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PHOTO-CONSISTENT OBJECT 3D RECONSTRUCTION FROM IMAGES USING A VOLUMETRIC METHOD

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ABSTRACT

Three-dimensional (3D) reconstruction of objects from 2D images has been a major research topic in Computer Vision in the last decades. However, it is still a complex problem to solve, when automation, speed and precision are required or when the objects involved present complex topologies or severe photo characteristics.

Methods for 3D reconstruction of objects are usually classified into contact or non-contact methods. Contac-based methods can achieve models with high accuracy. However, the data acquisition time can be large for objects of considerable dimensions. In addition, incorrect measurements can occur when reconstructing very soft objects. Nowadays, 3D models are mainly generated using non-contact methods. Most of these use image data, range sensors or a combination of both. Range sensors collect distance measurements from a known reference coordinate system to points on the surface of the object. They have been very popular when highly detailed models are required and there is a wide variety of software packages available to process and edit the acquired range data. However, they are spatially limited, expensive and some systems of this class do not provide colour information on the reconstructed object. Image-based methods are currently widely used, mainly because the required images can be acquired from video sequences or from photo-cameras, which are nowadays very accessible and of low cost.

The main goal of this work is to build 3D models of an object represented in a sequence of images, acquired using a turntable device and an off-the-shelf image camera. The 3D reconstruction is performed using *Generalized Voxel Coloring* (GVC), [1]. GVC belongs to a recent group of image-based methods denominated volumetric methods, which are based in the *visual-hull* concept, [2]. Briefly, this reconstruction process is initialized with a 3D bounding box of voxels containing in it the object to be reconstructed. The object's 3D shape is then constructed by removing (*carving*) the voxels that are not photo-consistent with the color values of its reprojected pixels in the input images. Moreover, a voxel is carved whenever it projects outside one of the silhouette images from which it is visible.

Our methodology consists of five steps, Fig. 1. First, two image sequences are acquired: a first one contains images of a planar chessboard calibration pattern, by moving it freely within the acquisition volume; and a second sequence formed by images with the object to reconstruct placed on a turntable device, with the same chessboard pattern beneath it, and spinning the device until a full rotation is performed. Then, the camera is calibrated using the *Zhang*'s algorithm, [3]. Thus, the intrinsic and

distortion parameters are obtained from the first sequence and the extrinsic parameters are determined from the second, which is the one to use in the reconstruction process. Object/background segmentation is performed on the second image sequence in order to obtain the associated object's silhouettes. Using the second image sequence and the associated silhouette images, combined with the camera calibration parameters, the object's model is built using GVC. Finally, the volumetric model obtained is polygonized and smoothed using the *Marching Cubes* algorithm, [4].

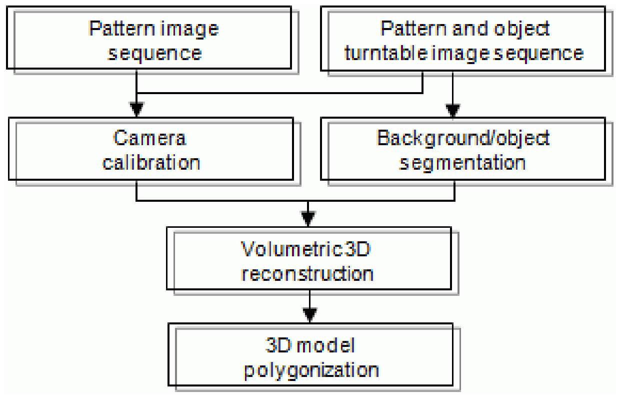

Fig. 1. Methodology used in our work for 3D reconstruction of objects using GVC.

Our methodology was experimentally tested using several real objects, see for example Fig. 2. Although the obtained 3D models were relatively good, their quality is highly dependent on the accuracy of the camera calibration and image segmentation results.

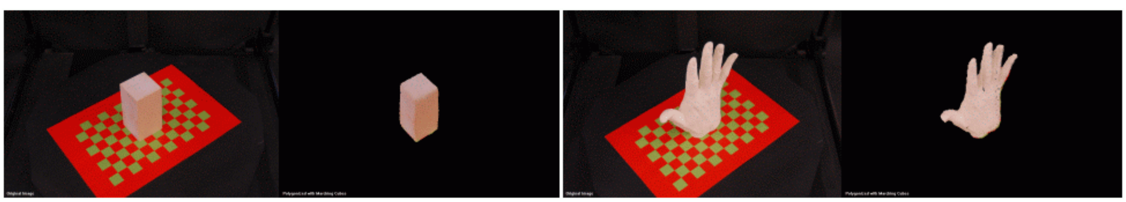

Fig. 2. Used object and its reconstructed 3D model: a parallelepiped object (left); a human hand model object (right).

Some of our future work will pass through the implementation of auto-calibration methods and regarding the 3D reconstruction of non-rigid objects. It was also observed that the GVC technique is very computational demanding and consequently slow, which can be unsuitable for interactive and/or real-time applications. Thus, some of our future work may consist in the implementation of a coarse-to-fine/multiresolution approach.

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