Cornsweet Surfaces for Selective Contrast Enhancement

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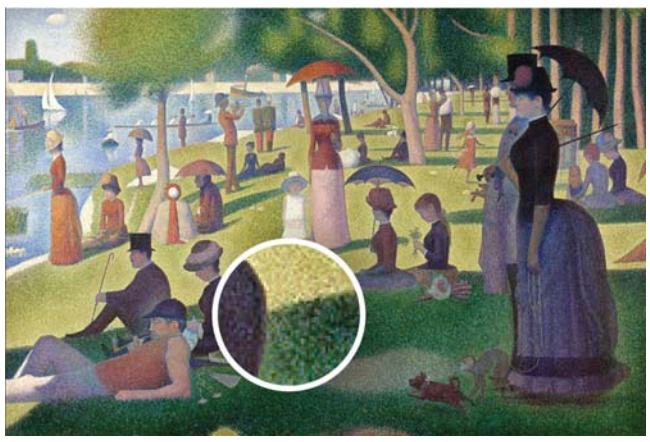
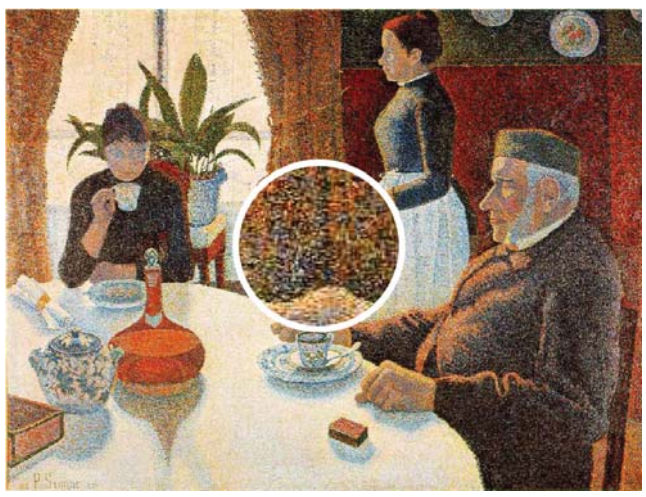
The contrast of photographs or rendered images is commonly enhanced to increase the image's visual appeal. Normal computer science approaches take no account of image content. In artwork, spatial configurations are use to increase apparent contrast. We have a spatially aware contrast enhancement algorithm, which uses image structure to hide the countershading profiles. We can achieve enhancements that better match the countershading used by artists, with no loss of contrast compared to traditional contrast enhancement techniques.

Counter-shading in art



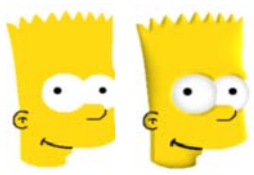
Seurat (above) and Signac (below) both made effective use of countershading, embedding the shading variations in to the scene such that they give the impression of increased contrast. The insets show magnifications of areas that show how countershading may respect edges to great effect.

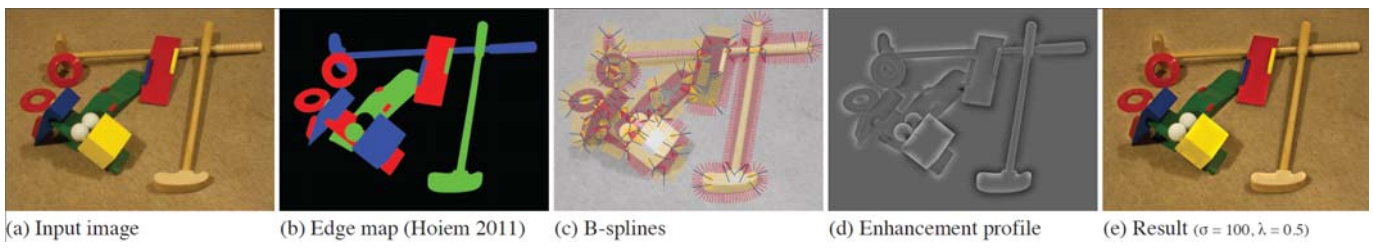


The strength of the enhancement can be related to the width of the countershading profile so that the result is an image with no objectionable artefacts and with increased contrast. Artists often apply shading in their paintings that resembles countershading. However, they vary the extent of their countershading to coincide with content elsewhere in the painting, thus embedding countershading into the image that is less obvious but still produces high edge contrasts.

Other applications

As well as improving images, countershading may be an appropriate alternative to existing methods of adding 3D-like effects to cartoons.



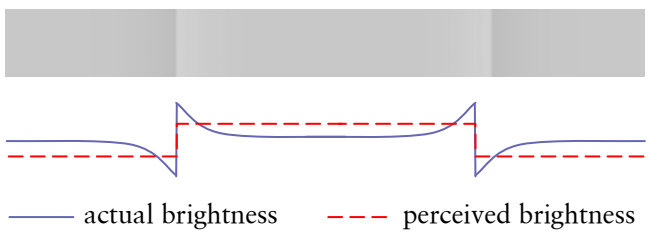


(a) Input image (b) Edge map (Hoiem 2011) (c) B-splines (d) Enhancement profile (e) Result ($\sigma = 100, \lambda = 0.5$)

From artistic inspiration to implementation

Implementation of this idea needs high-level image analysis and manipulation tools which are typically difficult to achieve with filter-based approaches or with any of the previous image-based techniques. We therefore investigated vectorising the image, which allowed us to produce spline-based countershading profiles that can be applied to the image. By adaptively extending the profiles as far as the image content allows, we are able to maximise the embedding of the profiles and thereby improve local contrast while avoiding the introduction of artefacts.

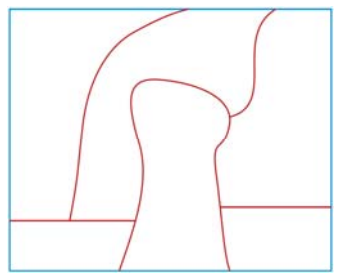
Cornsweet profiles



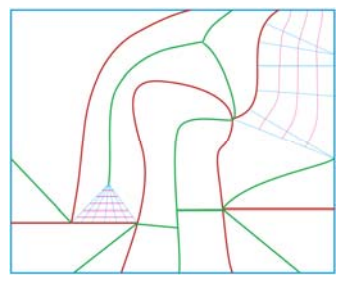
Cornsweet demonstrated that an appropriate increase or decrease in actual brightness immediately next to an edge dramatically increased a human's perception of the edge. This psychophysical effect is what we take advantage of in our countershading profiles. In the above example the centre of the bright bar is the same actual intensity as the outside ends of the dark bars.

Algorithm

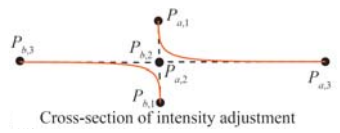
1. Find the key edges in the image. This can be done by an automatic edge-finder or manually. Convert these edges to cubic B-spline curves.



2. Segment the image into a collection of non-overlapping regions bounded by cubic B-spline curves (red and green lines). Produce B-spline patches in each region (two example patches shown with cyan and magenta parameter lines).

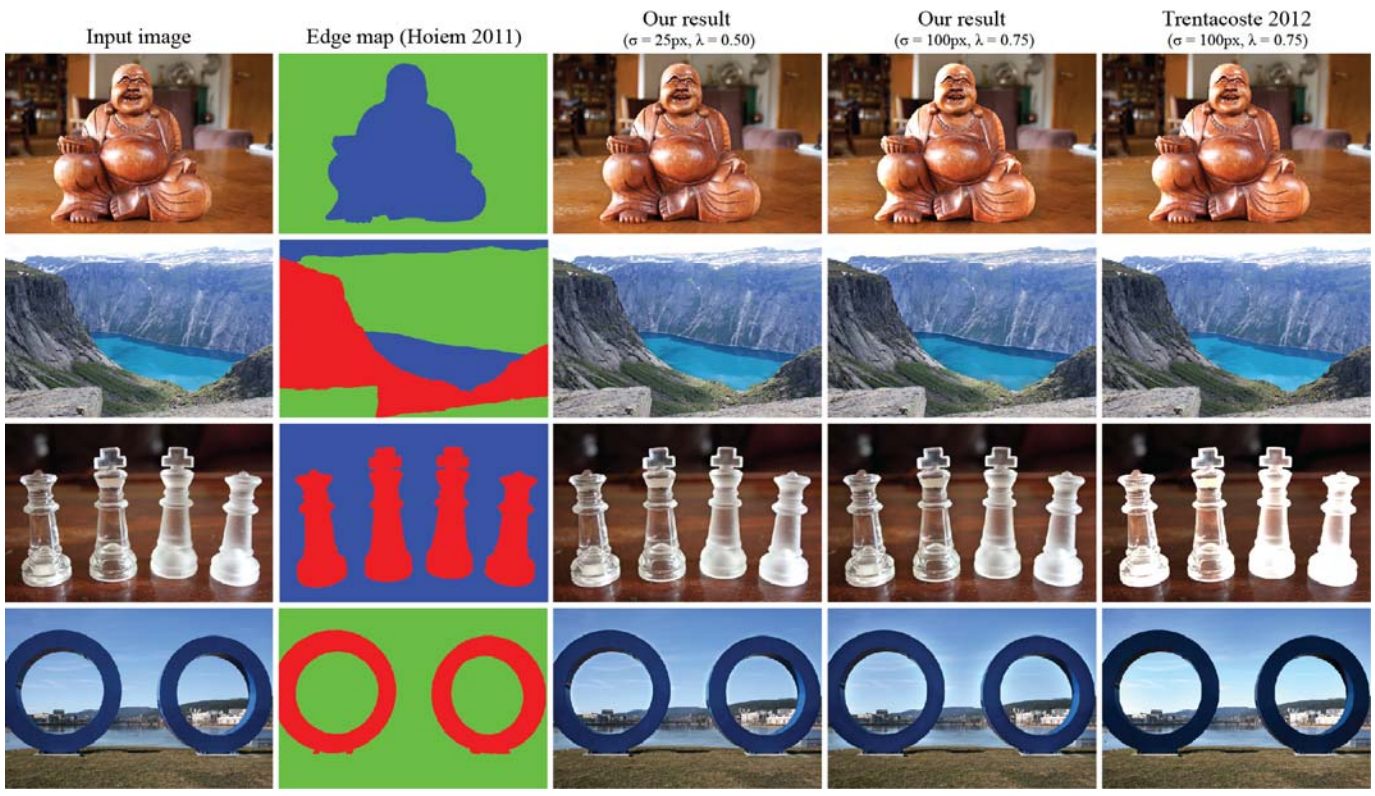


3. Determine an appropriate counter shading profile in each region, using B-spline patches to encode the intensity adjustments.



Cross-section of intensity adjustment

4. Apply the countershading to the image, using a measure of the texture density to further enhance contrast in regions of heavy texture.



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