# Global Multiple-View Color Consistency

Pierre Moulon, Bruno Duisit, Pascal Monasse

# Global Multiple-View Color Consistency

Pierre Moulon,[*] Bruno Duisit,[†] Pascal Monasse[‡]

Université Paris-Est, LIGM (UMR CNRS 8049), Center for Visual Computing, Mikros Image
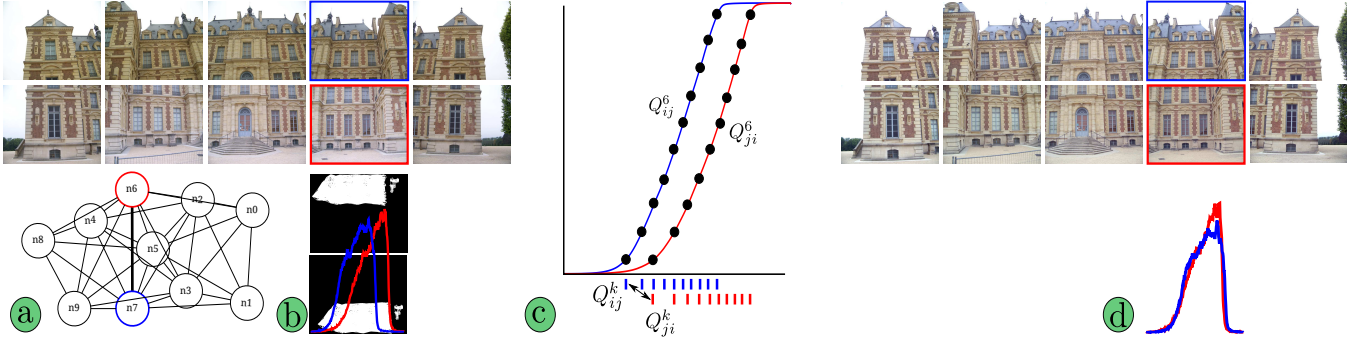
**Figure 1:** *The color consistency correction process is illustrated for the highlighted pair of images. White masks of common pixel data selection are used to build histograms (b). Cumulated histograms are computed and their quantiles positions are aligned under the $l_\infty$ norm (c). Computed gain and offset parameters are used to fix the color discrepancy and solve the color consistency, i.e. right images. After correction histograms are aligned (d). This process is solved globally for all the edges of the image matching graph (a).*

## 1 Introduction

In a multiple-view image acquisition process, color consistency is not ensured. This is an important problem for image fusion tasks: object texturing or mosaics blending for example. In automatic mode, the camera adapts its settings –shutter-speed and aperture– to the captured image content. Therefore the color of objects changes over an image sequence. In order to restore the color consistency, a transformation model between reference and observed colors have to be estimated. It introduces two main problems: the data selection (common pixels between images) and the estimation of a reliable color transformation between those pixels. While most techniques ensure only pairwise consistency [HaCohen et al. 2011; Reinhard et al. 2001] and possibly proceed incrementally [Snavely et al. 2008], we address the problem globally on the entire photo collection.

We propose a global multi-view color consistency solution that in a first step selects robustly the common color information between images and in a second step estimates the color transformations that set all pictures in a common color reference, which involves a global minimization. Our compact representation enables to process large image datasets efficiently.

## 2 Our approach

In a sequence of images $I_i, i = 1, \ldots, n$ we aim at having corresponding pixel colors as consistent as possible. We begin by computing the common plausible corresponding pixels per image pair. Geometrically coherent points are identified by local image matching techniques, such as SIFT keypoints, and an estimation of the epipolar geometry is performed. To extend this correspondence set, we use the VLD filter [Liu and Marlet 2012] that identifies common virtual segments between pairs of images. Using common segments as pixel masks, common but unadjusted pixel colors are extracted. Pixel by pixel alignment is not guaranteed, so we use histogram distribution of colors. Color consistency is solved by best aligning

a set of quantile positions of the cumulated histogram distribution under the $l_\infty$ norm. A gain $g_i$ and offset $o_i$ is used per image to normalize the shutter speed and the aperture time. This is applied for each color channel independently to build a look up table and align the colors. We solve the following Linear Programming problem:

$$\underset{\{g_l, o_l\}}{\text{minimize}} \; \underset{i,j,k}{\max} \; |(g_i Q_{ij}^k + o_i) - (g_j Q_{ji}^k + o_j)| \tag{1}$$
$$\text{subject to } g_l \geq 0 : \forall l \quad g_{\text{ref}} = 1 \text{ and } o_{\text{ref}} = 0,$$

where $Q_{ij}^k$ corresponds to the $k$th quantile of the histogram of common pixels of image $i$ with image $j$, and *ref* is the index of a chosen color reference image.

Notice that we do not use the whole set of common pixel colors but only quantiles of histograms. This ensures scalability of our solution. Also, our solution to register a series of color histograms is global and results in optimizing a convex problem based on histogram quantiles. In the experiment of Figure 1 we use 10 quantiles per histogram, with no noticeable difference when taking more.

## References

HACOHEN, Y., SHECHTMAN, E., GOLDMAN, D. B., AND LISCHINSKI, D. 2011. Non-rigid dense correspondence with applications for image enhancement. *ACM Trans. Graph. 30*, 4, 70:1–70:9.

LIU, Z., AND MARLET, R. 2012. Virtual line descriptor and semi-local matching method for reliable feature correspondence. In *British Machine Vision Conference 2012*.

REINHARD, E., ADHIKHMIN, M., GOOCH, B., AND SHIRLEY, P. 2001. Color transfer between images. *Computer Graphics and Applications, IEEE 21*, 5, 34–41.

SNAVELY, N., GARG, R., SEITZ, S. M., AND SZELISKI, R. 2008. Finding paths through the world's photos. In *ACM Trans. Graph.*, vol. 27, ACM.

---

[*]pierre.moulon@imagine.enpc.fr

[†]bdi@mikrosimage.eu

[‡]monasse@imagine.enpc.fr