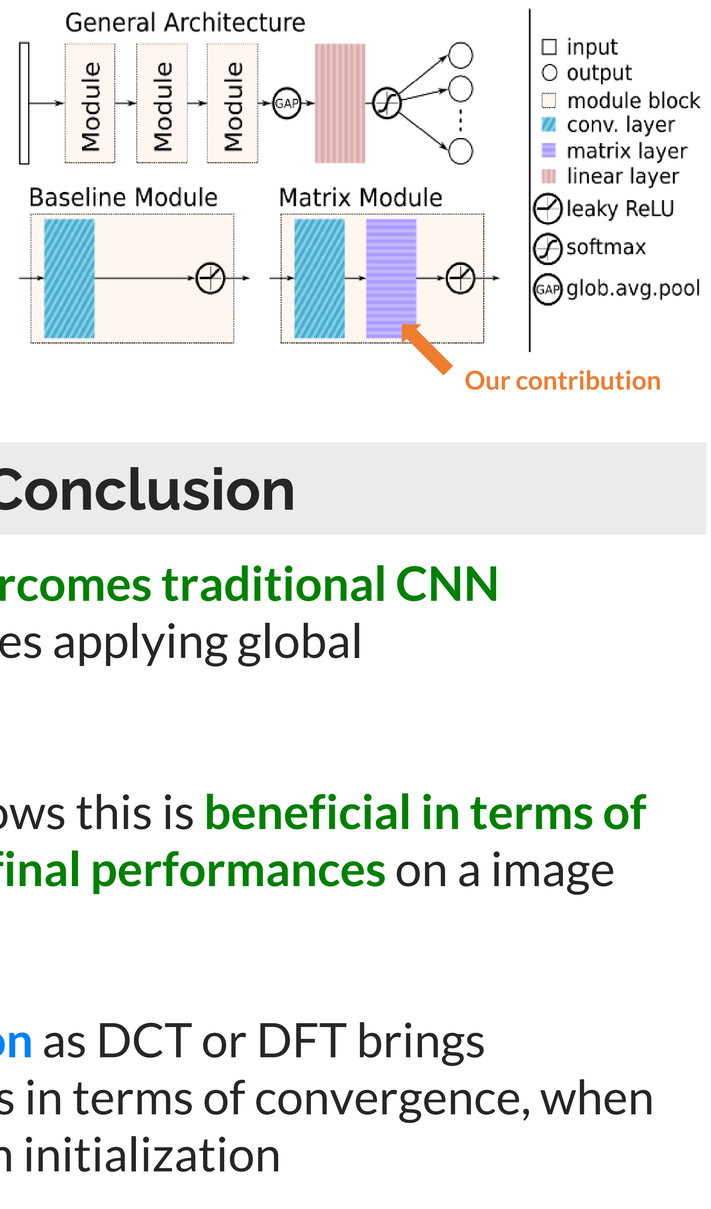
Matrix transform layer:

$$y_{mt} = W_1 \cdot x \cdot W_2^T$$

Instead of traditional:

$$y_{nn} = W \cdot x + b$$

Network Design



Results Overview

Models with matrix transformations **outperform the baseline**

Matrix transforms are **beneficial for convergence**

The DFT variants appears to be the **best performing**

Further research should also focus tasks such as video or medical tomography data analysis

Conclusion

Our component **overcomes traditional CNN limitation** and enables applying global transformations

Empirical results shows this is **beneficial in terms of learning speed and final performances** on a image classification task

Spectral initialization as DCT or DFT brings substantial speedups in terms of convergence, when compared to random initialization

1. Novel Module – https://github.com/NarayanSchuetz/SpectralLayersPyTorch
2. Deep Learning Framework - https://github.com/NarayanSchuetz/DeepDIVA