How redundant are luminance and chrominance in natural scenes?

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Introduction

Role of color in visual processing of natural scenes:

- Difficult to characterize empirically
- On the one hand, several studies which investigated joint distribution of luminance and color in natural images, claimed that luminance and chromatic edges were not independent of each other, and that most edges were defined by luminance contrast with color information being redundant [1].
- On the other hand, in 2009, Hansen and Gegenfurtner showed using mutual information that luminance and chromatic edges constitute independent sources of information, and that channel independence increases along successive stages of visual processing [2].

Hypothesis: The importance of color in visual processing is related to the amount of independence between luminance and chrominance information

Objectives & Contributions

Quantify the statistical redundancy between luminance and chrominance information in natural scenes

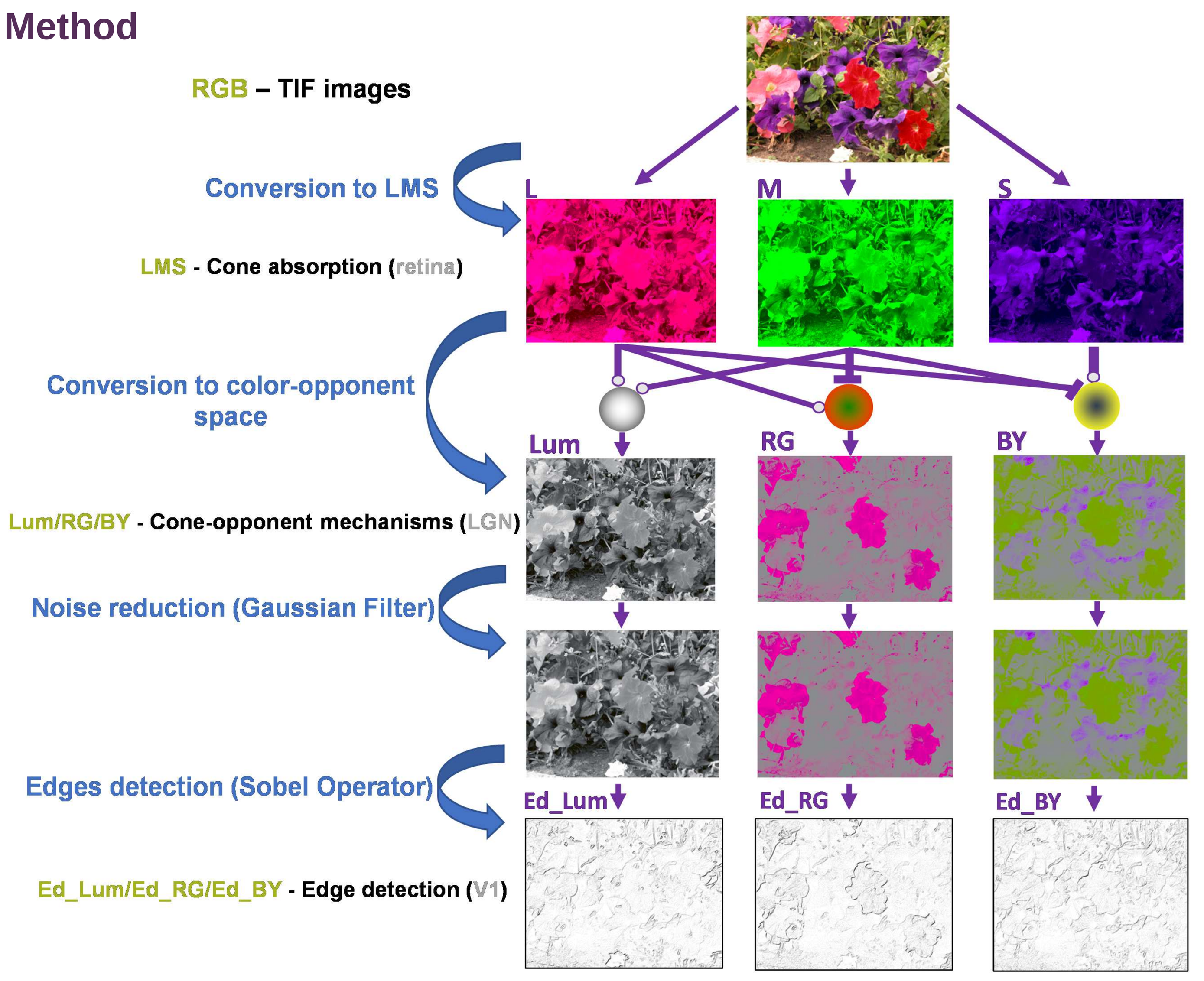
- **Propose a processing pipeline to compute mutual information between luminance and chrominance information in individual images**
- **Analyse sensitivity of results to the definition of color-opponent space**

Material & Method

Material

- **1338 images** from the publicly available McGill calibrated color image database [3].
- Dimensions: 768 x 576 pixels
- **9 categories**: animals, flowers, foliage, fruits, land water, man-made, shadows, snow and textures.

Method

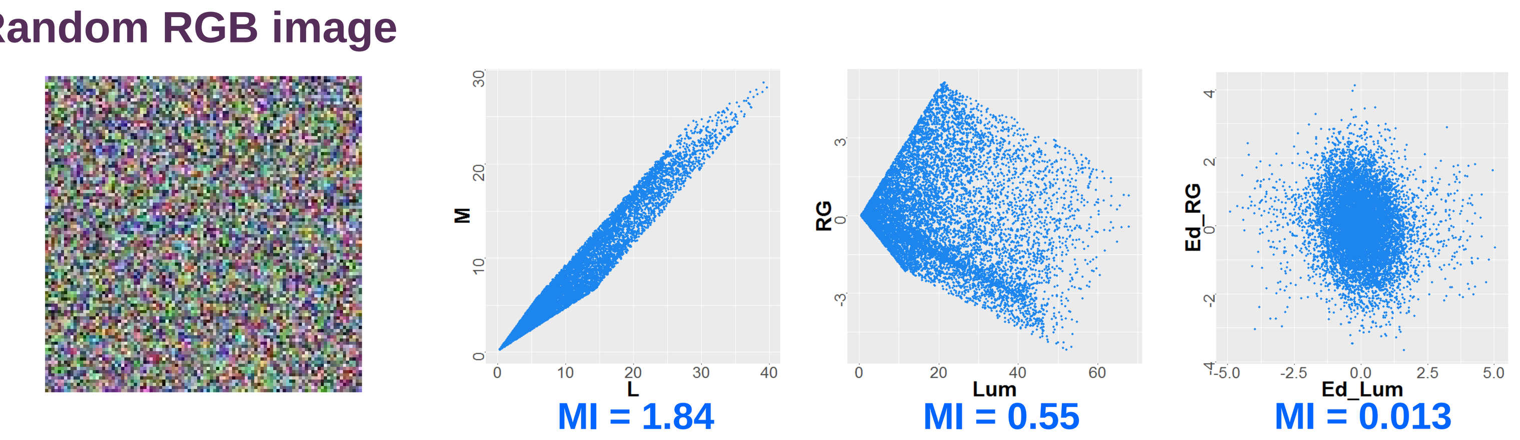


Mutual Information (MI)

= a measure of the mutual dependence between two variables

Mutual information versus correlation

Random RGB image



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Color-opponent space

Normalized definition [4]

$$Lum = L + M + \varepsilon$$

$$RG = \frac{L - M}{Lum}$$

$$BY = \frac{S - Lum}{S + Lum}$$

Linear definition [5]

$$Lum = L + M$$

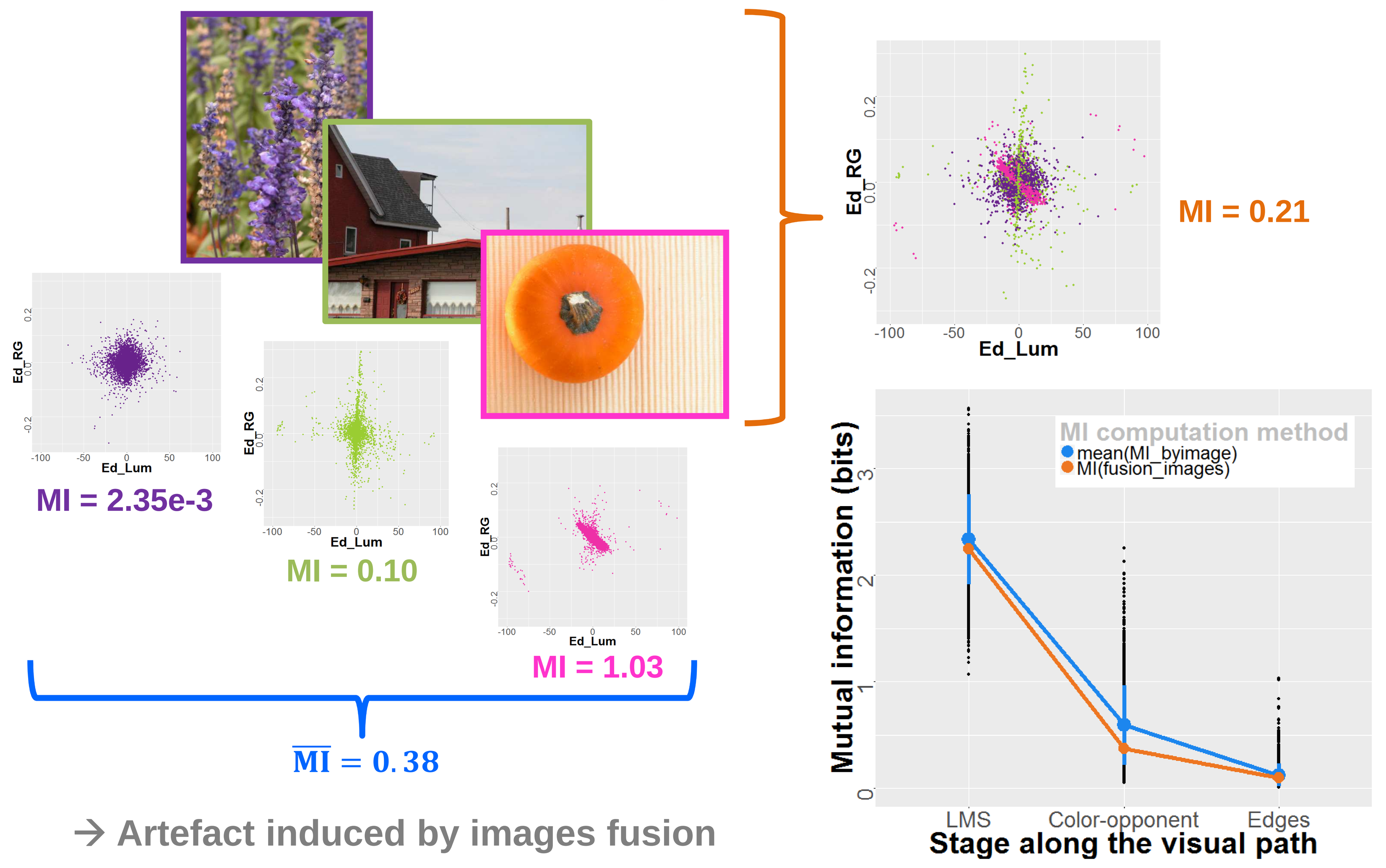
$$RG = L - M$$

$$BY = 2S - Lum$$

Divisive normalization stage ?

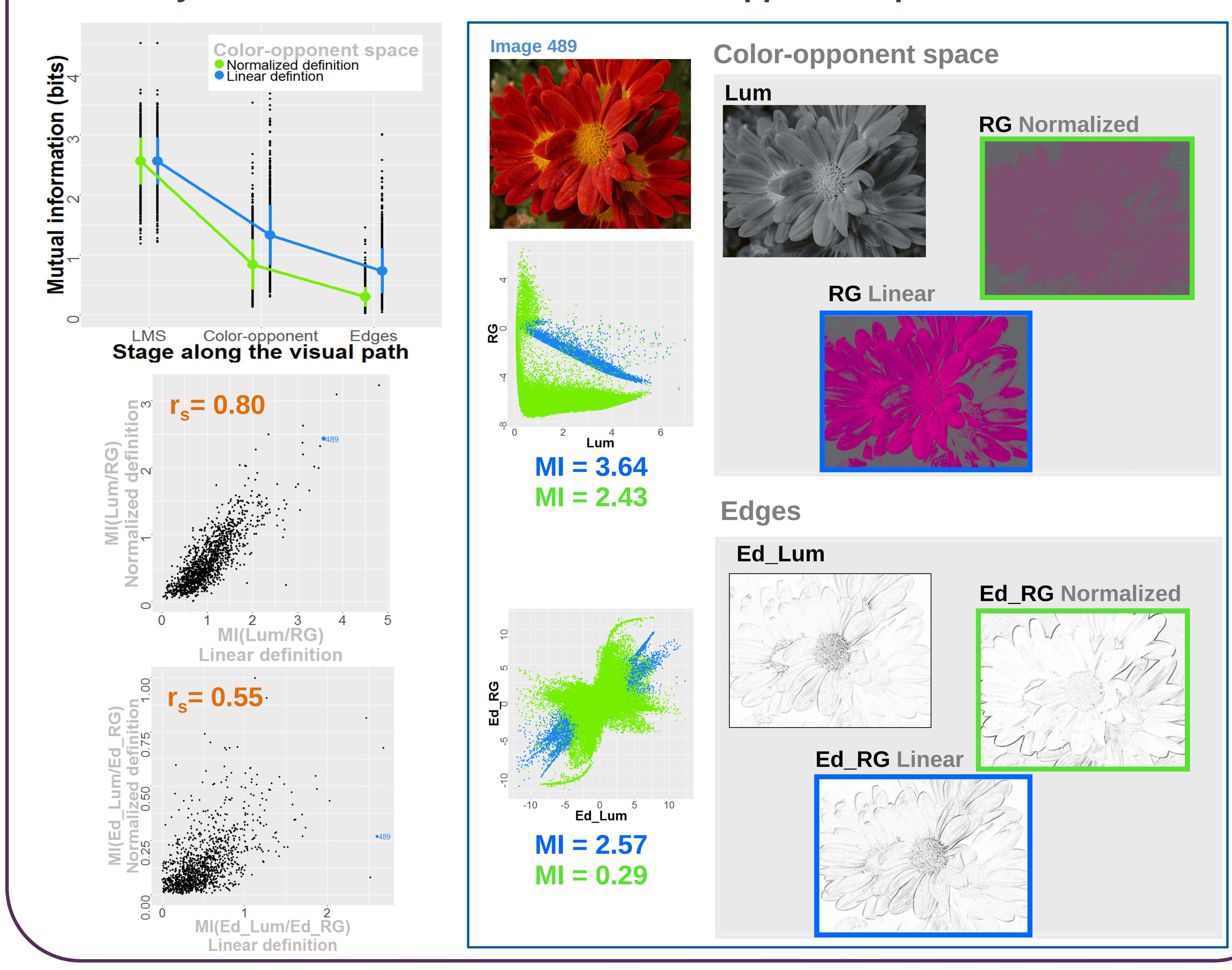
Results

Mutual information for individual images



→ Artefact induced by images fusion

Sensitivity of results to the definition of color-opponent space



Conclusion

- We improve and extend the analysis proposed in [2] by computing mutual information for each image individually
- We find that the estimated amount of mutual information strongly depends on the choice of color-opponent space. How redundant chrominance and luminance are, may thus depend on the precise definition of these two quantities, explaining some inconsistencies in the literature.

Additional experimental data are required to validate a plausible edge detection model, and so expand our understanding of the role color plays in visual perception.

References

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[5] Ruderman, D. L., Cronin, T. W., & Chiao, C. C. (1998). Statistics of cone responses to natural images: Implications for visual coding. *JOSA A*, *15*(8), 2036-2045.

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