



Photometric Stereo for Dermatology

Project Management and Software Development
for Medical Applications

General Info

Project Title Photometric Stereo for Dermatology

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Project Abstract

Provide a Brief summary about your project here (200 300 characters).

Background and Motivation

Traditional documentation of dermatological investigations are limited to taking photographs of the patient's skin. Without shape cues, these can be difficult to analyse later as the geometry of the skin is not known. Methods in Photometric stereo can be used to remedy this.

Photometric stereo:

Traditional stereo techniques determine range by relating two images of an object viewed from different directions. If the correspondence between pixels is known, then distance to the object can be calculated by triangulation. Unfortunately, it is difficult to determine this correspondence.

The idea of *photometric stereo* is to vary the direction of the incident illumination between successive images, while holding the viewing direction constant.

¹**Lambertian reflectance** is the property that defines an ideal diffusely reflecting surface. The apparent brightness of such a surface to an observer is the same regardless of the observer's angle of view [wiki].

²A **translucent material** not only reflects incoming light, but part of this light enters the object, scatters and then exits at an other location. Common examples are wax, marble and human skin (especially around the ears and nose)

It is shown that this provides sufficient information to determine surface orientation at each image point. Since the imaging geometry is not changed, the correspondence between image points is known *a priori* [3].

Material Properties and Skin:

In order to recover the orientation of the surface at each pixel, the assumption is made that the interaction of the surface with the incoming light is known. Photometric stereo usually assumes that the surface can be approximated by a lambertian model¹. This model often applies to objects with matte surfaces like statues.

Human skin is a considerably more challenging material because it not only has a specular component but also translucency² and running photometric stereo on images of human skin is considerably more challenging [4].

Students Tasks Description

The students work is organized into the following work packages:

Basic Surface Models:

In the first package the student will implement surface models describing the most basic light surface interactions:

- Lambertian
- Lambertian with multiple light bounces

- Lambertian with specular reflections
- Lambertian with specular reflections and multiple light bounces.

Synthetic data will be used to validate these models. 3D Modeling and scripting will be done in *blender*, and rendering either internally or with the *luxrender* physically based renderer.

Skin Model:

After the basic models have been validated, the student will implement a flexible model for human skin. This will be achieved by implementing a generic BRDF³ based model with numerical input data.

Technical Prerequisites

Programming Skills: Java or C++

Attended Courses: Computer Vision 1, Computer Graphics

Administrative Info

Working Time 10 hours per week for between 14 and 16 weeks.

Project Location AR Lab at the CAMP chair in Garching

Required Equipment

- Canon 600D DSLR
- Desktop or portable computer with a minimum of 4 GB of RAM

Timeline and Milestones

- **Familiarize with the state-of-the art:**
 - photometric stereo[3]
 - bidirectional reflectance distribution function

- human skin surface modelling [1, 2]

duration: 2 weeks

- **Basic surface models:**

duration: 4 weeks

- **Generic surface models:**

duration: 4 weeks

- **Validation:**

duration: 4 weeks

- **Documentation and Report:**

- document code
- finalize writing report on the project

duration: 2 weeks weeks

References

- [1] O. G. Cula, K. J. Dana, F. P. Murphy, and B. K. Rao. Skin texture modeling. *International Journal of Computer Vision*, 62(1):97119, 2005.
- [2] T. Weyrich, W. Matusik, H. Pfister, B. Bickel, C. Donner, C. Tu, J. McAndless, J. Lee, A. Ngan, H. W. Jensen, et al. Analysis of human faces using a measurement-based skin reflectance model. In *acm Transactions on Graphics*, volume 25, page 10131024, 2006.
- [3] R. J. Woodham. Photometric method for determining surface orientation from multiple images. *Optical engineering*, 19(1):191139–191139, 1980.
- [4] T. Yamada, H. Saito, and S. Ozawa. 3d reconstruction of skin surface from image sequence. In *IAPR Workshop on Machine Vision Applications (MVA98)*, pages 384–387, 1998.

³The **bidirectional reflectance distribution function (BRDF)** is a four-dimensional function that defines how light is reflected at an opaque surface [wiki].