REVERTIBLE DEEP CONVOLUTIONAL NETWORKS WITH ITERATED DIRECTIONAL FILTER BANK

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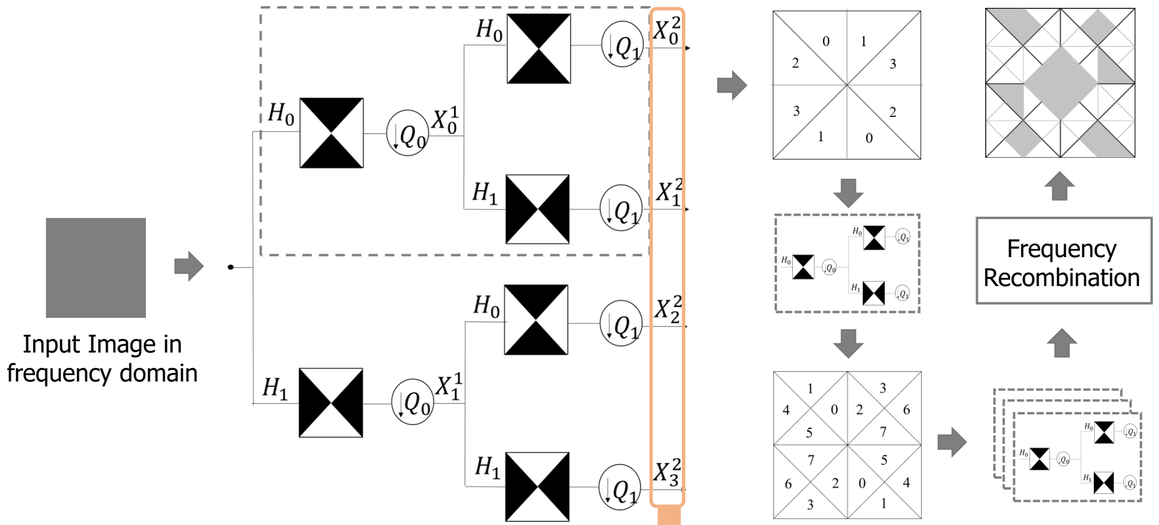
ABSTRACT

This paper proposes an invertible deep convolutional network where the entire architecture is constructed by a decomposition process and a frequency recombination process. The decomposition allows frequency division in both the lower and higher parts at the same time on each layer. It is implemented by using iterated directional filter banks. Perfect reconstruction is available if we adopt biorthogonal quincunx filter banks. The remaining frequency recombination process is adjoined to the architecture to transform the uniform frequency partition to non-uniform one and thereby increase the efficiency and flexibility. Numerical experiments reveal that the underlying network has good performance especially for images with large amount of fine-grained information.

Iterated DFB



$$X_k^l(\omega) = \frac{1}{|M_k^l|} \sum_{m \epsilon N(M_k^{l\,T})} \left[X\left(M_k^{l\,-\mathrm{T}}\omega - 2\pi M_k^{l\,-\mathrm{T}} m\right) \times H_k^l\left(M_k^{l\,-\mathrm{T}}\omega - 2\pi M_k^{l\,-\mathrm{T}} m\right) \right]$$

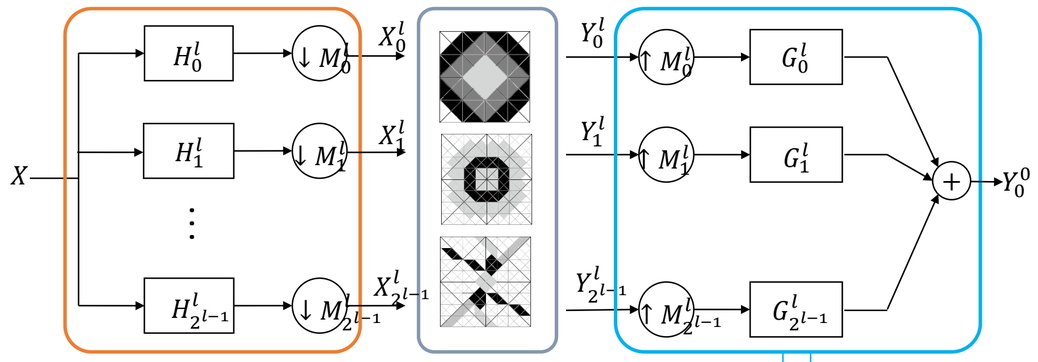
$$M_k^l = \prod_{i=0}^{l-1} Q_{(i \bmod 2)}$$

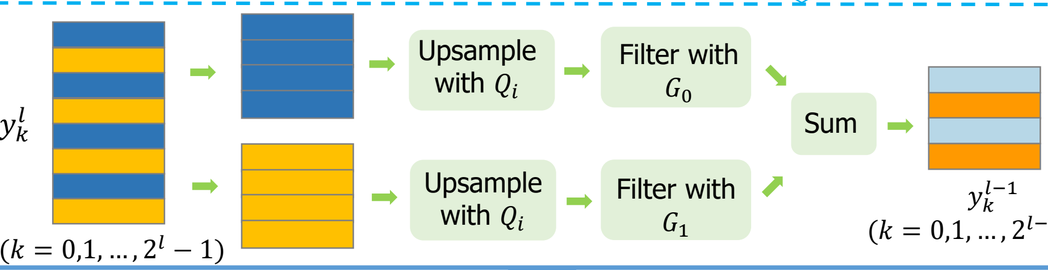
$$H_k^l(\omega) = H_{t_1} \prod_{i=2}^{l} H_{t_i}((M_k^{i-1})^T \omega)$$

$$Q_0 = \begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix} \qquad Q_1 = \begin{bmatrix} 1 & 1 \\ -1 & 1 \end{bmatrix}$$

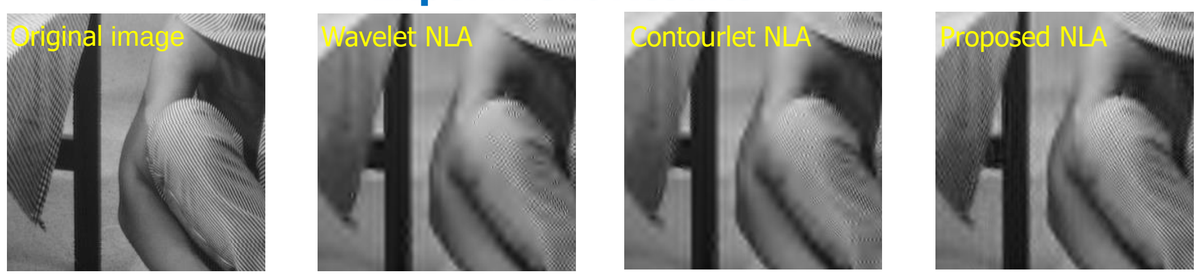
since the four sub-blocks in four corners of the frequency square have the same frequency configuration type as the quincunx filter, further decomposition on both the low and high frequency parts can be achieved by directly repeating the process in the box.

Reconstruction





Experiment Results



	Nonlinear Approximation			Denoising			
PSNR(dB)	wavelet	contourlet	proposed	noisy	wavelet	contourlet	proposed
Barbara	26.03	26.46	**26.92**	22.95	24.84	25.12	**25.69**
Cameraman	26.39	25.92	**26.58**	21.81	25.33	25.49	**28.41**
peppers	32.19	32.35	**32.56**	23.08	28.17	28.20	**32.56**
Fingerprint	21.68	22.01	**22.72**	20.71	21.25	21.29	**22.76**
Lena	**31.53**	31.01	30.60	24.04	28.22	**28.38**	28.23
baboon	22.03	22.09	**22.43**	21.65	22.54	22.81	**22.92**