Stereo Vision System Using Relative Stereo Disparity with Subpixel Resolution

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Abstract

For acquisition of 3-Dimensional information in real space, stereo vision system is suitable. In the stereo system, 3D real world position is derived from translation of coordinates between cameras and world. Thus, to use stereo vision, it is needed to construct a precise system which provides kinematically precise translation between camera and world coordinate, in spite of intricacy and hardness. So much cost and time should be spent to build the system. In this paper, facilely to solve previous problem, a method which can easily obtain 3D informations using reference objects and RSD(Relative Stereo Disparity) is proposed. Instead of direct computation of position with translation of coordinates, only relative stereo disparity in stereo pair of image is used to find the reference depth of objects, and real 3D position is computed with initial condition of reference objects. In computation, subpixel resolution is involved to find the disparity for accuracy. To find the RSD, corresponding points are calculated in subpixel resolution. So the result in experiment will be shown that subpixel resolution is more accurate than 1 pixel resolution.

1. Introduction

A stereo vision algorithm is applied to gain 3D informations which include width and height. It is similar to human's binocular eyes system. The principal of getting 3D depth is that the 3 dimensional structure of the world projects differently to a different viewpoint. In a stereo vision system, one camera is displaced from the other. The difference in the viewpoint position of the stereo vision system causes relative transformation of the corresponding item in the stereo image pair. Such relative transformation encodes the depth information which is lost when the 3D structure projects to a two-dimensional retinal plane. In stereo vision system, the encoded depth information is restored by matching the correspondent points in the stereo image pair and computation trigonometric problem using the disparities which are the difference of position in two images of correspondent points and kinematics parameter of the vision system which is usually called camera calibration.

In practice, camera calibration is error-sensitive[1]. Small calibration error can result in large error in the computed depth[2]. For this problem, there are a few of self-calibration algorithms as remedies[3][4]. But those are difficult to be archived in real stereo vision system, because they require much time for recalibration and some of them attach importance to inner camera parameters.

In this study, a easy and useful method of 3D information acquisition, which can reduce the matter of precision stereo vision system construction for correct camera calibrations, is proposed. This method is calculating the 3D depth using relative stereo disparities(RSD) between target object to be known and reference objects whose height are already known, not directly calculating 3D depth by analysis of the camera system kinematicaly. And in selection of corresponding points, subpixel resolution is used to finding line edge points for precision measurement.

2.RSD and subpixel resolution

2.1 RSD (relative stereo disparities)

In the general stereo vision system, depth is calculated as follows. Firstly, geometrical parameter between world coordinate and camera coordinate is defined and the depth is calculated with disparity within stereo image pairs using perspective projection. Fig.1 shows the configuration of this. In this study, normal stereo camera system, which is one of stereo vision system configurations, is used. In this system, the stereo pair of images is normal to z axis of camera reference coordinate. As system has structural constrains, 3D positions of objects which include depth, can obtained easily. In normal stereo method, 3D positions are obtained as follows[5],

$$X=\frac{b}{2}\frac{x_l+x_r}{x_l-x_r},\ Y=\frac{b}{2}\frac{y_l+y_r}{x_l-x_r},\ Z=\frac{bf}{x_l-x_r} \qquad (1)$$

By eq. (1), it can be found that X, Y, Z position is reciprocal proportional with x_l-x_r, disparity in x axis and especially the z is completely reciprocal to it. So the disparity is concerned to depth directly. Therefore, the relative disparity can be used for find the relative depth. A method using this idea was proposed and established mathematically by Wang and Yau in 1999[6]. In fig. 2, P_1, P_2, two Points in 3D world space, are (u_1, v_1) and (u_2, v_2) in image coordinates respectively. This method defines relative stereo disparity and as following

$$RSD = (u_{2l} - u_{1l}) - (u_{2r} - u_{1r}) \qquad (2)$$