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3D reconstruction methods

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Informations	Abstract
Mots clés : 3D reconstruction cloud point object model geometric *Correspondence : bouguerneimen@gmail.com	3D Reconstruction consists of generating a model 3d from information of the real scene. It is a very interesting alternative, because it aims to improve the modeling of environments 3D, in terms of precision and speed of design, as well as in terms of realism. The representations based geometry build on the use of a model geometric based on a mesh surface [7], a model volumetric [8] or a cloud point [9]. In this article we have given a study comparative of 3D reconstruction methods from an object.

1. Introduction

A system of vision artificial replacing the eye with a camera and the brain with a computer, and which uses one or more digital images acquired using a camera.

Vision by Computer (VA) reproduce the results obtained by vision human on a computer using data processing in order to extract the maximum amount of information relating to the scene to be recognized [17].

The possibilities for exploiting images (whatever their origin) have multiplied significantly following the recent emergence of new technologies for processing and acquiring information. These images represent, in fact, a considerable support of information whether as a support for reflection (decision-making aid, design, etc.) or as a support for communication (production, representation, etc.).

New and adorable manipulation tools allowing to directly exploit these images in an almost exclusively digital way, were born thanks to the evolution of processing capacities, both hardware and software. Thus providing a quality equivalent to that obtained by more traditional techniques.

Several methods of 3D reconstruction are proposed including the literature. And the effective stake is then to minimize the

computing times as much as possible or to improve the quality of the modeled scenes.

Applications that can benefit from 3D reconstruction are: CAD, Virtual Reality, Augmented Reality, training, simulation, commerce, leisure, and compression of data.

¹Computer-aided design (CAD) includes all the software and geometric modeling techniques allowing to design, to test virtually - using a computer and digital simulation techniques - and to produce manufactured and the tools to make them.

²Virtual reality is an immersive interactive visual, visual, sound and / or optical, computer simulation of real or imaginary environments.

³The concept of augmented reality designates the systems that make it possible to superimpose a 3D or 2D virtual model on the perception that we naturally have of reality and this in real time.

The contributions of this article are as follows: First, We try to make an overview of stereoscopic vision and the interest of 3D reconstruction, in the second section, we quote the most known methods in the literature, and this for get an idea about the techniques used for 3D reconstruction. In the third section we end our article with a conclusion and perspective.

2. Interests of 3D reconstruction

3D Reconstruction consists of generating a model 3D from information from a real scene. We have one or more representations 2D of an object and we want to determine the coordinates of the elements visible on these representations in a coordinate system of real space 3D; because it aims to improve the modeling of environments 3D, to facilitate design [4].

3. Stereoscopic vision

An image obtained with a pinhole camera is the result of a transformation geometric [5]. The latter changes from a representation three-dimensional of the scene to a representation two-dimensional (image).

The Stereoscopic Vision [16] aims to reconstruct the 3D structure of a scene. In order to carry out this reconstruction it is necessary to know the 3D coordinates of all the points of a scene. The scene is represented by a couple of stereoscopic images. These images are two representations of the scene taken from different angles. Each point of the scene is projected in the images (left and right) of the stereoscopic pair at different positions. The coordinates of these two projections of the same 3D point are obtained through a matching phase which aims to find, for a given point in one image, its corresponding point in the other image. These two points are the respective projections of the same 3D point in the right and left images.

The principle of the vision stereoscopic is represented in figure 1. In the phases of rectification and calculation of the 3D positions of the points it is necessary to carry out the calibration of the stereoscopic system so as to have intrinsic and extrinsic parameters of the system.

Stereoscopy proceeds by pairing then triangulation

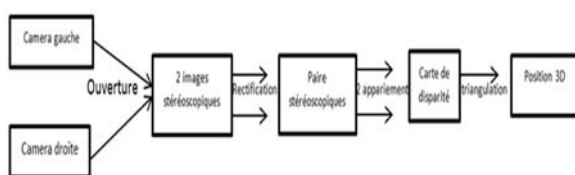


Fig. 1: the principle of vision stereoscopic

3. Methods of 3D reconstruction

There are many techniques of reconstruction 3D, We can classify in these three categories:

Reconstruction from epipolar geometry [18]: This is the most classic method since we already use epipolar geometry for the extraction of 3D points from objects and use visual control as a means of estimating camera positions.

Reconstruction from contours [19], [20]: 3D reconstruction based on the object's contours seems to be difficult to envisage on a natural object of any shape with very irregular contours.

Reconstruction from the movement of the camera (Factorization of Tomasi and Kanade) [21].

3.1 Reconstruction from epipolar geometry

The main steps are shown in Figure 2. The extraction of points and the matching are done exactly as for the visual servo, unlike and that one works on a sequence of images. The stereo pair calibration step must be done on images taken from the site without changing the intrinsic and extrinsic parameters of the cameras. The intrinsic parameters vary depending on the focal change. We will use a test pattern because the self-calibration is more restrictive, requiring specific movements of the camera. It will be assumed that the intrinsic parameters do not vary during the entire image acquisition phase. A first projective reconstruction is then carried out to initialize the rest of the reconstruction, using a bundle adjustment method. [12]

Then a dense pairing of the points belonging to the structure is calculated from, pairs of rectified images (The rectification of the images is also used for the pairing of the points used to control the cameras. Finally, a dense depth map is calculated for each paired point, then the 3D points are connected to each other by triangulation (Delaunay) [13]. Plating textures on surfaces finishes giving a photo-realistic aspect to the reconstructed object.

This reconstruction method must be applied to each subset of sequence of images corresponding to each position of the robot around the object, then the different reconstructed parts are then assembled. It is common to reconstruct from subsets of images

and then to merge the partial models thus obtained by a 3D alignment phase. The reconstruction and alignment algorithms are based on point or line correspondences between the images. The location of these points or lines in the images is affected by measurement noise, influencing the quality of the reconstructed 3D models. [14].

3D images are images that represent a three-dimensional scene. The pixel "is then called a voxel, [15] and represents an elementary volume.

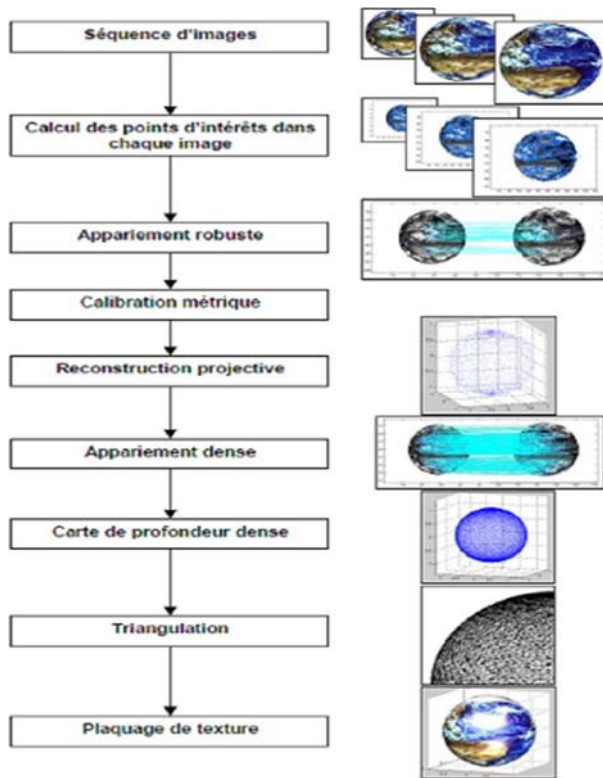


Fig. 2: Reconstruction method [3].

3.2 reconstruction using shape from contour (Shape from contour)

The principle (of Shape from contour) [1] is to reconstruct the normals of visible surfaces from their contours. It is then possible to reproduce the surface from a field of normals.

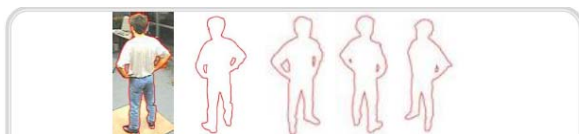


Fig. 3: contours of an object [1]

3.3 reconstruction using shape from silhouette

The purpose using these methods is to recover an object of interest in the scene. A silhouette image is a binary image whose value at a point indicates whether a ray from the camera center to this point intersects the object of interest or not. An example of a silhouette image is shown in Figure 4 [11] [10].

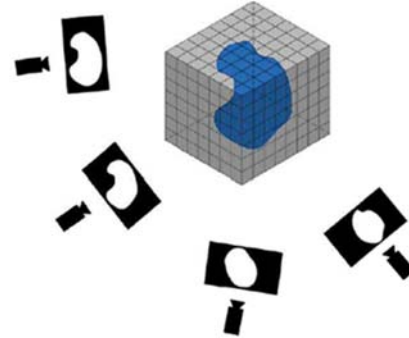


Fig. 4: reconstruction using shape from silhouette[11]

3.4 Reconstruction using Shape from shading

As its name indicates, it is a question of extracting a form starting from the variations of lights observed on the surface of an object [22], [23] at the beginning it was very little used in the systems of vision, one of the reasons for this state of affairs is the absence of robust algorithms capable of finding the fine and discriminating details of the surfaces of objects (see FIG. 5). Recently studies have been made on the possibility of using the shape from shading SFS in the recognition of 3D objects [23].

This category of techniques [2] uses strong hypotheses about the nature of the objects or the lighting conditions to reconstruct the shape of the surfaces. The light intensity that an object reflects can be used to calculate its three-dimensional structure. If we know; the positions of the camera and the light source, the object's reflectance laws, it is possible to calculate the shape of the object.

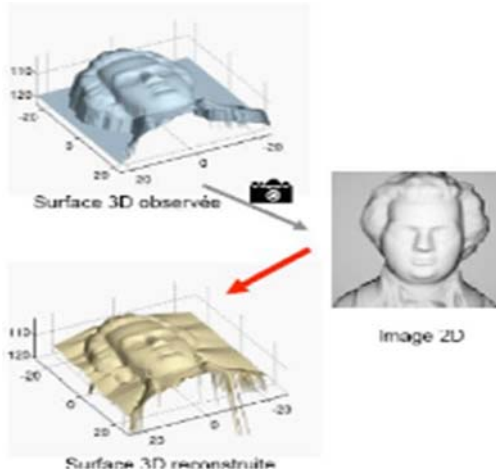


Fig 5 : application of the SFS on a 2D image. [2]

3.5 Representation by detection of shape deformation

This approach describes a new representation of deformable forms based on triangular polygons (see Figure 6), [24] [25] [26] it seeks a correspondence structure of deformable caliber, where we want to find a non-rigid transformation which draws the card of a model has a picture. The problem posed is the correspondence of the form to the image, the latter is defined in terms of an energy function. This energy function associates a cost with each potential transformation of the model. Typically the energy function is a sum of two terms; the first brings the distorted model closer to the image characteristics, while the second penalizes the large deformations of the model. Research on transformations is done efficiently by exploiting the properties of this representation for deformable forms.



Fig 6: triangular polygons of a rabbit and a pear.

3.6 Methods based on skeleton extraction

The representation of skeleton forms is introduced by Blum [27]. It has the possibility of preserving in compact form a large number of topological and geometrical information of the initial form. Another advantage that should be noted is the fact that the skeletons have a graph structure (see Figure 7) which allows the use of the powerful tools from graph theory. The skeleton of an object is a representation of the shape in a lower dimension. For a surface object (2D), the skeleton is a set of lines centered in the

shape, on the other hand for 3D objects there are two types of skeletons. The surface skeletons which are a set of surfaces centered in the shape and the curvilinear 3D skeletons which are a set of lines centered in the shape.



Fig 7: Topological skeletons of some objects.

4. Comparative analysis

Reconstruction from epipolar geometry is the most used method and must be applied to each subset of sequence of images corresponding to each position of the robot around the object, and then the different reconstructed parts are then assemblies.

The reconstruction by contour Even if they give rather good results in very precise situations, the assumptions requested by this method is in general too severe for a general use.

Reconstruction from shading is very little used due to the absence of robust algorithms capable of finding the surfaces of the object.

Reconstruction by detection of deformation of shapes gives an optimal global solution to the correspondence problem which allows detecting deformable objects without any kind of occlusion and background disorder.

5. Conclusion and perspective

In this article we discussed the concept of computer vision and the definition corresponding to the computer vision system and the classification of these systems according to a criterion of depth. We also introduced an overview on some 3D reconstruction method showing their definitions and principles.

3D reconstruction essentially aims to provide synthetic images at the lowest cost and best quality. Indeed, 3D reconstruction offers a double advantage: The elimination of the difficult problem of complete geometric and photometric modeling of the real world and the acceleration of the rendering stage.

Among these perceptual is to propose a new hybrid method for 3D reconstruction that

