How Satimage profilometers work

Satimage
http://www.satimage.fr

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Contents

1 About the present document

This document is intended as a short pedagogical introduction to the physical principle used in Satimage's profilometers.
Satimage's profilometers are vision systems that provide 3D dimensional measurements, they are a solution to various requirements for 3D readings and dimensions.

2 General principle

The basic principle of Satimage's profilometers is "triangulation". Below the principle is explained in more details.

A family of laser sensors works by triangulation. Those measure the distance between an object and the sensor, by using a single laser beam and a one-dimensional array of sensors.
Satimage's profilometers use a planar light beam and a two-dimensional array of sensors, and they provide sets of 3D coordinates of a surface.

3 The setup

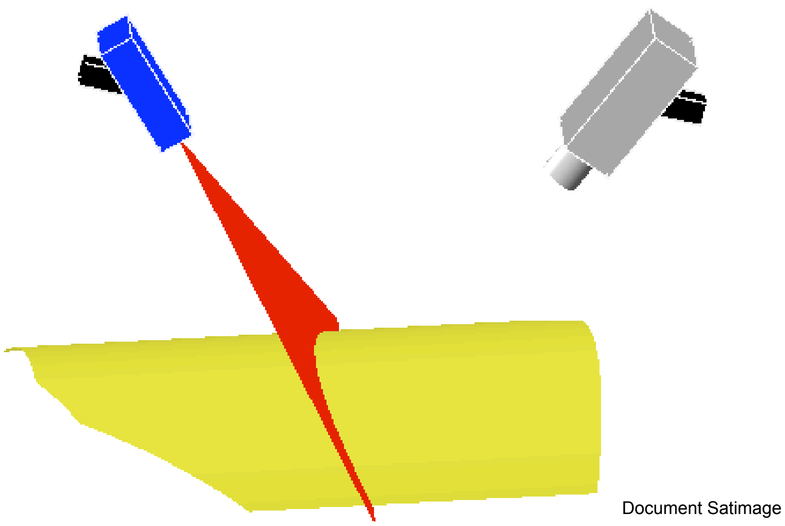

Figure 1: The setup for profilometric measurements. Blue: the lighting device. Red: the light beam. Gold: the part to be measured. Grey: the video camera and the optics

The setup is designed so as to create one illuminated line on the surface. That line is called a **profile**, it can be captured by a video camera.

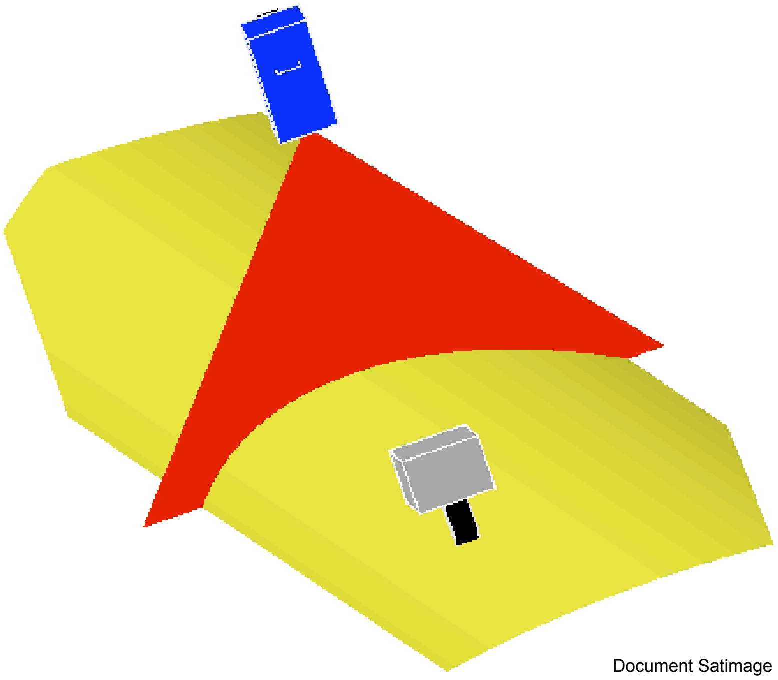

Figure 2: The setup as viewed from the camera.

Obtaining several profiles by translating the measuring device (or the surface), then gathering them into a digitalized surface, is what is called **3D scanning** — a topic not discussed here.

The setup consists in an illuminating device that produces a planar beam of light, and a video camera. The camera and the lighting device aim the surface at different angles (Fig. 1).
Note that, for the sake of clarity, the illustration visualizes the light beam. Actually, the light beam itself is essentially invisible. Like for a slide projector, only the line that is projected on the part is visible.

The intersection of the beam with the surface to be measured is what we call the profile. Stating the obvious, we emphasize that the profile belongs both to the surface (this is why we are interested in its 3D location) and to the plane defined by the beam (this is what will allow to compute that location). The camera views the profile from a different angle, so the image of the profile for the camera is a non straight line (Fig. 2).

4 The measurement

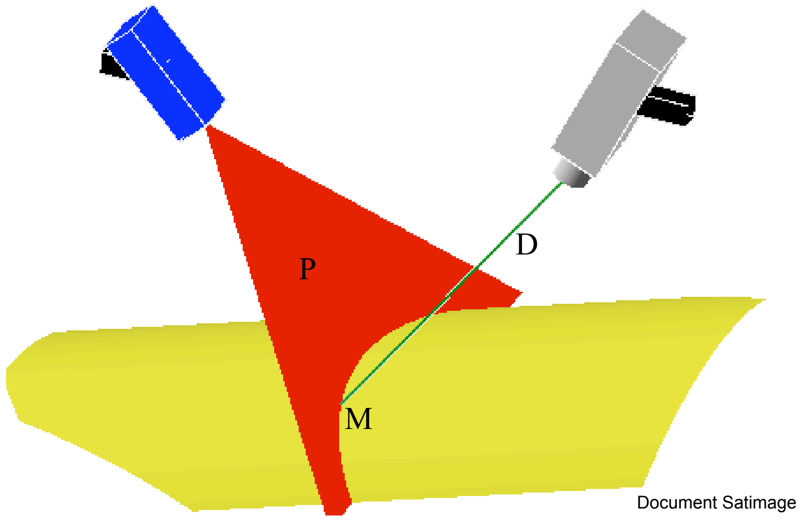

Figure 3: Since P is fixed, the camera knows how far it is from itself in any direction D.

The next step is to compute the 3D location of the profile. Here we shall describe how the profilometer produces 3D coordinates relative to the sensor's own referential[1].

Consider one given point M of the profile: the camera has to compute the 3D coordinates of M.
Roughly speaking, the camera views M as a given pixel in its 2D-array sensor. The camera cannot guess the distance of M to itself: so far, the camera can only tell that M belongs to a given line D (Fig. 3).

Now the camera will use the fact that M belongs to the planar beam. Following some preliminary calibration — which can be performed by various means — the camera knows the position of the planar beam P in its own

[1]Referring the 3D data with respect to an external referential is achieved by various means, out of the scope of this document. For instance in the example illustrated in this document the system does produce 3D data that are relative to an external referential — namely, the plane that supports the part.

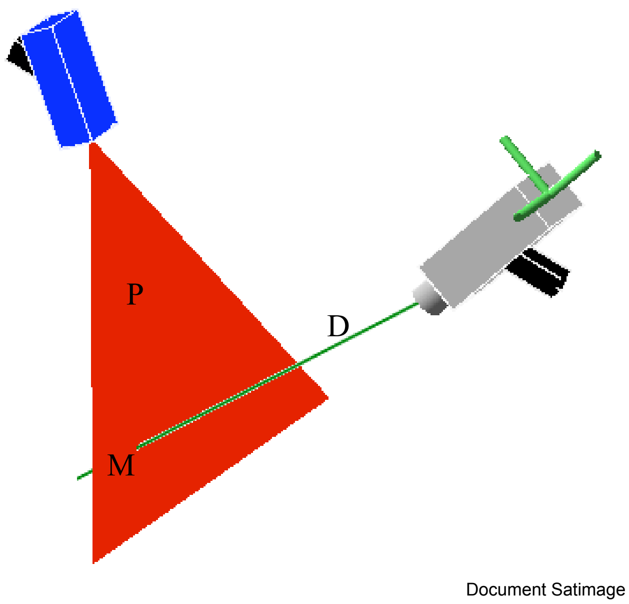

Figure 4: The system computes the 3D location of each point of the profile in its own referential.

referential. M belongs to the beam. Knowing also the equation of D (which is provided by the location of the image of M in the 2D-array sensor), the system computes the 3D coordinates of M as the intersection between D and P (Fig. 4).