A 3D vision system with only one camera

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Abstract

The 3D vision of an object requires the observation of this object from several different view points. We present herein a method which uses only one camera and a set of mirrors. We show the feasibility of the method and give the relations which allow the calibration of the device as well as the determination of the coodinates, thus the dimensions of the object observed.

1 Introduction

3D reconstruction is in principle not possible with only one 2D view. Classically, either several cameras (stereovision), or one camera associated with a structured lighting system is used. We present herein a 3D vision system with only one camera. The views of an object under different view angles which enable the reconstruction are in fact obtained by a set of mirrors, the object as well its reflections being simultaneously observed by the camera. Firstly, we describe the principle of the system then we will establish the elementary geometrical reflection relations and finally we will indicate the calibration method used.

2 Principle and diagram of the system

2.1 Diagram of the system

The CCD camera is positioned vertically and directed towards the bottom. It allows us to observe the system of height mirrors oriented according to the sides of an upside down octagonal pyramid (figure 1). The object to be reconstructed is placed at the center of the mirrors.

All the sides of the object can thus be viewed except the bottom side. The system is equivalent to a nine-camera system, where eight of them are virtual, reflections of the real camera by the different mirrors.

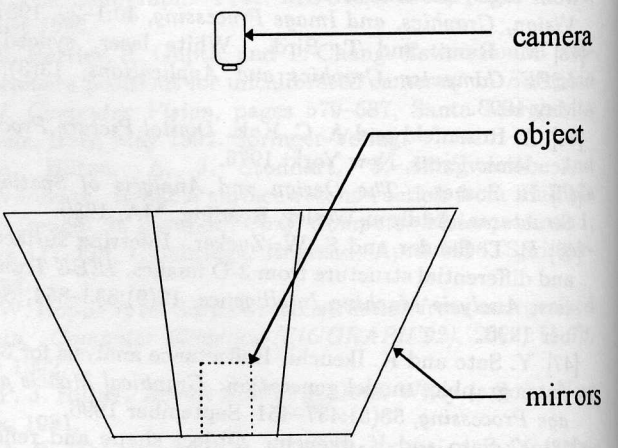

Figure 1: Lateral view of the system.

2.2 Notations

The coordinates of the objects will be given with respect to the reference axes of the camera centered on the center of projection of the latter. The z axis is merged with the optical axis of the camera, and is directed toward the bottom. The coordinates of the points of the image are measured in pixels in a two-dimensional reference associated with the image. We will use the intrinsic parameters of the camera : u_0, v_0, k_u, k_v, f. u_0, v_0 are the coordinates, measured in pixels, of the center of projection or main point in the image reference, k_u, the horizontal scaling factor (in pixels per mm), k_v, the vertical scaling factor and f the focal length. The coordinates in the image reference of $A(u,v)$, the image of a point $A(x,y,z)$ of the object, will be thus be