

## Chapter 12

# “Scanning from Heating” and “Shape from Fluorescence”: Two Non-Conventional Imaging Systems for 3D Digitization of Transparent Objects

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### ABSTRACT

*3D surface acquisition is a subject which has been studied to a large extent. A significant number of techniques for acquiring shape have been proposed, and a wide range of commercial solutions are available. Nevertheless, today's systems still have difficulties when digitizing objects with non-Lambertian surfaces in the visible light spectrum, as is the case of transparent, semi-transparent or highly reflective materials (e.g. glass, crystals, some plastics and shiny metals). In this chapter, some of the issues of traditional scanning systems are addressed by considering various approaches using the radioactive properties of materials, the polarization information of the reflected light as well as the generated fluorescence applied*

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*to the digitization of transparent object These approaches led to three recent techniques which can be referred as shape from polarization, shape from fluorescence as well as shape from heating (SFH). The two latest approaches will be exposed throughout this chapter.*

## **INTRODUCTION**

The computer vision community has extensively developed techniques to determine the shape of objects. Laser light based scanning systems and structured lighting systems are probably the most commonly used techniques for acquiring the 3D shape of objects, however, reliable solutions are still lacking for non-opaque materials (specular or transparent objects). To overcome this problem, powder is usually spread onto the object prior digitization. This supplementary step is troublesome (the object has to be cleaned afterwards), and the accuracy is dependent on the powder thickness and homogeneousness. Various attempts have been proposed over the last few years for 3D surface acquisition of transparent objects and an exhaustive review can be found in (Ihrke, 2008) but the presented methods require a priori about the object or assumptions about the interactions of the light with the object surface.

This chapter presents two new approaches which are an extension of the well known structured lighting method to the thermal infrared range as well as to the UV range with induced fluorescence.

## **BACKGROUND**

In this chapter, we present a new technique for 3D range scanning of transparent objects. 3D range scanning has been investigated for several decades and most of the proposed approaches assume a diffuse reflectance of the object’s surface. The broad literature on the subject is usually divided into active and passive techniques. Active light techniques, whose recent review is proposed by

Blais (2004), include laser range scanning, coded structured light systems (Salvi, 2004) and time-of-flight scanners (Bokhabrine 2010) whereas passive techniques are mainly stereovision (Horn, 1986), “shape from optical flow”, shape from shading . . . or multiview acquisition system (Harvent, 2010).

The further a surface deviates from the Lambertian reflectance assumption, the less accurate standard 3D range scanning techniques become. Figure 1 is an example of a glass bottle scanned by a commercial scanner without any preparation of the sample surface (powder spray) prior digitization.

Coating the object with a powder prior digitization might solve the problem (see Figure 2), on the other hand, this cannot be done in many applications because it involves additional handlings of the objects (coating, cleaning) which include higher processing costs.

The literature survey (Ihrke, 2008), (Ihrke, 2010) pinpoints several techniques to partially overcome this problem. For instance, in the computer graphics community Goesele et al., (Goesele, 2004) proposed a method for determining the scattering behaviour of translucent objects by using a laser, but the geometry was initially acquired by covering the object with a white coating. Similarly, Matusik et al., (Matuzik, 2002) presented an acquisition and rendering system for transparent and refractive objects from arbitrary viewpoints using a novel illumination, but the recovered geometry is just the visual hull (i.e. a very rough approximation of the object’s shape). Morris and Kutulakos (Morris, 2007) proposed a method based on scatter-trace photography that provides good results for complex objects with an inhomogeneous interior. Ohara *et al.* (Ohara, 2003) estimated the depth of the edge of a trans-

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