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SHINE_color: controlling low-level properties of colorful images

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Software

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Summary

Pupil dilation responses are versatile measures that can be used to study an array of complex psychological phenomena. However, controlling stimuli properties is an essential step to minimize experimental confounds that can result in unwanted pupil dilation. Here we describe an adapted MATLAB toolbox for controlling properties of colorful images.

Statement of need

Pupil dilation responses can be used to investigate an array of cognitive abilities across the lifespan (Hepach & Westermann, 2016; Sirois & Brisson, 2014; Zhang et al., 2019; Zhao et al., 2019). Whereas it is a versatile measure of high-level abilities, pupil dilation can be greatly affected by low-level properties of stimuli and experimental setting such as luminance of visual stimuli and experimental room (e.g., Hepach & Westermann, 2016; Tsukahara & Engle, 2020).

One powerful way to control low-level properties of experimental stimuli is to use the SHINE toolbox for MATLAB (Willenbockel et al., 2010). This toolbox contains a set of functions that allows users to precisely specify luminance and contrast, histogram, and Fourier amplitude spectra of visual stimuli. These parametric manipulations minimize potential low-level confounds when investigating higher-level processes (e.g., cognitive effort, recognition). However, SHINE only works with greyscale images. Whereas this serves well to many research purposes (e.g., Lawson et al., 2017; Rodger et al., 2015), other research goals might benefit from colorful images (e.g., Cheng et al., 2019; Hepach & Westermann, 2016; Zhang et al., 2019). Here, we describe the SHINE_color, an adaptation of SHINE that allow users to perform all operations from SHINE toolbox to colorful images.

Implementation

The SHINE_color toolbox works in an intuitive way (Figure 1). Once called in the command window of MATLAB, by typing SHINE_color, the script guides the user through a series of questions that specify the input files characteristics (either a set of images or a video) and the operations to be performed (luminance, histogram, Fourier amplitude spectra specification; Figure 1; see Ruedeerat (2018) for a similar approach that normalize RGB images directly). Following, the input RGB images are transformed to HSV images. If a video is provided, its frames are first extracted, then they are transformed to HSV color space. The HSV color space separates Hue, Saturation, and Value (luminance) channels. Once transformed, Hue and Saturation are held in memory and are not manipulated, but the Value channel (originally ranging from 0 to 1) is rescaled to match greyscale range (from 0 to 255). Then, all operations from SHINE (Table 1) can be performed in the scaled Value channel. Following, the Value channel is rescaled to its original range (0-1) and is combined with its original Hue and Saturation channels. These HSV images are transformed back to RGB images. For videos, the frames are recombined back into a video. In addition, to quantify the changes, the mean and standard deviation of each image's Value channel is automatically calculated before and after manipulations.

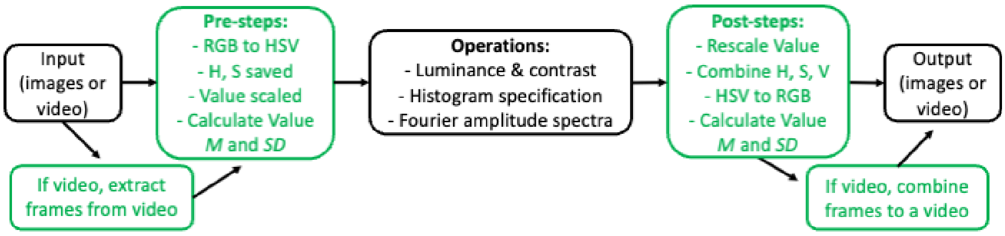

Figure 1: SHINE_color workflow. Green boxes are adaptations that allow SHINE operations to be performed on colorful images.

Table 1. Overview of the functions from SHINE_color. Most functions come from the SHINE toolbox, and their descriptions are also available on REF. Single stars (*) denotes functions that has been adapted from SHINE, double stars (**) indicates new functions from SHINE_color. Functions are listed in alphabetical order.

Function	Description
avgHist	computes average histogram
frames2mpeg**	creates a mpeg (.mp4) video from a sequence of frames
getAllFilesInFolder**	read all frames from a folder
getRMSE	computes root mean square error
hist2list	transforms histogram into a sorted (darker-to-brigther) list
histMatch	exact histogram matching across images
imstats	computes image statistics
lum_calc**	computes the luminance average and standard deviation
lumMatch	scales mean luminance and contrast
match	histogram specification
readImages*	read input images and apply the v2scale function (see below)
rescale	luminance rescaling
scale2v**	scales the Value channel from greyscale range to HSV range
separate	foreground-background segregation
sfMatch	equates the rotational average of the amplitude spectra
sfPlot	plots the energy at each spatial frequency
SHINE_color*	main function for loading, equating, and saving greyscale and colorful images
specMatch	matches amplitude spectrum
spectrumPlot	plots amplitude spectrum
ssim_index	computes Structural Similarity index
ssim_sens	computes SSIM gradient
tarhist	computes a target histogram
v2scale**	converts RGB to HSV color spaces, extracts the Value channel, and scale it to greyscale range
video2frames**	extracts all frames from a video

The SHINE_color toolbox is openly available at OSF and GitHub. Plans for future development include a MATLAB guided user interface and an adaptation to Python language, for integration with experimental packages such as PsychoPy (Peirce et al., 2019). The control of low-level properties of visual stimuli is an essential step for minimizing confounds that might affect pupil dilation responses (Hepach & Westermann, 2016; Sirois & Brisson, 2014; Tsukahara & Engle, 2020). SHINE_color allow users to take full advantage of the powerful functions from the SHINE toolbox (Willenbockel et al., 2010) for controlling low-level properties of colorful images and videos.

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