

Shadow Relighting

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Shadow Relighting

- Goal: given a picture taken with strong cast shadows, identify cast shadows and re-light them so as to make them "disappear".
- Project Implemented in MATLAB
 - Image Processing toolbox



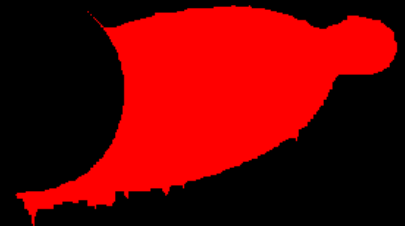
Shadow Detection using HSI Space and Color Attenuation

- Convert RGB to a modified, customized version of HSI color space
- Create a ratio map using $RM = H/(I+1)$
- Select a threshold at which RM is evaluated to see whether or not a given pixel is a shadow or non-shadow pixel.



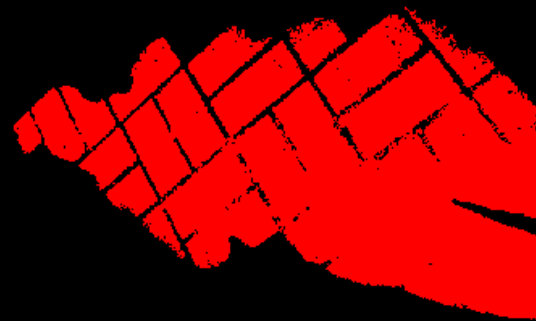
Shadow Detection using HSI Space and Color Attenuation

- PROBLEM: method also detecting shadows on the object!
- Solution: Only consider pixels whose $B > R$ or $B > \text{certain threshold}$
- Rayleigh scattering of sunlight means that the shadow pixels are bluer than their surrounding background



Shadow Detection using HSI Space and Color Attenuation

- **PROBLEM:** Sometimes holes/blemishes appear in the shadow mask due to error
- **Solution:** dilate the shadow mask to fill in any of the holes, then erode the edges to bring the shadow region back to its original size.



Shadow Removal using HSV Space

- HSV (Hue-Saturation-Value)
 - The *hue* (H) of a color refers to which pure color it resembles.
 - The *saturation* (S) of a color describes how white the color is.
 - The *value* (V) of a color, also called its *lightness*, describes how dark the color is.
- HSV color space can reflect the intensity and color information better than RGB color space, and it has better color perception.
- The lightness of the shadow region is lower than that of the background area. Chrominance and luminance information can be effectively separated in the HSV color space. So HSV color space is commonly used to detect and remove shadows.

Shadow Removal using HSV Space

- Step:
- Transform the image from RGB space to HSV space, choose a rectangle area from shadow region and background, and compute the difference values of H, S and V between shadow region and background.
 - $HIm = HIm2 - HIm1 = 0.0121;$
 - $SIm = SIm2 - SIm1 = -0.0397;$
 - $VIm = VIm2 - VIm1 = 0.2797;$

- Find the shadow region in the foreground image.
 - Num=find(shadow_map==1); %Find the nonzero elements in the matrix shadow_map
 - RGB=zeros(length(Num),1,3);
 - for i=1:length(Num)
 - sh=fix(Num(i)/ImSize(1));
 - yu=rem(Num(i),ImSize(1));
 - if(yu~=0)
 - sh=sh+1;
 - else
 - yu=ImSize(1);
 - end
 - RGB(i,1,:)=Im(yu,sh,:);
 - end

- Transform the pixel points in the shadow area from RGB to HSV model and adjust the value of H, S and V in the HSV model.

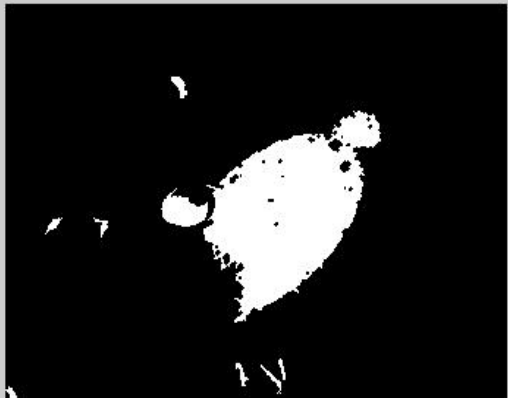
- `RGB=uint8(RGB);`
- `HSV=rgb2hsv(RGB);`
- `for i=1:length(Num)`
- `HSV(i,1,1)=HSV(i,1,1)+HIm;`
- `HSV(i,1,2)=HSV(i,1,2)+SIm;`
- `HSV(i,1,3)=HSV(i,1,3)+VIm;`
- `end`

- Transform the adjusted pixel points in the shadow area from HSV model to RGB model to remove shadow region.

- `RGB=hsv2rgb(HSV);`
- `RGB=floor(255*RGB);`
- `for i=1:length(Num)`
- `sh=fix(Num(i)/ImSize(1));`
- `yu=rem(Num(i),ImSize(1));`
- `if(yu~=0)`
- `sh=sh+1;`
- `else`
- `yu=ImSize(1);`
- `end`
- `Im(yu,sh,:)=RGB(i,1,:);`
- `end`



- Result



- Result



Shadow Removal using CIE-Lab Space

- Convert RGB to CIE-Lab space, where we can use the “L” to adjust lightness
- Once a shadow mask has been made, need to make the shadow areas blend into the background
- Adjust lightness and color according to surrounding background pixels
 - averaging the lightness of non-shadow pixels gives us a guide as to how much we should lighten



← The blue tinge from Rayleigh scattering is now more obvious

Shadow Removal using CIE-Lab Space

- The Blue value of the shadow pixels need to be adjusted. A factor of 0.85 is chosen empirically.
- Texture is preserved



Shadow Removal using CIE-Lab Space

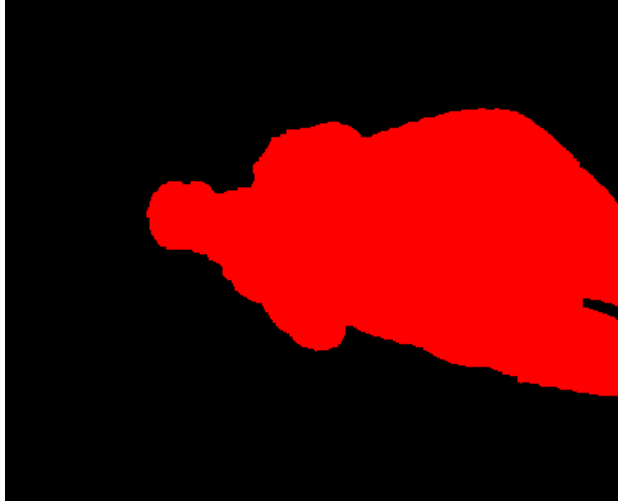
- The border of shadow region leaves a dark line that needs to be removed
- Use averaging filter along this shadow edge to blur it out



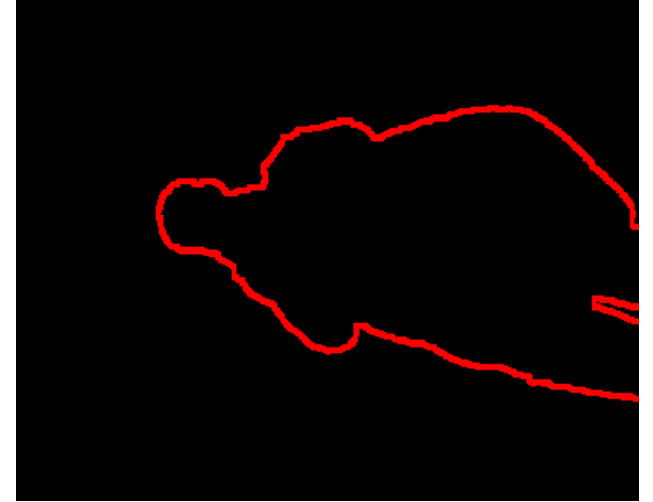
Original



Shadow Map



Shadow Edge



Lightness Corrected



Color Corrected



Final Image



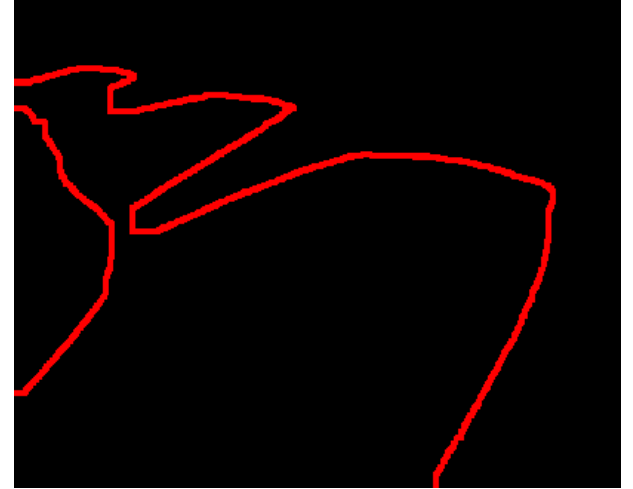
Original



Shadow Map



Shadow Edge



Lightness Corrected



Color Corrected



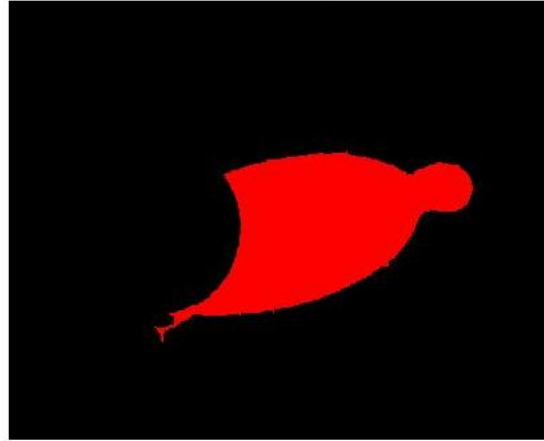
Final Image



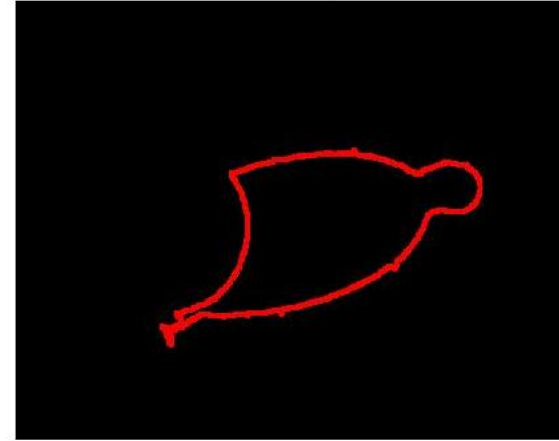
Original



Shadow Map



Shadow Edge



Lightness Corrected



Color Corrected



Final Image



Sources

- Jyothisree V. and Smitha Dharan, (2013, April). “Shadow Detection Using Tricolor Attenuation Model Enhanced With Adaptive Histogram Equalization. *International Journal of Computer Science & Information Technology (IJCSIT)*” Vol 5, No 2.
- Wenxuan Shi and Jie Li, (2012). “Shadow detection in color aerial images based on HSI space and color attenuation relationship. *EURASIP Journal on Advances in Signal Processing*”
- N. Salamati, A. Germain, S. Susstrunk, “Removing Shadows From Images Using Color And Near-infrared. *School of Computer and Communication Sciences*”
- *Color Conversion Algorithms*: http://www.cs.rit.edu/~ncs/color/t_convert.html