Light Source Detection in images

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Overview

- Objectives
- Steps & Algorithms
- Results
- More in the paper

Objective

Current Objectives

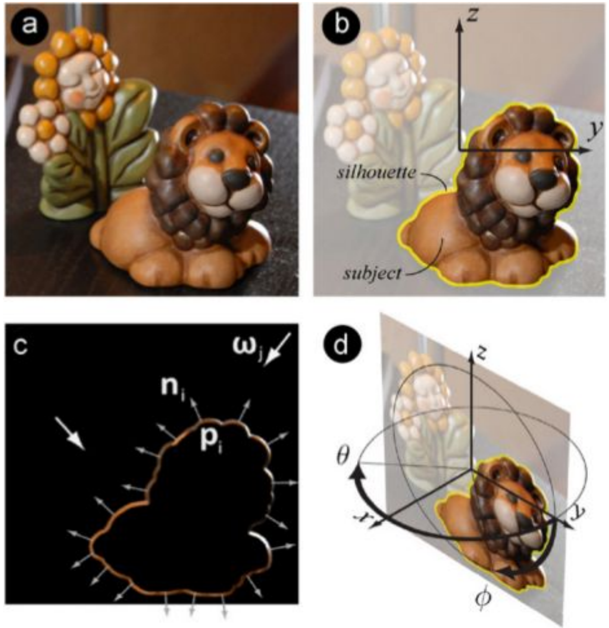
01 To estimate the number of lights N and their respective azimuthal angles ϕ_n with the help of diffuse lighting equation

02 To estimate the zenith angles θ_n of the lights and their relative intensities

03 To replicate the paper: Compositing images through light source detection(Moreno et al)

Some Initial Assumptions & Coordinate System

- By crowd-sourcing, I already know the estimate of number of lights in the image
- Any object in the image can be used as a virtual light probe as long as it covers a reasonable area in the image
- Assumed that surface normals of the object at the silhouette lie in the image plane
- Globally convex assumption used while estimating the zenith angles



Source: Compositing images through light source detection

Steps & Algorithms

Estimating Azimuth Angles

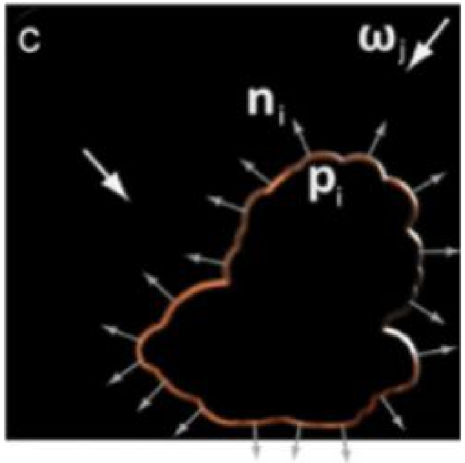
Analyzed the silhouette assuming the surface normals lie in the image plane.

Let's say there are N discrete lights with unknown luminance L_j and unknown direction ω_j, assuming nominal Lambertian surface.

L_i^v : Known luminance of pixel i,   Correcting, I have assumed K_i^d to be light's luminance.

$$L_i^v = \sum_{j=1}^{N} \Omega_{ij} L_j$$

$$\Omega_{ij} = \Omega(\mathbf{n}_i, \omega_j) = \begin{cases} 0 & \text{if } \mathbf{n}_i \cdot \omega_j < 0 \\ K_i^d \mathbf{n}_i \cdot \omega_j & \text{if } \mathbf{n}_i \cdot \omega_j \geq 0 \end{cases}$$



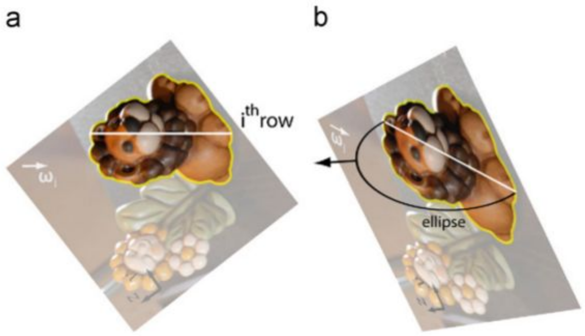
Source: Compositing images through light source detection

Contour Voting Algorithm

Voting method based on the Ω function to form ‘fuzzy’ clusters.

sort($\mathbf{L}^v, \mathbf{n}, \boldsymbol{\phi}^n$) {sort by decreasing luminances}
$\boldsymbol{\phi}^l \equiv \{\phi_j^l\} \mid j \in [1 \dots N]$ {azimuth coordinates of the lights}
seed($\boldsymbol{\phi}^l$)
$\boldsymbol{\alpha}^{\oplus} \equiv \{\alpha_j^{\oplus}\} \mid j \in [1 \cdots N]$ {aggregate of weights per light}
$\boldsymbol{\alpha}^{\oplus} \leftarrow \mathbf{0}$
Repeat
  for all $L_i^v \in \mathbf{L}^v$ **do**
    $\omega_j \leftarrow [0, \sin(\phi_j^l), \cos(\phi_j^l)]^T$ {current direction}
    $\Omega_i^{\oplus} \leftarrow \sum_j \Omega(\mathbf{n}_i, \omega_j)$ {total weight}
    for all $j \in [1 \dots N]$ **do**
      $\omega_j \leftarrow [0, \sin(\phi_j^l), \cos(\phi_j^l)]^T$ {current direction}
      $\alpha_{ij} \leftarrow L_i^v \Omega(\mathbf{n}_i, \omega_j) / \Omega_i^{\oplus}$ {weight of normal i}
      $\phi_j^l \leftarrow \alpha_j^{\oplus} \phi_j^l + \alpha_{ij} \phi_i^n$ {update direction}
      $\alpha_j^{\oplus} \leftarrow \alpha_j^{\oplus} + \alpha_{ij}$
      $\phi_j^l \leftarrow \phi_j^l / \alpha_j^{\oplus}$
    end for
  end for
until convergence($\boldsymbol{\phi}^l$)
return $\boldsymbol{\phi}^l$

Estimating Zenith angles(1/2)

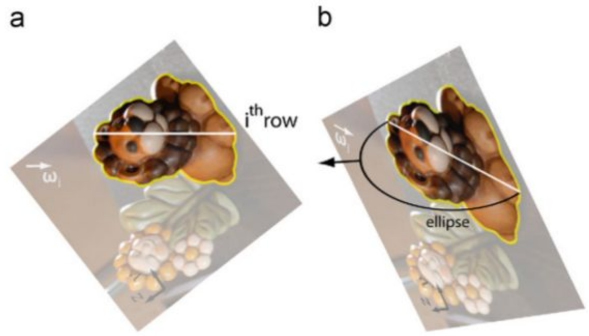


Directional Derivative: $\omega_j \cdot \nabla L^v$ at silhouette pixel is the main indicator of the shading from particular light j aligned to its direction.

Case 1:

If positive, light directed towards camera from the image. Luminance increases if we march along the straight line along this direction. **First local maxima** $\mathbf{p_j^{hi}}$

Therefore, $\boldsymbol{\theta_j = \theta^n(p_j^{hi})}$ (Surface Normal to the ellipse points in the direction of the light)



Estimating Zenith angles(2/2)

Case 2:

If negative, it is an indication of backlighting. Luminance successively decrease if we march along the straight line along the directional derivative. **Change in sign p_j^{lo}**

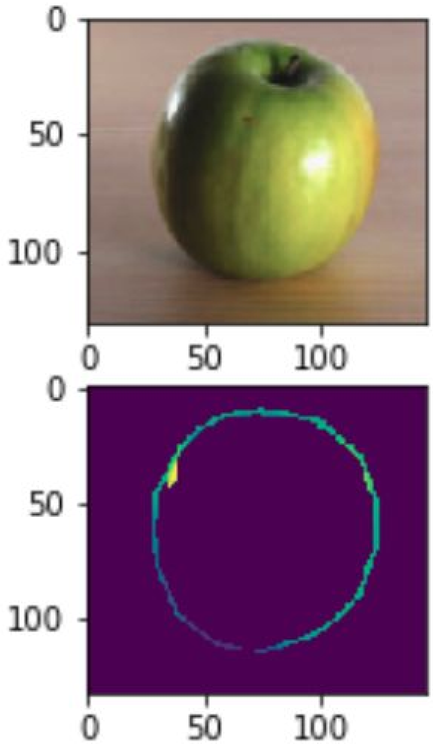
Therefore, $\boldsymbol{\theta_j - \theta^n(p_j^{lo}) = \pi/2 \ \ (\theta_j<0)}$ (Surface Normal to the ellipse perpendicular to light direction)

Results

Apple 1

2 lights can be approximated.

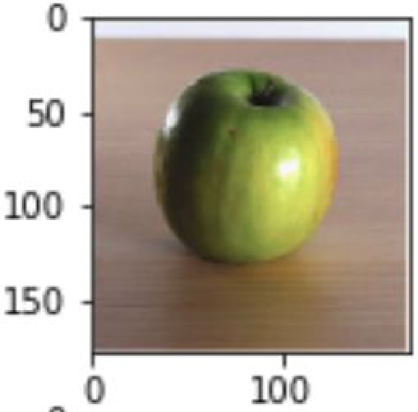
	Light 1		Light 2	
	ϕ	θ	ϕ	θ
Real	-15 or 345	40	165	-40
Value returned	276.21	73.99	210.17	-155.26
Error	**68.79**	**33.99**	**45.17**	**115.26**

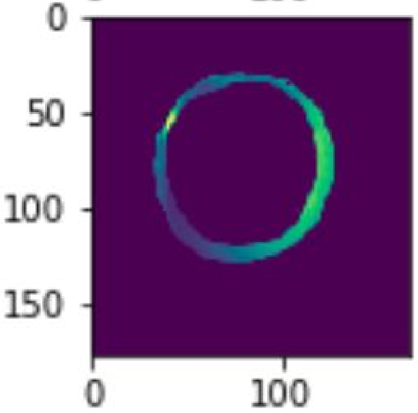


Apple 1 (on increasing the size of silhouette)

2 lights can be approximated.

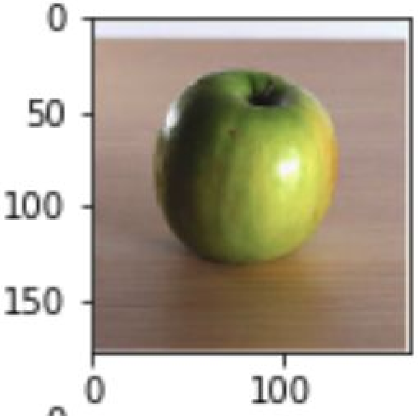
	Light 1		Light 2	
	ϕ	θ	ϕ	θ
Real	-15 or 345	40	165	-40
Value returned	279.71	46.83	202.62	-69.15
Error	**65.29**	**6.83**	**37.62**	**29.15**

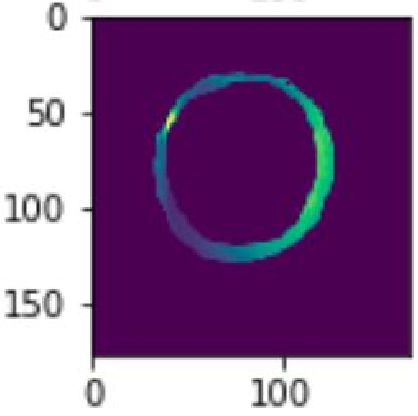




Apple 1 (on increasing the number of lights)

No of lights	Azimuth Angles observed
1	[275.09]
2	[279.71 202.62]
3	[196.86 273.37 279.64]
4	[212.89 279.73 277.22 221.60]





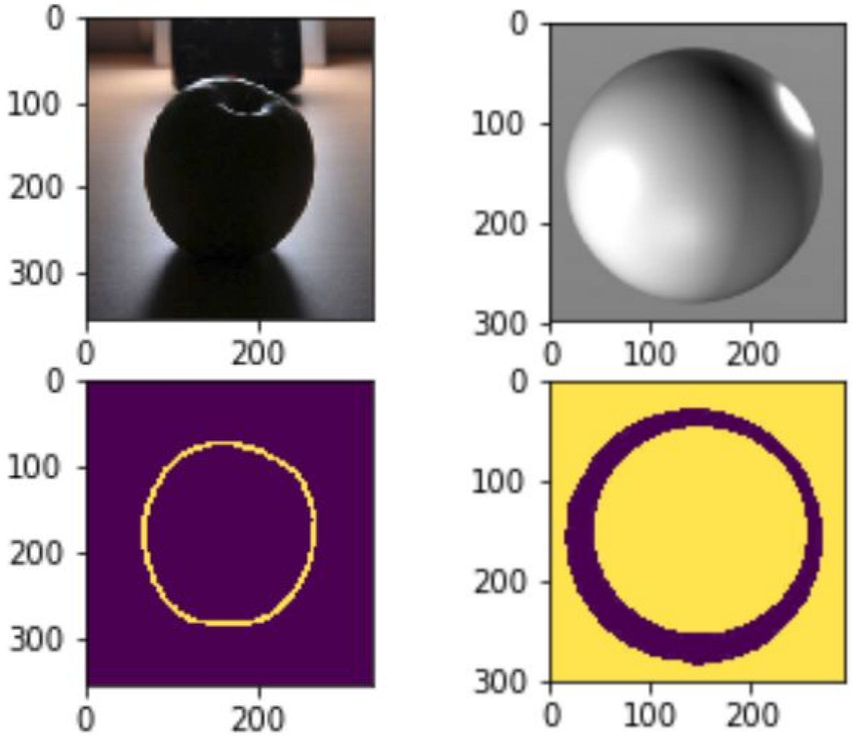
Observed Results in paper

	Light 1		Light 2		Light 3	
	ϕ	θ	ϕ	θ	ϕ	θ
Apple 1						
R	−15.00	40.00	165.00	−40.00	–	–
A	5.71	35.31	162.25	−64.03	–	–
E	**20.71**	**4.69**	**2.75**	**24.03**	–	–
Apple 2						
R	90.00	−70.00	–	–	–	–
A	94.54	−65.70	–	–	–	–
E	**4.54**	**4.3**	–	–	–	–

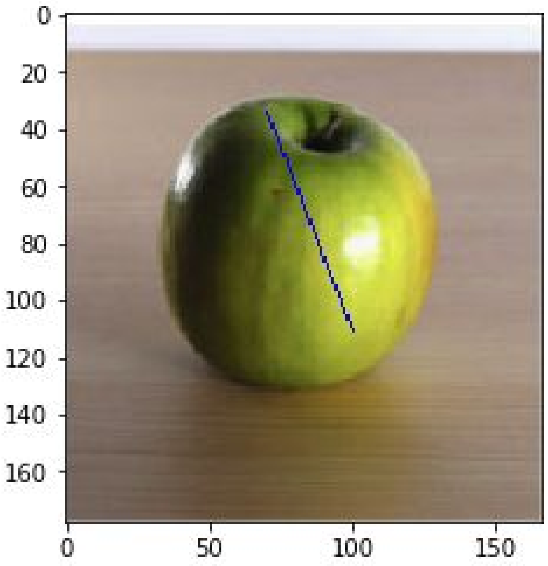
Apple 2 & Synthetic Ball

Apple 2	Light 1	
	ϕ	θ
Real	90	-70
Value returned	138.20	-82.89
Error	**48.20**	**12.89**

	Light 1		Light 2	
	ϕ	θ	ϕ	θ
Value returned	167.71	134.94	134.58	120.02



Thank You



0
20
40
60
80
100
120
140
160
0
50
100
150