Chapter 24
3D Scanner, State of the Art

Francesco Bellocchio
Università degli Studi di Milano, Italy

Stefano Ferrari
Università degli Studi di Milano, Italy

ABSTRACT

The digital models of real objects are used today in many fields: medicine, archeology, and entertainment are some examples of areas in which these models are applied. Generally, the first step of the creation of a real object's 3D model consists in capturing the geometrical information of the physical object. Real objects can be small as coins or big as buildings: the different requirements have brought to the development of a very variegated set of techniques for the acquisition of geometrical information of the object. The aim of this chapter is to present and explain the techniques the 3D scanners are based on and compare them in terms of accuracy, speed, and applicability, in order to understand advantages and disadvantages of the different approaches.

INTRODUCTION

A digital tridimensional model is a numerical representation of the visual features of the object. From the digital model, it is possible to compute a realistic representation of the object in a bidimensional image. This image through the use of some techniques as prospective and shading, can emulate the human eye perception, giving a realistic representation of the object tridimensionality. A 3D visualization system, generally, is composed of two elements: the scene, a mathematical representation of the tridimensional objects, and the render, the technique to compute the 2D images of the scene.

The applications based on the tridimensional model processing are today very diffuse thanks to the increasing availability of tridimensional graphic devices and the decreasing trend of the cost of computational power. These applications are used in many fields such as design, archeology, medicine and entertainment. The chance to use digital 3D model can have many advantages. It is possible to use the model for digital simulation or

DOI: 10.4018/978-1-61350-326-3.ch024

to create a modified digital version of the object. In the entertainment field, the 3D modeling allows to use real objects or people for the creation of characters or environments in the digital animation. Furthermore, for the study of large objects like buildings or geographical regions it can be very useful handling scalable digital models.

The digital 3D model can come from two different ways: Computer Aided Design (CAD) and physical object measurement. In a CAD environment, simple objects can be represented through simple equations: for instance, the equation $x^2+y^2+z^2 = r^2$ can be used for representing a sphere with radius r. Although these simple equations can seem limitative, the set of representable objects can be extended through a technique called Constructive Solid Geometry (CSG); this technique is based on the combination of simple solid objects (e.g., cube, cone, sphere) in order to create more complex objects through operations as union, intersection, difference (e.g., a tube can be seen as a difference of two cylinders with different radius). Anyway, this method is not suitable to describe a large class of real objects and then is not commonly used. Nowadays, the CAD software allows the creation of very complex models that are, generally, based on Non-Uniform Rational B-Spline (NURBS) (Piegel, 1997), a mathematical model that allows the generation of curves and surfaces with great flexibility and precision. The NURBS is suitable for handling both analytic and freeform shapes.

On the other hand, the digitization through physical object measurement is a process that allows for obtaining the 3D model in a semi-automatic way. It is based on the measurement of geometric features of the object and on its visual features as the color and texture. With respect to the CAD, the digitization is characterized by a generally faster creation process and a higher (or, at least, measurable) level of accuracy. Furthermore, the digitization, being substantially a measurement process, does not require artistic abilities for the operator.

The applications that make use of digitization form a huge class. For instance:

- The archeology and the arts are characterized by two divergent necessities: it is very important to preserve an artwork, but it is also desirable that many people can appreciate it. The virtual museum allows a larger public access than a real museum without risk for the exposed objects and, at the same time, it can be a way to attract visitors to the real museum. The user interested to a single artwork has the possibility of explore it directly and in a deep way. In fact, if an artwork is placed in a theca, the field of view can be strongly limited, while, as the 3D model can be observed from different points of view and at different scales, every details of the object can be appreciated from its realistic virtual copy. Furthermore the 3D modeling can improve both the study of an artwork and the accuracy of the cataloging.
- There are several applications in which 3D model of human parts are used. In virtual fashion a model of each customer is acquired, allowing the computation of the cloth size. Then, the model can be dressed with different clothes in order to drive the customer through the shopping. In medicine, the 3D models of organs can help the physician in the diagnosis; for instance, the 3D ultrasonography is used to check the fetal morphology.
- The representation of an object through the quantification of its features allows for performing an efficient comparison of different objects belonging to the same class. This concept is applied in different contexts. For example in manufacturing it is applied for the quality control, while in security it is applied for identity identification through anthropometric measurement (biometrics). Both the applica-