Across-channel dependencies between local luminance and contrast in natural images

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Previous research has suggested that visual systems process luminance and contrast separately (eg. [1,2,3]). This separate processing has been attributed to weak statistical dependencies between these two quantities in natural images [1,2].

We studied local luminance and contrast in natural images using established measures, and found that when these two quantities are examined as spatial channels, spatial across-channel dependencies are revealed [4] that were not apparent in previous pointwise analyses [1,2].

In particular, we computed local luminance as weighted average ($LUM = E_w[x]$) and local contrast as weighted standard deviation, normalized by the corresponding local luminance ($RMS/L = STD_w[x]/(E_w[x] + L_0)$, where $L_0$ is a fixed dark-light coefficient). We used raised cosine taper window as the localizing weighting mask $w$. This processing is identical to the one used in [1,2]. We then applied these two operators over whole images in convolutive fashion and examined dependencies that hold between the resulting two (retinotopic) images that we call spatial channels. This split was performed on 4,000+ natural images to obtain the channel images used in subsequent statistical analyses.

Our main results are as follows. 1) We show empirically that the luminance channel can be used to compute a correlate of the contrast channel that closely reflects the true channel. This shows that there is a strong redundancy between local luminance and contrast. 2) We demonstrate that relying on higher-order statistics, Independent Component Analysis learns paired spatial features for luminance and contrast. These features are shown to share orientation and localization, with the filters corresponding to the features dependent in their outputs. 3) We demonstrate that the found dependencies also exist in artificial images generated from a dead leaves model, but in a stronger degree. This implies that more complex conditions present in natural images may work towards decreasing dependencies between local luminance and contrast.

Our results suggest that the separate processing of local luminance and contrast can not be attributed to their independence in natural images.

References