A geometrical method of diffuse and specular image components separation

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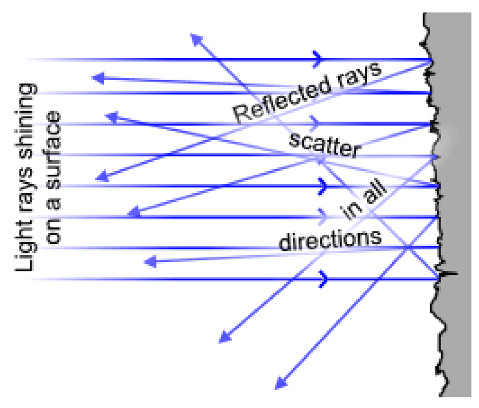
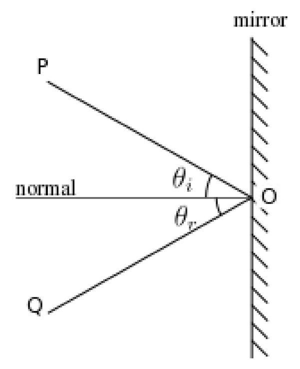
Diffuse and specular Reflections



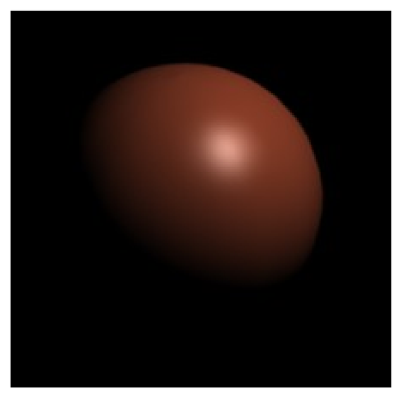
Diffuse or Lambertian reflection

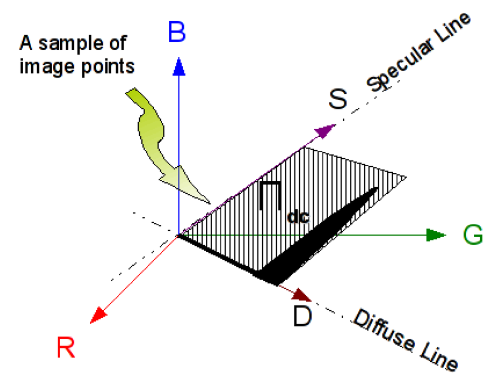


Specular reflection
(speculum = mirror)

Dichromatic Reflection Model

DRM explains the formation of the image of the observed surface as the addition of a diffuse component D and an specular component S.
Algebraically, the DRM is **$I(x)=m_d(x)D+m_s(x)S$** where md and ms are the diffuse and specular component weights respectively.





General Description of the Method

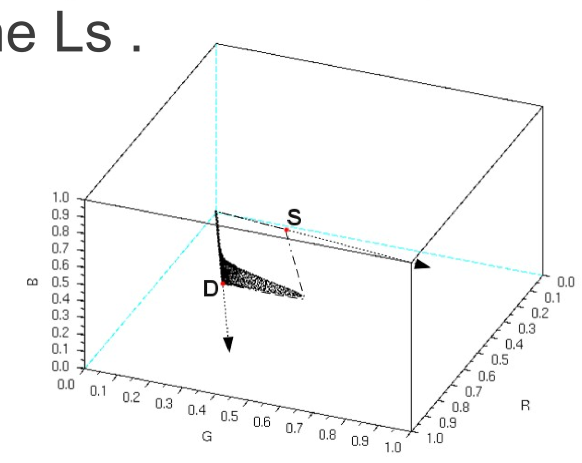
1. Chromatic line estimation:
Estimate the diffuse line Ld and the specular line **Ld**

2. Dichromatization:
We compute the parameters of the chromatic plane in the RGB cube, and we project all the pixel colors into this plane.
This step involves some additive noise removal.

3. Component separation:
We compute the pure diffuse image component and the specular image component.

Chromatic lines estimation

We can easily appreciate the two main directions in the data. The most clear is the one corresponding to the diuse line Ld which rises from the coordinate system origin.
The second, less dened, appearing at the end of the diffuse elongation, is the specular direction identied by the specular line Ls .



We perform a Principal Component Analysis (PCA) which give us the direction of the chromatic line
Therefore the diffuse chromatic line is dened as

Ld : (r, g, b) = P + s***u*** ; ∀ s ∈ R

Analogously, we select the brightest pixels, obtaining a mean point Q in the RGB cube and the largest eigenvector for the specular color, therefore the specular chromaticity line is expressed as follows

Ls : (r, g, b) = Q +t***v*** ; ∀ t ∈ R

Dichromatization

Once we know the chromatic lines, we build the dichromatic plane Π, which is the best planar approximation to the color distribution in RGB.
It can be expressed as follows:
Π : (r, g, b) = P +s ***u*** + t***v*** ; ∀s,t ∈ R, and the normal vector is N : ***u*** × ***v*** , where × denotes the conventional vector product.

To remove noise and regularize the image colors we project the pixel's colors into this dichromatic plane Π .

For each image point color in the RGB cube **pi** we compute the line Lin : (r, g, b) = **pi** + kN; ∀k ∈ R, which is orthogonal to the dichromatic plane Π , and to regularize **pi** we compute its projection as the intersection of Lin with Π.

Components Separation

Our goal is to bring the pixels to the chromatic line, that is ***∀x : ms (x) = 0***.
We proceed as follows: for each regularized image point ***p*** lying in the plane Π we draw the line

Lis : (r, g, b) = ***p*** + t***v***; ∀t ∈ R
where ***v*** is the specular line vector director.

The pixel diffuse component corresponds to the intersection point ***pd*** of this line with the diffuse line

Ld : (r, g, b) = P + s***u***; ∀s ∈ R

and it exists because they lie in the same plane Π and they are not parallel lines.

Components Separation

We have obtained ***Id (x) = md (x)D*** so that ***∀x, : m(x) = 0***, and the resulting image Id (x) is purely diffuse, without specular components.

Obtaining the specular image component is then trivial if we recall the DRM denition:

Is (x) = I(x) − Id (x) = I(x) − md (x)D = ms(x)S

Some Experimental Results