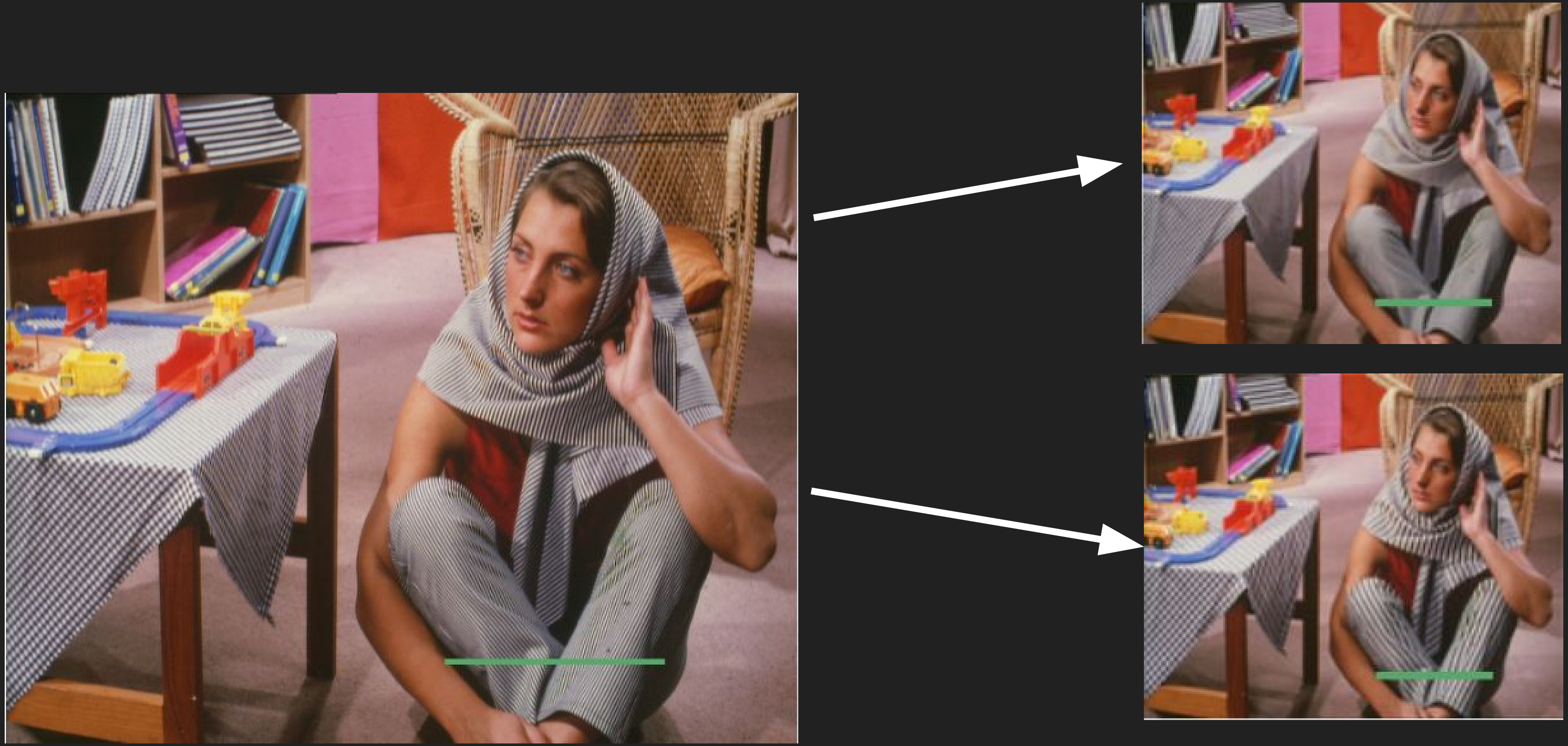
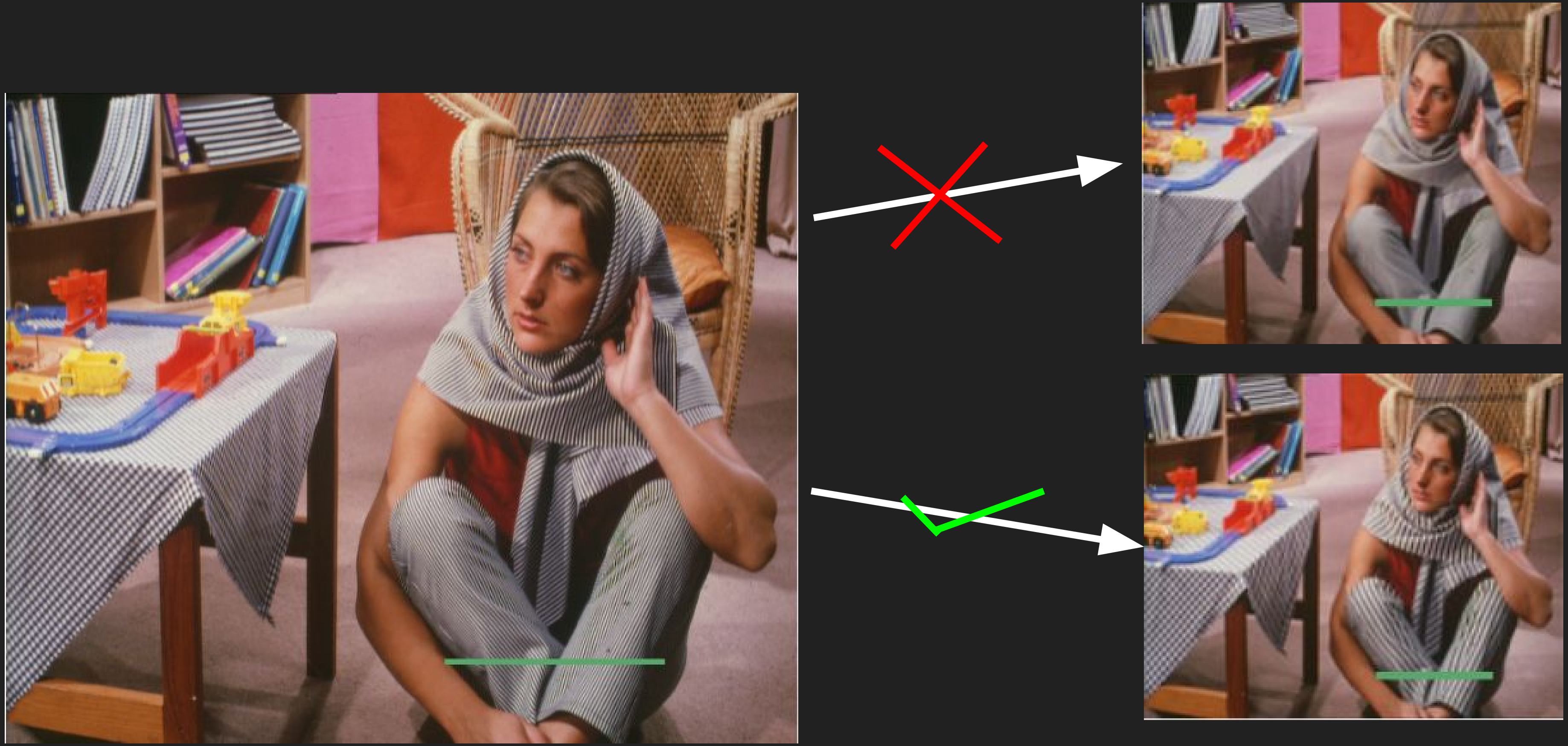
Spectral Re-mapping for Image Downscaling

Final Presentation

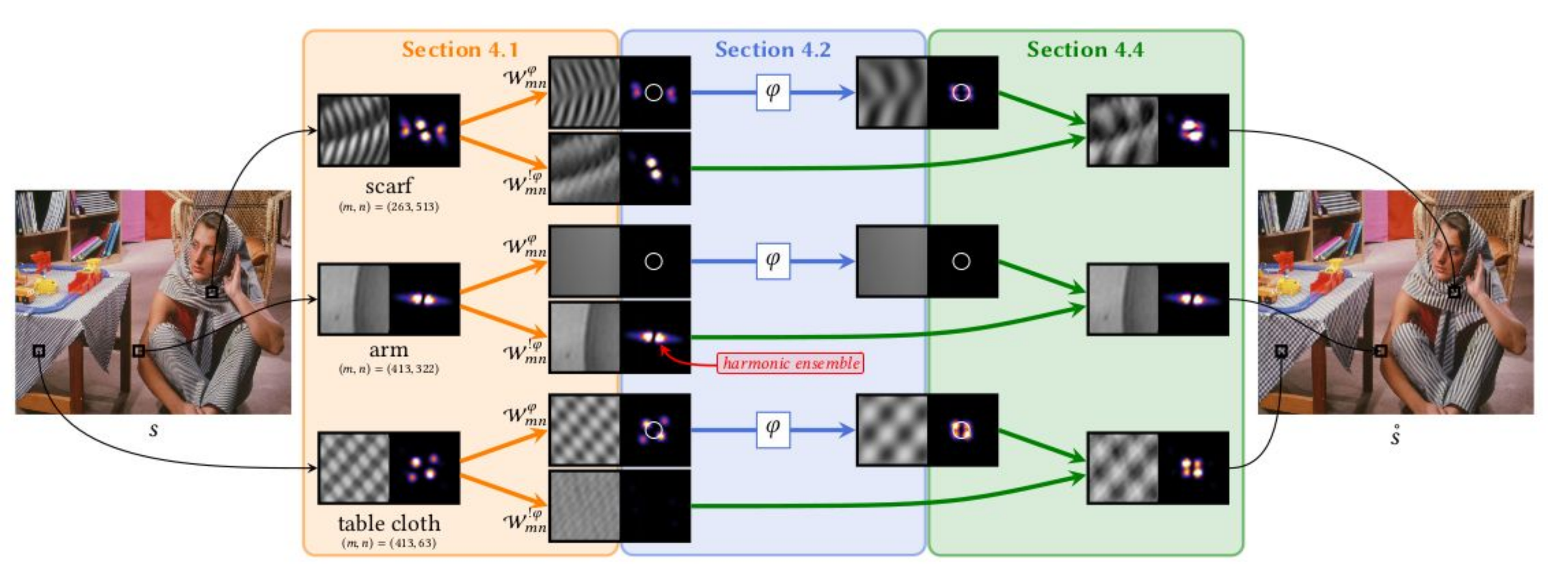
Abstract

This paper presents an image downscaling technique capable of appropriately representing high-frequency structured patterns. The proposed method, instead of discarding high-frequency information to avoid aliasing, controls aliasing by remapping such information to the representable range of the downsampled spectrum. The resulting images provide more faithful representations of their original counterparts, retaining visually-important details that would otherwise be lost. It also demonstrate its effectiveness on a large number of images downscaled in combination with various resampling strategies.





Rough Pipeline:-



Rough Pipeline:

An image s is separated into a series of overlapping patches centered at pixels s (m, n), of which three are shown (scarf, arm, and table cloth). The image to the right of each patch shows its (mean-centered) Fourier power spectrum after windowing with a φ Gaussian function.

1. Waves in W are outside the spectral circle C (in white), and thus would be non-representable after downscaling.
2. All waves in W are remapped by the function φ to a new location inside C.
3. Remapped waves' phases are re-computed in order to preserve their alignments (not shown).
4. Remapped waves are combined with the non-remapped residual in order to form the final spectrally-remapped image s̊.

Detecting Local Waves

- First detect the waves that best describes the image around pixel (m,n)
- To do the above we try to minimize the following error equation using an iterative algorithm based on finding maximal peaks in the power spectrum.

$$E(\mathcal{W}_{mn}) = \left\| s \cdot g_{mn} - \sum_{(\alpha, \mathrm{a}, \mathrm{b}, \mathrm{c}) \in \mathcal{W}_{mn}} w_{\alpha, \mathrm{a}, \mathrm{b}, \mathrm{c}} \cdot g_{mn} \right\|, \qquad (5)$$

Remapping the Waves

- For each non-representable wave, we apply a function φ that remaps its frequency coordinates to a new location inside the representable range

$$\varphi(\mathrm{a},\mathrm{b}) = \left(\frac{0.4}{R}\cos\vartheta, \frac{0.4}{R}\sin\vartheta\right), \quad \text{where} \quad \vartheta = \mathrm{atan2}(\mathrm{b},\mathrm{a}),$$

- But there will be some waves are not meant to be remapped for eg. those corresponding to the edges
- So we remove remove all

- But there will be some waves are not meant to be remapped for eg. those corresponding to the edges
- Thus, we do not remap (a, b) to φ(a, b) if the energy of the wave, measured by its amplitude α, is less than or equal to the signal’s energy at frequency φ (a, b)

$$\alpha \leq \frac{10^{0.06}}{\langle 1 \mid g_{mn} \rangle} \left| \langle \bar{s}_{mn} \cdot g_{mn} \mid f_{\varphi(\mathrm{a,b})} \rangle \right|.$$

Aligning Remapped Waves

Alignment of two waves is defined as-

$$\mu_{mn}(\mathrm{w}_1, \mathrm{w}_2) = \exp\left(-\delta^2/\lambda^2\right)$$

$$\delta = \frac{1}{\min(\alpha_1, \alpha_2)} \sqrt{\sum_{(m',n') \in \mathcal{N}_{mn}} \left| w_{\mathrm{w}_1}(m',n') - w_{\mathrm{w}_2}(m',n') \right|^2}.$$

Aligning Remapped Waves

$$\begin{array}{ccccccccc}
\mathcal{W}_{00} & — & \mathcal{W}_{01} & — & \mathcal{W}_{02} & — & \mathcal{W}_{03} & \cdots \\
| & & | & & | & & | & \\
\mathcal{W}_{10} & — & \mathcal{W}_{11} & — & \mathcal{W}_{12} & — & \mathcal{W}_{13} & \cdots \\
\vdots & & \vdots & & \vdots & & \vdots &
\end{array}$$

Fig. 5. Graph topology defined by the sets $\mathcal{W}_{mn}$.

$$w_{\varphi(\mathrm{w}_1)}(\bar{m},\bar{n}) = w_{\varphi(\mathrm{w}_2)}(\bar{m},\bar{n}), \text{ where } \begin{aligned}\bar{m} &= (m+m')/2,\\ \bar{n} &= (n+n')/2.\end{aligned}$$

$$\left[\mu_{\bar{m}\bar{n}}(\mathrm{w}_1,\mathrm{w}_2)\left|(\mathrm{a}_1^{\varphi}\bar{m} + \mathrm{b}_1^{\varphi}\bar{n} + \mathrm{c}_1^{\varphi}) - (\mathrm{a}_2^{\varphi}\bar{m} + \mathrm{b}_2^{\varphi}\bar{n} + \mathrm{c}_2^{\varphi})\right|\right]^2.$$

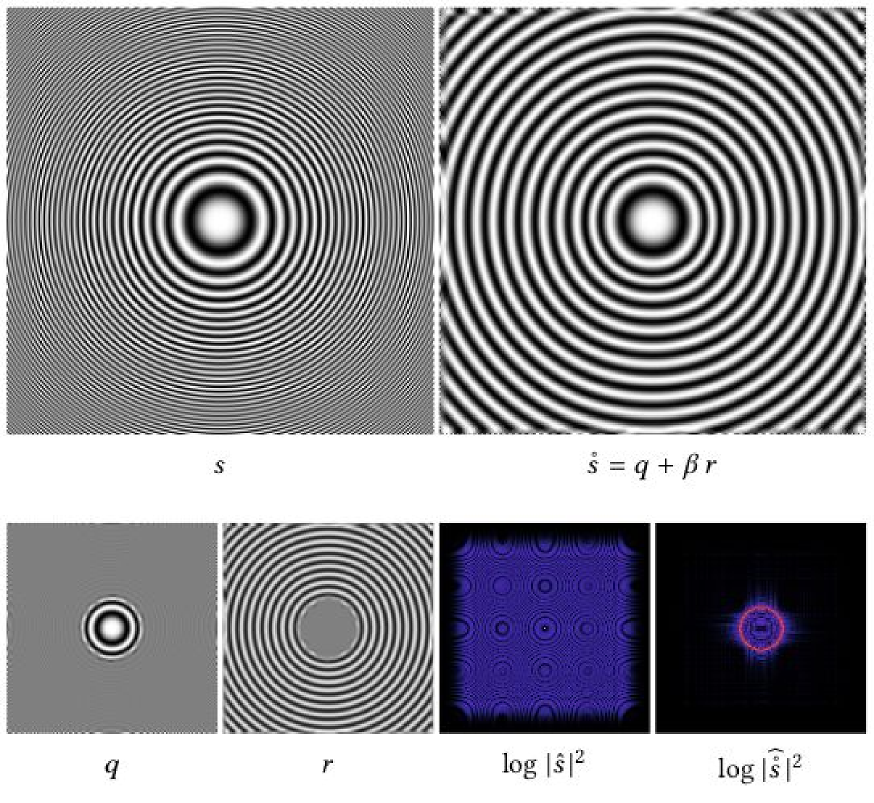
Image Reconstruction

$$\mathring{s} = q + \beta r$$

where, for $g_{mn}^2 \stackrel{\text{def}}{=} g_{mn} \cdot g_{mn}$,

$$q = \sum_{\forall m,n} \sum_{\forall \mathrm{w} \in \mathcal{W}_{mn}^{!\varphi}} w_{\mathrm{w}} \cdot g_{mn}^2, \quad r = \sum_{\forall m,n} \sum_{\forall \mathrm{w} \in \mathcal{W}_{mn}^{\varphi}} w_{\varphi(\mathrm{w})} \cdot g_{mn}^2.$$

Example



Work Division

Reading the Paper and understanding the working - > ALL

Detecting Local Waves : Mohd Sharique

Remapping the Waves : Manan Sharma

Aligning the remapped Waves : Yaghyavardhan Singh

& Reconstruction Image

We used MATLAB for implementing the research paper.

Source: **https://github.com/ShariqueMohd/Spectral-Remapping-for-Image-Downscaling**