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RAPPORT TECHNIQUE

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Abstract

In this paper, we show how relative 3D reconstruction from multiple uncalibrated images can be achieved through reference points. The original contributions with respect to other related works in the field are mainly a direct non linear method for relative 3D reconstruction, a geometrical method to select the set of reference points among all image points and a geometrical interpretation of the linear reconstruction method. Experimental results from both simulated and real image sequences are presented.

1 Relative positioning

From a single image, no depth can be computed without *a priori* information. Even more, no invariant can be computed from a general set of points [3]. This problem becomes feasible using multiple images. The process is composed of two major steps. First image features are matched in the different images. Then, from such a correspondence, depth is easily computed using standard triangulation. This kind of classical technique needs careful calibration of the imaging system and usually it is performed by computing each camera parameters in an aboslute reference frame.

This approach suffers from several drawbacks: firstly the calibration process is an error sensitive process, secondly it cannot always be performed off line, particularly when the imaging system is obtained by a dynamic system with zooming, focusing and moving. Similarly stereo vision with a moving camera is impossible as the standard tool for locating the position of a camera with translation and rotation does not reach the required precision for calibrating such a multistereo system. Introducing in each image beacons with exact known position may overcome these drawbacks: calibration and reconstruction are then solved in the same process [2, 1]. But for many problems it is impossible to provide such carefully positioned reference points.

The alternative approach is to use points in the scene as reference frame without knowing their coordinates nor the camera parameters. This has been investigated by several researchers these past few years. It is also the goal of this paper.

Using parallel projection for the imaging system, Kœnderink and van Doorn [10] were able to choose 4 points as an affine reference frame in the scene and reconstruct all other points seen in at least two images. Using also parallel projection but with a very different approach, Tomasi and Kanade [17] were able to reconstruct a scene from images. Dealing with real images, their results were satisfactory as the imaging system was equipped with a long focal lens. Their contribution is also a nice way to deal with erroneous data using SVD[1] for filtering noise from information.

Approaching the problem for real perspective projection implies to leave the affine geometry for the projective geometry. Two major orientations were developed these two last years. Sparr [16, 15] developed an affine shape descriptor; such a descriptor contains the affine information of the relative position of this group of points; it is related to its perspective projection by a major theorem which allows to recover relative depth or shape. This approach is particularly well suited when affine information can be used like observing parallelograms, of when the imaging system has a known affine reference frame.

Using the more standard tool of projective geometry, we proposed to generalize the Kœnderink and Doorn's method with additional reference points [11, 13]. The right way to approach the problem was first described by Faugeras [4]. This paper is largely inspired by his paper and uses the epipolar geometry reconstruction method he provides.

The original contributions of this paper are a geometrical way to choose among the set of points those which can be selected as reference points, a geometrical interpretation of the reconstruction, a direct solution of the

[1] Singular Value Decomposition